



PSAP Countermeasures: Background and Application Methodology

Texas Pedestrian Safety Action
Plan (PSAP)

June 2023

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Abbreviations and Acronyms

CMF	Crash Modification Factor
CRF	Crash Reduction Factor
DES	TxDOT's Design Division
FHWA	Federal Highway Administration
HSIP	Highway Safety Improvement Program
KABCO	Refers to all crash injury severities (K-fatal injury, A-suspected serious injury, B-suspected minor injury, C-possible injury, O- unknown injury)
PSAP	Pedestrian Safety Action Plan
PTN	TxDOT's Public Transportation Division
TRF	TxDOT's Traffic Safety Division
TxDOT	Texas Department of Transportation
VPD	Vehicles per Day

1 Introduction

The purpose of this Countermeasures Methodology Memorandum is to provide an overview of the countermeasure selection process and the data-driven approach to assigning engineering safety improvements to applicable locations.

An overview of the Texas Pedestrian Safety Action Plan (PSAP) data-driven process is featured in Figure 1.

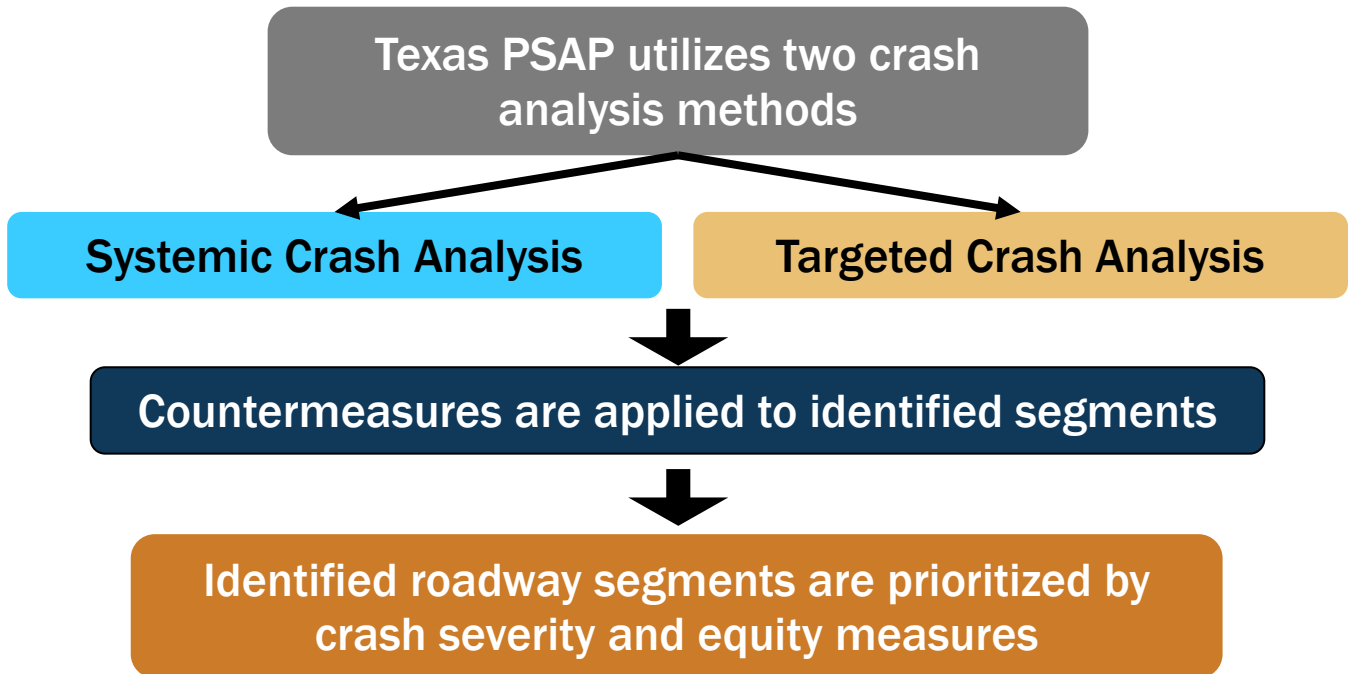


Figure 1-1: Texas PSAP Overview

This memo will refer specifically to the application of countermeasures to roadway locations around the state. Additional information on overall methodology for the entire Texas PSAP can be found in the PSAP Statewide Summary.

2 Countermeasure Identification and Selection Process

Investments in safety countermeasures which have been proven effective by research and analysis can mitigate future crashes involving pedestrians and reduce the injury severities resulting from those crashes. The Texas PSAP selected and applied pedestrian crash countermeasures in the following general process:

1. Identification of engineering and programmatic countermeasures
2. Development of logic to assess suitable locations
3. Application of countermeasures to potential risk and hot spot segments

Each step in the process was reviewed by a team of TxDOT Division staff from PTN, DES, and TRF with additional input from TxDOT District staff and TxDOT's Bicycle and Pedestrian Advisory Committee. Initial research and conversations with these stakeholders led to a comprehensive list of safety improvements that

are eligible for Highway Safety Improvement Program (HSIP) and other state and federal highway funds and can be viewed as actionable upon the completion and adoption of the PSAP.

