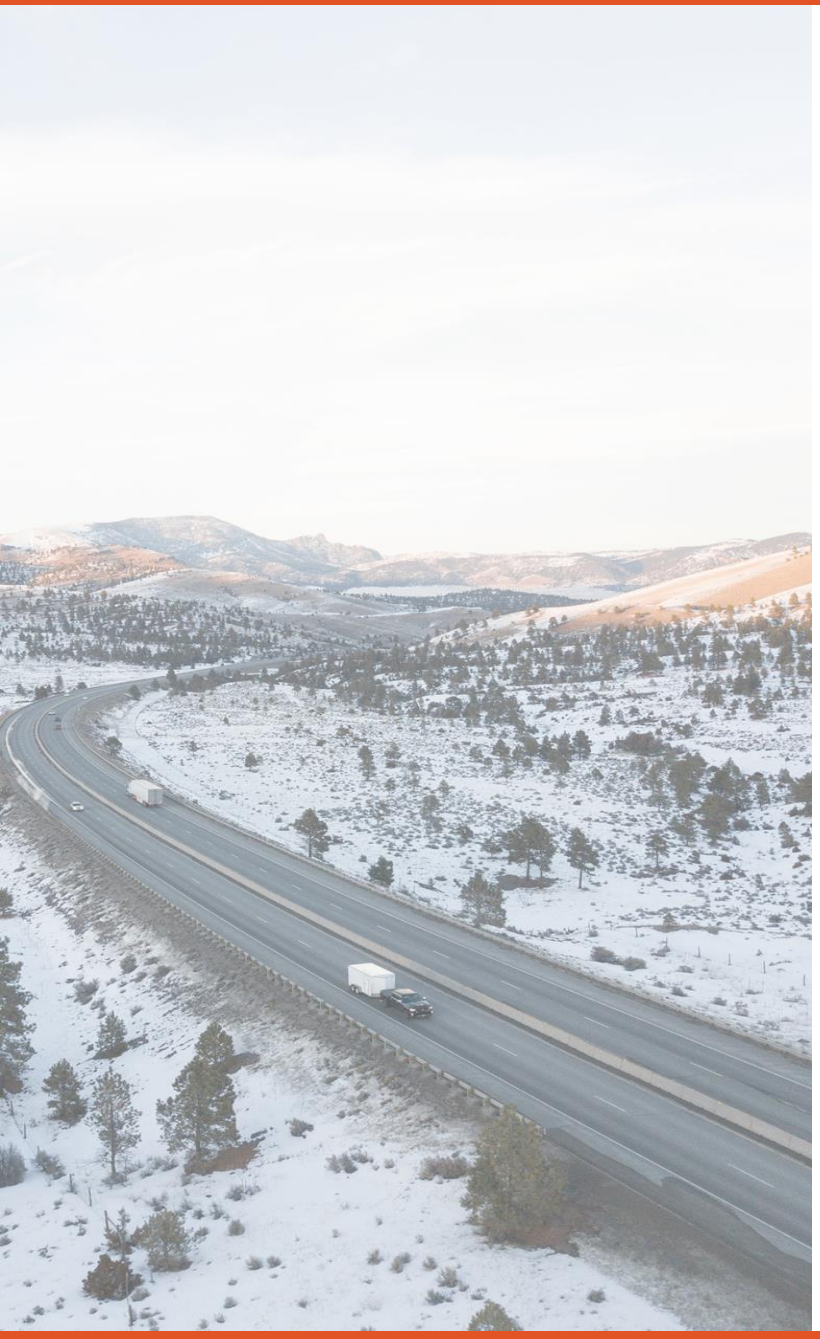

Safer Roads

Implementing Safety Countermeasures

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2024 Annual Transportation Safety Meeting

October 17, 2024

VISION ZERO

Proven Safety Countermeasure Focus Areas

- Roadway Departure
  - 6 Countermeasures
- Intersections
  - 7 Countermeasures
- Pedestrian/Bicyclist
  - 8 Countermeasures
- Speed Management
  - 3 Countermeasures
- Crosscutting
  - 4 Countermeasures

Roadway Departure

Enhanced Delineation for Horizontal Curves

Longitudinal Rumble Strips and Stripes on Two-Lane Roads

Median Barriers

Roadside Design Improvements at Curves

SafetyEdge℠

Wider Edge Lines

Roadway Departure: Enhanced Delineation for Horizontal Curves

Potential strategies that can be implemented in advance of or within curves, in combination, or individually.

