CHAPTER 5: SAFE STREET TOOLKIT

INTRODUCTION

This Safe Street Toolkit summarizes the safety improvement countermeasures to be considered for the Waco metropolitan area. The countermeasures are drawn from proven strategies identified by FHWA. The list of FHWA's proven safety countermeasures is included in the **Appendix F.**

The Safe Street Toolkit provides information on each countermeasure's applicability to different crash types, expected crash reduction factors (CRF), expected service life, and the opportunity for systemic implementation across the region. The countermeasure information was derived from the research compiled in the FHWA's Crash Modification Factor Clearinghouse as well as guidance in the FHWA's Roadway Departure Safety, Intersection Safety, and Roadway Safety Information Analysis publications.

NAVIGATING THE TOOLKIT

The countermeasures are grouped into the following categories:

- Signalized Intersections: This category includes countermeasures that can be applied at intersections controlled by traffic signals, such as signal timing adjustments, improved signage/markings, or geometric improvements.
- Unsignalized Intersections: These are countermeasures for intersections that do not have a traffic signal, such as stop-controlled or uncontrolled intersections. Examples include installing signals, roundabouts, improved signing/striping, etc.
- Roadway Segments: Countermeasures in this group are focused on improving safety along roadway sections between intersections. This includes treatments like rumble strips, lighting, guardrails, curve realignments, etc.
- Other Countermeasures: This category lists potential safety strategies such as educational campaigns or enforcement programs.

For each countermeasure, the toolkit provides:

- Crash Types Addressed: Indicates what crash types the countermeasure is intended to mitigate, such as all crashes, pedestrian/bicycle crashes, nighttime crashes, etc.
- Crash Reduction Factor (CRF): The expected percentage reduction in crashes that can be achieved by implementing this countermeasure, based on research studies.
- Expected Service Life: The anticipated number of years the countermeasure will be effective before requiring major rehabilitation or replacement, typically 10 or 20 years.
- Systemic Implementation Opportunity: The potential for proactively implementing this countermeasure across the region using a systemic risk-based approach, rather than just at individual high crash locations. This has been ranked as Very High, High, Medium or Low opportunity.

COMPREHENSIVE APPROACH

While this toolkit focuses primarily on engineering countermeasures, additional strategies are included to encourage a comprehensive approach, incorporating Engineering, Enforcement, Education, and Emergency Services. Reducing severe crashes often requires a balanced approach beyond just infrastructure improvements.

Common violation types like speeding, impaired driving, distracted driving, and failure to yield may warrant supplementing engineering treatments with targeted enforcement or educational campaigns. Coordination with law enforcement and community partners is recommended when applying countermeasures to address these violation types.

The following toolkit entries provide information on the recommended countermeasures and guidance on their applicability within the Waco metropolitan area.

SIGNALIZED INTERSECTION COUNTERMEASURES

Add intersection lighting

Provision of lighting at intersection.

Crash Type	Night
CRF	40%
Expected Life (Years)	20
Systemic Approach Opportunity	Medium

Improve signal hardware: lenses, back-plates with retro-reflective borders, mounting, size, and number

Includes new LED lighting, signal back plates, retro-reflective tape outlining the back plates, or visors to increase signal visibility, larger signal heads, relocation of the signal heads, or additional signal heads.

Crash Type	All
CRF	15%
Expected Life (Years)	10
Systemic Approach Opportunity	Very High

Improve signal timing (coordination, phases, red, yellow, or operation)

Includes adding phases, lengthening clearance intervals, eliminating or restricting higher-risk movements, and coordinating signals at multiple locations.

Crash Type	All
CRF	15%
Expected Life (Years)	10
Systemic Approach Opportunity	Very High

Install emergency vehicle pre-emption systems

Corridors that have a history of crashes involving emergency response vehicles. The target of this strategy is signalized intersections where normal traffic operations impede emergency vehicles and where traffic conditions create a potential for conflicts between emergency and nonemergency vehicles. These conflicts could lead to almost any type of crash, due to the potential for erratic maneuvers of vehicles moving out of the paths of emergency vehicles.

Crash Type	Emergency Vehicle
CRF	70%
Expected Life (Years)	10
Systemic Approach Opportunity	High

SIGNALIZED INTERSECTION COUNTERMEASURES

Install left-turn lane and add turn phase (signal has no left-turn lane or phase before)

Intersections that do not currently have a left-turn lane or a related left-turn phase that are experiencing a large number of crashes. Many intersection safety problems can be traced to difficulties in accommodating left-turning vehicles, in particular where there is currently no accommodation for left turning traffic. A key strategy for minimizing collisions related to left-turning vehicles (angle, rear-end, sideswipe) is to provide exclusive left-turn lanes and the appropriate signal phasing, particularly on high-volume, and high-speed major-road approaches.