2.1 Engineering Countermeasures

Twenty-five engineering-related countermeasures were selected based on a review of Federal Highway Administration (FHWA) best practices¹, [TxDOT's Highway Safety Improvement Program](#), and a review of the Crash Modification Factor ([CMF Clearinghouse](#)). All TxDOT HSIP work codes that relate to mitigating pedestrian crash outcomes and the associated crash reduction factors were utilized. Table 1 summarizes all of these identified engineering countermeasures. As of Spring 2023, TxDOT HSIP work codes are only available for less than half of this list; however, TxDOT TRF has begun investigating incorporating some of these countermeasures into future HSIP guidelines. Incorporating additional countermeasures into the HSIP adds funding flexibility and opportunities to TxDOT Districts when programming pedestrian improvements in their areas, specifically allowing Category 8 funding for additional pedestrian investments. Even though some of these improvements are not identified in the TxDOT HSIP, FHWA and the CMF Clearinghouse have supporting research and documentation that provide a range of effectiveness if a countermeasure is implemented.

Another set of tools available to TxDOT District staff is the [Safety Scoring Tools](#) which have a broader focus than just pedestrian design elements and are intended to assist roadway design engineers in making safety-driven decisions during the project development and design process. These Excel-based tools are currently available for rural highways (two lane and multi-lane) and urban intersections. An additional urban highways safety scoring tool is in development. For more information, visit the DES Division's Safety Score Tool webpage on TxDOT's website (<https://www.txdot.gov/business/resources/design-tools-training.html>).

There are two general categories that define where these engineering countermeasures can be implemented for both systemic and targeted analyses – along segments and at spot locations. The segment-related pedestrian countermeasures are intended to support safety improvements along a corridor, such as installing sidewalks or raised medians. In some cases, these countermeasures target pedestrian crashes that occur along a roadway between intersections, however, these segment-related countermeasures could improve safety performance at intersections as well.

The other category of countermeasures is focused on spot treatments or safety improvements at intersections or at crossing locations. There are multiple spot treatments that would modify the traffic control configuration at an intersection and there are options for providing/improving mid-block crossings by installing active crossing devices like pedestrian hybrid beacons or rectangular rapid flashing beacons. Pedestrian refuge islands, in-street pedestrian signs or raised pedestrian crossings are examples of passive crossing devices that are intended to improve pedestrian visibility while simultaneously reducing speeds of approaching vehicles.

This list of countermeasures is not exhaustive and, as research continues in the area of improving pedestrian safety, new countermeasures may be identified. Suggested countermeasures were applied statewide with the best available data followed up by a statewide quality control process. However, a robust implementation

¹ [Proven Safety Countermeasures for Pedestrians, PEDSAFE, Toolbox of Pedestrian Countermeasures and Their Potential Effectiveness.](#)

review of prioritized locations paired with local stakeholder engagement will help validate safety investments for specific locations.

Table 2-1: Engineering Countermeasures

Countermeasure Name	Countermeasure Description	Analysis Type	Target Crash Types	TxDOT HSIP Code (TxDOT CRF) ²	CMF CLEARING-HOUSE ID(s) ³	CMF CLEARING-HOUSE FACTORS (CRF / CMF)
Curb Geometrics	Reduce right-turn curb radii to reduce right turn vehicle speeds or bump out/extend curb ramps at intersections to reduce the crossing distance.	Targeted	Vehicle/ Pedestrian	--	STEP Countermeasure Tech Sheet	--
Flashing Yellow Pedestrian Protection	Modify signal phasing to implement a Protected Pedestrian Interval call during a Flashing Yellow Arrow Phase.	--	Vehicle/ Pedestrian	--	--	--
Improve School Zones	Improve an existing school zone by upgrading signing, pavement markings, or signals.	Both	All Crash Types	133 (5%)	--	--
In-Street Pedestrian Sign	R1-6a sign placed in the middle of the street or W11-2, W16-7P at crossing locations. These signs serve to remind road users of laws regarding right-of-way.	Targeted	Vehicle/ Pedestrian	--	STEP Countermeasure Tech Sheet	--
Install Roundabouts	Convert an existing intersection to a single lane roundabout design.	--	Intersection Related	547 (62%)	--	--
Install School Zones	Install school zones to include flashers, signing, and/or pavement markings where none existed previously. Refer to HSIP Work Code 403 for pedestrian crosswalk markings.	Systemic	All Crash Types	114 (20%)	--	--
Install Sidewalk	Install sidewalks where none existed previously.	Both	Pedestrian, Pedalcyclist	407 (65%)	--	--

² For more information on TxDOT HSIP Codes and Crash Reduction Factors, refer to [TxDOT's 2021 HSIP Guidelines](#)

³ CMF ID numbers are unique to the [Crash Modification Factors Clearinghouse](#)