Potential Strategies	In advance of curve	Within curve
Pavement markings (standard width or wider)	X	X
In-lane curve warning pavement markings	X	
Retroreflective strips on sign posts	X	X
Delineators		X
Chevron signs		X
Enhanced Conspicuity (larger, fluorescent, and/or retroreflective signs)	X	X
Dynamic curve warning signs (including speed radar feedback signs)	X	
Sequential dynamic chevrons		X

Sequential Dynamic Chevrons

60% reduction in fatal and injury crashes[3]

In-Lane Curve Warning Pavement Markings

35-38% reduction in all crashes.[4-5]

New Fluorescent Curve Signs or Upgrade Existing Curve Signs to Fluorescent Sheeting

18% reduction in non-intersection, head-on, run-off-road, and sideswipe in rural areas.[1]

Roadway Departure:
Enhanced Delineation for Horizontal Curves

MT-41, North of Dillion

Roadway Departure: Longitudinal Rumble Strips and Stripes on Two-Lane Roads

- Considerations
  - Cost?
    - Rumble strips are relatively low-cost
  - Noise concerns?
    - “Mumble Strips”*
  - Maintenance?
    - Typically, no issues when placed on pavement joints, if the pavement is in good condition
    - Studies have shown no evidence of issues related to snow, ice, or rain build-up

Safety Benefits:

Center Line Rumble Strips

44-64%

reduction in head-on fatal and injury crashes on two-lane rural roads.[4]

Shoulder Rumble Strips

13-51%

reduction in single vehicle, run-off-road fatal and injury crashes on two-lane rural roads.[4]

Roadway Departure: Median Barriers

- Types
  - Cable Barriers
  - Metal-Beam Guardrail
  - Concrete Barriers

Safety Benefits:

8%

of all fatalities on divided highways are due to head-on crashes.[1]

Median Barriers Installed on Rural Four-Lane Freeways

97%

reduction in cross-median crashes.[2]

Roadway Departure: Median Barriers

I-15, Helena

Roadway Departure: Roadside Design Improvements at Curves

- Provide for a Safe Recovery
  - Clear Zones
  - Slope Flattening
  - Adding or Widening Shoulders
- Reduce Crash Severity
  - Cable Barrier
  - Metal-Beam Guardrail
  - Concrete Barrier

Increase the distance to roadside features from 3.3 ft to 16.7 ft:

22%

reduction for all crashes.[3]

Increase the distance to roadside features from 16.7 ft to 30 ft:

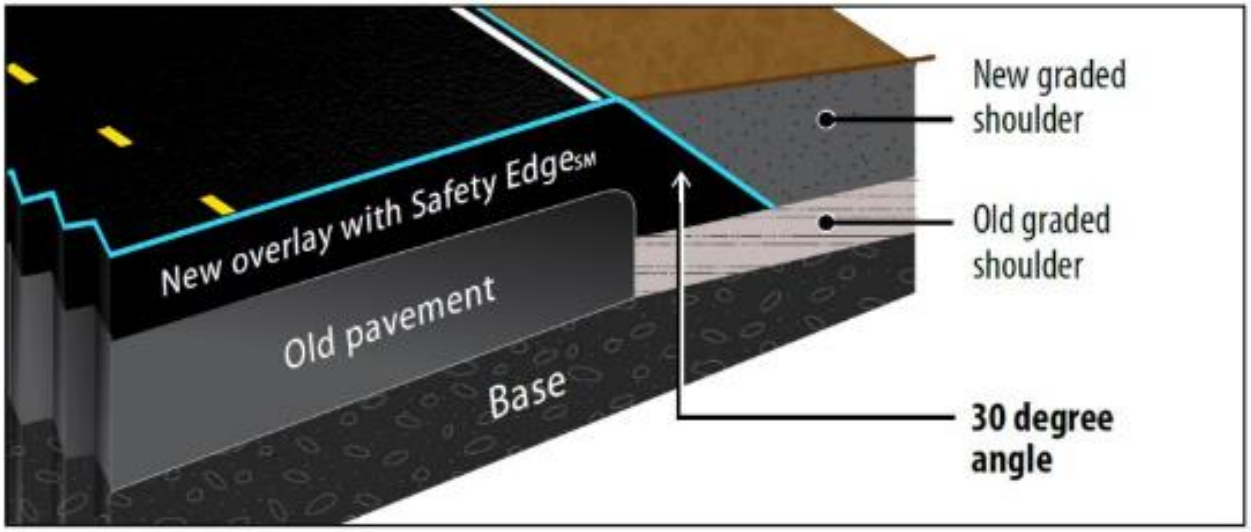
44%

reduction for all crashes.[3]

Roadway Departure:
Roadside Design Improvements at Curves

Roadway Departure: SafetyEdge[SM]

- Shapes the edge of the pavement at ~30˚
- Eliminated vertical drop-off
- Can improve pavement durability



Cross-section view of an overlay with the SafetyEdge[SM].

Source: FHWA-SA-17-044

Safety Benefits:

11%

reduction in fatal and injury crashes.[2]

21%

reduction in run-off road crashes.[2]

19%

reduction in head-on crashes.[2]

Benefit-Cost Ratio Range[3]

700:1 to 1,500:1

Roadway Departure: Wider Edge Lines

- 4-inch to 6-inch width
- Considerations
  - Relatively low cost
  - Can be implemented with existing maintenance equipment
  - As automated vehicle usage increases, wider edge lines can help with vehicles' sensors

Safety Benefits:

Wider edge lines can reduce crashes up to:

37%

for non-intersection, fatal and injury crashes on rural, two-lane roads.[2]

22%

for fatal and injury crashes on rural freeways.[3]

Benefit-Cost Ratio

25:1

for fatal and serious injury crashes on two-lane rural roads.[4]

Intersections

Backplates with Retroreflective Borders

Corridor Access Management

Dedicated Left- and Right-Turn Lanes at Intersections

Reduced Left-Turn Conflict Intersections

Roundabouts

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

Yellow Change Intervals

Intersections: Backplates with Retroreflective Borders

- Backplates improve visibility of signal heads
- Considerations
  - Low-cost safety treatment
  - Structural limitations due to added wind load

Safety Benefits:

15%

reduction in total crashes.[1]

Signal backplate framed with a retroreflective border.

Source: FHWA

Intersections: Corridor Access Management

- Strategies
  - Reduce driveway density
  - Manage spacing of intersections and access points
  - Limit allowable movements (Ex. Right-In, Right-Out)
  - Install raised median
  - Utilize alternative intersection designs
  - Provide turn lanes

Safety Benefits:

Reducing driveway density

5-23%

reduction in total crashes along 2-lane rural roads.[3]

25-31%

reduction in fatal and injury crashes along urban/suburban arterials.[4]

Intersections: Dedicated Left- and Right-Turn Lanes at Intersections

- Benefits
  - Physical separation for turning traffic
  - Deceleration prior to a turn
  - Storage for vehicles

