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“Making Our Roads Safer One Countermeasure At A Time”

*Roadway Departure
Proven Safety Countermeasures
FHWA-SA-18-029*

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U.S. Department of Transportation
Federal Highway Administration



Making Our Roads Safer

ONE COUNTERMEASURE AT A TIME

*20 Proven Safety Countermeasures
that offer significant and measurable
impacts to improving safety*

Proven Safety Countermeasures

ROADWAY DEPARTURE.....



1. Enhanced Delineation and Friction for Horizontal Curves



2. Longitudinal Rumble Strips and Stripes



3. SafetyEdge_{sm}



4. Roadside Design Improvements at Curves



5. Median Barriers

INTERSECTIONS.....



6. Backplates with Retroreflective Borders



7. Corridor Access Management



8. Left- and Right-Turn Lanes at Two-Way Stop-Controlled Intersections



9. Reduced Left-Turn Conflict Intersections



10. Roundabouts



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12. Yellow Change Intervals

PEDESTRIANS/BICYCLES.....



13. Leading Pedestrian Intervals



14. Medians and Pedestrian Crossing Islands in Urban and Suburban Areas



15. Pedestrian Hybrid Beacons



16. Road Diets/Reconfigurations



17. Walkways

CROSSCUTTING.....



18. Local Road Safety Plans



19. Road Safety Audits



20. USLIMITS2

This proven safety countermeasure for reducing crashes at curves includes a variety of potential strategies that can be implemented in combination or individually. These strategies fall into two categories: enhanced delineation and increased pavement friction.



Chevron signs installed along a curve.

Enhanced Delineation

Enhanced delineation treatments can alert drivers in advance of the curve and vary by the severity of the curve and operating speed. Price ranges for these strategies are low to moderate. Treatments include the following:

- Pavement markings.
- Post-mounted delineation.
- Larger signs and signs with enhanced retroreflectivity.
- Dynamic advance curve warning signs and sequential curve signs.

Increased Pavement Friction

High friction surface treatment (HFST) is another highly cost-effective countermeasure. HFST compensates for the high friction demand at curves where the available pavement friction is not adequate to support operating speeds due to one or more of the following situations:

- Sharp curves.
- Inadequate cross-slope design.
- Wet conditions.
- Polished roadway surfaces.
- Driving speeds in excess of the curve advisory speed.

To implement these proven safety countermeasures, agencies can take the following steps:

1. Develop a process for identifying and treating problem curves.
2. Use the appropriate application for the identified problem(s), consider the full range of enhanced delineation and friction treatments.
3. Improve consistency in application of horizontal curve guidance provided in the *Manual on Uniform Traffic Control Devices* for new and existing devices.
4. Review signing practices and policies to ensure they comply with the intent of the new guidance.

1. Enhanced Delineation and Friction for Horizontal Curves



SAFETY BENEFITS:

CHEVRON SIGNS

25%

Reduction in nighttime crashes

16%

Reduction in non-intersection fatal and injury crashes

Source: CMF Clearinghouse, CMF IDs 2438 and 2439

HIGH FRICTION SURFACE TREATMENTS

52%

Reduction in wet road crashes

24%

Reduction in curve crashes

Source: CMF Clearinghouse, CMF IDs 7900 and 7901

2. Longitudinal Rumble Strips and Stripes



SAFETY BENEFITS:



CENTER LINE RUMBLE STRIPS

44-64%

Head-on, opposite-direction, and sideswipe fatal and injury crashes

SHOULDER RUMBLE STRIPS

13-51%

Single vehicle, run-off-road fatal and injury crashes



Source: NCHRP Report 641, *Guidance for the Design and Application of Shoulder and Centerline Rumble Strips*.



Shoulder rumble strips and center line rumble strips are installed on this roadway.

Source: FHWA

Longitudinal rumble strips are milled or raised elements on the pavement intended to alert drivers through vibration and sound that their vehicles have left the travel lane. They can be installed on the shoulder, edge line of the travel lane, or at or near center line of an undivided roadway.

Rumble stripes are edge line or center line rumble strips where the pavement marking is placed over the rumble strip, which can result in an increased visibility of the pavement marking during wet, nighttime conditions.

With roadway departure crashes accounting for more than half of the fatal roadway crashes annually in the United States, rumble strips and stripes are designed to address these crashes caused by distracted, drowsy, or otherwise inattentive drivers who drift from their lane. They are most effective when deployed in a systemic application since driver error may occur on all roads.

Transportation agencies should consider milled center line rumble strips (including in passing zone areas) and milled edge line or shoulder rumble strips with bicycle gaps for systemic safety projects, location-specific corridor safety improvements, as well as reconstruction or resurfacing projects.



Example of an edge line rumble stripe.

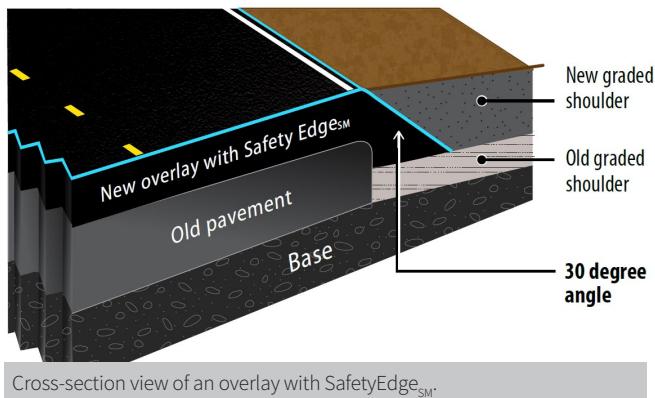
Source: Missouri DOT



3. SafetyEdge_{SM}



SafetyEdge_{SM} technology shapes the edge of the pavement at approximately 30 degrees from the pavement cross slope during the paving process. This systemic safety treatment eliminates the vertical drop-off at the pavement edge,



Cross-section view of an overlay with SafetyEdge_{SM}. Source: FHWA-SA-17-044

allowing drifting vehicles to return to the pavement safely. It has minimal effect on asphalt pavement project cost with the potential to improve pavement life.