Countermeasure Name	Countermeasure Description	Analysis Type	Target Crash Types	TxDOT HSIP Code (TxDOT CRF) ²	CMF CLEARING-HOUSE ID(s) ³	CMF CLEARING-HOUSE FACTORS (CRF / CMF)
Install/Upgrade Safety Lighting	Provide roadway lighting, either partial or continuous, where either none existed previously, or major improvements are being made. Refer to HSIP Work Code 305 for intersection lighting.	Both	Lighting Conditions: Dark, Not Lighted; Dark, Lighted; Dark, Unknown Lighting	304 (49%)	--	--
Install Traffic Signal	Provide a traffic signal where none existed previously. This does not include the installation of flashing beacons.	--	Intersection Related Pedestrian/ Pedalcyclist Angle, Sideswipe, Head On	107 (35%)	--	--
Leading Pedestrian Interval	Modify signal phasing to implement a Leading Pedestrian Interval.	Targeted	Vehicle/ Pedestrian	--	1993, 9903, 9906, 9909, 9912, 9915, 9918	(9% - 58.7%) / (0.91 - 0.413)
Median Barriers	Construct a concrete or cable safety system median barrier where none existed previously.	Systemic	Head On	201 (75%)	--	--
Median Barrier Height Extensions	Increase height/vertical clearance on median barrier walls for high-speed facilities.	--	Vehicle/ Pedestrian	--	--	--
Pedestrian Crosswalk Markings	Place pedestrian crosswalk markings where none existed previously. Refer to HSIP Work Code 114 for school zones and HSIP Work Code 110 for pedestrian signals.	--	Pedestrian	403 (10%)	--	--
Pedestrian Hybrid Beacon (PHB)	Provide pedestrian hybrid beacons at established crosswalks or in conjunction with installation of new crosswalks (HSIP Work Code 403). Requires TRF approval.	Both	Pedestrian	143 (15%)	--	--
Pedestrian Refuge Islands	A pedestrian refuge island is a median with a refuge area that is intended to help protect pedestrians who are crossing a multi-lane road.	Targeted	Vehicle/ Pedestrian	--	STEP Countermeasure Tech Sheet	32% / 0.68

Countermeasure Name	Countermeasure Description	Analysis Type	Target Crash Types	TxDOT HSIP Code (TxDOT CRF) ²	CMF CLEARING-HOUSE ID(s) ³	CMF CLEARING-HOUSE FACTORS (CRF / CMF)
Pedestrian Scramble	Implement exclusive pedestrian phase at signalized intersections.	Targeted	Vehicle/ Pedestrian	--	4117, 5244	(35% - 51%) / (0.65 - 0.49)
Pedestrian Over/Underpass	Construct a pedestrian over/underpass where none existed previously.	--	Pedestrian	523 (95%)	--	--
Raised Median	Install a roadway divider using barrier curb.	Systemic	Angle Sideswipe Head On	203 (25%)	--	--
Raised Pedestrian Crosswalks	Install elevated pedestrian crosswalks with appropriate signs and pavement markings.	Targeted	Vehicle/ Pedestrian	--	136	46% / 0.54
Rectangular Rapid Flashing Beacon (RRFB)	Install pedestrian activated rectangular rapid flashing beacons (RRFB) at existing crosswalks or in conjunction with installation of new crosswalks (HSIP Work Code 403). Requires TRF approval.	Both	Pedestrian	144	9024, 11158, 11168, 11169	(47% - 73%) / (0.53 - 0.27)
Shared Use Path	Installed shared use paths where none existed previously.	Both	Vehicle/ Bicyclist	--	9250	25% / 0.75
SOXSOP	Safety and Operational Cross Section Optimization utilizes existing roadway layout and configuration to repurpose thru lanes and turn lanes to improve safety along a corridor and when accessing driveways and intersections.	Systemic	All Crash Types	--	199, 874, 875, 876, 2841, 5553, 5554, 7828, 7829, 11128, 11129, 11133, 11134, 11135, 11136, 11230, 11231	(0% - 64%) / (1 - 0.36)
Stop Lines at Traffic Signals	Provide stop bar pavement markings at signalized intersections.	--	Vehicle/ Pedestrian	--	--	--

Countermeasure Name	Countermeasure Description	Analysis Type	Target Crash Types	TxDOT HSIP Code (TxDOT CRF) ²	CMF CLEARING-HOUSE ID(s) ³	CMF CLEARING-HOUSE FACTORS (CRF / CMF)
Traffic Calming	Provide roadway improvements intended to reduce driver speed by introducing horizontal deflection devices (chicanes), reduced travel way space (lane narrowing), vertical deflection (speed humps/tables), or other means to change the perception of a high-speed roadway.	Systemic	All Crash Types	--	128, 129, 131, 132, 134, 586, 587, 588	(6% - 50%) / (0.94 - 0.5)

2.2 Educational, Programmatic, and Operational Countermeasures

Infrastructure investments have been shown to reduce the frequency and severity of pedestrian crashes. Similarly, investment in educational, programmatic, and operational countermeasures have been shown to improve pedestrian crash outcomes. Table 2 provides a list of strategies and programmatic and educational countermeasures that are intended to help facilitate safe social norms when drivers and pedestrians interact on public roadways.

Table 2-2: Educational, Programmatic, and Operational Countermeasures

Countermeasure Name	Type	Description/Example
Undertake Education Campaigns or Programs	Educational	<ul style="list-style-type: none"> ● Traffic Safety Campaigns ● Pedestrian Safety Campaigns <ul style="list-style-type: none"> ○ Educate pedestrians to walk against, not with, the flow of traffic and to stay off the travel lane. ○ Encourage pedestrians and bicyclists to wear reflective or brightly colored clothing to improve their conspicuity. ○ Educate school-aged children on safety practices that they should follow while waiting for the bus (e.g., stay out of the road, limit horseplay, be aware of traffic, etc.) ● Stay Safe Priority ● Unintended pedestrians/stranded motorists along high-speed roadways (E.g.: Wisconsin DOT Stranded Driver tips)
Expand Disabled Vehicle Programs	Programmatic	Highway Emergency Response Operator (HERO) Program
Speed Trailer Program		Enforcement Strategy: Speed trailers discourage speeding and can be deployed at various locations and can be relocated periodically.