Crash Type	All
CRF	55%
Expected Life (Years)	20
Systemic Approach Opportunity	Low

Provide protected left turn phase (left turn lane already exists)

Left-turns are widely recognized as the highest-risk movements at signalized intersections. Providing Protected left-turn phases for signalized intersections with existing left-turn pockets significantly improve the safety for left-turn maneuvers by removing the need for the drivers to navigate through gaps in oncoming/opposing through vehicles.

Crash Type	All
CRF	30%
Expected Life (Years)	20
Systemic Approach Opportunity	High

Convert signal to mast arm (from pedestal-mounted)

Providing better visibility of intersection signs and signals aids the drivers' advance perception of the upcoming intersection. Visibility and clarity of the signal should be improved without creating additional confusion or distraction for drivers.

Crash Type	All
CRF	30%
Expected Life (Years)	20
Systemic Approach Opportunity	Medium

Install raised pavement markers and striping

Adding clear pavement markings can guide motorists through complex intersections. When drivers approach and traverse through complex intersections, drivers may be required to perform unusual or unexpected maneuvers.

Crash Type	All
CRF	10%
Expected Life (Years)	10
Systemic Approach Opportunity	Very High

SIGNALIZED INTERSECTION COUNTERMEASURES

Install flashing beacons as advance warning

Increased driver awareness of an approaching signalized intersection and an increase in the driver's time to react.

Crash Type	**All**
CRF	**30%**
Expected Life (Years)	**10**
Systemic Approach Opportunity	**Medium**

Improve pavement friction (High Friction Surface Treatments)

Improving the skid resistance at locations with high frequencies of wet road crashes and/or failure to stop crashes.

Crash Type	**All**
CRF	**55%**
Expected Life (Years)	**10**
Systemic Approach Opportunity	**Medium**

Install raised median on approaches

Raised medians next to left-turn lanes at intersections offer a cost effective means for reducing crashes and improving operations at higher volume intersections.

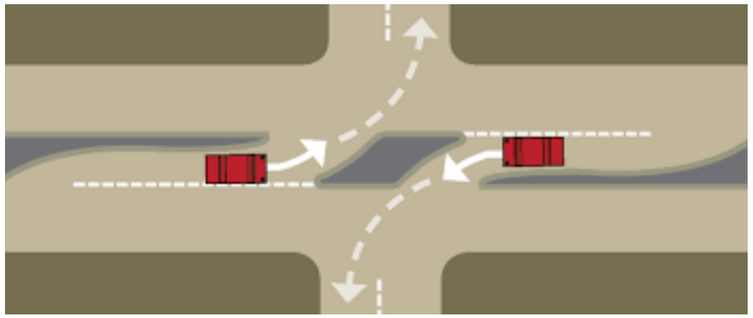
Crash Type	**All**
CRF	**25%**
Expected Life (Years)	**20**
Systemic Approach Opportunity	**Medium**

Install pedestrian median fencing on approaches

Signalized Intersections with high pedestrian-generators nearby (e.g. transit stops) may experience a high volumes of pedestrians J-walking across the travel lanes at mid-block locations instead of walking to the intersection and waiting to cross during the walk-phase.

Crash Type	**P & B**
CRF	**35%**
Expected Life (Years)	**20**
Systemic Approach Opportunity	**Low**

SIGNALIZED INTERSECTION COUNTERMEASURES



Create directional median openings to allow (and restrict) left-turns and U-turns

Crashes related to turning maneuvers include angle, rear-end, pedestrian, and sideswipe (involving opposing left turns) type crashes. If any of these crash types are an issue at an intersection, restriction or elimination of the turning maneuver may be the best way to improve the safety of the intersection.

Crash Type	All
CRF	50%
Expected Life (Years)	20
Systemic Approach Opportunity	Medium

Reduced left-turn conflict intersections

Reduced left-turn conflict intersections are geometric designs that alter how left-turn movements occur in order to simplify decisions and minimize the potential for related crashes. Two highly effective designs that rely on U-turns to complete certain left-turn movements are known as the restricted crossing U-turn (RCUT) and the median U-turn (MUT).

Crash Type	All
CRF	50%
Expected Life (Years)	20
Systemic Approach Opportunity	Medium

Convert intersection to roundabout (from signal)

Signalized intersections that have a significant crash problem and the only alternative is to change the nature of the intersection itself. Roundabouts can also be very effective at intersections with complex geometry and intersections with frequent left-turn movements.

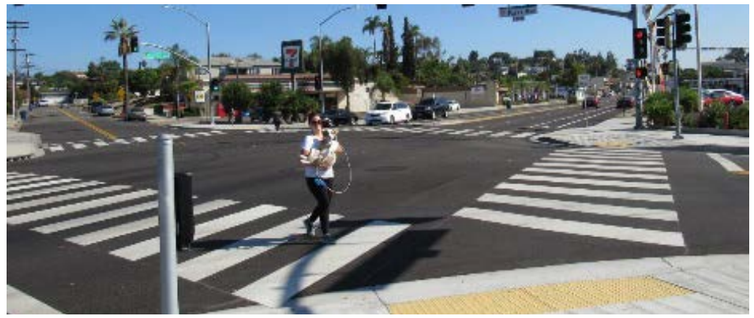
Crash Type	All
CRF	Varies
Expected Life (Years)	20
Systemic Approach Opportunity	Low

Install pedestrian countdown signal heads

Signals that have signalized pedestrian crossing with walk/don't walk indicators and where there have been pedestrian vs. vehicle crashes.

