



# **Pedestrian Safety Countermeasures Toolbox**

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Produced by:

**FEHR & PEERS**



# Introduction

This document provides a set of tools for improving pedestrian safety on the State Highway System. It was designed to be used to address issues identified during traffic safety investigations conducted while evaluating high collision

concentration locations and systemic safety locations. However, these tools may be used more generally to improve pedestrian safety.

This document should not provide the sole source of guidance when resolving a pedestrian safety issue.

Each location and situation is unique, and engineering judgment should be used when applying these tools and selecting the best solution for any location.



# Acknowledgements



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Developed with key input from the Orange County Transportation Authority

# Countermeasure Toolbox

## Summary

This Toolbox presents 47 safety countermeasures applicable in different roadway contexts across California •

Many of the countermeasures included in this toolbox have an associated **Crash Modification Factor (CMF)** as found in the Federal Highway Administration Crash Modification Factors Clearinghouse. A CMF is a multiplicative factor that indicates the proportion of crashes that would be expected after implementing a countermeasure.

CMFs with a value less than 1.0 indicate an expected decrease in

crashes. CMFs greater than 1.0 indicate an expected increase in crashes. The expected change in crashes can be calculated by multiplying the associated CMF by the total crashes per year at a site.

By giving a quantitative estimate of the effectiveness of a countermeasure, CMFs can indicate which countermeasure will have the greatest impact on decreasing crashes. CMFs can also assist in determining cost-effectiveness for safety funding.

A **Crash Reduction Factor (CRF)** is another way of representing the expected effect of a countermeasure in terms of the percentage decrease in crashes. A CRF is equal to  $100 \times (1 - \text{CMF})$ . The safety field has moved to using CMFs due in part to confusion that can arise when a countermeasure

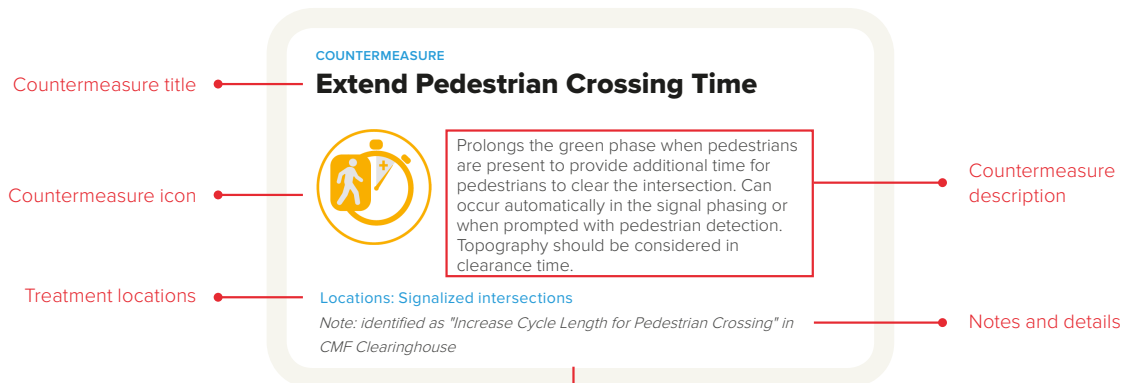
is expected to increase crashes.

CMFs and CRFs can be calculated for all crashes or for specific types of crashes, such as only those involving pedestrians or only involving bicycles.

Countermeasures not in the CMF Clearinghouse are emerging tools that have been included based on their potential to complement or enhance the efficacy of other countermeasures. References for these countermeasures are found in the Appendix.

Additional information for determining where best to use each countermeasure, including collision conditions, location and context, and relative cost for each countermeasure can be found in Tables 1-3.

## What You'll See in This Toolbox:



Low Cost & Quick Build countermeasures are identified with a pale blue background



## SUMMARY OF COUNTERMEASURES

### A. SIGNAL TIMING & PHASING

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- Additional Signal Heads
- Extend Pedestrian Crossing Time
- Flashing Yellow Turn Phase
- Leading Pedestrian Interval
- Install Traffic Signal
- Pedestrian Phase Recall
- Permissive Lefts To Protected
- Separate Right-Turn Phasing
- Pedestrian Scramble
- Reduce Cycle Lengths

### B. INTERSECTION & ROADWAY DESIGN

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- Close Slip Lane
- Raised Intersection
- Convert Two-Way Stop to All-Way Stop
- Install Sidewalk
- Protected Intersection
- Raised Median
- Paint and Plastic Median
- Hardened Centerline
- Left Turn Enhanced Daylighting/Slow Turn Wedge
- Realign Intersection to 90 Degrees
- Road Diet
- Widen Shoulder
- Roundabout
- Paint and Plastic Mini Circle
- Splitter Island

### C. SIGNS & MARKINGS

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- Advance Stop Markings
- Advance Yield Markings
- Prohibit Right-Turn-On-Red
- Yield To Pedestrians Sign

### D. PEDESTRIAN CROSSINGS

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- ADA Ramps & Audible Push Button Upgrades
- Extended Time Pushbutton
- Install Pedestrian Countdown Timer
- Pedestrian Hybrid Beacon (PHB)
- Curb Extensions
- Paint and Plastic Curb Extension
- High-Visibility Crosswalk
- Pedestrian Detection
- Pedestrian-Level Lighting
- Pedestrian Median Barrier
- Raised Crosswalk
- Restripe Crosswalk
- Upgrade Curb Ramp
- Pedestrian Refuge Island
- Paint and Plastic Pedestrian Refuge Area
- Rectangular Rapid Flashing Beacon

### E. OTHER

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- Access Management/Close Driveway
- Intersection, Street-Scale Lighting

## A. SIGNAL TIMING & PHASING

COUNTERMEASURE

### Additional Signal Heads



Additional signal heads allow drivers to anticipate signal changes farther away from intersections, decreasing the likelihood of driver error resulting in a collision with a pedestrian.

Locations: Signalized Intersections

COUNTERMEASURE

### Install Traffic Signal



New traffic signals can help to organize travel of all modes at an intersection, limiting interactions between vehicles, pedestrians, and bicyclists with conflicting movements.

Locations: Unsignalized Street Crossings

Note: see Countermeasure References for additional information.

COUNTERMEASURE

### Extend Pedestrian Crossing Time



Increases time for pedestrian walk phases, especially to accommodate vulnerable populations, such as children and the elderly.

Locations: Signalized intersections

Note: identified as "Increase Cycle Length for Pedestrian Crossing" in CMF Clearinghouse.

COUNTERMEASURE

### Pedestrian Phase Recall



Signals can be put in "recall" full time or for key time periods of day such as peak business hours or school drop-off/pick-up times. During these periods the "WALK" signal would be displayed every signal cycle without prompting by a pedestrian push button.

Locations: Signalized intersections

Note: not in CMF Clearinghouse. See Countermeasure References.

COUNTERMEASURE

### Flashing Yellow Turn Phase



Flashing yellow turn arrow alerts drivers to proceed with caution and decide if there is a sufficient gap in oncoming traffic to safely make a turn. To be used only when a pedestrian walk phase is not called. Protected-only phases should be used when pedestrians are present.

Locations: Signalized Intersections

COUNTERMEASURE

### Permissive Lefts to Protected



Provides a protected green arrow phase for left turning vehicles while showing a red light for both on-coming traffic and parallel pedestrian crossings. Eliminates conflicts between pedestrians and left-turning vehicles.

Locations: Signalized Intersections

Note: identified as "Change Permissive Left-Turn Phasing to Protected Only" in CMF Clearinghouse.

COUNTERMEASURE

### Leading Pedestrian Interval



Gives people walking a head start, making them more visible to drivers turning right or left. "WALK" signal comes on a few seconds before the cars get their green light. May be used in combination with No Right Turn on Red restrictions.

Locations: Signalized Intersections

COUNTERMEASURE

### Separate Right-Turn Phasing



Provides a green arrow phase for right-turning vehicles. Avoids conflicts between right-turning traffic and bicyclists or pedestrians crossing the intersection on their right.

Locations: Signalized Intersections

Note: not in CMF Clearinghouse. See Countermeasure References.