Vehicles may leave the roadway for various reasons, ranging from distracted driver errors to low visibility, or to the presence of an animal on the road. Exposed vertical pavement edges can cause vehicles to be unstable and prevent their safe return to the roadway. SafetyEdge_{SM} gives drivers the opportunity to return to the roadway while maintaining control of their vehicles.

For both SafetyEdge_{SM} and traditional edge, agencies should bring the adjacent shoulder or slope flush with the top of the pavement. Since over time the edge may become exposed due to settling, erosion, and tire wear, the gentle slope provided by SafetyEdge_{SM} is preferred versus the traditional vertical pavement edge.

Transportation agencies should develop standards for implementing SafetyEdge_{SM} on all new asphalt paving and resurfacing projects where curbs are not present, while encouraging standard application for concrete pavements.



Example of SafetyEdge_{SM} after backfill material settles or erodes. Source: FHWA

SAFETY BENEFIT:



11 %

Reduction in fatal and injury crashes



Source: Safety Effects of the SafetyEdge_{SM}, FHWA-SA-17-044.

SafetyEdge_{SM} adds nominal cost to repaving a road.

Rural road crashes involving edge drop-offs are

Calculated benefit-cost ratios typically range between

500-1400



2 to 4 times

more likely to include a fatality than other crashes on similar roads.

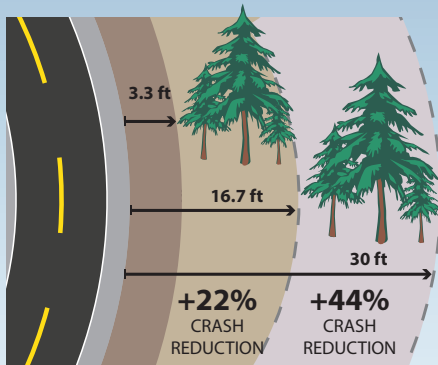
Source: Safety Effects of the SafetyEdge_{SM}, FHWA-SA-17-044.

Source: S.L. Hallmark, et al., Safety Impacts of Pavement Edge Drop-offs, (Washington, DC: AAA Foundation for Traffic Safety: 2006), p 93.

4. Roadside Design Improvements at Curves



Increasing the Clear Zone prevents crashes



Source: Leidos. Data Source: CMF Clearinghouse (CMF IDs 35 and 36)

SAFETY BENEFIT:

27%

of all fatal crashes occur at curves

80%

of all fatal crashes at curves are roadway departure crashes



Source: Fatality Analysis Reporting System (FARS)

Roadside design improvement at curves is a strategy encompassing several treatments that target the high-risk roadside environment along the outside of horizontal curves. These treatments prevent roadway departure fatalities by giving vehicles the opportunity to recover safely and by reducing crash severity.

Roadside design improvements can be implemented alone or in combination and are particularly recommended at horizontal curves—where data indicates a higher-risk for roadway departure fatalities—and where cost effectiveness can be maximized.

Roadside Design Improvements to Provide for a Safe Recovery

In cases where a vehicle leaves the roadway, strategic roadside design elements, including clear zone addition or widening, slope flattening, and shoulder addition or widening, can provide drivers with an opportunity to regain control and re-enter the roadway.

- A **clear zone** is an unobstructed, traversable area beyond the edge of the through traveled way for the recovery of errant vehicles. Clear zones are free of rigid fixed objects such as trees and utility cabinets or poles. AASHTO's *Roadside Design Guide* details the clear zone width adjustment factors to be applied at horizontal curves.
- **Slope flattening** reduces the steepness of the sideslope to increase drivers' ability to keep the vehicle stable, regain control of the vehicle, and avoid obstacles.
- **Adding or widening shoulders** gives drivers more recovery area to regain control in the event of a roadway departure.

Roadside Design Improvements to Reduce Crash Severity

Since not all roadside hazards can be removed at curves, installing roadside barriers to shield unmovable objects or embankments may be an appropriate treatment. Roadside barriers come in three forms:

- **Cable barrier** is a flexible barrier made from wire rope supported between frangible posts.
- **Guardrail** is a semi-rigid barrier, usually either a steel box beam or W-beam. These deflect less than flexible barriers, so they can be located closer to objects where space is limited.
- **Concrete barrier** is a rigid barrier that does not deflect. These are typically reserved for use on divided roadways.



Shoulder is provided along roadway curve.

Source: Alaska DOT



Median barriers are longitudinal barriers that separate opposing traffic on a divided highway and are designed to redirect vehicles striking either side of the barrier. Median barriers significantly reduce the severity of cross-median crashes, which are attributed to the



Median cable barrier prevents a potential head-on crash.

Source: Washington State DOT

relatively high speeds that are typical on divided highways. Approximately 8 percent of all fatalities on divided highways are due to head-on crashes.

In the past, median barriers were typically only used when medians were less than 30 feet wide, but many States realized they were experiencing cross-median fatal crashes in medians that exceeded 30 feet. AASHTO's *Roadside Design Guide* was revised in 2006 to encourage consideration of barriers in medians up to 50 feet wide.

The application of cable median barriers is a very cost-effective means of reducing the severity of median crossover crashes. Median barriers can be **cable**, **concrete**, or **beam guardrail**.