Crash Type	P & B
CRF	25%
Expected Life (Years)	20
Systemic Approach Opportunity	Very High

SIGNALIZED INTERSECTION COUNTERMEASURES



Install pedestrian crossing

Signalized Intersections with no marked crossing and pedestrian signal heads, where pedestrians are known to be crossing intersections that involve significant turning movements. They are especially important at intersections with (1) multiphase traffic signals, such as left-turn arrows and split phases, (2) school crossings, and (3) double-right or double-left-turns. At signalized intersections, pedestrian crossings aroften safer when the left-turns have protected phases that do not overlap the pedestrian walk phase.

Crash Type	**P & B**
CRF	**25%**
Expected Life (Years)	**20**
Systemic Approach Opportunity	**High**

Pedestrian scramble

Pedestrian Scramble is a form of pedestrian "WALK" phase at a signalized intersection in which all vehicular traffic is required to stop, allowing pedestrians/bicyclists to safely cross through the intersection in any direction, including diagonally. Pedestrian Scramble may be considered at signalized intersections with very high pedestrian/bicycle volumes, e.g. in an urban business district.

Crash Type	**P & B**
CRF	**40%**
Expected Life (Years)	**20**
Systemic Approach Opportunity	**High**

Install advance stop bar before crosswalk (Bicycle Box)

Signalized Intersections with a marked crossing, where significant bicycle and/or pedestrians volumes are known to occur.

Crash Type	**P & B**
CRF	**15%**
Expected Life (Years)	**10**
Systemic Approach Opportunity	**Very High**

Modify signal phasing to implement a Leading Pedestrian Interval (LPI)

Addition of LPI gives pedestrians the opportunity to enter an intersection three to seven seconds before vehicles are given a green indication; only minor signal timing alteration is required.

Crash Type	**P & B**
CRF	**60%**
Expected Life (Years)	**10**
Systemic Approach Opportunity	**Very High**

NON SIGNALIZED INTERSECTION COUNTERMEASURES

Add intersection lighting

Provision of lighting at intersection.

Crash Type	**Night**
CRF	**40%**
Expected Life (Years)	**20**
Systemic Approach Opportunity	**Medium**

Convert to all-way STOP control (from 2-way or Yield control)

Unsignalized intersection locations that have a crash history and have no controls on the major roadway approaches. However, all-way stop control is suitable only at intersections with moderate,and relatively balanced volume levels on the intersection approaches. Under other conditions, the use of all-way stop control may create unnecessary delays and aggressive driver behavior.

Crash Type	**All**
CRF	**50%**
Expected Life (Years)	**10**
Systemic Approach Opportunity	**High**

Install signals

Installation of traffic signals

Crash Type	**All**
CRF	**30%**
Expected Life (Years)	**20**
Systemic Approach Opportunity	**Low**

Convert intersection to roundabout (from all way stop)

Intersections that have a high frequency of right-angle and left-turn type crashes. Whether such intersections have existing crash patterns or not, a roundabout provides an alternative to signalization. The primary target locations for roundabouts should be moderate-volume unsignalized intersections.

Crash Type	**All**
CRF	**Varies**
Expected Life (Years)	**20**
Systemic Approach Opportunity	**Low**

NON SIGNALIZED INTERSECTION COUNTERMEASURES

Convert intersection to roundabout (from stop or yield control on minor road)

Intersections that have a high frequency of right-angle and left-turn type crashes. Whether such intersections have existing crash patterns or not, a roundabout provides an alternative to signalization. The primary target locations for roundabouts should be moderate-volume unsignalized intersections.

Crash Type	**All**
CRF	**Varies**
Expected Life (Years)	**20**
Systemic Approach Opportunity	**Low**

Convert intersection to mini-roundabout

Mini-roundabouts are characterized by a small diameter (45-90 feet) and traversable islands (central island and splitter islands).

Crash Type	**All**
CRF	**30%**
Expected Life (Years)	**20**
Systemic Approach Opportunity	**Medium**

Install/upgrade larger or additional stop signs or other intersection warning/regulatory signs

Additional regulatory and warning signs at or prior to intersections will help enhance the ability of approaching drivers to percieve them.

Crash Type	**All**
CRF	**15%**
Expected Life (Years)	**10**
Systemic Approach Opportunity	**Very High**

Upgrade intersection pavement markings

Typical improvements include “Stop Ahead” markings and the addition of centerlines and stop bars.