## A. SIGNAL TIMING & PHASING

### COUNTERMEASURE

#### Pedestrian Scramble



A form of pedestrian "WALK" phase at a signalized intersection in which all vehicular traffic is required to stop, allowing pedestrians to safely cross through the intersection in any direction, including diagonally.

Locations: Signalized Intersections

Note: identified as "Implement Barnes Dance" in CMF Clearinghouse.

### COUNTERMEASURE

#### Reduce Cycle Lengths



Traffic signal cycles should be kept short (preferably 90 seconds maximum) to reduce pedestrian delay. When delay is significant, pedestrians are more inclined to ignore signal indications.

Locations: Signalized Intersections

Note: not in CMF Clearinghouse. See Countermeasure References.



## B. INTERSECTION & ROADWAY DESIGN

COUNTERMEASURE

### Close Slip Lane



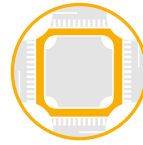
Modifies the corner of an intersection to remove the sweeping right turn lane for vehicles. Results in shorter crossings for pedestrians, reduced speed for turning vehicles, better sight lines, and space for landscaping and other amenities.

Locations: Signalized Intersections

Note: not in CMF Clearinghouse. See Countermeasure References.

COUNTERMEASURE

### Protected Intersection



Protected intersections use corner islands, curb extensions, and colored paint to delineate bicycle and pedestrian movements across an intersection. Slower driving speeds and shorter crossing distance increase safety for pedestrians. Separates bicycles from pedestrians.

Locations: Signalized Intersections

Note: not in CMF Clearinghouse. See Countermeasure References.

COUNTERMEASURE

### Raised Intersection



Elevates the intersection to bring vehicles to the sidewalk level and increases the visibility of pedestrians. Serves as a traffic calming measure by extending the sidewalk context across the road.

Locations: Unsignalized Street Crossings

Note: See Countermeasure References for additional discussion.

COUNTERMEASURE

### Raised Median



A concrete or landscaped area between the two directions of travel. Increases safety by reducing vehicular speeding and reducing pedestrian crossing distance.

Locations: Unsignalized Street Crossings

COUNTERMEASURE

### Convert Two-Way Stop to All-Way Stop



Converting two-way stops to all-way stops prevents motorists, bicyclists, and pedestrians from having to cross free-flowing lanes of traffic at a side-street stop-controlled intersection and reduces the risk of collision.

Locations: Unsignalized Street Crossings

COUNTERMEASURE

### Paint and Plastic Median



A painted median with plastic posts between the two directions of travel. Reduces vehicular speeding and discourages risky turning movements, increasing pedestrian safety.

Locations: Along the Road

Note: reference "Raised Median" in CMF Clearinghouse.

COUNTERMEASURE

### Install Sidewalk



Sidewalks and walkways are "pedestrian lanes" that provide people with space to travel within the public right-of-way that is separated from roadway vehicles. They are associated with reduced crashes where pedestrians were walking along the roadway.

Locations: Along the Road

Note: See Countermeasure References for additional discussion.

COUNTERMEASURE

### Hardened Centerline



Uses paint to widen left-turn radii and rubber curb with plastic bollards on the receiving roadway's centerline to modify the angle of motorists turning left. Widening the turning radii of left-turning vehicles expands the field of vision for drivers and increases the visibility of pedestrians.

Locations: Signalized Intersections, Unsignalized Street Crossings

Note: reference "Raised Median" in CMF Clearinghouse.



## B. INTERSECTION & ROADWAY DESIGN

## COUNTERMEASURE

### Left Turn Enhanced Daylighting/ Slow Turn Wedge



Uses paint and bollards to extend the curb and slow left turns at intersections of one-way to one-way or two-way streets. Widening the turning radii of left-turning vehicles expands the field of vision for drivers and increases the visibility of pedestrians.

Locations: Signalized Intersections, Unsignalized Street Crossings

Note: not in CMF Clearinghouse. See Countermeasure References for "Curb Extension."

## COUNTERMEASURE

### Roundabout



Roundabouts are circular intersections designed to eliminate left turns by requiring traffic to travel in a counter-clockwise direction and exit to the right. Installed to manage vehicular speeds, reduce pedestrian exposure, improve safety at intersections through eliminating angle collisions, and help traffic flow more efficiently.

Locations: Signalized Intersections, Unsignalized Street Crossings, Roundabouts

## COUNTERMEASURE

### Realign Intersections to 90 Degrees



By eliminating acute or obtuse angles between intersection roadways, intersection sight angles may be improved, allowing motorists to see pedestrians more easily.

Locations: Signalized Intersections, Unsignalized Street Crossings

Note: not in CMF Clearinghouse. See Countermeasure References.

## COUNTERMEASURE

### Paint and Plastic Mini Circle



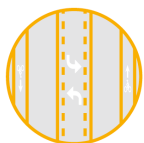
Mini circles use paint and soft hit posts to replace stop-controlled intersections with a circular design that slows traffic and eliminates left turns, also reducing conflict points with pedestrians. Also helps traffic flow more efficiently.

Locations: Unsignalized Street Crossings

Note: not in CMF Clearinghouse. See Countermeasure References.

## COUNTERMEASURE

### Road Diet



Depending on the street, road diets may change the number of lanes, turn lanes, center turn lanes, bike lanes, parking lanes, and/or sidewalks. Road diets optimize street space to benefit all users by improving the safety and comfort of pedestrians and bicyclists, and reducing vehicle speeds and the potential for rear end collisions.

Locations: Along the Road

## COUNTERMEASURE

### Splitter Island

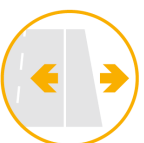


A raised area that separates the two directions of travel on the minor street approach at an unsignalized intersection or roundabout. Helps channelize traffic in opposing directions of travel. Typically installed at skewed intersections or where speeds on minor roads are high. Provides a refuge for pedestrians.

Locations: Unsignalized Street Crossings, Roundabouts

## COUNTERMEASURE

### Widen Shoulder



Widened shoulders create greater separation between vehicles and pedestrians and also provide motor vehicle safety benefits, such as space for inoperable vehicles to pull out of the travel lane.

Locations: Along the Road

## C. SIGNS & MARKINGS

COUNTERMEASURE

### Advance Stop Markings



A stop bar placed ahead of the crosswalk at stop signs and signals reduces conflict with pedestrians from vehicles encroaching on the crosswalk.

Locations: Signalized Intersections, Unsignalized Street Crossings

COUNTERMEASURE

### Advance Yield Markings



Yield lines are placed 20 to 50 feet in advance of multi-lane pedestrian crossings to increase visibility of pedestrians. Can reduce the likelihood of a multiple-threat crash.

Locations: Unsignalized Street Crossings

COUNTERMEASURE

### Prohibit Right-Turn-on-Red



Prohibiting right-run-on-red movements should be considered at skewed intersections, or where exclusive pedestrian "WALK" phases, Leading Pedestrian Intervals (LPis), sight distance issues, or high pedestrian volumes are present. Can help prevent crashes between vehicles turning right on red from one street and through vehicles on the cross street, and crashes involving pedestrians.

Locations: Signalized Intersections

COUNTERMEASURE

### Yield To Pedestrians Sign



The "Yield Here to Pedestrians" signs alert drivers about the presence of pedestrians. These signs are required with Advance Yield Lines. Other sign types can be placed on the centerline in the roadway.

Locations: Unsignalized Street Crossings

Note: identified as "Install Advanced Yield or Stop Marking and Signs" in CMF Clearinghouse.

## D. PEDESTRIAN CROSSINGS

### COUNTERMEASURE

#### ADA Ramps & Audible Push Button Upgrades



Curb ramps and push buttons must comply with the Americans with Disability Act (ADA) standards for accessibility. Pushbuttons should be visible and conveniently located for pedestrians waiting at a crosswalk. Accessible pedestrian signals, including audible push buttons, improve access for pedestrians who are blind or have low vision. DIB 82-06 includes accessibility design guidance.

Locations: [Signalized Intersections](#)

Note: not in CMF Clearinghouse. See Countermeasure References.