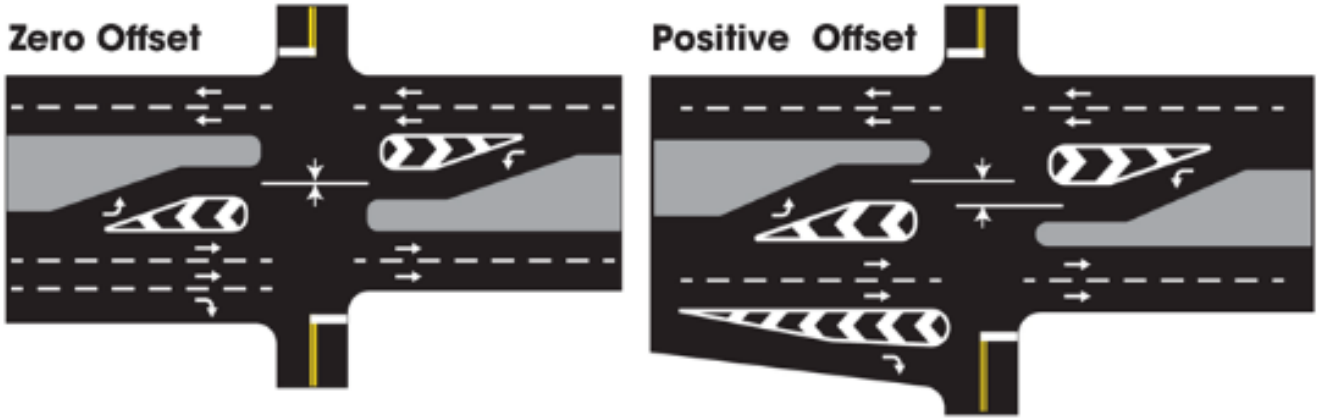


Illustration comparing zero offset to positive offset of left- and right-turn lanes. Source: FHWA

Safety Benefits:

Left-Turn Lane

28-48%

reduction in total crashes.[1]

Positive Offset Left-Turn Lanes

36%

reduction in fatal and injury crashes.[2]

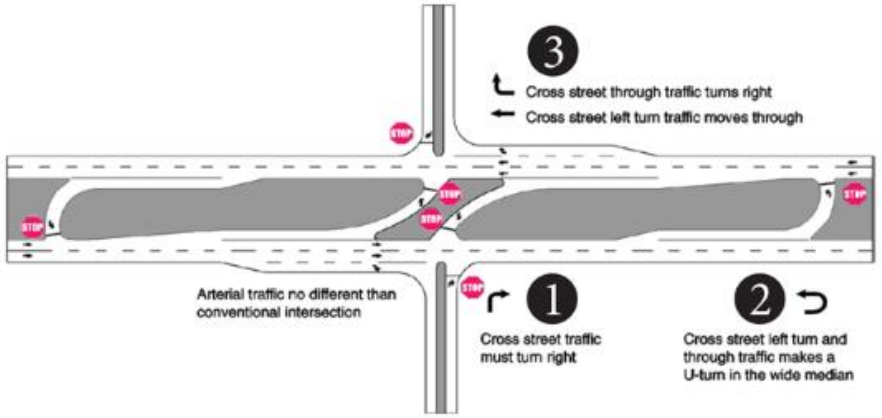
Right-Turn Lanes

14-26%

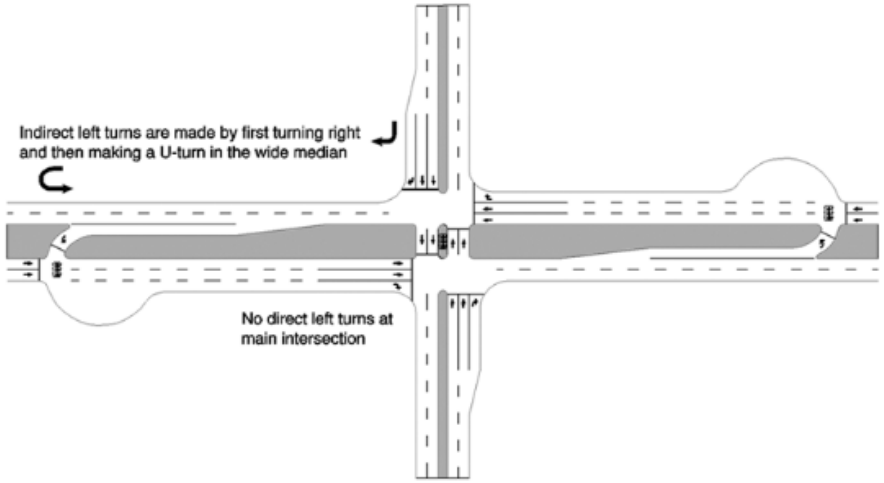
reduction in total crashes.[1]

Intersections:
Reduced Left-Turn Conflict Intersections

- Restricted Crossing U-Turn (RCUT)
  - AKA J-Turn, Superstreet, or Reduced Conflict Intersection
- Median U-Turn (MUT)



Example of an unsignalized RCUT intersection. Source: FHWA



Example of a MUT intersection. Source: FHWA

Safety Benefits:

Unsignalized Intersection to Unsignalized RCUT:

63%

reduction in fatal and injury crashes.[4]

MUT

30%

reduction in intersection-related injury crash rate.[5]

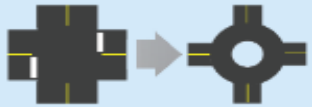
Intersections: Roundabouts

Example of a single-lane roundabout. Source: FHWA

Illustration of a multi-lane roundabout. Source: FHWA

Safety Benefits:

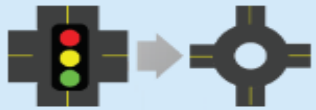
Two-Way Stop-Controlled Intersection to a Roundabout



82%

Reduction in fatal and injury crashes[1]

Signalized Intersection to a Roundabout



78%

Reduction in fatal and injury crashes[1]

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

- Through Approach Treatments
  - Double-up, oversized advance intersections warning signs
    - Optional – Supplemental street name plaques or flashing beacons
  - Retroreflective sheeting on signposts
  - Enhanced pavement markings
- Stop Approach Treatments
  - Double-up, oversized advance “Stop Ahead” intersection warning signs
    - Optional – Flashing Beacons
  - Double-up, oversized stop signs
  - Retroreflective sheeting on signposts
  - Properly placed stop bar
  - Double arrow warning sign for T-intersections

Safety Benefits:

10%

reduction of fatal and injury crashes at all locations/types/areas.

15%

reduction of nighttime crashes at all locations/types/areas.

27%

reduction of fatal and injury crashes at rural intersections.

19%

reduction of fatal and injury crashes at 2-lane by 2-lane intersections.

Average Cost-Benefit Ratio

12:1

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

Intersections: Yellow Change Intervals

- Adjusting the length of time for a yellow signal indication
- Reduces red light running

Safety Benefits:

36-50%

reduction in red-light running.[3]

8-14%

reduction in total crashes.[3]

12%

reduction in injury crashes.[3]

Pedestrian/Bicyclist

Bicycle Lanes

Crosswalk Visibility Enhancements

Leading Pedestrian Interval

Medians and Pedestrian Refuge Islands in Urban and Suburban Areas

Pedestrian Hybrid Beacons

Rectangular Rapid Flashing Beacons (RRFB)

Road Diets (Roadway Reconfiguration)

Walkways

Pedestrian/Bicyclist: Bicycle Lanes

Considerations

- Design will vary with roadway characteristics, user needs, and land-use
- Bike lane widths and existing policies/standards
- Increase ridership and manage roadway capacity
- Rumble strips in rural areas

Safety Benefits:

Bicycle Lane Additions can reduce crashes up to:

49%

for total crashes on urban 4-lane undivided collectors and local roads.[7]

30%

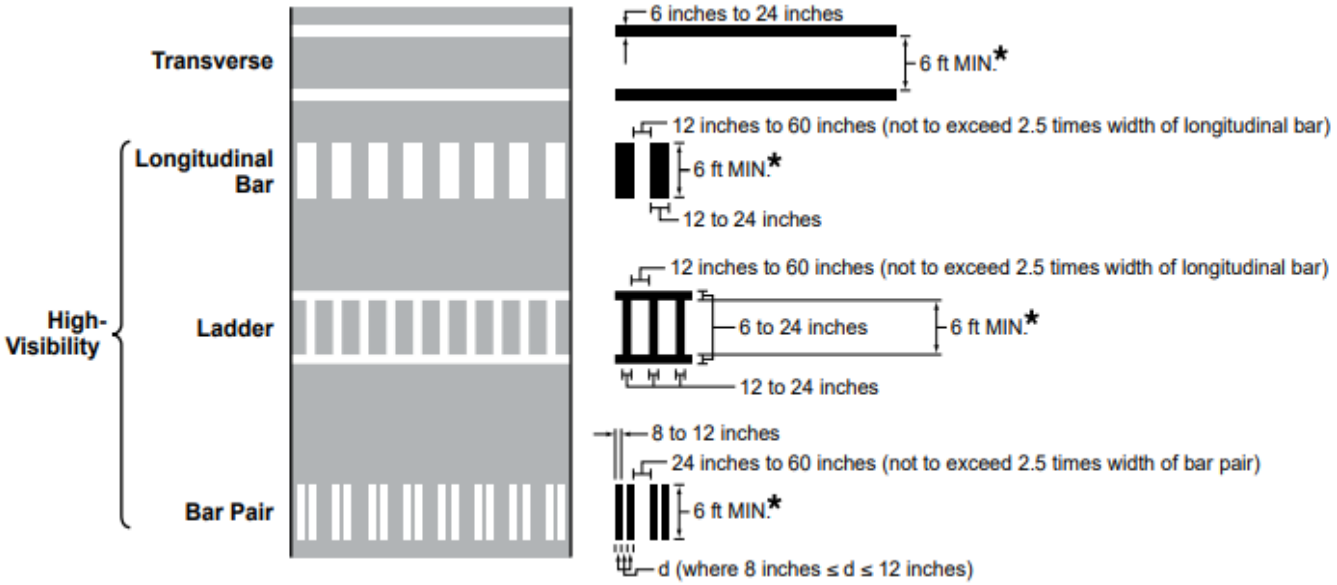
for total crashes on urban 2-lane undivided collectors and local roads.[7]