Countermeasure Name	Type	Description/Example
Undertake Frontage Road Study	Operational	Focuses on frontage roads with greater proportion of crashes (E.g.: US 287 Frontage Road Improvements Feasibility Study or I-20 Midland-Odessa Corridor Study)
Undertake Speed Study		Focuses on corridors with greater proportion of speeding-related crashes, looking for speed limit reduction opportunities (Guidance: TxDOT Manual: Procedures for Establishing Speed Zones, Speed Zone Studies and NACTO Speed Safety Study guidance)
Undertake Roadway Safety Audit		Review of safety conditions and plan for improvements (FHWA guidance)
Consider Right-Turn-on-Red Restrictions		Identify signalized intersections with high right-turning volumes (FHWA Intersection Safety Campaign guidance)

The purpose of these strategies is to complement the engineering countermeasures by reminding roadway users of their responsibilities, providing assistance to potential unintended pedestrians, and identifying situational deficiencies in roadway operations. All of these efforts should involve active engagement with local stakeholders and residents to help promote a positive safety culture. This list is not exhaustive and District staff are encouraged to start thinking about implementing some of these strategies as shifting community attitudes and behavior are lengthy processes.

While some of these strategies require the organization of group leaders and safety champions, operational strategies can be incorporated into District standard practices to regularly assess locations of concern as it relates to frontage roads, excessive speed, and signalized intersections with heavy right-turning volumes. Engineering-level analysis is likely needed if specific locations are identified for actionable improvements. In subsequent sections, locations are identified based on statewide data analysis and may require additional local knowledge and review.

3 Logic Methodology and Assignment

This section describes the data-driven approaches used to identify suitable safety countermeasures for the systemic and targeted safety analysis results. There are 13 suggested countermeasures specific to the systemic analysis results (Section 3.1) and 12 suggested countermeasures for the targeted analysis results (Section 3.2). The logic associated with each countermeasure is similar between the two analyses and deviate slightly when presence of crash history or presence of risk factors are considered. The countermeasure logic was applied to all systemic segments and only to hot-spot segments where there was a history of crashes. The countermeasure logic was only applied when data and/or applicable guidance was readily available. For example, there is insufficient data indicating the locations of traffic signals on Texas roadways to adequately apply any logic for the countermeasure “Install stop lines at traffic signals.”

3.1 Systemic Analysis Countermeasures

As a reminder, there are 19,045 centerline miles of Focus Facilities that were considered for the systemic analysis. The logic/criteria were applied to all focus facilities regardless of the “potential risk” designation. The

results shown in Table 3-1 provide the number of centerline miles that met the specific logic/criteria for each countermeasure and there are many locations where multiple countermeasure criteria applied to a single segment.

Table 3-1: Systemic Analysis Countermeasure Summary

Countermeasure	Centerline Miles	Locations
Install Sidewalk	5,961	--
Install Shared Use Path	6,801	--
Install School Zones	--	2,371
Improve School Zones	--	12
Install Pedestrian Hybrid Beacon (PHB)	--	81
Install Rectangular Rapid Flashing Beacon (RRFB)	--	384
Install Median Barriers	956	--
Install Raised Median	400	--
Install/Upgrade Lighting	4,464	--
Install Traffic Calming	966	--
SOXSOP	460	--
Frontage Road Study	470	--
Speed Study	1,062	--

The following sections describe the specific set of criteria that each systemic analysis segment met for a countermeasure to be suggested.

3.1.1 Install Sidewalk

The Install Sidewalk countermeasure was suggested if:

CRITERION #1

- Sidewalk Coverage = “Mostly Present” to “None Present”
- Functional Classification
 - Other Principal Arterial
 - Minor Arterial
 - Major Collector
 - Minor Collector
 - Local
- Posted Speed Limit ≤ 55 mph

CRITERION #2

- Sidewalk Coverage = “Mostly Present” to “None Present”
- Functional Classification
 - Interstate
 - Other Freeway and Expressway
- Area Type = Urban

3.1.2 Install Shared Use Path

The Install Shared Use Path countermeasure was suggested if:

CRITERION #1

- Curb is present on both sides of roadway
- Posted speed limit \leq 45 MPH
- $(\text{ROW width} - \text{roadbed width})/2 \geq 14$ feet

CRITERION #2

- Curb is present on both sides of roadway
- Posted speed limit \geq 50 MPH
- $(\text{ROW width} - \text{roadbed width})/2 \geq 16$ feet

CRITERION #3

- Curb is Not Present
- $(\text{ROW width} - \text{roadbed width})/2 \geq 20$ feet
- Area Type = Urban

Shared Use Path criteria were based on [TxDOT Roadway Design Manual §6.4.4, Table 6-6](#).