### COUNTERMEASURE

#### Curb Extensions



Widens the sidewalk at intersections or midblock crossings to shorten the pedestrian crossing distance, to make pedestrians more visible to vehicles, and to reduce the speed of turning vehicles.

Locations: [Intersection Geometry](#), [Unsignalized Street Crossings](#)

Note: not in CMF Clearinghouse. See Countermeasure References.

### COUNTERMEASURE

#### Extended Time Pushbutton



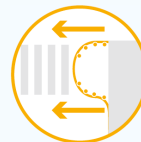
A pushbutton that can be pressed to request extra time for using the crosswalk, beyond the standard crossing time. Ideal near senior-serving land uses.

Locations: [Signalized Intersections](#)

Note: not in CMF Clearinghouse. See Countermeasure References.

### COUNTERMEASURE

#### Paint and Plastic Curb Extension



Widens the sidewalk at intersections or midblock crossings to shorten the pedestrian crossing distance, to make pedestrians more visible to motorists, and to reduce the speed of turning vehicles.

Locations: [Signalized Intersections](#), [Unsignalized Street Crossings](#)

Note: not in CMF Clearinghouse. See Countermeasure References.

### COUNTERMEASURE

#### Install Pedestrian Countdown Timer



Displays "countdown" of seconds remaining on the pedestrian signal. Countdown indications improve safety for all road users, and are required for all newly installed traffic signals where pedestrian signals are installed.

Locations: [Signalized Intersections](#)

### COUNTERMEASURE

#### High-Visibility Crosswalk



A crosswalk that is designed to be more visible to approaching drivers. Crosswalks should be designed with continental markings and use high-visibility material, such as inlay tape or thermoplastic tape instead of paint.

Locations: [Signalized Intersections](#), [Unsignalized Street Crossings](#)

### COUNTERMEASURE

#### Pedestrian Hybrid Beacon



Pedestrian-activated beacon used at mid-block crosswalks and side-street stop-controlled intersections to notify oncoming motorists to stop with a series of red and yellow lights. Also known as a High-Intensity Activated crossWalk (HAWK) beacon

Locations: [Unsignalized Street Crossings](#), [Roundabouts](#)

### COUNTERMEASURE

#### Pedestrian Detection



An intersection treatment that relies on sensors to detect when a pedestrian is waiting at a crosswalk and automatically triggers the pedestrian "WALK" phase. Reduces crossings at inappropriate times and ensures that pedestrians have enough time to safely cross the roadway.

Locations: [Signalized Intersections](#)

Note: not in CMF Clearinghouse. See Countermeasure References.

## D. PEDESTRIAN CROSSINGS

COUNTERMEASURE

### Pedestrian-Level Lighting



Specialty pedestrian-level lighting may be placed over the sidewalks to improve pedestrian comfort, security, and safety. Well-lit pedestrian areas make people walking through the area feel safer. At intersections, lighting should also be placed before the crosswalk on the approach into the intersection.

Locations: Unsignalized Street Crossings

Note: not in CMF Clearinghouse. See Countermeasure References.

COUNTERMEASURE

### Upgrade Curb Ramp



Tactile warning devices must be detectable to visually impaired pedestrians. Curb ramps must follow the DIB 82-06 design guidelines.

Locations: Signalized Intersections, Unsignalized Street Crossings

Note: not in CMF Clearinghouse. See Countermeasure References.

COUNTERMEASURE

### Pedestrian Median Barrier



Pedestrian median barriers restrict pedestrians from crossing the median at locations where nearby crossings are available and midblock crossings may have poor sight distance or insufficient crossing enhancements for the conditions.

Locations: Along the Road

Note: identified as "Median Treatment for Ped/Bike Safety" in CMF Clearinghouse.

COUNTERMEASURE

### Pedestrian Refuge Island



Pedestrian refuge islands provide a protected area for pedestrians at the center of the roadway. They reduce the exposure time for pedestrians crossing the intersection. They simplify crossings by allowing pedestrians to focus on one direction of traffic at a time.

Locations: Signalized Intersections, Unsignalized Street Crossings

Note: identified as "Raised Median with Crosswalk" in CMF Clearinghouse.

COUNTERMEASURE

### Raised Crosswalk



The crosswalk is elevated to match the sidewalk to make pedestrians more visible to approaching vehicles. Typically located at midblock crossings or across free right turns, they encourage motorists to yield to pedestrians and reduce vehicle speed. An entire intersection may be raised similarly.

Locations: Unsignalized Street Crossings, Roundabouts

COUNTERMEASURE

### Paint and Plastic Pedestrian Refuge Area



Paint and plastic posts designate pedestrian refuge spaces at the center of the roadway. Pedestrian refuge areas constructed from paint and plastic may be implemented in conjunction with additional safety devices, such as a Rectangular Rapid Flashing Beacon (RRFB) or road diet, to reduce pedestrian exposure.

Locations: Unsignalized Street Crossings

Note: reference "Raised Median with Crosswalk" in CMF Clearinghouse.

COUNTERMEASURE

### Restripe Crosswalk



Periodic restriping of crosswalks is necessary to ensure the traffic markings are visible. Crosswalk may be restriped with high visibility markings.

Locations: Signalized Intersections, Unsignalized Street Crossings

Note: not in CMF Clearinghouse. See Countermeasure References.

COUNTERMEASURE

### Rectangular Rapid Flashing Beacon



Pedestrian-activated flashing lights and additional signage enhance the visibility of marked crosswalks and alert motorists to pedestrian crossings.

Locations: Unsignalized Street Crossings, Roundabouts



## E. OTHER

### COUNTERMEASURE

#### Access Management/Close Driveway



Vehicles entering and exiting driveways may conflict with pedestrians and with vehicles on the main road, especially at driveways within 250 feet of intersections. Closing driveways near intersections with high crash rates related to driveways may reduce potential conflicts.

Locations: [Along the Road](#)

Note: see *Countermeasure References* for additional discussion.

### COUNTERMEASURE

#### Intersection, Street-Scale Lighting



Street and intersection lighting helps make pedestrians and other road users or hazards more visible to motorists at night, improving driver perception and reaction time and reducing the risk of collision.

Locations: [Unsignalized Street Crossings, Roundabouts](#)

Note: identified as "Highway Lighting" in *CMF Clearinghouse*.



# Using the CMF Clearinghouse

The CMF Clearinghouse (<http://www.cmfclearinghouse.org/>) is an online repository of data on the effectiveness of countermeasures. The Clearinghouse includes identification of the research behind each CMF and is updated quarterly. The Clearinghouse is funded by FHWA and maintained by the University of North Carolina Highway Safety Research Center. To find appropriate CMFs for the conditions of a location, perform the following:

1. Use the search box on the home page to find the countermeasure by name.

2. In the search results, use results from the category "Pedestrians" where available. This will provide results based on studies of safety improvements for pedestrians. Other categories, such as "Roadway," may contain data more broadly applicable to all crash types, including pedestrians, and may also be used if a pedestrians category is not available.

- ▶ Category: Access management (145)
- ▶ Category: Bicyclists (4)
- ▶ Category: Pedestrians (7)
- ▶ Category: Roadway (20)

3. Expand the "Category" and "Subcategory" to see each countermeasure.

4. Use specific details for the study site to identify the category and subcategory that best fit location conditions.

5. Use information provided in "Crash Type," "Crash Severity," "Area Type," and "Comments" to help select the most appropriate CMF for site conditions.

Quality	Crash Type	Crash Severity	Area Type	Reference	Comments
★★★★☆	Vehicle/pedestrian	All	Urban and Suburban	Zegeer et al., 2002	The study design was a ... [read more]

- > "Crash Type" may include details such as "Vehicle/pedestrian" or "Rear end."
- > "Crash Severity" may include all severities or be limited to categories such as fatalities or serious injuries.
- > "Area Type" may provide further breakdown by urban, suburban, rural. If the particular area type is not available, select the type most similar to the location.
- > "Comments" may provide more study details.

The "Compare" tool may be used to directly compare details on multiple studies.