Crash Type	**All**
CRF	**25%**
Expected Life (Years)	**10**
Systemic Approach Opportunity	**Very High**

NON SIGNALIZED INTERSECTION COUNTERMEASURES

Install Flashing Beacons at Stop-Controlled Intersections

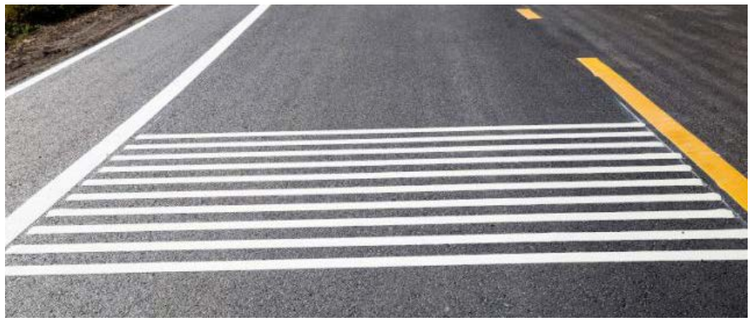
Flashing beacons can reinforce driver awareness of the Non-Signalized intersection control and can help mitigate patterns of right-angle crashes related to stop sign violations. Post-mounted advanced flashing beacons or overhead flashing beacons can be used at stop-controlled intersections to supplement and call driver attention to stop signs.

Crash Type	All
CRF	15%
Expected Life (Years)	10
Systemic Approach Opportunity	High

Install flashing beacons as advance warning

Installation of advance flashing beacons to call drivers attention to intersection control signs.

Crash Type	All
CRF	30%
Expected Life (Years)	10
Systemic Approach Opportunity	High



Install transverse rumble strips on approaches

Transverse rumble strips are installed in the travel lane for the purposes of providing an auditory and tactile sensation for each motorist approaching the intersection.

Crash Type	All
CRF	20%
Expected Life (Years)	10
Systemic Approach Opportunity	High

Improve sight distance to intersection (clear sight triangles)

Unsignalized intersections with restricted sight distance and patterns of crashes related to lack of sight distance where sight distance can be improved by clearing roadside obstructions without major reconstruction of the roadway.

Crash Type	All
CRF	55%
Expected Life (Years)	10
Systemic Approach Opportunity	Medium

NON SIGNALIZED INTERSECTION COUNTERMEASURES

Improve pavement friction (High Friction Surface Treatments)

Non-signalized Intersections noted as having crashes on wet pavements or under dry conditions when the pavement friction available is significantly less than needed for the actual roadway approach speeds. This treatment is intended to target locations where skidding and failure to stop is determined to be a problem in wet or dry conditions and the target vehicle is unable to stop due to insufficient skid resistance.

Crash Type	All
CRF	55%
Expected Life (Years)	10
Systemic Approach Opportunity	Medium

Install splitter-islands on the minor road approaches

The installation of a splitter island allows for the addition of a stop sign in the median to make the intersection more conspicuous.

Crash Type	All
CRF	40%
Expected Life (Years)	20
Systemic Approach Opportunity	Medium

Install raised median on approaches

Effective access management is key to improving safety at, and adjacent to, intersections. The number of intersection access points coupled with the speed differential between vehicles traveling along the roadway often contributes to crashes. Any access points within 250 feet upstream and downstream of an intersection are generally undesirable.

Crash Type	All
CRF	25%
Expected Life (Years)	20
Systemic Approach Opportunity	Medium

Create directional median openings to allow (and restrict) left-turns and u-turns

Crashes related to turning maneuvers include angle, rear-end, pedestrian, and sideswipe (involving opposing left turns) type crashes. If any of these crash types are an issue at an intersection, restriction or elimination of the turning maneuver may be the best way to improve the safety of the intersection.

Crash Type	All
CRF	50%
Expected Life (Years)	20
Systemic Approach Opportunity	Medium

NON SIGNALIZED INTERSECTION COUNTERMEASURES

Reduced left-turn conflict intersections

Reduced left-turn conflict intersections are geometric designs that alter how left-turn movements occur in order to simplify decisions and minimize the potential for related crashes.

Crash Type	All
CRF	50%
Expected Life (Years)	20
Systemic Approach Opportunity	Medium

Install right-turn lane

Many collisions at unsignalized intersections are related to right-turn maneuvers. A key strategy for minimizing such collisions is to provide exclusive right-turn lanes, particularly on high-volume and high-speed major-road approaches. When considering new right-turn lanes, potential impacts to non-motorized users should be considered and mitigated as appropriate.

Crash Type	All
CRF	20%
Expected Life (Years)	20
Systemic Approach Opportunity	Low

Install left-turn lane (where no left-turn lane exists)

Many collisions at unsignalized intersections are related to left-turn maneuvers. A key strategy for minimizing such collisions is to provide exclusive left-turn lanes, particularly on high-volume and high-speed major-road approaches. When considering new left-turn lanes, potential impacts to non-motorized users should be considered and mitigated as appropriate.

Crash Type	All
CRF	35%
Expected Life (Years)	20
Systemic Approach Opportunity	Low

Install raised medians/refuge islands

Intersections that have a long pedestrian crossing distance, a higher number of pedestrians, or a crash history. Raised medians decrease the level of exposure for pedestrians and allow pedestrians to concentrate on (or cross) only one direction of traffic at a time.