- **Cable barriers** are softer, resulting in less impact force and redirection, are more adaptable to slopes typically found in medians, and can be installed through less invasive construction methods.
- **Concrete barriers** are rigid, yielding little to no deflection upon impact, and absorbing little crash energy. Although this system is expensive to install, it performs well when hit and only requires repair in the most extreme circumstances.
- **Beam guardrails** are considered semi-rigid barriers. When impacted, they deform and deflect, absorbing some of the crash energy, and usually redirecting the vehicle. Beam guardrails are less expensive to install than rigid barriers, and are more resilient than cable barriers.

To reduce the number and severity of cross-median crashes, transportation agencies should review their median crossover crash history to identify the locations where median barriers are most warranted. Agencies should also consider implementing a systemic median barrier policy based on cross-median crash risk factors.

5. Median Barriers



8%

OF ALL FATALITIES ON DIVIDED HIGHWAYS ARE DUE TO HEAD-ON CRASHES¹



SAFETY BENEFIT:

**MEDIAN BARRIERS
INSTALLED ON RURAL
FOUR-LANE
FREEWAYS**

97%

Reduction in cross-median crashes²



¹ Fatality Analysis Reporting System (FARS).

² NCHRP Report 794, *Median Cross-Section Design for Rural Divided Highways*.

6. Backplates with Retroreflective Borders



SAFETY BENEFIT:

15%
Reduction in total
crashes

Source: CMF Clearinghouse, CMF ID 1410.

Backplates added to a traffic signal indication improve the visibility of the illuminated face of the signal by introducing a controlled-contrast background. The improved visibility of a signal head with a backplate is made even more conspicuous by framing it with a retroreflective border. Signal heads that have backplates equipped with retroreflective borders are more visible and conspicuous in both daytime and nighttime conditions.

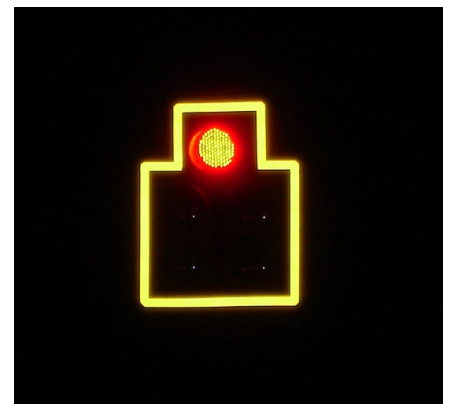
This treatment is recognized as a human factors enhancement of traffic signal visibility, conspicuity, and orientation for both older and color vision deficient drivers. This countermeasure is also advantageous during periods of power outages when the signals would otherwise be dark, providing a visible cue for motorists.

Transportation agencies should consider backplates with retroreflective borders as part of their efforts to systemically improve safety performance at signalized intersections. Adding a retroreflective border to an existing signal backplate is a very low-cost safety treatment. The most effective means of implementing this proven safety countermeasure is to adopt it as a standard treatment for signalized intersections across a jurisdiction.



Example of a signal backplate framed with a retroreflective border.

Source: FHWA



Retroreflective borders are highly visible during the night.

Source: South Carolina DOT

Access management refers to the design, application, and control of entry and exit points along a roadway. This includes intersections with other roads and driveways that serve adjacent properties. Thoughtful access management along a corridor can simultaneously enhance safety for all modes, facilitate walking and biking, and reduce trip delay and congestion.



A raised median reduces conflict points along this roadway.

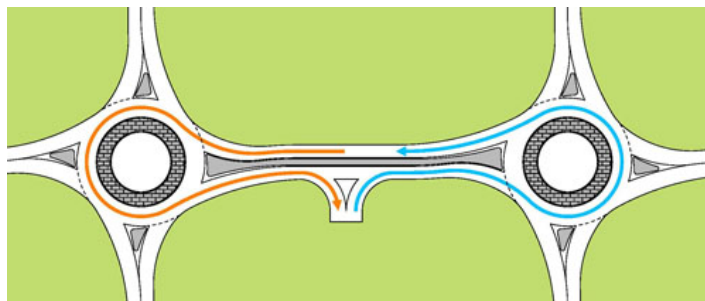
Source: Missouri DOT

Every intersection, from a signalized intersection to an unpaved driveway, has the potential for conflicts between vehicles, pedestrians, and bicycles. The number and types of conflict points—locations where the travel paths of two users intersect—influence the safety performance of the intersection or driveway.

The following access management strategies can be used individually or in combination with one another:

- Driveway closure, consolidation, or relocation.
- Limited-movement designs for driveways (such as right-in/right-out only).
- Raised medians that preclude cross-roadway movements.
- Intersection designs such as roundabouts or those with reduced left-turn-conflicts (such as J-turns, median U-turns, etc.).
- Turn lanes (i.e., left-only, right-only, or interior two-way left).
- Lower speed one-way or two-way off-arterial circulation roads.

Successful corridor access management involves balancing overall safety and corridor mobility for all users along with the access needs of adjacent land uses.



Use of roundabouts, raised median, and right-in/right-out driveways can be an effective access management plan.

Source: FHWA-SA-15-005

7. Corridor Access Management



This intersection design restricts left-turn movements to improve safety.

Source: FHWA

SAFETY BENEFITS:

5-23%

Reduction in total crashes along 2-lane rural roads

25-31%

Reduction in injury and fatal crashes along urban/suburban arterials

Source: Highway Safety Manual

8. Left and Right Turn Lanes at Two-Way Stop-Controlled Intersections



SAFETY BENEFITS:



LEFT-TURN LANES

28-48%

Reduction in total crashes

RIGHT-TURN LANES

14-26%

Reduction in total crashes



Source: Highway Safety Manual

Auxiliary turn lanes—either for left turns or right turns—provide physical separation between turning traffic that is slowing or stopped and adjacent through traffic at approaches to intersections. Turn lanes can be designed to provide for deceleration prior to a turn, as well as for storage of vehicles that are stopped and waiting for the opportunity to complete a turn.