Compare	CMF	CRF(%)	Quality
<input type="checkbox"/>	0.742	25.8	★★★★☆
<input checked="" type="checkbox"/>	0.714	28.6	★★★★☆
<input checked="" type="checkbox"/>	0.741	25.9	★★★★☆

6. Where available, use studies with "Quality" of three stars or more. The higher the number of stars, the better the study has been judged by reviewers for study design, sample size, standard error, potential bias, and data source. Studies with one or two stars may be used if other data is not available.

## Table 1: Collision Conditions Countermeasures Guidance

This table provides guidance about appropriate countermeasures for specific collision conditions. Use the circumstances of the collision to determine a column which matches collision history.

COUNTERMEASURE	Along roadway	Turning vehicle not yielding	Through vehicle not yielding	Speed related	Crossing outside of crosswalk	Pedestrian signal violation
<b>A. SIGNAL TIMING &amp; PHASING</b>						
Additional Signal Heads		x				
Extend Pedestrian Crossing Time			x			x
Flashing Yellow Turn Phase		x				
Leading Pedestrian Interval		x				x
Install Traffic Signal		x	x	x	x	
Pedestrian Phase Recall		x				x
Permissive Lefts to Protected		x				
Separate Right-Turn Phasing		x				
Pedestrian Scramble		x	x		x	x
Reduce Cycle Lengths						x
<b>B. INTERSECTION &amp; ROADWAY DESIGN</b>						
Close Slip Lane		x		x		
Raised Intersection		x	x	x		
Convert Two-Way Stop to All-Way Stop		x	x	x	x	
Install Sidewalk	x					
Protected Intersection		x		x		
Raised Median				x	x	
Paint and Plastic Median				x	x	
Hardened Centerline		x	x	x	x	
Left Turn Enhanced Daylighting/Slow Turn Wedge		x		x		
Realign Intersection to 90 Degrees		x		x	x	
Road Diet	x		x	x		
Widen Shoulder	x			x		
Roundabout			x	x		
Paint and Plastic Mini Circle			x	x		
Splitter Island				x		



COUNTERMEASURE	Along roadway	Turning vehicle not yielding	Through vehicle not yielding	Speed related	Crossing outside of crosswalk	Pedestrian signal violation
<b>C. SIGNS &amp; MARKINGS</b>						
Advance Stop Markings		x	x			
Advance Yield Markings		x	x			
Prohibit Right Turn on Red		x				
Yield to Pedestrians Sign		x	x			
<b>D. PEDESTRIAN CROSSINGS</b>						
ADA Ramps & Audible Push Button Upgrades					x	
Extended Time Pushbutton			x			x
Install Pedestrian Countdown Timer						x
Pedestrian Hybrid Beacon (PHB)		x		x		
Curb Extensions		x				
Paint and Plastic Curb Extension		x				
High-Visibility Crosswalk		x	x	x	x	
Pedestrian Detection	x					x
Pedestrian-Level Lighting	x	x	x	x		
Pedestrian Median Barrier				x	x	x
Raised Crosswalk			x	x		
Restripe Crosswalk		x	x	x		
Upgrade Curb Ramp					x	
Pedestrian Refuge Island		x	x	x		x
Paint and Plastic Pedestrian Refuge Area		x	x	x		x
Rectangular Rapid Flashing Beacon (RRFB)			x		x	
<b>E. OTHER</b>						
Access Management/Close Driveway	x					
Intersection, Street-Scale Lighting		x	x	x		
Education	x	x	x	x	x	x
Enforcement		x	x	x	x	x

Note: Low Cost & Quick Build countermeasures are identified with a pale blue background.

## Table 2: Location Context Countermeasures Guidance

This table provides guidance about appropriate countermeasures for specific location contexts. Use the characteristics of the location to determine a column which matches local conditions.

COUNTERMEASURE	Commercial Corridor	Unprotected Left Turn	Dual Right Turn/High Right Turn Volume	Freeway Interchange	Single Family Residential Area	Driveway Turns	Senior- and Child Serving Land Uses	Skewed Intersection	Free Right/ Presence of Slip Lane
<b>A. SIGNAL TIMING &amp; PHASING</b>									
Additional Signal Heads	x	x	x					x	x
Extend Pedestrian Crossing Time	x		x	x	x	x	x	x	
Flashing Yellow Turn Phase	x						x		
Leading Pedestrian Interval	x					x		x	x
Install Traffic Signal	x	x	x	x		x	x		x
Pedestrian Phase Recall	x						x		
Permissive Lefts to Protected	x	x					x		
Separate Right-Turn Phasing			x						x
Pedestrian Scramble	x								
Reduce Cycle Lengths	x			x					
<b>B. INTERSECTION &amp; ROADWAY DESIGN</b>									
Close Slip Lane									x
Raised Intersection					x				
Convert Two-Way Stop to All-Way Stop					x		x		
Install Sidewalk						x			
Protected Intersection	x								
Raised Median						x			
Paint and Plastic Median						x	x		
Hardened Centerline	x	x				x			
Left Turn Enhanced Daylighting/ Slow Turn Wedge	x	x					x		
Realign Intersection to 90 Degrees								x	
Road Diet	x				x		x		
Widen Shoulder					x				
Roundabout	x			x			x	x	
Paint and Plastic Mini Circle					x		x		
Splitter Island					x				x

COUNTERMEASURE	Commercial Corridor	Unprotected Left Turn	Dual Right Turn/High Right Turn Volume	Freeway Interchange	Single Family Residential Area	Driveway Turns	Senior- and Child Serving Land Uses	Skewed Intersection	Free Right/ Presence of Slip Lane
<b>C. SIGNS &amp; MARKINGS</b>									
Advance Stop Markings	x	x	x	x	x			x	
Advance Yield Markings	x								x
Prohibit Right Turn on Red	x		x					x	
Yield to Pedestrians Sign						x			x
<b>D. PEDESTRIAN CROSSINGS</b>									
ADA Ramps & Audible Push Button Upgrades	x						x		
Extended Time Pushbutton	x						x		
Install Pedestrian Countdown Timer	x		x						
Pedestrian Hybrid Beacon (PHB)	x				x		x		
Curb Extensions	x						x		
Paint and Plastic Curb Extension	x						x		
High-Visibility Crosswalk	x	x	x	x		x		x	x
Pedestrian Detection	x								
Pedestrian-Level Lighting	x			x	x				x
Pedestrian Median Barrier	x					x	x		
Raised Crosswalk					x		x	x	x
Restripe Crosswalk	x						x		x
Upgrade Curb Ramp	x				x		x		
Pedestrian Refuge Island	x						x		
Paint and Plastic Pedestrian Refuge Area	x						x		
Rectangular Rapid Flashing Beacon (RRFB)	x			x			x		
<b>E. OTHER</b>									
Access Management/Close Driveway	x					x			
Intersection, Street-Scale Lighting	x								x
Education							x		
Enforcement	x				x		x		

Note: Low Cost & Quick Build countermeasures are identified with a pale blue background.

### Table 3: Relative Countermeasure Cost

This table provides relative costs of the countermeasures presented in this toolbox. Costs will vary based on local conditions, existing infrastructure, and other factors.