3.1.3 Install School Zones

The Install School Zone countermeasure was suggested if:

- Segment is within 0.5-mile buffer of school point
- Posted Speed Limit < 50 MPH

Install school zone references:

- [Safe Routes Partnership: Too Far to Walk?](#) = 0.5 to 1.5 miles
- [The Threshold Distance Associated with Walking from Home to School](#) = 0.497 miles (0.8 km)
- [Evaluating the effects of active morning commutes on students' overall daily walking activity in Singapore: Do walkers walk more?](#) = 0.42 to 0.84 miles

3.1.4 Improve School Zones

The Improve School Zone countermeasure was suggested if:

- Segment Crash Flag = "Active School Zone Flag"

3.1.5 Install Pedestrian Hybrid Beacon (PHB)

The Install Pedestrian Hybrid Beacon (PHB, commonly known as HAWK) countermeasure was suggested if:

- Sidewalk Coverage = "Mostly to Fully Present"
- Posted Speed Limit \leq 40 MPH
- Number of Lanes = 6

Install PHB/HAWK criteria were based on [TxDOT RRFB & PHB 2018 Memo](#). A total of 81 segments/locations were identified statewide.

3.1.6 Install Rectangular Rapid Flashing Beacon (RRFB)

The Install Rectangular Rapid Flashing Beacon countermeasure was suggested if:

- Sidewalk Coverage
 - Partially to Fully Present
- Posted Speed Limit \leq 40 MPH
- Number of Lanes $<$ 6

Install RRFB criteria were based on [TxDOT RRFB & PHB 2018 Memo](#). A total of 384 segments/locations were identified statewide.

3.1.7 Install Median Barriers

Install Median Barrier specifically refers to construction of a concrete or cable safety system median barrier where none existed previously. This countermeasure was suggested if:

- Median Type = “Unprotected”
- Median Width $>$ 10 feet
- Posted Speed Limit \geq 50 MPH
- Crash Flag = “Pedestrian Failed to Yield ROW to Vehicle”

3.1.8 Install Raised Medians

The Install Raised Median countermeasure was suggested if:

- Median Type = “None” or “Unprotected”
- Median Width = 6 feet \leq 17 feet
- Number of Lanes \leq 6

3.1.9 Install/Upgrade Lighting

The Install/Upgrade Lighting countermeasure was suggested if:

- Dark Lighting Crash Ratio $>$ 50%

The *Dark Lighting Crash Ratio* is defined by the total number of crashes with lighting condition “Dark, Not Lighted” + “Dark, Lighted” + “Dark, Unknown Lighting” divided by the total number of crashes:

$$\frac{('Dark, Not Lighted' + 'Dark, Lighted' + 'Dark, Unknown Lighting')}{Total\ number\ of\ crashes}$$

NOTE: Presence of lighting data was unavailable for this analysis.

3.1.10 Install Traffic Calming

The Install Traffic Calming countermeasure was suggested if:

- Lane Width \geq 12 feet
- Number of Lanes \leq 4
- Speed Limit Risk Factor Present
- Area Type = Urban

3.1.11 Safety and Operational Cross Section Optimization (SOXSOP)

Safety and Operational Cross Section Optimization (SOXSOP) evaluates the trade-offs between lane and shoulder configurations within the existing roadway width that may be needed during the design life of the highway. TxDOT currently requires any roadway modifications that reduce vehicle capacity to navigate a specific approval process. Please contact TxDOT's Design Division for more information. SOXSOP is an FHWA [Proven Safety Countermeasure](#). FHWA has information guides and [more materials online](#). The SOXSOP countermeasure was suggested if:

- Number of Lanes \leq 4
- Traffic Volume \leq 15,000 VPD
- Posted Speed Limit \leq 40 MPH

3.1.12 Frontage Road Study

The Frontage Road Study countermeasure was suggested if:

- Frontage Road Crash Ratio \geq 60%

The *Frontage Road Crash Ratio* is defined as the number of crashes coded as "Service / Frontage Road" based on the CRIS Road Part ID divided by the total number of crashes:

$$\frac{\text{Crashes with CRIS Road Part ID as "Service" or "Frontage Road Crashes"}}{\text{Total number of crashes}}$$

3.1.13 Speed Study

The Speed Study countermeasure was suggested if:

- Speeding Related Crash Ratio \geq 20%

The *Speeding Related Crash Ratio* is defined as the number of crashes that have a "Contributing Factor" or "Potential Contributing Factor" coded as:

- Failed to Control Speed
- Unsafe Speed
- Speeding - (Over limit)

Divided by the total number of crashes on the segment:

$$\frac{\text{(Total number of crashes with the above 'Contributing Factors' or 'Potential contributing factors')}}{\text{Total number of segment crashes}}$$

3.2 Targeted (Hot Spot) Analysis Countermeasures

The 12 suggested countermeasures for the Targeted (Hot Spot) analysis were applied to over 300,000 miles of on-system and off-system roads – a much larger set of roadway segments than was used for the systemic analysis. The logic associated with each countermeasure is similar to the systemic analysis but considers presence of crash history. The countermeasure logic was only applied when data and/or applicable guidance was readily available. Table 4 summarizes the number of centerline miles and locations that met the specific logic/criteria for each countermeasure by on- and off-system networks. Since the targeted analysis segmented urban and rural roadways to 0.2- and 0.4-mile lengths, respectively, these countermeasures are intended to be implemented at spot locations, whether at an intersection or mid-block.