Example of left-turn lanes.

Source: FHWA

While turn lanes provide measurable safety and operational benefits at many types of intersections, they are particularly helpful at two-way stop-controlled intersections. Crashes occurring at these intersections are often related to turning maneuvers. Since the major route traffic is free flowing and typically travels at higher speeds, crashes that do occur are often severe. The main crash types include collisions of vehicles turning left across opposing through traffic and rear-end collisions of vehicles turning left or right with other vehicles following closely behind. Turn lanes reduce the potential for these types of crashes.

Installing left-turn lanes and/or right-turn lanes should be considered for the major road approaches for improving safety at both three- and four-leg intersections with two-way stop control on the minor road, where significant turning volumes exist, or where there is a history of turn-related crashes. Pedestrian and bicyclist safety and convenience should also be considered when adding turn lanes at an intersection.



Example of a right-turn lane.

Source: FHWA



9. Reduced Left-Turn Conflict Intersections

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



Example of RCUT intersection.

Source: FHWA

Restricted Crossing U-turn (RCUT)

The RCUT intersection modifies the direct left-turn and through movements from cross-street approaches. Minor road traffic makes a right turn followed by a U-turn at a designated location – either signalized or unsignalized – to continue in the desired direction.

The RCUT is suitable for a variety of circumstances, including along rural, high-speed, four-lane, divided highways or signalized routes. It also can be used as an alternative to signalization or constructing an interchange. RCUTs work well when consistently used along a corridor, but also can be used effectively at individual intersections.

Median U-turn (MUT)

The MUT intersection modifies direct left turns from the major approaches. Vehicles proceed through the main intersection, make a U-turn a short distance downstream, followed by a right turn at the main intersection. The U-turns can also be used for modifying the cross-street left turns.

The MUT is an excellent choice for heavily traveled intersections with moderate left-turn volumes. When implemented at multiple intersections along a corridor, the efficient two-phase signal operation of the MUT can reduce delay, improve travel times, and create more crossing opportunities for pedestrians and bicyclists.



Example of MUT intersection.

Source: FHWA

SAFETY BENEFITS:



RCUT

54%

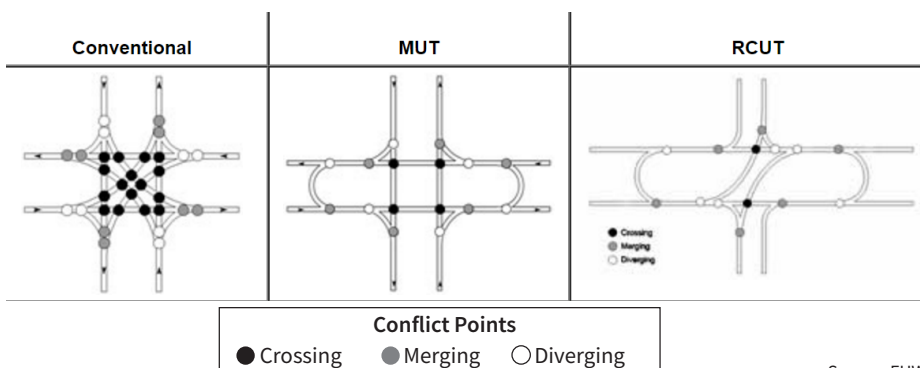
Reduction in injury and fatal crashes¹

MUT

30%

Reduction in intersection-related injury crash rate²

MUT and RCUT Can Reduce Conflict Points by 50%



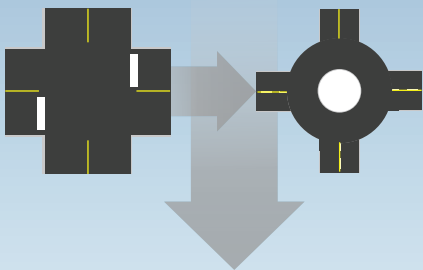
Source: FHWA

¹ Edara et al., "Evaluation of J-turn Intersection Design Performance in Missouri," December 2013.
² FHWA, *Median U-Turn Intersection Informational Guide*, FHWA-SA-14-069 (Washington, DC: 2014), pp. 41-42.

10. Roundabouts



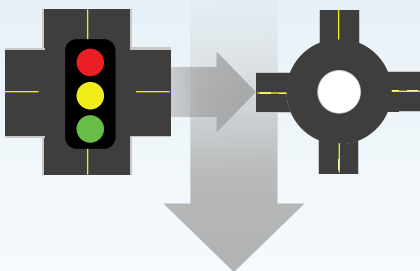
TWO-WAY STOP-CONTROLLED INTERSECTION TO A ROUNDABOUT



82%

Reduction in severe crashes

SIGNALIZED INTERSECTION TO A ROUNDABOUT



78%

Reduction in severe crashes

Source: Highway Safety Manual

The modern roundabout is a type of circular intersection configuration that safely and efficiently moves traffic through an intersection. Roundabouts feature channelized approaches and a center island that results in lower



Example of a single-lane roundabout.

Source: FHWA

speeds and fewer conflict points. At roundabouts, entering traffic yields to vehicles already circulating, leading to improved operational performance.

Roundabouts provide substantial safety and operational benefits compared to other intersection types, most notably a reduction in severe crashes.

Roundabouts can be implemented in both urban and rural areas under a wide range of traffic conditions. They can replace signals, two-way stop controls, and all-way stop controls. Roundabouts are an effective option for managing speed and transitioning traffic from high-speed to low-speed environments, such as freeway interchange ramp terminals, and rural intersections along high-speed roads.



Example of a multi-lane roundabout.