Pedestrian/Bicyclist: Crosswalk Visibility Enhancements

Treatments

- High-visibility crosswalks
  - Bar pairs, continental, ladder, etc. patterns
- Improved lighting
- Enhanced signing and pavement markings

Figure 3C-1. Crosswalk Markings



* Minimum crosswalk width shall be 8 feet where the posted speed limit is 40 mph or greater at a non-intersection crosswalk.

Source: MUTCD 11th Edition

Safety Benefits:

High-visibility crosswalks can reduce pedestrian injury crashes up to[1]

40%

Intersection lighting can reduce pedestrian crashes up to[2]

42%

Advance yield or stop markings and signs can reduce pedestrian crashes up to[3]

25%

Pedestrian/Bicyclist: Leading Pedestrian Interval

Benefits

- Increased visibility of crossing pedestrians
- Reduced conflicts between pedestrians and vehicles
- Increases likelihood of vehicles yielding
- Enhanced safety for pedestrians that are mobility-assisted

Safety Benefits:

13%

reduction in pedestrian-vehicle crashes at intersections.[2]

Pedestrian/Bicyclist: Medians and Pedestrian Refuge Islands in Urban and Suburban Areas

Median and pedestrian refuge island near a roundabout.
Source: www.pedbikeimages.org / Dan Burden

Example of a road with a median and pedestrian refuge islands.
Source: City of Charlotte, NC

Safety Benefits:

Median with Marked Crosswalk

46%

reduction in pedestrian crashes.[2]