Table 3-2: Targeted Analysis Countermeasure Summary

Countermeasure	On-System		Off-System	
	Miles	Locations	Miles	Locations
Install Sidewalk	3,718	--	7,076	--
Install Shared Use Path	2,957	--	0	--
Improve School Zones	--	33	--	226
Install Pedestrian Hybrid Beacon	--	286	--	0
Install Rectangular Rapid Flashing Beacon	--	1,069	--	24
Install In-Street Pedestrian Signs	--	164	--	20,007
Install/Upgrade Lighting	1,034	--	1,139	--
Install Raised Crosswalks	--	30	--	18,467
Modify Curb Geometrics	--	2,678	--	31
Implement Leading Pedestrian Interval	--	1,201	--	2,061
Implement Pedestrian Scramble	--	651	--	1,432
Install Pedestrian Refuge Island	--	817	--	1

3.2.1 Install Sidewalk

The Install Sidewalk countermeasure was suggested if:

CRITERION #1

- Sidewalk Coverage = “Mostly Present” to “None Present”
- Functional Classification
 - Other Principal Arterial
 - Minor Arterial
 - Major Collector
 - Minor Collector
 - Local
- Posted Speed Limit ≤ 55 mph
- Pedestrian crash > 0

CRITERION #2

- Sidewalk Coverage = “Mostly Present” to “None Present”
- Functional Classification
 - Interstate
 - Other Freeway and Expressway
- Area Type = Urban
- Pedestrian crash > 0

3.2.2 Install Shared Use Path

The Install Shared Use Path countermeasure was suggested if:

CRITERION #1

- Curb is present on both sides of roadway
- Posted speed limit ≤ 45 MPH
- $(\text{ROW width} - \text{roadbed width})/2 \geq 14$ feet
- Pedestrian crash > 0

CRITERION #2

- Curb is present on both sides of roadway
- Posted speed limit ≥ 50 MPH
- $(\text{ROW width} - \text{roadbed width})/2 \geq 16$ feet
- Pedestrian crash > 0

CRITERION #3

- Curb is “Not Present”
- $(\text{ROW width} - \text{roadbed width})/2 \geq 20$ feet
- Area Type = Urban
- Pedestrian crash > 0

Shared Use Path criteria were based on [TxDOT Roadway Design Manual §6.4.4, Table 6-6](#).

3.2.3 Improve School Zones

The Improve School Zone countermeasure was suggested if:

- Segment Crash Flag = “Active School Zone Flag”

3.2.4 Install Pedestrian Hybrid Beacon (PHB)

The Install Pedestrian Hybrid Beacon (PHB, commonly known as HAWK) countermeasure was suggested if:

- Sidewalk Coverage = “Mostly Present” to “Fully Present”
- Posted Speed Limit ≤ 40 MPH
- Number of Lanes = 6
- Pedestrian crash > 0

Install PHB/HAWK criteria were based on [TxDOT RRFB & PHB 2018 Memo](#).

3.2.5 Install Rectangular Rapid Flashing Beacon (RRFB)

The Install Rectangular Rapid Flashing Beacon countermeasure was suggested if:

- Sidewalk Coverage= “Partially Present” to “Full Present”
- Posted Speed Limit ≤ 40 MPH
- Number of Lanes < 6
- Pedestrian crash > 0

Install RRFB criteria were based on [TxDOT RRFB & PHB 2018 Memo](#).

3.2.6 Install In-Street Pedestrian Signs

The Install In-Street Pedestrian Signs countermeasure was suggested if:

- Traffic Volume < 10,000 VPD
- Number of Lanes < 4
- Posted Speed Limit ≤ 30 MPH
- Signal Related Crashes = 0
- Pedestrian crash > 0

3.2.7 Install/Upgrade Lighting

The Install/Upgrade Lighting countermeasure was suggested if:

- Dark Lighting Crash Ratio > 50%
- Pedestrian crash > 0

The *Dark Lighting Crash Ratio* is defined by the total number of crashes with lighting condition “Dark, Not Lighted” + “Dark, Lighted” + “Dark, Unknown Lighting” divided by the total number of crashes:

$$\frac{('Dark, Not Lighted' + 'Dark, Lighted' + 'Dark, Unknown Lighting')}{Total\ number\ of\ crashes}$$

NOTE: Presence of lighting data was unavailable for this analysis.

3.2.8 Install Raised Crosswalks

The Install Raised Crosswalk countermeasure was suggested if:

- Functional Class =
 - Major Collector
 - Minor Collector
 - Local
- Traffic Volume < 9,000 VPD
- Posted Speed Limit ≤ 30 MPH
- Number of Lanes < 4
- Signal Related Crashes = 0

- Pedestrian crash > 0

3.2.9 Modify Curb Geometrics

The Modify Curb Geometrics countermeasure includes curb extensions and/or radii reductions. This countermeasure was suggested if:

CRITERION #1

- Area Type = Urban
- Presence of Transit Stop
- Pedestrian crash > 0

CRITERION #2

- Area Type = Urban
- Presence of On-Street Parking
- Pedestrian crash > 0

3.2.10 Implement Leading Pedestrian Interval

The Implement Leading Pedestrian Interval countermeasure was suggested if:

- Signal Related Crash Ratio $\geq 50\%$

NOTE: Data indicating the locations or characteristics of intersections using Leading Pedestrian Intervals was not available for this analysis.

Countdown timers and push buttons or some sort of pedestrian detection should be present or added in these locations to be effective.