Source: FHWA

FHWA encourages agencies to consider roundabouts during new construction and reconstruction projects as well as for existing intersections that have been identified as needing safety or operational improvements.



This systemic approach to intersection safety involves deploying a group of multiple low-cost countermeasures, such as enhanced signing and pavement markings, at a large number of stop-controlled intersections within a jurisdiction. It is designed to increase driver awareness and recognition of the intersections and potential conflicts.



Example of countermeasures on the through approach.

Source: South Carolina DOT

Average Benefit-Cost Ratio

12:1

The systemic approach to safety has three components:

(1) analyze systemwide data to identify a problem, (2) look for similar risk factors present in severe crashes, and (3) deploy on a large scale low-cost countermeasures that address the risk factors contributing to crashes.

The low-cost countermeasures for stop-controlled intersections generally consist of the following treatments:

On the Through Approach

- Doubled up (left and right), oversized advance intersection warning signs, with street name sign plaques.
- Enhanced pavement markings that delineate through lane edge lines.

On the Stop Approach

- Doubled up (left and right), oversized advance “Stop Ahead” intersection warning signs.
- Doubled up (left and right), oversized Stop signs.
- Retroreflective sheeting on sign posts.
- Properly placed stop bar.
- Removal of any vegetation, parking, or obstruction that limits sight distance.
- Double arrow warning sign at stem of T-intersections.

Source: T. Le et al, “Safety Effects of Low-Cost Systemic Safety Improvements at Signalized and Stop-Controlled Intersections,” 96th Annual Meeting of the Transportation Research Board, Paper Number 17-05379, January 2017. id.trb.org/view.aspx?id=1439120

11. Systemic Application of Multiple Low-Cost Countermeasures at Stop-Controlled Intersections



Example of countermeasures on the stop approach.

Source: South Carolina DOT

SAFETY BENEFITS:

10%

Reduction in injury and fatal crashes

15%

Reduction in nighttime crashes

12. Yellow Change Intervals



SAFETY BENEFITS:

36-50%

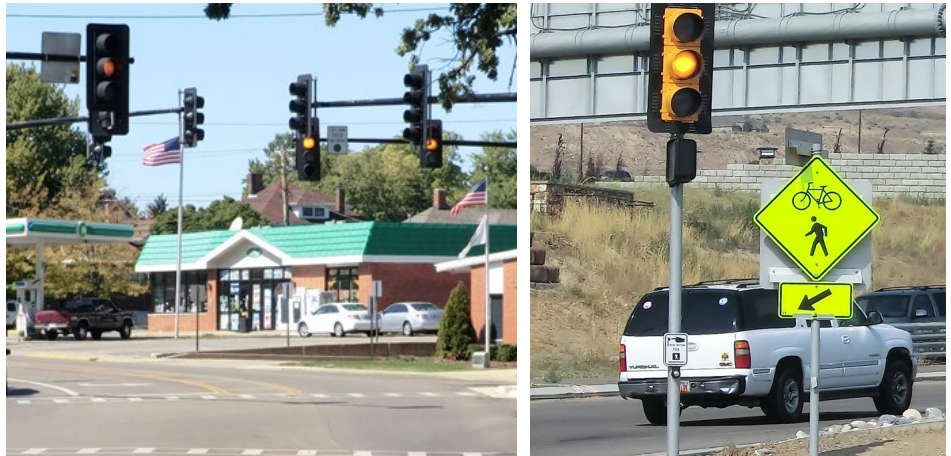
Reduction in red light running

8-14%

Reduction in total crashes

12%

Reduction in injury crashes



Properly-timed yellow change intervals can reduce red-light running and improve overall intersection safety.

Source: FHWA

At a signalized intersection, the yellow change interval is the length of time that the yellow signal indication is displayed following a green signal indication. The yellow signal confirms to motorists that the green has ended and that a red will soon follow.

Since red-light running is a leading cause of severe crashes at signalized intersections, it is imperative that the yellow change interval be appropriately timed. Too brief an interval may result in drivers being unable to stop safely and cause unintentional red-light running, while too long an interval may result in drivers treating the yellow as an extension of the green phase and invite intentional red light running. Factors such as the speed of approaching vehicles, driver perception-reaction time, vehicle deceleration rates, intersection width, and roadway approach grades should all inform the timing calculation.

Transportation agencies can improve signalized intersection safety and reduce red-light running by reviewing and updating their traffic signal timing policies and procedures concerning the yellow change interval. Agencies should institute regular evaluation and adjustment protocols for existing traffic signal timing. Refer to the *Manual on Uniform Traffic Control Devices* for basic requirements and further recommendations about yellow change interval timing.

Source: NCHRP Report 731, *Guidelines for Timing Yellow and All-Red Intervals at Signalized Intersections*.



A leading pedestrian interval (LPI) gives pedestrians the opportunity to enter an intersection 3-7 seconds before vehicles are given a green indication. With this head start, pedestrians can better establish their presence in the crosswalk before vehicles have priority to turn left.

LPIs provide the following benefits:

- Increased visibility of crossing pedestrians.
- Reduced conflicts between pedestrians and vehicles.
- Increased likelihood of motorists yielding to pedestrians.
- Enhanced safety for pedestrians who may be slower to start into the intersection.

FHWA's *Handbook for Designing Roadways for the Aging Population* recommends the use of the LPI at intersections with high turning-vehicle volumes. Transportation agencies should refer to the *Manual on Uniform Traffic Control Devices*

for guidance on LPI timing. Costs for implementing LPIs are very low, since only signal timing alteration is required. This makes it an easy and inexpensive countermeasure that can be incorporated into pedestrian safety action plans or policies and can become routine agency practice.