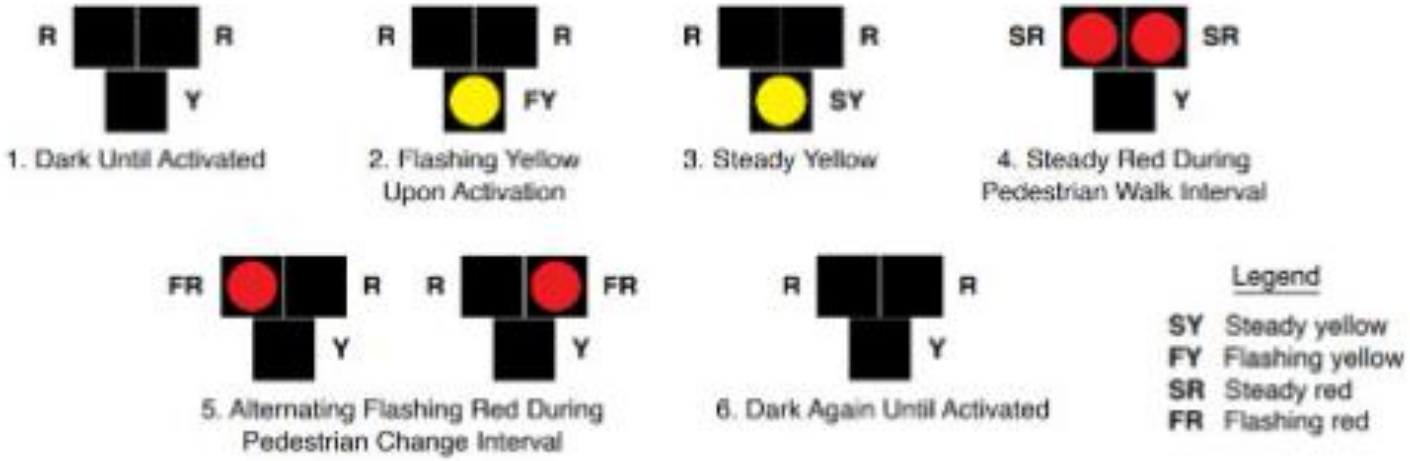
Pedestrian Refuge Island

56%

reduction in pedestrian crashes.[2]

Pedestrian/Bicyclist: Pedestrian Hybrid Beacons

Designed for crossing higher-speed roadways either at midblock crossings or uncontrolled intersections



Sequence for a PHB. Source: MUTCD 2023 Edition, Chapter 4J, FHWA

Safety Benefits:

55%

reduction in pedestrian crashes.[3]

29%

reduction in total crashes.[4]

15%

reduction in serious injury and fatal crashes.[4]

Pedestrian/Bicyclist:
Rectangular Rapid Flashing Beacons (RRFB)

Designed for crossing lower speed (<40 MPH) roadways either at midblock crossings or uncontrolled intersections

Intersection of 11th Ave. and N Sanders St., Helena. Source: Google Maps

Safety Benefits:

RRFBs can reduce crashes up to:

47%

for pedestrian crashes.[4]

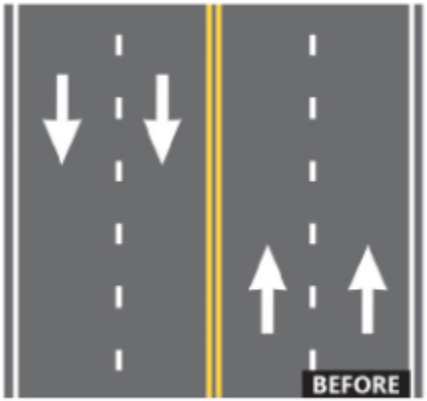
RRFBs can increase motorist yielding rates up to:

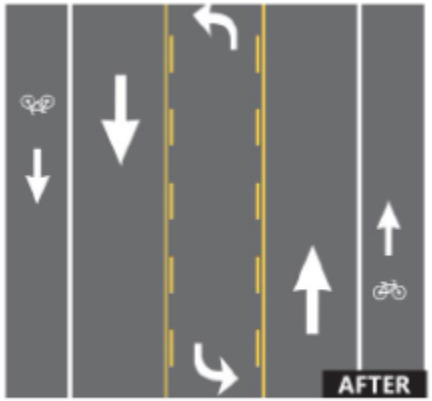
98%

varies by speed limit, number f lanes, crossing distance, and time of day).[3]

Pedestrian/Bicyclist: Road Diets (Roadway Reconfiguration)

- Benefits
  - Reductions of rear-end and left-turn crashes due to dedicated left-turn lanes
  - Reduced right-angle crashes
  - Fewer lanes for pedestrians to cross
  - Opportunities to install pedestrian refuge islands, bicycle lanes, on-street parking, or transit stops
  - Traffic calming and more consistent speeds





Before and after example of a Road Diet. Source: FHWA

Safety Benefits:

4-Lane to 3-Lane, Road Diet Conversions

19-47%

reduction in total crashes.[1]

Pedestrian/Bicyclist: Walkways

Types of walkways

- Shared-use paths
- Sidewalks
- Roadway shoulders

Safety Benefits:

Sidewalks

65-89%

reduction in crashes involving pedestrians walking along roadways.[3]

Paved Shoulders

71%

reduction in crashes involving pedestrians walking along roadways.[3]

Speed Management

Appropriate Speed Limits for All Road Users

Speed Safety Cameras

Variable Speed Limits

Speed Management: Appropriate Speed Limits for All Road Users

- Tools
  - USLIMITS2
  - NCHRP 966: Posted Speed Limit Setting Procedure and Tool
  - Safe System Approach
- Montana
  - MCA 61-8-303, 61-8-309, 61-8-310, and 61-8-312
  - Speed limits changes are set by the Transportation Commission or a local agency