3.2.11 Implement Pedestrian Scramble

The Implement Pedestrian Scramble countermeasure was suggested if:

- Signal Related Crash Ratio $\geq 95\%$
- Functional Classification =
 - Other Principal Arterial
 - Minor Arterial
 - Major Collector
 - Minor Collector
 - Local

3.2.12 Install Pedestrian Refuge Island

The Install Pedestrian Refuge Island countermeasure was suggested if:

- Median Type =
 - None
 - Unprotected
 - Curbed

- Non-Intersection Related Crash Presence
- Signal Related Crashes = 0
- Median Width \geq 6 feet
- Traffic Volume \geq 9,000 VPD

3.3 Other Engineering Countermeasures

3.3.1 Installing Smart Intersection Improvements

In 2023, the Texas A&M Transportation Institute (TTI) in partnership with TxDOT won a research grant for the [Smarter Intersection Pilot Project](#). This award will allow transportation researchers to continue investigating technology connecting intersection infrastructure to connected transit vehicles (Vehicle-to-Everything). TTI initially began this research to help bus drivers prevent crashes with vulnerable road users with pilot tests in College Station, TX ([Research Project 0-6875](#)). As this vehicle-to-infrastructure technology improves, future countermeasure investment may include improvements to intersection’s ability to communicate to vehicles.

3.3.2 Countermeasure Research Overlap & Exclusions

The University of Texas at Austin’s (UT) Center for Transportation Research (CTR) completed the [Developing Countermeasures to Decrease Pedestrian Deaths](#) research project that identified 48 different improvements or investments intended to reduce pedestrian crashes and their severity. Some improvements did not have a long history of implementation or supportive academic research pointing to their efficacy; however, others were established countermeasures proven to improve pedestrian safety. From UTCTR’s list of 48 improvements, 20 were not included as suggested countermeasures in TxDOT’s PSAP. The following three tables provide a list of those pedestrian improvements with explanations why they that were not included and considerations for how they may contribute to a safer pedestrian environment. While these investments were not included in the PSAP, these improvements should be considered in future PSAP updates as they could greatly benefit pedestrian safety and supplement the existing countermeasures.

Table 5 features 8 pedestrian improvements generally related to standard TxDOT roadway design practices. For example, installing curb and gutter is a roadway design element not considered as a suggested PSAP countermeasure because there isn’t an established connection between this improvement and improved pedestrian safety. While curb and gutter investments are frequently tied to alleviating drainage concerns, a curb can provide a positive barrier between vehicles and pedestrian pathways. Another example, installing curb ramp improvements should be standard practices for TxDOT to meet ADA compliance meanwhile installing signage is a standard practice to provide adequate advance warning for drivers that pedestrians may be present.

Table 3-3: Roadway Design Improvements in UT Research Absent from PSAP

Improvements Included by UTCTR, but not PSAP	Countermeasure Category
Basic Curb & Gutter	General Roadway Design Elements
Flashing Beacon	
Advanced Stop/Yield Sign	
Adding Crosswalk Signage (when crosswalks already exist)	

Install Crosswalk Sign	
Curb Ramps (to crossings)	
Access Management Improvements	
Sidewalk Railings	

Table 6 shows 6 countermeasures related to signalized intersection control that were not separately listed in the PSAP countermeasures list. The 4 pedestrian hardware or signal components were not included because there was not enough data readily available to support suggesting those countermeasures. An intersection GIS layer that distinguishes between signalized and unsignalized intersections does not exist and the countermeasures listed in Table 6 are variations of pedestrian enhancements specific to signals. The PSAP includes implementing a leading pedestrian interval with the assumption that countdown timers and push buttons or some sort of pedestrian detection are also present in those locations. If neither of those components were present at a signal, the leading pedestrian interval could not be implemented.

Table 3-4: Signalized Intersection Improvements in UT Research Absent from PSAP

Improvements Included by UTCTR, but not PSAP	Countermeasure Category
Prohibition of Left Turns	Minor Signal or Intersection Operational Changes
Pedestrian Detection - Detector (actuate)	
Pedestrian Detection - Push Button	
Audible Pedestrian Signal	
Increase Crossing Time	
Countdown Timers	

Table 7 shows suggested countermeasures that could be used to enhance those from the PSAP list. For example, in-pavement lighting has been used in conjunction with RRFBs. In addition, general-purpose fences can be a valuable deterrent to unsafe crossing practices when paired with safe roadway crossing access points. While hardened left turns and “daylighting” left turns both focus on channeling left turning vehicles and improving the driver’s visibility of vulnerable road users, these pedestrian improvements still need additional research and experimentation in addition to local engineering and/or planning knowledge to appropriately locate these pedestrian countermeasures. As additional evidence and roadway data becomes available, perhaps these pedestrian improvements can be included in future TxDOT PSAP updates.

Table 3-5: Signalized Intersection Improvements in UT Research Absent from PSAP

Improvements Included by UTCTR, but not PSAP	Countermeasure Category
Hardened Left Turns	Insufficient Evidence. Further Consideration Needed
In-Pavement Lighting (flashing crosswalks)	
Daylighting Left Turns & Crossing Locations	
Fence (general purpose)	
Bollards (at crossing points)	

4 Summary of Results and Prioritization

The following sections provide a statewide summary of how countermeasures were applied to both the systemic and targeted analysis results. The countermeasure application process used available roadway characteristics and usage data to isolate specific locations where particular countermeasures could be applied. This statewide, high-level analysis requires additional local knowledge and insights.

4.1 Systemic Countermeasure Summary

The data-driven countermeasure application process was able to successfully identify countermeasures for on-system roadway segments that were identified as both Focus Facilities and as Potential-Risk segments. For Focus Facilities, 62% of segments had at least one suggested countermeasure. Meanwhile, for those portions of the Focus Facility network identified as Potential-Risk, 72% of centerline miles had at least one suggested countermeasure. See Figure 4-1 for a graphic representation of these relationships.