An LPI allows a pedestrian to establish presence in the crosswalk before vehicles are given a green indication.

Source: FHWA



Pedestrians wait for the walk signal.

Source: pedbikeimages.org / Burden

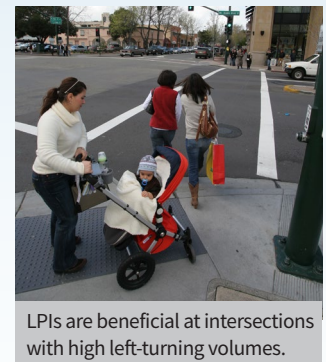
13. Leading Pedestrian Intervals



SAFETY BENEFIT:

60%

Reduction in pedestrian-vehicle crashes at intersections



LPIs are beneficial at intersections with high left-turning volumes.

Source: pedbikeimages.org / Burden

Source: Aaron C. Fayish and Frank Gross, "Safety Effectiveness of Leading Pedestrian Intervals Evaluated by a Before-After Study with Comparison Groups," *Transportation Research Record* 2198 (2010): 15-22. DOI: 10.3141/2198-03

14. Medians and Pedestrian Crossing Islands in Urban and Suburban Areas



Median and pedestrian crossing islands near a roundabout.

Source: www.pedbikeimages.org / Dan Burden

SAFETY BENEFITS:



RAISED MEDIAN

46%

Reduction in pedestrian crashes

PEDESTRIAN CROSSING ISLAND

56%

Reduction in pedestrian crashes

Source: *Desktop Reference for Crash Reduction Factors*, FHWA-SA-08-011, September 2008, Table 11.



Example of a road with a median and pedestrian crossing islands.

Source: City of Charlotte, North Carolina



Example of a pedestrian crossing island.

Source: pedbikeimages.org / Dan Burden

A **median** is the area between opposing lanes of traffic, excluding turn lanes. Medians in urban and suburban areas can be defined by pavement markings, raised medians, or islands to separate motorized and non-motorized road users.

A **pedestrian crossing island** (or refuge area) is a raised island, located between opposing traffic lanes at intersection or midblock locations, which separate crossing pedestrians from motor vehicles.

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Pedestrian crashes account for approximately 15 percent of all traffic fatalities annually, and over 75 percent of these occur at non-intersection locations.¹ For pedestrians to safely cross a roadway, they must estimate vehicle speeds, adjust their walking speed, determine gaps in traffic, and predict vehicle paths. Installing raised medians or pedestrian crossing islands can help improve safety by simplifying these tasks and allowing pedestrians to cross one direction of traffic at a time.

Transportation agencies should consider medians or pedestrian crossing islands in curbed sections of urban and suburban multi-lane roadways, particularly in areas with a significant mix of pedestrian and vehicle traffic and intermediate or high travel speeds. Some example locations that may benefit from raised medians or pedestrian crossing islands include:

- Mid-block areas.
- Approaches to multi-lane intersections.
- Areas near transit stops or other pedestrian-focused sites.

¹ National Highway Traffic Safety Administration, *Traffic Safety Facts - 2015 Data - Pedestrians*. Report DOT HS 812 375, (Washington, DC: 2017).



15. Pedestrian Hybrid Beacons

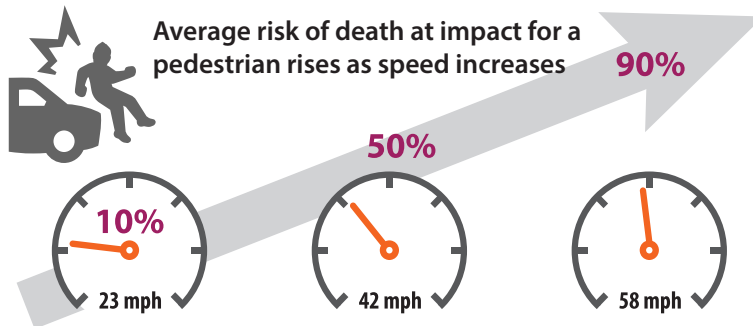
The pedestrian hybrid beacon (PHB) is a traffic control device designed to help pedestrians safely cross busy or higher-speed roadways at midblock crossings and uncontrolled intersections. The beacon head consists of two red lenses above a single yellow lens. The lenses remain “dark” until a pedestrian desiring to cross the street pushes the call button to activate the beacon. The signal then initiates a yellow to red lighting sequence consisting of steady and flashing lights that directs motorists to slow and come to a stop. The pedestrian signal then flashes a WALK display to the pedestrian. Once the pedestrian has safely crossed, the hybrid beacon again goes dark.



Example of PHBs mounted on a mast arm.

Source: FHWA

More than 75 percent of pedestrian fatalities occur at non-intersection locations, and vehicle speeds are often a major contributing factor.¹ As a safety strategy to address this pedestrian crash risk, the PHB is an intermediate option between a flashing beacon and a full pedestrian signal because it assigns right of way and provides positive stop control. It also allows motorists to proceed once the pedestrian has cleared their side of the travel lane, reducing vehicle delay.



Data from the AAA Foundation for Traffic Safety, *Impact Speed and a Pedestrian's Risk of Severe Injury or Death*, September 2011.

Transportation agencies should refer to the *Manual on Uniform Traffic Control Devices* for information on the application of PHBs. In general, PHBs are typically used when gaps in traffic are not large enough or vehicle speeds are too high for pedestrians to cross safely. PHBs are not widely implemented, so agencies should consider an education and outreach effort when implementing a PHB within a community.

¹ National Highway Traffic Safety Administration, *Traffic Safety Facts - 2015 Data - Pedestrians*. Report DOT HS 812 375, (Washington, DC: 2017).