COUNTERMEASURE	RELATIVE COST
<b>A. SIGNAL TIMING &amp; PHASING</b>	
Additional Signal Heads	\$\$
Extend Pedestrian Crossing Time	\$
Flashing Yellow Turn Phase	\$\$
Install Traffic Signal	\$\$\$
Leading Pedestrian Interval	\$
Pedestrian Phase Recall	\$
Pedestrian Scramble	\$\$
Permissive Lefts to Protected	\$\$
Reduce Cycle Lengths	\$
Separate Right-Turn Phasing	\$\$
<b>B. INTERSECTION &amp; ROADWAY DESIGN</b>	
Close Slip Lane	\$\$
Convert Two-Way Stop to All-Way Stop	\$
Install Sidewalk	\$\$ - \$\$\$
Protected Intersection	\$\$\$
Raised Intersection	\$\$\$
Raised Median	\$\$
Realign Intersection to 90 Degrees	\$\$\$
Road Diet	\$\$\$
Roundabout	\$\$\$
Splitter Island	\$\$
Widen Shoulder	\$\$\$
Hardened Centerline	\$
Paint and Plastic Mini Circle	\$
Paint and Plastic Median	\$
Left Turn Enhanced Daylighting/Slow Turn Wedge	\$



COUNTERMEASURE	RELATIVE COST
<b>C. SIGNS &amp; MARKINGS</b>	
Advance Stop Markings	\$
Advance Yield Markings	\$
Prohibit Right Turn on Red	\$
Yield to Pedestrians Sign	\$
<b>D. PEDESTRIAN CROSSINGS</b>	
ADA Ramps & Audible Push Button Upgrades	\$\$
Curb Extensions	\$\$
Extended Time Pushbutton	\$\$
High-Visibility Crosswalk	\$
Install Pedestrian Countdown Timer	\$\$
Pedestrian Detection	\$\$
Pedestrian Hybrid Beacon (PHB)	\$\$\$
Pedestrian-Level Lighting	\$\$\$
Pedestrian Median Barrier	\$\$
Pedestrian Refuge Island	\$\$
Raised Crosswalk	\$\$\$
Rectangular Rapid Flashing Beacon (RRFB)	\$\$
Restripe Crosswalk	\$
Upgrade Curb Ramp	\$\$
Paint and Plastic Curb Extension	\$
Paint and Plastic Pedestrian Refuge Area	\$
<b>E. OTHER</b>	
Access Management/Close Driveway	\$\$
Intersection, Street-Scale Lighting	\$\$\$
Education	\$\$
Enforcement	\$

Note: Low Cost & Quick Build countermeasures are identified with a pale blue background.

**Relative cost ranges:**

\$: less than \$10,000

\$\$: \$10,000 to \$100,000

\$\$\$: greater than \$100,000

# Summary of Policy & Design Guidance

## Summary

This section summarizes the procedures and design standards relevant for the countermeasures described in this report.

Additional guidance is available in various ITE manuals including the ITE 2010 Recommended Practice Designing Walkable Urban Thoroughfares, the ITE Context Sensitive Solutions Practitioners' Guide, the ITE Recommended Design Guidelines Accommodating Pedestrians and Bicycles at Interchanges, various NACTO Design Guides, the FHWA Countermeasure Selection Guide, the FHWA Design Guidance Accommodating Bicycle and Pedestrian Travel: A Recommended Approach, and the Main Street California Guide.

**The matrix on pages 17-20 provides high-level information from relevant documents described in this chapter.**

## California Highway Design Manual

This Manual contains uniform policies and procedures to carry out the highway design functions of Caltrans.

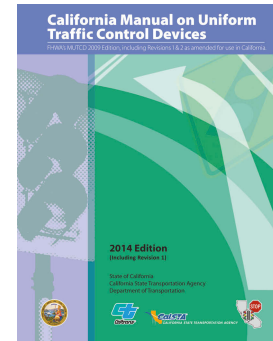
## Caltrans Complete Intersections Guide

This Guide provides countermeasures, intersection design treatments, operational changes, and speed management treatments to address challenges people walking and biking face at intersections and interchanges.



## California Manual on Uniform Traffic Control Devices (CA MUTCD)

This Manual contains the basic principles that govern the selection, application, design, and use of traffic control devices for all streets, highways, bikeways, and private roads open to public travel regardless of roadway ownership. Not all countermeasures listed in this report's Safety Countermeasures Toolbox are considered to be traffic control




CA MUTCD

devices, and will thus not be governed by the MUTCD. There are also countermeasures that may have current FHWA interim approval. Countermeasures not included in the MUTCD should not be assumed to be disallowed in California. Please reference the additional sources included in this section for guidance on countermeasure implementation.


## Local Road Safety Manual (LRSM)

This Manual provides insights to local agencies to proactively identify and analyze their safety issues and to position themselves to compete effectively in Caltrans' statewide, data-drive call for projects. The Manual provides countermeasures compliant to the Caltrans HSIP Call for Projects for signalized intersections, non-signalized intersections, and roadway segments.

TOPIC/COUNTERMEASURE		CALTRANS COMPLETE INTERSECTIONS GUIDE	CA MUTCD	CA HIGHWAY DESIGN MANUAL
<b>Signal Modification</b> 	Additional Signal Heads		<b>SECTION 4B.113</b> provides guidance regarding the modifications of existing signals.	<b>SECTION 403.9</b> Effective Signal Control refers to CA MUTCD
	Extend Pedestrian Crossing Time	✓	Guidance on extending the pedestrian crossing phase is provided in <b>SECTION 4E.06</b> .	<b>SECTION 403.9</b> Effective Signal Control refers to CA MUTCD
	Flashing Yellow Turn Phase		Interim approval IA-10 for optional use of flashing yellow arrow for permissive left turn lanes was issued 11/3/08	<b>SECTION 403.9</b> Effective Signal Control refers to CA MUTCD
	Leading Pedestrian Interval		<b>SECTION 4E.06</b> provides information about pedestrian intervals and signal phases. The option of leading pedestrian intervals is introduced for locations with high pedestrian volumes and high conflicting turning vehicle volumes.	<b>SECTION 403.9</b> Effective Signal Control refers to CA MUTCD
	Install Traffic Signal		<b>CHAPTER 4C</b> provides studies and factors for justifying traffic control signals	<b>SECTION 403.9</b> Effective Signal Control refers to CA MUTCD
	Pedestrian Scramble		<b>SECTION 4E</b> provides guidance regarding the application of signal heads	
	Pedestrian Phase Recall		<b>SECTION 4B.113</b> provides guidance regarding the modifications of existing signals.	<b>SECTION 403.9</b> Effective Signal Control refers to CA MUTCD
	Permissive Lefts to Protected		Permissive left turn phasing guidance is provided in <b>SECTION 4D.111</b> . Standard application for signal indications for left turn movements are provided in <b>SECTION 4D.17 - 20</b> .	<b>SECTION 403.9</b> Effective Signal Control refers to CA MUTCD
	Reduce Cycle Lengths		<b>SECTIONS 4D.113</b> and <b>4D.114</b> provide guidance for the proper operations of traffic signals.	<b>SECTION 403.9</b> Effective Signal Control refers to CA MUTCD
	Separate Right-Turn Phasing		<b>SECTION 4B.113</b> provides guidance regarding the modifications of existing signals.	<b>SECTION 403.9</b> Effective Signal Control refers to CA MUTCD
<b>Intersection &amp; Roadway Design</b> 	Close Slip Lane		Not a traffic control device	<b>SECTION 504.3</b> Ramps discusses ramp intersection design <b>SECTION 405.3</b> Right Turn Channelization emphasizes low vehicle speeds
	Convert Two-Way Stop to All-Way Stop		<b>SECTION 2B.05</b> provides guidance regarding the use of All-Way Stop signs.	<b>SECTION 401.5</b> Intersection Type refers to CA MUTCD

TOPIC/COUNTERMEASURE	CALTRANS COMPLETE INTERSECTIONS GUIDE	CA MUTCD	CA HIGHWAY DESIGN MANUAL
<p><b>Intersection &amp; Roadway Design (cont.)</b></p> 	Install Sidewalk	✓	Not a traffic control device <b>SECTION 105.1</b> describes design options in a variety of settings
	Protected Intersection		Not a traffic control device <b>DIB 89</b> discusses protected intersections
	Raised Intersection		Not a traffic control device <b>DIB 82</b> provides guidance on blended transitions for raised crossings
	Raised Median		Guidance provided in <b>SECTIONS 2B.32, 2C.63-2C.66</b> . Support provided in <b>SECTION 9C.04</b> . Option provided in <b>SECTION 3I.04</b> and <b>8C.04</b> <b>SECTION 303.2</b> Curb Types and Uses
	Realign Intersection to 90 Degrees	✓	Not a traffic control device <b>SECTION 403.3</b> Angle of Intersection
	Road Diet		Not a traffic control device <b>TOPIC 403</b> - Principles of Channelization
	Roundabout	✓ Areas with 45 mph or less speed limit	<b>SECTION 4C.01</b> requires consideration of roundabouts on State Highways and suggests their consideration on local streets and highways. Section 4C.01.01c references Traffic Operations Policy Directive 13-02, which specifies the Intersection Control Evaluation procedures used to justify the use of traffic signal systems, yield (roundabout), or multi-way stop control. This directive supplements the California MUTCD warrant and engineering study requirements, adding yield control to the menu of intersection control options. <b>SECTION 405.10</b> Roundabouts
	Splitter Island	✓	Splitter islands are defined in <b>SECTION 1A.13.03.213</b> . Sign and striping guidance is provided throughout the manual. <b>SECTION 405.10</b> Roundabouts provides guidance on Splitter Islands at roundabouts
	Widen Shoulder		Shoulder is defined in <b>SECTION 1A.13.03.191A</b> as the portion of highway contiguous with the roadway for accommodations or pedestrians, bicyclists, stopped vehicles, for emergency use, and for lateral support of base and surface courses. Sign and striping guidance is provided throughout the manual. <b>TOPIC 302</b> - Highway Shoulder Standards