Crash Type	P & B
CRF	45%
Expected Life (Years)	20
Systemic Approach Opportunity	Medium

NON SIGNALIZED INTERSECTION COUNTERMEASURES

Install pedestrian crossing at uncontrolled locations (new signs and markings only)

Non-signalized intersections without a marked crossing, where pedestrians are known to be crossing intersections that involve significant vehicular traffic. They are especially important at school crossings and intersections with right and/or left turns pockets.

Crash Type	**P & B**
CRF	**25%**
Expected Life (Years)	**10**
Systemic Approach Opportunity	**High**

Install/upgrade pedestrian crossing at uncontrolled locations (with enhanced safety features)

Non-signalized intersections where pedestrians are known to be crossing intersections that involve significant vehicular traffic. They are especially important at school crossings and intersections with turn pockets, flashing beacons, curb extensions, advanced "stop" or "yield" markings, and other safety features should be added to complement the standard crossing elements.

Crash Type	**P & B**
CRF	**60%**
Expected Life (Years)	**10**
Systemic Approach Opportunity	**Very High**

Install Rectangular Rapid Flashing Beacon (RRFB)

The RRFB includes pedestrian-activated flashing lights and additional signage that enhance the visibility of marked crosswalks and alert motorists to pedestrian crossings. It uses an irregular flash pattern that is similar to emergency flashers on police vehicles. RRFBs are installed at unsignalized intersections and mid-block pedestrian crossings.

Crash Type	**P & B**
CRF	**35%**
Expected Life (Years)	**20**
Systemic Approach Opportunity	**Medium**

Install pedestrian signal (including Pedestrian Hybrid Beacon (PHB))

Intersections noted as having a history of pedestrian vs. vehicle crashes and in areas where the likelihood of the pedestrian presence is high. Corridors should also be assessed to determine if there are adequate safe opportunities for non-motorists to cross and if a pedestrian signal, or a Pedestrian Hybrid Beacon (PHB) (also called High-Intensity Activated crossWalK beacon (HAWK)) are needed to provide an active warning to motorists when a pedestrian is in the crosswalk.

Crash Type	**P & B**
CRF	**55%**
Expected Life (Years)	**20**
Systemic Approach Opportunity	**Low**

ROADWAY SEGMENT COUNTERMEASURES

Add intersection lighting

Provision of lighting along roadways.

Crash Type	Night
CRF	35%
Expected Life (Years)	20
Systemic Approach Opportunity	Medium

Remove or relocate fixed objects outside of clear recovery zone

Known locations or roadway segments prone to collisions with fixed objects such as utility poles, drainage structures, trees, and other fixed objects, such as the outside of a curve, end of lane drops, and in traffic islands. A clear recovery zone should be developed on every roadway, as space is available. In situations where public right-of-way is limited, steps should be taken to request assistance from property owners, as appropriate.

Crash Type	All
CRF	35%
Expected Life (Years)	20
Systemic Approach Opportunity	High

Install median barrier

Areas where crash history indicates drivers are unintentionally crossing the median and the cross-overs are resulting in high severity crashes. The installation of median barriers can increase the number of PDO and non-severe injuries. The net result in safety from this countermeasure is connected more to reducing the severity of crashes not the number of crashes.

Crash Type	All
CRF	25%
Expected Life (Years)	20
Systemic Approach Opportunity	Medium

Install guardrail

Guardrail is installed to reduce the severity of lane departure crashes. However, guardrail can reduce crash severity only for those conditions where striking the guardrail is less severe than going down an embankment or striking a fixed object. Guardrail should only be installed where it is clear that crash severity will be reduced, or there is a history of run-off-the-road crashes at a given location that have resulted in severe crashes.

Crash Type	All
CRF	25%
Expected Life (Years)	20
Systemic Approach Opportunity	High

ROADWAY SEGMENT COUNTERMEASURES

Install impact attenuators

Impact attenuators are typically used to shield rigid roadside objects such as concrete barrier ends, steel guardrail ends and bridge pillars from oncoming automobiles. Attenuators should only be installed where it is impractical for the objects to be removed.

Crash Type	All
CRF	25%
Expected Life (Years)	10
Systemic Approach Opportunity	High

Flatten side slopes

Roadways experiencing frequent lane departure crashes that result in roll-over type crashes as a result of the roadway slope being so severe as to not accommodate a reasonable degree of driver correction. When there is a need to reduce the severity of lane departure crashes without installing a barrier system that could result in increased numbers of crashes.

Crash Type	All
CRF	30%
Expected Life (Years)	20
Systemic Approach Opportunity	Medium

Flatten side slopes and remove guardrail

Locations where high number of crashes originate as a lane departure and result in collision with guardrail or a fixed object located on the side slope shielded by guardrail. The guardrail may or may not meet current standards. Even though guardrails are generally installed to reduce the severity of departure crashes, they still can result in severe crashes in some locations.