SAFETY BENEFITS:



55%

Reduction in pedestrian crashes

29%

Reduction in total crashes

15%

Reduction in serious injury and fatal crashes



Pedestrians cross the roadway at a PHB location.

Source: City of Tuscon, Arizona

Source: Zegeer, C., R. Srinivasan, B. Lan, D. Carter, S. Smith, C. Sundstrom, N.J. Thirsk, J. Zegeer, C. Lyon, E. Ferguson, and R. Van Houten. (2017). NCHRP Report 841: Development of Crash Modification Factors for Uncontrolled Pedestrian Crossing Treatments. Transportation Research Board, Washington, D.C.

16. Road Diets

(Roadway Reconfiguration)



A “Road Diet,” or roadway reconfiguration, can improve safety, calm traffic, provide better mobility and access for all road users, and enhance overall quality of life.

SAFETY BENEFIT:



**4-LANE → 3-LANE
ROAD DIET
CONVERSIONS
19-47%
Reduction in total crashes**

Source: *Evaluation of Lane Reduction “Road Diet” Measures on Crashes*, FHWA-HRT-10-053.



Before and after photos of a Road Diet project.

Source: City of Orlando, Florida

A Road Diet typically involves converting an existing four-lane undivided roadway to a three-lane roadway consisting of two through lanes and a center two-way left-turn lane (TWLTL).

Benefits of Road Diet installations may include:

- An overall crash reduction of 19 to 47 percent.
- Reduction of rear-end and left-turn crashes due to the dedicated left-turn lane.
- Reduced right-angle crashes as side street motorists cross three versus four travel lanes.
- Fewer lanes for pedestrians to cross.
- Opportunity to install pedestrian refuge islands, bicycle lanes, on-street parking, or transit stops.
- Traffic calming and more consistent speeds.
- A more community-focused, “Complete Streets” environment that better accommodates the needs of all road users.

A Road Diet can be a low-cost safety solution when planned in conjunction with a simple pavement overlay, and the reconfiguration can be accomplished at no additional cost.



Road Diet project in Honolulu, Hawaii.

Source: Leidos



A walkway is any type of defined space or pathway for use by a person traveling by foot or using a wheelchair. These may be pedestrian walkways, shared use paths, sidewalks, or roadway shoulders.¹



Example of a sidewalk in a residential area.

Source: pedbikeimages.org / Burden

With more than 5,000 pedestrian fatalities and 70,000 pedestrian injuries occurring in roadway crashes annually, it is important for transportation agencies to improve conditions and safety for pedestrians and to integrate walkways more fully into the transportation system.²



Paved shoulder used as a walkway.

Source: pedbikeimages.org / Burden

Well-designed pedestrian walkways, shared use paths, and sidewalks improve the safety and mobility of pedestrians. In some rural or suburban areas, where these types of walkways are not feasible, roadway shoulders provide an area for pedestrians to walk next to the roadway.

Transportation agencies should work towards incorporating pedestrian facilities into all roadway projects unless exceptional circumstances exist. It is important to provide and maintain accessible walkways along both sides of the road in urban areas, particularly near school zones and transit locations, and where there is pedestrian activity. Walkable shoulders should also be considered along both sides of rural highways routinely used by pedestrians.

17. Walkways



SAFETY BENEFITS:



SIDEWALKS

65-89%

Reduction in crashes involving pedestrians walking along roadways

PAVED SHOULDERS

71%

Reduction in crashes involving pedestrians walking along roadways



Example of a shared use path.

Source: pedbikeimages.org / Burden

Source: Desktop Reference for Crash Reduction Factors, FHWA-SA-08-011, Table 11.

¹ FHWA defines a pedestrian walkway as a continuous way designated for pedestrians and separated from motor vehicle traffic by a space or barrier. By contrast, sidewalks are walkways that are paved and separated from the street, generally by a curb and gutter.

<https://safety.fhwa.dot.gov/legislationay>

² National Highway Traffic Safety Administration, *Traffic Safety Facts - 2015 Data - Pedestrians*. Report DOT HS 812 375, (Washington, DC: 2017).

18. Local Road Safety Plans



Local roads experience
3x the fatality rate
of the
Interstate Highway System.

Source: FARS and FHWA Highway Statistics Series (2014)



Safety improvements on local roads can be determined through the LRSP process.

Source: Delaware Valley Regional Planning Commission

A local road safety plan (LRSP) provides a framework for identifying, analyzing, and prioritizing roadway safety improvements on local roads. The LRSP development process and content are tailored to local issues and needs. The process results in a prioritized list of issues, risks, actions, and improvements that can be used to reduce fatalities and serious injuries on the local road network.

While local roads are less traveled than State highways, they have a much higher rate of fatal and serious injury crashes. Developing an LRSP is an effective strategy to improve local road safety for all road users and support the goals of a State's overall strategic highway safety plan.

Although the development process and resulting plan can vary depending on the local agency's needs, available resources, and targeted crash types, aspects common to LRSPs include:

- Stakeholder engagement representing the 4E's – engineering, enforcement, education, and emergency medical services, as appropriate.
- Collaboration among municipal, county, Tribal, State and/or Federal entities to leverage expertise and resources.
- Identification of target crash types and crash risk with corresponding recommended proven safety countermeasures.
- Timeline and goals for implementation and evaluation.

Local road agencies should consider developing an LRSP to be used as a tool for reducing roadway fatalities, injuries, and crashes.¹ The plan should be viewed as a living document that can be updated to reflect changing local needs and priorities.



¹ *Developing Safety Plans: A Manual for Local Rural Road Owners*, FHWA-SA-12-017, provides guidance on developing an LRSP.