TOPIC/COUNTERMEASURE	CALTRANS COMPLETE INTERSECTIONS GUIDE	CA MUTCD	CA HIGHWAY DESIGN MANUAL
<p><b>Signage &amp; Markings</b></p> 	<p>Advance Stop Markings</p> <p>Advance Yield Markings</p> <p>Prohibit Right-Turn-on-Red</p> <p>Yield to Pedestrian Sign</p>	<p><b>SECTION 3B.16</b> provides standard and guidance language for the use of stop and yield lines.</p> <p><b>SECTION 3B.16</b> provides standard and guidance language for the use of stop and yield lines.</p> <p><b>SECTION 2B.54</b> provides guidance on consideration of this treatment, and standards for sign installation. Standard application for signal indications for right turn movements are provided in <b>SECTION 4D.21 - 24</b>. Sign numbers include R10-11 Series, R10-17a, and R10-30.</p> <p><b>SECTION 2B.11</b> provides standards, support, guidance and options for the placement of Yield Here to Pedestrians Signs. Sign numbers include R1-5, R1-5A, R1-6</p>	<p><b>TOPIC 405</b> - Intersection Design Standards</p> <p><b>TOPIC 702</b> references CA MUTCD for pavement marking guidance</p> <p><b>SECTION 403.9</b> Effective Signal Control refers to CA MUTCD</p> <p><b>TOPIC 702</b> references CA MUTCD for sign guidance</p>
<p><b>Pedestrian Crossings</b></p> 	<p>Reconstructed curbside sidewalks should meet ADA requirements</p> <p>Construct curbside extensions at non-corner crosswalk end</p> <p>Design principle to improve visibility</p> <p>Accessible signals</p> <p>Ample lighting for crosswalks</p>	<p>Standards, guidance, options and support for Accessible Pedestrian Signals and Detectors is provided in <b>SECTION 4E.09 THROUGH 4E.13</b>.</p> <p><b>SECTION 4B.04</b> provides alternatives to traffic control signals, including curb extensions and median refuge islands.</p> <p>Direction on Pedestrian Detectors is provided in <b>SECTION 4E.08</b>.</p> <p>Guidance on crosswalk markings is provided in <b>SECTION 3B.18</b>.</p> <p><b>SECTION 4E.07</b> provides standards, options and guidance for Countdown Pedestrian Signals.</p> <p>Guidance provided in <b>SECTION 4C.05</b></p> <p><b>CHAPTER 4F</b> provides information for the application, design and operation of Pedestrian Hybrid Beacons.</p> <p>Not a traffic control device</p>	<p>Guidelines for the location and design of curb ramps provided in <b>SECTION 105.5</b></p> <p><b>DIB 82-06</b> Pedestrian Accessibility Guidelines for Highway Projects</p> <p><b>SECTION 303.4</b> defines bulbout and placement, curb type and dimensions and references MUTCD for signs and pavement markings as well as <b>DIB 82</b> requirements. This section also describes busbulbs and busbays. Landscaping and appurtenant facilities are to comply per <b>TOPIC 405</b>.</p> <p><b>SECTION 403.9</b> Effective Signal Control refers to CA MUTCD <b>CHAPTER 4E</b></p> <p><b>SECTION 105.6</b> refers to CA MUTCD and California Vehicle Code, and <b>DIB 82</b></p> <p><b>SECTION 403.9</b> Effective Signal Control refers to CA MUTCD</p> <p>Not discussed in HDM. See Caltrans Traffic Manual, Section 9-10 Highway Safety Lighting Design Standards.</p> <p><b>SECTION 403.9</b> Effective Signal Control refers to CA MUTCD</p> <p>Referred to in <b>SECTION 105.2</b>, Sidewalks and Walkways</p>

CALTRANS PEDESTRIAN SAFETY COUNTERMEASURES TOOLBOX

TOPIC/COUNTERMEASURE	CALTRANS COMPLETE INTERSECTIONS GUIDE	CA MUTCD	CA HIGHWAY DESIGN MANUAL
<b>Pedestrian Crossings (cont.)</b> 	<p><b>Pedestrian Median Barrier</b></p>	<p>Signs and pavement markings for median barriers are described in the Manual, however no specifications are provided because these are not traffic control devices.</p>	<p><b>SECTION 305.3</b> "Median Barriers" refers the reader to Traffic Safety Systems guidance</p>
<p><b>Pedestrian Refuge Island</b></p>	<p><input checked="" type="checkbox"/> If pedestrians are unable to cross in one cycle</p>	<p><b>CHAPTER 3L</b> describes treatments and pavement marking and sign applications for pedestrian islands and medians.</p>	<p><b>SECTION 405.4:</b> including "At unsignalized intersections in rural city/town centers (rural main streets), suburban, or urban areas, a pedestrian refuge should be provided between opposing traffic where pedestrians are allowed to cross 2 or more through traffic lanes in one direction of travel, at marked or unmarked crosswalks"</p>
<p><b>Raised Crosswalk</b></p>		<p><b>SECTION 2C.29</b> provides guidance, options and support for speed humps. Pavement markings for Speed Tables and Speed Humps with Crosswalks are provided in <b>FIGURE 3B-30</b>.</p>	<p><b>DIB 82</b> provides guidance on blended transitions for raised crossings</p>
<p><b>Restripe Crosswalk</b></p>	<p><input checked="" type="checkbox"/> Do not let cross walk markings/ striping fade</p>	<p><b>SECTION 3B.18</b> provides installation guidance and design standards.</p>	<p><b>SECTION 105.6</b> An option at pedestrian crossings, in accordance with CA MUTCD.</p>
<p><b>Rectangular Rapid-Flashing Beacon (RRFB)</b></p>	<p><input checked="" type="checkbox"/> Or in-pavement flashers</p>	<p><b>INTERIM APPROVAL IA-21</b> allows the installation of RRFBs at uncontrolled marked crosswalks adopted 4/9/18 in California</p>	<p>References MUTCD in <b>SECTION 403.9</b>. Pedestrian activated devices, signals or beacons are not required but must be evaluated where directional, multi-lane, pedestrian crossings occur.</p>
<p><b>Upgrade Curb Ramp</b></p>		<p>Not a traffic control device</p>	<p><b>SECTION 105.5</b> Guidelines for the location and design of curb ramps  <b>DIB 82-06</b> Pedestrian Accessibility Guidelines for Highway Projects</p>
<p><b>Other</b></p> 	<p><b>Access Management/ Close Driveway</b></p> <p><b>Intersection, Street-Scale Lighting</b></p>	<p>Not a traffic control device</p> <p>Not a traffic control device</p>	<p><b>SECTION 405.6</b> Access Control</p> <p>Not discussed in HDM. See Caltrans Traffic Manual, Section 9-10 Highway Safety Lighting Design Standards.</p>

## Education and Enforcement

The California Highway Patrol and local police departments are essential to the prevention of collisions through safety education, community outreach, and increased and targeted enforcement. Efforts should use collision history to focus on targeted audiences. Typical campaigns are often focused on videos and downloadable materials. These campaign messages can be reformatted to be more public facing and reach wider audiences through social media communication tactics. Key messages can be finessed to reach the areas, groups and situational attributes identified as over-represented in collisions. The table below and the following case

studies outline actions that can be taken to focus resources on identified issues.