Crash Type	All
CRF	40%
Expected Life (Years)	20
Systemic Approach Opportunity	Medium

Install raised median

Areas experiencing head-on collisions that may be affected by both the number of vehicles that cross the centerline and by the speed of oncoming vehicles. Installing a raised median is a more restrictive approach in that it represents a more rigid barrier between opposing traffic.

Crash Type	All
CRF	25%
Expected Life (Years)	20
Systemic Approach Opportunity	Medium

ROADWAY SEGMENT COUNTERMEASURES

Install median (flush)

Areas experiencing head-on collisions that may be affected by both the number of vehicles that cross the centerline and by the speed of oncoming vehicles. Roadways with oversized lanes offer an opportunity to restripe the roadway to reduce the lanes to standard widths and use the extra width for the median.

Crash Type	All
CRF	15%
Expected Life (Years)	20
Systemic Approach Opportunity	Medium

Install pedestrian median fencing on approaches

Roadway segments with high pedestrian-generators and pedestrian-destinations nearby (e.g. transit stops) may experience a high volume of pedestrians J-walking across the travel lanes at mid-block locations instead of walking to the nearest intersection or designated mid-block crossing. When this safety issue cannot be mitigated with shoulder, sidewalk and/or crossing treatments, then installing a continuous pedestrian barrier in the median may be a viable solution.

Crash Type	P & B
CRF	35%
Expected Life (Years)	20
Systemic Approach Opportunity	Low

Install acceleration/deceleration lanes

Areas proven to have crashes that are the result of drivers not being able to turn onto a high speed roadway to accelerate until the desired roadway speed is reached and areas that do not provide the opportunity to safety decelerate to negotiate a turning movement.

Crash Type	All
CRF	25%
Expected Life (Years)	20
Systemic Approach Opportunity	Low

Widen lane (initially less than 10 feet)

Horizontal curves or tangents and low speed or high speed roadways identified as having lane departure crashes, sideswipe or head-on crashes that can be attributed to an existing pavement width less than 10 feet.

Crash Type	All
CRF	25%
Expected Life (Years)	20
Systemic Approach Opportunity	Medium

ROADWAY SEGMENT COUNTERMEASURES

Add two-way left-turn lane

Roadways having a high frequency of drivers being rear-ended while attempting to make a left turn across oncoming traffic. Also can be effective for drivers crossing the centerline of an undivided multilane roadway inadvertently.

Crash Type	All
CRF	30%
Expected Life (Years)	20
Systemic Approach Opportunity	Medium

Road Diet (reduce travel lanes and add a two way left-turn and bike lanes)

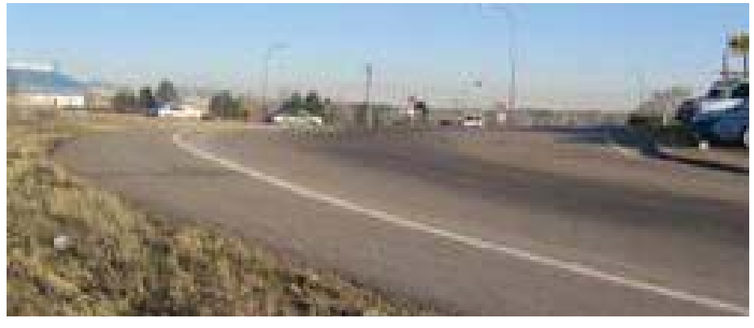
Areas noted as having a higher frequency of head-on, left-turn, and rear-end crashes with traffic volumes that can be handled by only two free flowing lanes. Using this strategy in locations with traffic volumes that are too high could result in diversion of traffic to routes less safe than the original four-lane design.

Crash Type	All
CRF	35%
Expected Life (Years)	20
Systemic Approach Opportunity	Medium

Widen shoulder

Roadways that have a frequent incidence of vehicles leaving the travel lane resulting in an unsuccessful attempt to reenter the roadway. The probability of a safe recovery is increased if an errant vehicle is provided with an increased paved area in which to initiate such a recovery.

Crash Type	All
CRF	30%
Expected Life (Years)	20
Systemic Approach Opportunity	Medium



Curve shoulder widening (outside only)

Roadway curves noted as having frequent lane departure crashes due to inadequate or no shoulders, resulting in an unsuccessful attempt to reenter the roadway.

Crash Type	All
CRF	45%
Expected Life (Years)	20
Systemic Approach Opportunity	Medium

ROADWAY SEGMENT COUNTERMEASURES

Improve horizontal alignment (flatten curves)

Roadways with horizontal curves that have experienced lane departure crashes as a result of a roadway segment having compound curves or a severe radius. This strategy should generally be considered only when less expensive strategies involving clearing of specific sight obstructions or modifying traffic control devices have been tried and have failed to ameliorate the crash patterns.