19. Road Safety Audits

While most transportation agencies have established traditional safety review procedures, a road safety audit (RSA) is unique. RSAs are performed by a multi-disciplinary team independent of the project. RSAs consider all road users, account for human factors and road user capabilities, are documented in a formal report, and require a formal response from the road owner. (See the eight steps for conducting an RSA below.)



Multi-disciplinary team performs field review during an RSA.

Source: FHWA

RSAs provide the following benefits:

- Reduced number and severity of crashes due to safer designs.
- Reduced costs resulting from early identification and mitigation of safety issues before projects are built.
- Improved awareness of safe design practices.
- Increased opportunities to integrate multimodal safety strategies and proven safety countermeasures.
- Expanded ability to consider human factors in all facets of design.

RSAs can be performed in any phase of project development, from planning through construction. RSAs can also be conducted on any size project, from minor intersection and roadway retrofits to large-scale construction projects. Agencies are encouraged to conduct an RSA at the earliest stage possible, as all roadway design options and alternatives are being explored.



A road safety audit is a proactive, formal safety performance examination of an existing or future road or intersection by an independent and multi-disciplinary team.

SAFETY BENEFIT:

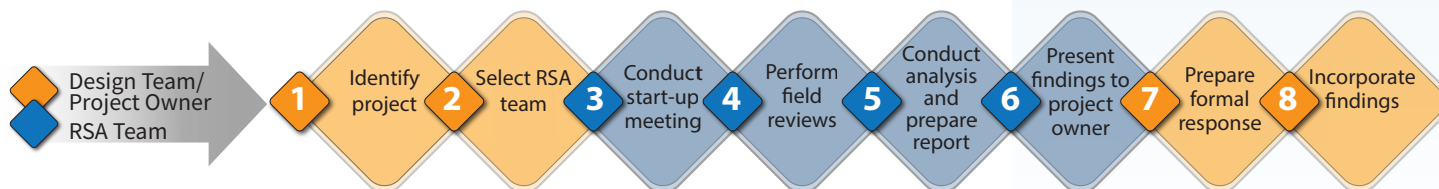


10-60%

Reduction in total crashes

Source: *Road Safety Audits: An Evaluation of RSA Programs and Projects*, FHWA-SA-12-037; and *FHWA Road Safety Audit Guidelines*, FHWA-SA-06-06.

CONDUCTING AN RSA



20. USLIMITS2



USLIMITS2 helps practitioners assess and establish safe, reasonable, and consistent speed limits



USLIMITS2 helps support speed limit decisions.

Source: Richard Retting

“USLIMITS2 acts as an external, impartial, second set of eyes.”

Georgia DOT Traffic Engineer

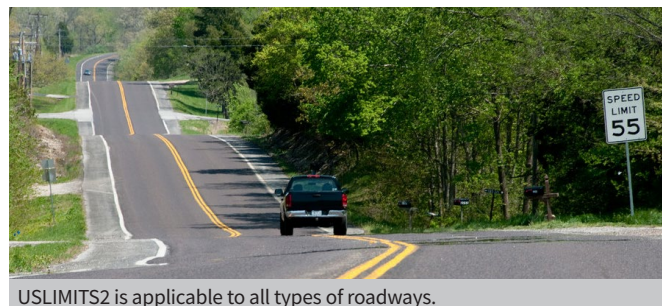
USLIMITS2¹ is a free, web-based tool designed to help practitioners assess and establish safe, reasonable, and consistent speed limits for specific segments of roadway.

It is applicable to all types of facilities, from rural and local roads and residential streets to urban freeways.

USLIMITS2 supports customary engineering studies² used to determine appropriate speed limits. These studies typically include evaluating criteria such as 85th percentile speed, traffic volumes, roadway type, roadway setting, number of access points, crash history, pedestrian/bicyclist activity, etc. Similarly, USLIMITS2 produces an unbiased and objective suggested speed limit value based on 50th and 85th percentile speeds, traffic volume, roadway characteristics, and crash data.

Traffic engineers often communicate with the public, community leaders, and government officials to explain the methodology behind setting speed limits. USLIMITS2 provides an objective second opinion and helps support these speed limit decisions. USLIMITS2 augments the credibility of engineering speed studies, helping to address concerns from local government officials and private citizens when speed limits are adjusted.

To begin using USLIMITS2, users create a new project or upload an existing project file for revisions or updates through the online tool. The website contains the user guide, information on the tool's decision logic and related research, and frequently asked questions.



USLIMITS2 is applicable to all types of roadways.

Source: Missouri DOT

USLIMITS Speed Zoning Report	
Project name: 44 speed	Date: 08-14-2017
Analyst: John Doe	Crash Data Information:
Basic Project Information	Crash Data Years: 0
Project Number: Project 1	Crash AADT: N/A
Route Name: US 44	Total Number of Crashes: N/A
From: Street A	Total Number of Injury Crashes: N/A
To: Street B	Traffic Information
State: Alabama	85th Percentile Speed: 55 mph
County: Baldwin County	50th Percentile Speed: 45 mph
City: Daphne City	AADT: 5000 veh/day
Route Type: Road Section in Undeveloped Area	
Route Status: Existing	
Roadway Information	
Section length: 2 mile(s)	
Statutory Speed Limit: 55 mph	
Adverse Alignment: Yes	

Users can save their USLIMITS2 project files for future analysis or reviews.

1 USLIMITS2 is available free online at <https://safety.fhwa.dot.gov/uslimits/>.

2 For more information on setting speed limits based on engineering studies, refer to the *Manual on Uniform Traffic Control Devices*.





[https://safety.fhwa.dot.gov/provencountermeasures.](https://safety.fhwa.dot.gov/provencountermeasures)



U.S. Department of Transportation

FHWA-SA-18-029

Safe Roads for a Safer Future
Investment in roadway safety saves lives
<http://safety.fhwa.dot.gov>