- Anaheim: Targeted and Saturated Patrols

Enforcement activities included review of traffic collision locations for the previous week by the Anaheim Traffic Bureau. The reviews were done on a weekly basis and officers were sent to conduct enforcement at locations with the highest number of collisions. Primary Collision Factors such as speeding, running red lights, and driver impairment (alcohol) were the focus of the enforcement, but officers enforced any traffic violations that occurred.

- Pleasanton: Outreach and Education

The Pleasanton Police Department visits local schools twice a year to educate students on bicycle and pedestrian safety, as well as attending Parent Teacher Association (PTA) meetings to educate parents on safe driving, specifically near schools. Additionally, Pleasanton offers first time offenders courtesy citations for minor traffic violations by motorists, bicyclists and pedestrians. This allows officers to educate violators on the issue and provide safety information. The police department tracks the courtesy citations to ensure that officers are aware of repeat offenders.

TARGET AREA	MESSAGES & PROGRAMS	COMMUNICATION TACTICS	EXAMPLES
AREA	<ul style="list-style-type: none"> <li>• Hang banners and billboards throughout the area highlighting the importance of safe driving, biking and walking</li> <li>• Create network for tracking vehicles, pedestrians and bicycles in high KSI areas</li> <li>• Geofence audible messages on approach to over-represented locations through wayfinding or music apps</li> <li>• Partner with companies collecting speed and traffic volume information to focus on key locations</li> </ul>	<ul style="list-style-type: none"> <li>• Banners</li> <li>• Billboards</li> <li>• Bus exteriors</li> <li>• Transit shelters</li> <li>• Social media, including audio, graphics and pre-written Tweets and posts</li> <li>• Partnerships (Ambassadors and Community Organizations)</li> <li>• Gas pump videos</li> </ul>	<ul style="list-style-type: none"> <li>• “Accident Area” signage, Kingman, AZ <a href="https://kdminer.com/news/2015/may/11/dps-kingman-battalion-chief-failed-to-yield-in-fa/">https://kdminer.com/news/2015/may/11/dps-kingman-battalion-chief-failed-to-yield-in-fa/</a></li> <li>• High-crash corridor traffic sensors, Portland, OR <a href="https://nextcity.org/daily/entry/portland-deploys-data-tracking-traffic-sensors-to-save-lives">https://nextcity.org/daily/entry/portland-deploys-data-tracking-traffic-sensors-to-save-lives</a></li> <li>• Comprehensive Bike Study, Wilkes Barre, PA <a href="https://www.psdispatch.com/news/63333/making-downtown-wilkes-barre-bicycle-pedestrian-friendly-focus-of-new-study">https://www.psdispatch.com/news/63333/making-downtown-wilkes-barre-bicycle-pedestrian-friendly-focus-of-new-study</a></li> </ul>
USER COMMUNITY	<ul style="list-style-type: none"> <li>• Partner with Senior Centers and/or Retirement Communities to educate older adults on the importance of crossing in a crosswalk</li> <li>• Hang pedestrian focused banners at over-represented intersections (roads with 5 or more lanes, high volume streets, etc.)</li> <li>• Distribute printed materials at community events (farmer’s markets, block parties, etc.) highlighting importance of situational awareness while walking</li> <li>• Work with area schools and youth organizations to share education on walking without looking at phones</li> </ul>	<ul style="list-style-type: none"> <li>• Banners</li> <li>• Bus interiors</li> <li>• Printed materials</li> <li>• Events and classes</li> <li>• Social media, including audio, graphics and pre-written Tweets and posts</li> <li>• Partnerships (Ambassadors and Community Organizations)</li> </ul>	<ul style="list-style-type: none"> <li>• Walking Tips for Seniors, Toronto, ON <a href="http://walkandrollpeel.ca/walking/seniors.htm">http://walkandrollpeel.ca/walking/seniors.htm</a></li> </ul>

# Appendix:

## Countermeasure Sources



### General Sources

The countermeasures included in the Toolbox draw from the sources listed below. Safety practitioners are encouraged to use these references to learn more about pedestrian countermeasures.

- > The Crash Modification Factors Clearinghouse, FHWA  
<http://www.cmfclearinghouse.org/>
- > A Vision for Transportation Safety, SFMTA and SFDPH for TRB, 2015  
<https://trid.trb.org/view/1393412>
- > Application of Pedestrian Crossing Treatments for Streets and Highway, NCHRP, 2016  
<http://www.trb.org/Publications/Blurbs/175419.aspx>
- > California Local Roadway Safety Manual, Caltrans, FHWA & SafeTREC, 2016  
<http://www.dot.ca.gov/hq/LocalPrograms/HSIP/2016/CA-LRSM.pdf>
- > Development of Crash Modification Factors for Uncontrolled Pedestrian Crossing Treatments, NCHRP, 2017  
<http://www.trb.org/Main/Blurbs/175381.aspx>

- > Evaluation of Pedestrian-Related Roadway Measures, Pedestrian and Bicycle Information Center, 2014  
[http://www.pedbikeinfo.org/cms/downloads/PedestrianLitReview\\_April2014.pdf](http://www.pedbikeinfo.org/cms/downloads/PedestrianLitReview_April2014.pdf)
- > NCHRP Report 500 Series: Volumes 4, 5, 6, 7, 10, 12, 13, and others  
<http://www.trb.org/Main/Blurbs/152868.aspx>
- > Highway Safety Manual (HSM), First Edition, 2010  
<http://www.highwaysafetymanual.org>
- > Toolbox of Countermeasures to Reduce Pedestrian Crashes  
[http://safety.fhwa.dot.gov/ped\\_bike/tools\\_solve/ped\\_tctpepc/](http://safety.fhwa.dot.gov/ped_bike/tools_solve/ped_tctpepc/)
- > FHWA Manual for Rural Road Owners:
  - > Roadway Departure Safety
  - > Intersection Safety
  - > Non-Motorized Safety  
[http://safety.fhwa.dot.gov/local\\_rural/training/](http://safety.fhwa.dot.gov/local_rural/training/)
- > FHWA Desktop Reference for Crash Reduction Factors  
<http://safety.fhwa.dot.gov/tools/crf/resources/fhwasa08011/>
- > FHWA Pedestrian Safety Guide and Countermeasure Selection System  
<http://www.pedbikesafe.org/PEDSAFE/countermeasures.cfm>

- > Recommended Design Guidelines to Accommodate Pedestrians and Bicycles at Interchanges  
<https://trid.trb.org/view/1326321>
- > FHWA Design Guidance; Accommodating Bicycle and Pedestrian Travel: a Recommended Approach  
[https://safety.fhwa.dot.gov/intersection/other\\_topics/fhwasa09027/resources/Design%20Guidance%20Accommodating%20Bicycle%20and%20Pedestrian%20Travel.pdf](https://safety.fhwa.dot.gov/intersection/other_topics/fhwasa09027/resources/Design%20Guidance%20Accommodating%20Bicycle%20and%20Pedestrian%20Travel.pdf)

At this time, several tools in common practice do not have documented CMFs. This is largely due to limited funding to evaluate devices. These tools have been included based on their potential to complement or enhance the efficacy of other countermeasures, and/or "proxy" safety studies of efficacy that have led to their inclusion in national manuals and resources.

Caltrans will continue to periodically update this list of countermeasures as new safety research data becomes available. With this in mind, Caltrans is interested in feedback and suggestions from safety practitioners on the overall countermeasure list as well as specific details of individual countermeasures, including locally developed safety effectiveness information.

## Countermeasure References

Specific references for countermeasures not in the CMF Clearinghouse are provided below.