Crash Type	All
CRF	50%
Expected Life (Years)	20
Systemic Approach Opportunity	Low

Flatten crest vertical curve

The target for this strategy is usually unsignalized intersections with restricted sight distance due to vertical geometry and with patterns of crashes related to that lack of sight distance that cannot be ameliorated by less expensive methods. This strategy should generally be considered only when less expensive strategies involving clearing of specific sight obstructions or modifying traffic control devices have been tried and have failed to ameliorate the crash patterns.

Crash Type	All
CRF	25%
Expected Life (Years)	20
Systemic Approach Opportunity	Low

Improve curve super elevation

Roadways noted as having frequent lane departure crashes and inadequate or no super elevation. Safety can be enhanced when the super elevation is improved or restored along curves where the actual super elevation is less than the optimal.

Crash Type	All
CRF	45%
Expected Life (Years)	20
Systemic Approach Opportunity	Medium

Convert from two-way to one-way traffic

One-way streets can offer improved signal timing and accommodate odd-spaced signals. One-way streets can simplify crossings for pedestrians, who must look for traffic in only one direction. While studies have shown that conversion of two-way streets to one-way generally reduces pedestrian crashes and the number of conflict points, one-way streets tend to have higher speeds which creates new problems.

Crash Type	All
CRF	35%
Expected Life (Years)	20
Systemic Approach Opportunity	Medium

ROADWAY SEGMENT COUNTERMEASURES

Improve pavement friction (high friction surface treatments)

Improving the skid resistance at locations with high frequencies of wet road crashes and/or failure to stop crashes.

Crash Type	**All**
CRF	**55%**
Expected Life (Years)	**10**
Systemic Approach Opportunity	**High**

Install/upgrade signs with new fluorescent sheeting (regulatory or warning)

Additional or new signage can address crashes caused by lack of driver awareness or compliance of roadway signing.

Crash Type	**All**
CRF	**15%**
Expected Life (Years)	**10**
Systemic Approach Opportunity	**Very High**

Install chevron signs on horizontal curves

Roadways that have an unacceptable level of crashes on relatively sharp curves during periods of light and darkness.

Crash Type	**All**
CRF	**40%**
Expected Life (Years)	**10**
Systemic Approach Opportunity	**Very High**

Install curve advance warning signs

Addition of advance curve warning signs; may also include horizontal alignment and/or advisory speed warning signs.

Crash Type	**All**
CRF	**25%**
Expected Life (Years)	**10**
Systemic Approach Opportunity	**Very High**

ROADWAY SEGMENT COUNTERMEASURES

Install curve advance warning signs (flashing beacon)

Roadways that have an unacceptable level of crashes on relatively sharp curves. Flashing beacons in conjunction with warning signs should only be used on horizontal curves that have an established severe crash history to help maintain their effectiveness.

Crash Type	All
CRF	30%
Expected Life (Years)	10
Systemic Approach Opportunity	High

Install dynamic/variable speed warning signs

Includes the addition of dynamic speed warning signs (also known as Radar Speed Feedback Signs). Curvilinear roadways that have an unacceptable level of crashes due to excessive speeds on relatively sharp curves.

Crash Type	All
CRF	30%
Expected Life (Years)	10
Systemic Approach Opportunity	High

Install delineators, reflectors, and/or object markers

Installation of delineators, reflectors, and/or object markers are intended to warn drivers of an approaching curve or fixed object that cannot easily be removed.

Crash Type	All
CRF	15%
Expected Life (Years)	10
Systemic Approach Opportunity	Very High

Install edge-lines and centerlines

Any road with a history of run-off-road right, head-on, opposite-direction-side-swipe, or run-off-road-left crashes is a candidate for this treatment -install where the existing lane delineation is not sufficient to assist the motorist in understanding the existing limits of the roadway. Depending on the width of the roadway, various combinations of edge line, and/or center line pavement markings may be the most appropriate.

Crash Type	All
CRF	25%
Expected Life (Years)	10
Systemic Approach Opportunity	Very High

ROADWAY SEGMENT COUNTERMEASURES

Install no-passing line

Roadways that have a high percentage of head-on crashes suggesting that many head-on crashes may relate to failed passing maneuvers. No-passing lines should be installed where drivers "passing sight distance" is not available due to horizontal or vertical obstructions.

Crash Type	All
CRF	45%
Expected Life (Years)	10
Systemic Approach Opportunity	Very High

Install centerline rumble strips/stripes

Center Line rumble strips/stripes can be used on virtually any roadway especially those with a history of head-on crashes.

Crash Type	All
CRF	20%
Expected Life (Years)	10
Systemic Approach Opportunity	High

Install edge line rumble strips/stripes

Shoulder and edge line milled rumble strips/stripes should be used on roads with a history of roadway departure crashes.

Crash Type	All
CRF	15%
Expected Life (Years)	10
Systemic Approach Opportunity	High

Install bike lanes

Roadway segments noted as having crashes between bicycles and vehicles or crashes that may be preventable with a buffer/shoulder.