Focus Facility Road Segments:

- Total Focus Facility road segment centerline miles – 19,045 (23.6% of all on-system miles)
- Focus Facility centerline miles with at least one suggested countermeasure – 11,812 (62.0% of all Focus Facility miles)

Potential Risk Road Segments:

- Total Potential-Risk road segment centerline miles – 6,241 (7.7% of all on-system miles)
- Potential-Risk segments with at least one suggested countermeasure – 4,493 (72% of Potential-Risk miles)

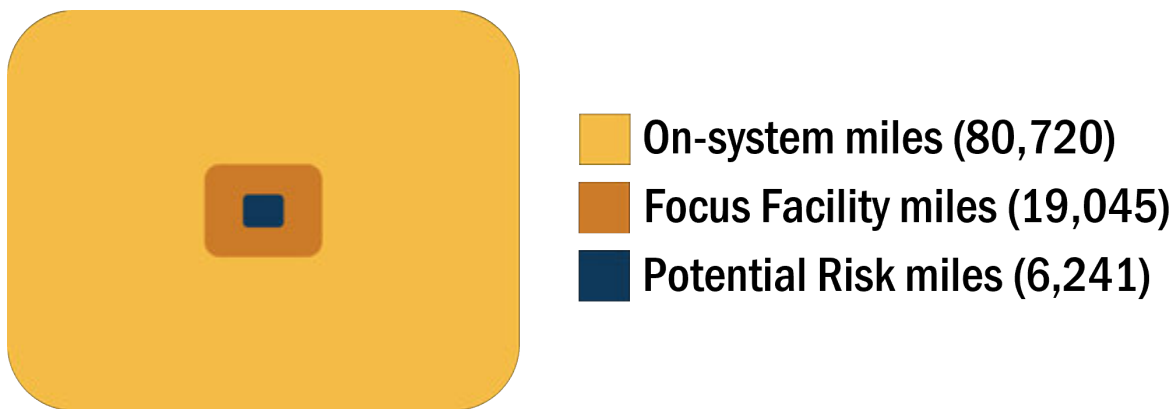


Figure 4-1: Relationship Between Systemic Analysis Terminologies

4.2 Targeted Countermeasure Summary

For the targeted analysis, the data-driven countermeasure application process was able to successfully identify countermeasures for on-and off-system roadway segments where there was history of crashes. The on-system network is comprised of 72,978 miles and the off-system network is comprised of 241,169 miles for a grand total of 314,147 network miles. See Figure 4-2 for a graphic representation of these relationships.

On-System Countermeasure Summary:

- On-system segment centerline miles with crash history – 5,985 (8.2% of on-system miles)

- On-system segment centerline miles with at least one suggested countermeasure – 4,642 (78% of on-system miles with crash history)
- On-system segment centerline miles with at least one suggested countermeasure and a KA Crash Density Tier⁴ of “Very High” – 566 (12.2% of on-system miles with crash history and at least one suggested countermeasure)

Off-System Countermeasure Summary:

- Off-system segment centerline miles with crash history – 7,995 (3.3% of off-system miles)
- Off-system segment centerline miles with at least one suggested countermeasure – 7,248 (90.7% of off-system miles with crash history)
- Off-system segment centerline miles with at least one suggested countermeasure and a KA Crash Density Tier of “Very High” – 343 (4.7% of off-system miles with crash history and at least one suggested countermeasure)

Statewide (On- and Off-System combined) Countermeasure Summary:

- Centerline miles with crash history – 13,980 (4.5% of statewide miles)
- Centerline miles with at least one suggested countermeasure – 11,890 (85.1% of statewide miles with crash history)
- Centerline miles with at least one suggested countermeasure and a KA Crash Density Tier of “Very High” – 909 (7.7% of statewide miles with crash history and at least one suggested countermeasure)

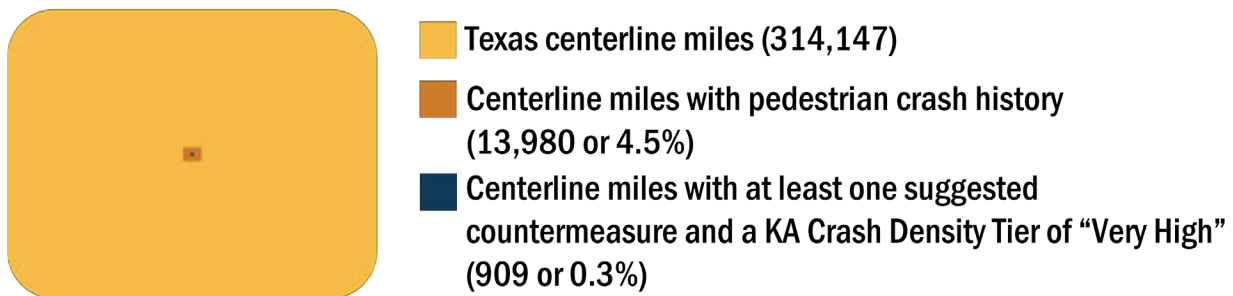


Figure 4-1: Relationship between Targeted Analysis Results

⁴ For more information on Crash Density Tiers, please refer to the Statewide PSAP Summary Document.