- › Install Traffic Signal  
Currently the CMF Clearinghouse has only one reference for ped/vehicle collisions which indicates an increase in crash likelihood. However, a majority of references for all crash types show a decrease in collisions.
- › Pedestrian Phase Recall: Evaluation of Pedestrian-Related Roadway Measures, Pedestrian and Bicycle Information Center, 2014  
[http://www.pedbikeinfo.org/cms/downloads/PedestrianLitReview\\_April2014.pdf](http://www.pedbikeinfo.org/cms/downloads/PedestrianLitReview_April2014.pdf)
- › Separate Right-Turn Phasing: Evaluation of Pedestrian-Related Roadway Measures, Pedestrian and Bicycle Information Center, 2014  
[http://www.pedbikeinfo.org/cms/downloads/PedestrianLitReview\\_April2014.pdf](http://www.pedbikeinfo.org/cms/downloads/PedestrianLitReview_April2014.pdf)
- › Reduce Cycle Lengths: FHWA Pedestrian Safety Guide and Countermeasure Selection System  
[http://www.pedbikesafe.org/PEDSAFE/countermeasures\\_detail.cfm?CM\\_NUM=45](http://www.pedbikesafe.org/PEDSAFE/countermeasures_detail.cfm?CM_NUM=45)
- › Close Slip Lane: FHWA Pedestrian Safety Guide and Countermeasure Selection System  
[http://www.pedbikesafe.org/PEDSAFE/countermeasures\\_detail.cfm?CM\\_NUM=24](http://www.pedbikesafe.org/PEDSAFE/countermeasures_detail.cfm?CM_NUM=24)
- › Install Sidewalk:  
Data in the CMF Clearinghouse is currently limited to bicycle/vehicle collisions. See additional reference: FHWA Pedestrian Safety Guide and Countermeasure Selection System.  
[http://www.pedbikesafe.org/PEDSAFE/countermeasures\\_detail.cfm?CM\\_NUM=1](http://www.pedbikesafe.org/PEDSAFE/countermeasures_detail.cfm?CM_NUM=1)
- › Protected Intersection: Evolution of the Protected Intersection, Alta Planning and Design, December 2015  
[https://altaplanning.com/wp-content/uploads/Evolution-of-the-Protected-Intersection\\_ALTA-2015.pdf](https://altaplanning.com/wp-content/uploads/Evolution-of-the-Protected-Intersection_ALTA-2015.pdf)
- › Raised Intersection  
Note: some studies in CMF Clearinghouse show an increase in crashes. See additional source below showing decrease.  
(1) Perkins+Will Consultant Team. "Pedestrians at Multi-Modal Intersections." Better Market Street Existing Conditions & Best Practices, Part Two: Best Practices 36-58, City & County of San Francisco, San Francisco.  
<http://www.bettermarketstreetsf.org/about-reports-existing-conditions.html>  
(2) Bhatt, Shailen, Natalie Barnhart, Mark Luszczyk, Tom Meyer, & Michael Sommers. "Delaware Traffic Calming Design Manual." Delaware Department of Transportation, State of Delaware, Dover, DE  
[https://nacto.org/wp-content/uploads/2015/04/DE-Traffic-Calming-Manual\\_2012.pdf](https://nacto.org/wp-content/uploads/2015/04/DE-Traffic-Calming-Manual_2012.pdf)  
(3) King, Michael R, Jon A Carnegie, and Reid Ewing. "Pedestrian Safety through a Raised Median and Redesignated Intersections." Journal of the Transportation Research Board 1828 (1), 56-66, Transportation Research Board, Washington, DC.  
<https://trid.trb.org/view/663867>  
(4) Fitzpatrick, Kay, Mark D Wooldridge, and Joseph D Blaschke. "Urban Intersection Design Guide: Volume 1—Guidelines." Texas Transportation Institute, Texas A&M University System, Texas Department of Transportation, Austin, TX.  
<https://static.tti.tamu.edu/tti.tamu.edu/documents/0-4365-P2.pdf>
- › Realign Intersection to 90 Degrees: A Guide for Addressing Unsignalized Intersection Collisions, NCHRP, 2003  
[http://onlinepubs.trb.org/Onlinepubs/nchrp/nchrp\\_rpt\\_500v5.pdf](http://onlinepubs.trb.org/Onlinepubs/nchrp/nchrp_rpt_500v5.pdf)
- › Prohibit Right-Turn-on-Red: Currently the CMF Clearinghouse does not include specific studies; however, permitting right-turns-on-red shows an increase in ped/vehicle crashes. Additional information is available at the FHWA Pedestrian Safety Guide and Countermeasure Selection System.  
[http://www.pedbikesafe.org/PEDSAFE/countermeasures\\_detail.cfm?CM\\_NUM=49](http://www.pedbikesafe.org/PEDSAFE/countermeasures_detail.cfm?CM_NUM=49)
- › Audible Push Button Upgrade and Extended Time Pushbutton: FHWA Pedestrian Safety Guide and Countermeasure Selection System  
[http://www.pedbikesafe.org/PEDSAFE/countermeasures\\_detail.cfm?CM\\_NUM=52](http://www.pedbikesafe.org/PEDSAFE/countermeasures_detail.cfm?CM_NUM=52)
- › Pedestrian-Level Lighting: FHWA Pedestrian Safety Guide and Countermeasure Selection System  
[http://www.pedbikesafe.org/PEDSAFE/countermeasures\\_detail.cfm?CM\\_NUM=8](http://www.pedbikesafe.org/PEDSAFE/countermeasures_detail.cfm?CM_NUM=8)
- › Curb Extensions:  
(1) Application of Pedestrian Crossing Treatments for Streets and Highways, NCHRP, 2016  
<https://www.nap.edu/catalog/24634/application-of-pedestrian-crossing-treatments-for-streets-and-highways>  
(2) Development of Crash Modification Factors for Uncontrolled Pedestrian Crossing Treatments, NCHRP, 2017  
<https://www.nap.edu/catalog/24627/development-of-crash-modification-factors-for-uncontrolled-pedestrian-crossing-treatments>  
(3) Evaluation of Pedestrian-Related Roadway Measures, Pedestrian and Bicycle Information Center, 2014  
[http://www.pedbikeinfo.org/cms/downloads/PedestrianLitReview\\_April2014.pdf](http://www.pedbikeinfo.org/cms/downloads/PedestrianLitReview_April2014.pdf)
- › Pedestrian Detection: FHWA Pedestrian Safety Guide and Countermeasure Selection System  
[http://www.pedbikesafe.org/PEDSAFE/countermeasures\\_detail.cfm?CM\\_NUM=11](http://www.pedbikesafe.org/PEDSAFE/countermeasures_detail.cfm?CM_NUM=11)
- › Restripe Crosswalk: FHWA Pedestrian Safety Guide and Countermeasure Selection System  
[http://www.pedbikesafe.org/PEDSAFE/countermeasures\\_detail.cfm?CM\\_NUM=4](http://www.pedbikesafe.org/PEDSAFE/countermeasures_detail.cfm?CM_NUM=4)

- > Upgrade Curb Ramp:  
FHWA Pedestrian Safety Guide and Countermeasure Selection System  
[http://www.pedbikesafe.org/PEDSAFE/countermeasures\\_detail.cfm?CM\\_NUM=3](http://www.pedbikesafe.org/PEDSAFE/countermeasures_detail.cfm?CM_NUM=3)
- > Access Management/Close Driveway:  
The CMF Clearinghouse has limited research related to vehicle/pedestrian crashes. See additional reference: FHWA Pedestrian Safety Guide and Countermeasure Selection System  
[http://www.pedbikesafe.org/PEDSAFE/countermeasures\\_detail.cfm?CM\\_NUM=20](http://www.pedbikesafe.org/PEDSAFE/countermeasures_detail.cfm?CM_NUM=20)
- > Paint and Plastic Curb Extension:  
Evaluation of Pedestrian-Related Roadway Measures, Pedestrian and Bicycle Information Center, 2014  
[http://www.pedbikeinfo.org/cms/downloads/PedestrianLitReview\\_April2014.pdf](http://www.pedbikeinfo.org/cms/downloads/PedestrianLitReview_April2014.pdf)
- > Paint and Plastic Mini Circle:  
FHWA Pedestrian Safety Guide and Countermeasure Selection System  
[http://www.pedbikesafe.org/PEDSAFE/countermeasures\\_detail.cfm?CM\\_NUM=34](http://www.pedbikesafe.org/PEDSAFE/countermeasures_detail.cfm?CM_NUM=34)