Crash Type	P & B
CRF	35%
Expected Life (Years)	20
Systemic Approach Opportunity	High

ROADWAY SEGMENT COUNTERMEASURES

Install separated bike lanes

Separated bike ways are most appropriate on streets with high volumes of bike traffic and/or high bike-vehicle collisions, presumably in an urban or suburban area. Separation types range from simple, painted buffers and flexible delineators, to more substantial separation measures including raised curbs, grade separation, bollards, planters, and parking lanes.

Crash Type	P & B
CRF	45%
Expected Life (Years)	20
Systemic Approach Opportunity	High

Install sidewalk/pathway (to avoid walking along roadway)

Areas noted as not having adequate or no sidewalks and a history of walking along roadway pedestrian crashes. In rural areas asphalt curbs and/or separated walkways may be appropriate.

Crash Type	P & B
CRF	80%
Expected Life (Years)	20
Systemic Approach Opportunity	Medium

Install/upgrade pedestrian crossing (with enhanced safety features)

Roadway segments with no controlled crossing for a significant distance in high-use midblock crossing areas and/or multilane roads locations. Flashing beacons, curb extensions, medians and pedestrian crossing islands, and/or other safety features should be added to complement the standard crossing elements.

Crash Type	P & B
CRF	35%
Expected Life (Years)	20
Systemic Approach Opportunity	Medium

Install raised pedestrian crossing

On lower-speed roadways, where pedestrians are known to be crossing roadways that involve significant vehicular traffic.

Crash Type	P & B
CRF	35%
Expected Life (Years)	120
Systemic Approach Opportunity	Medium

ROADWAY SEGMENT COUNTERMEASURES

Install Rectangular Rapid Flashing Beacon (RRFB)

The RRFB includes pedestrian-activated flashing lights and additional signage that enhance the visibility of marked crosswalks and alert motorists to pedestrian crossings. It uses an irregular flash pattern that is similar to emergency flashers on police vehicles. RRFBs are installed at unsignalized intersections and mid-block pedestrian crossings.

Crash Type	**P & B**
CRF	**35%**
Expected Life (Years)	**20**
Systemic Approach Opportunity	**Medium**

Install animal fencing

At locations with high number of vehicular/animal crashes (reactive) or where there is a known high number of animals crossing due to migratory patterns (proactive).

Crash Type	**Animal**
CRF	**80%**
Expected Life (Years)	**20**
Systemic Approach Opportunity	**Medium**

ADDITIONAL COUNTERMEASURES

Crosswalk visibility enhancements

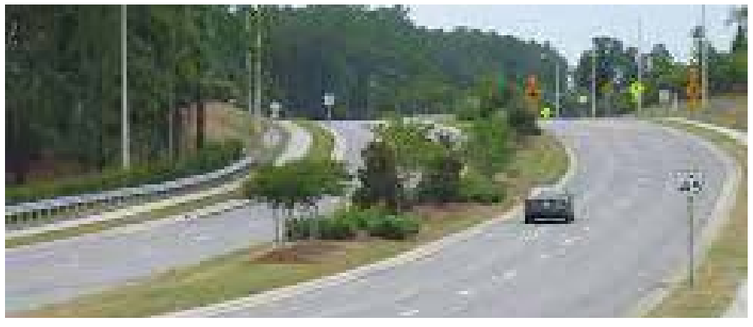
Poor lighting conditions, obstructions such as parked cars, and horizontal or vertical roadway curvature can reduce visibility at crosswalks.

Crash Type	**All**
CRF	**N/A**
Expected Life (Years)	**N/A**
Systemic Approach Opportunity	**N/A**

Variable Speed Limits

Speed limits are established with an engineering study based on inputs like traffic volumes, operating speeds, roadway characteristics, and crash history. However, conditions on the roadway are susceptible to change in a short amount of time (e.g., congestion, crashes, weather).

Crash Type	**All**
CRF	**N/A**
Expected Life (Years)	**N/A**
Systemic Approach Opportunity	**N/A**



Corridor access management

Access management refers to the design, application, and control of entry and exit points along a roadway. This includes intersections with other roads and driveways that serve adjacent properties.

Crash Type	**All**
CRF	**N/A**
Expected Life (Years)	**N/A**
Systemic Approach Opportunity	**N/A**

SafetyEdge^{SM}

The SafetyEdge^{SM} technology shapes the edge of the pavement at approximately 30 degrees from the pavement cross slope during the paving process. This safety practice eliminates the potential for vertical drop-off at the pavement edge, has minimal effect on project cost, and can improve pavement durability by reducing edge raveling of asphalt.

Crash Type	**All**
CRF	**N/A**
Expected Life (Years)	**N/A**
Systemic Approach Opportunity	**N/A**

ADDITIONAL COUNTERMEASURES

Appropriate speed limits for all road users

There is broad consensus among global roadway safety experts that speed control is one of the most important methods for reducing KSI. Speed is an especially important factor on non-limited access roadways where vehicles and vulnerable road users mix.

Crash Type	All
CRF	N/A
Expected Life (Years)	N/A
Systemic Approach Opportunity	N/A