Speed Management: Speed Safety Cameras

- Types
  - Fixed Units
  - Point-to-Point (P2P) Units
  - Mobile Units
- Not used in Montana
  - MCA 61-8-203
- MDT performs Speed Studies that are then passed onto the Transportation Commission to determine changing speed limits
  - MCA 61-8-303, 61-8-309, and 61-8-310

P2P units can reduce crashes on urban expressways, freeways, and principal arterials up to:

37%

for fatal and injury crashes.[2]

Mobile units can reduce crashes on urban principal arterials up to:

20%

for fatal and injury crashes.[5]

Speed Management: Variable Speed Limits

- Applications
  - Congestion
  - Incidents/Crashes
  - Work Zones
  - Inclement Weather
- Considerations
  - Effective on urban and rural high-speed roadways (> 40 MPH)
  - Implemented into Active Traffic Management plans or into existing Road Weather Information Systems
  - Can be applied to entire roadway or individual lanes

Safety Benefits:

VSLs can reduce crashes on freeways up to:[1]

34%

for total crashes.

65%

for rear-end crashes.

51%

for fatal and injury crashes.

Benefit/Cost Ratios range between[1]

9:1 - 40:1

Crosscutting

Lighting

Local Road Safety Plans

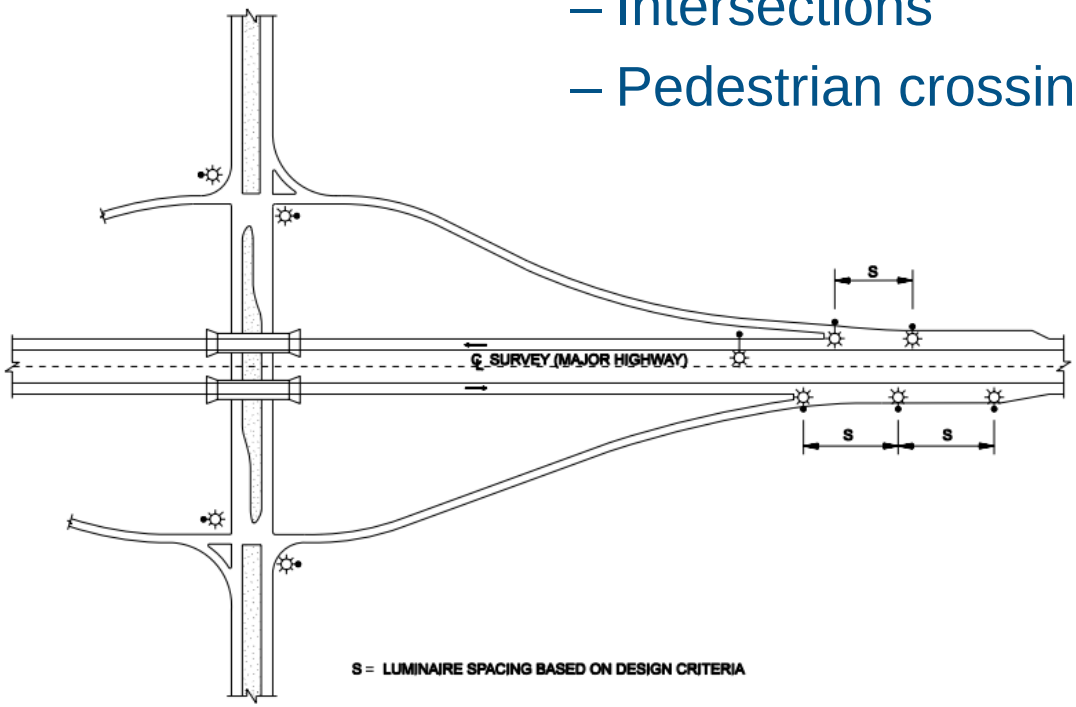
Pavement Friction Management

Road Safety Audit

Crosscutting: Lighting

Applications

- Roadway segments
- Intersections
- Pedestrian crossings



PARTIAL INTERCHANGE LIGHTING
Figure 13.6J

Source: MDT Traffic Engineering Manual

Safety Benefits:

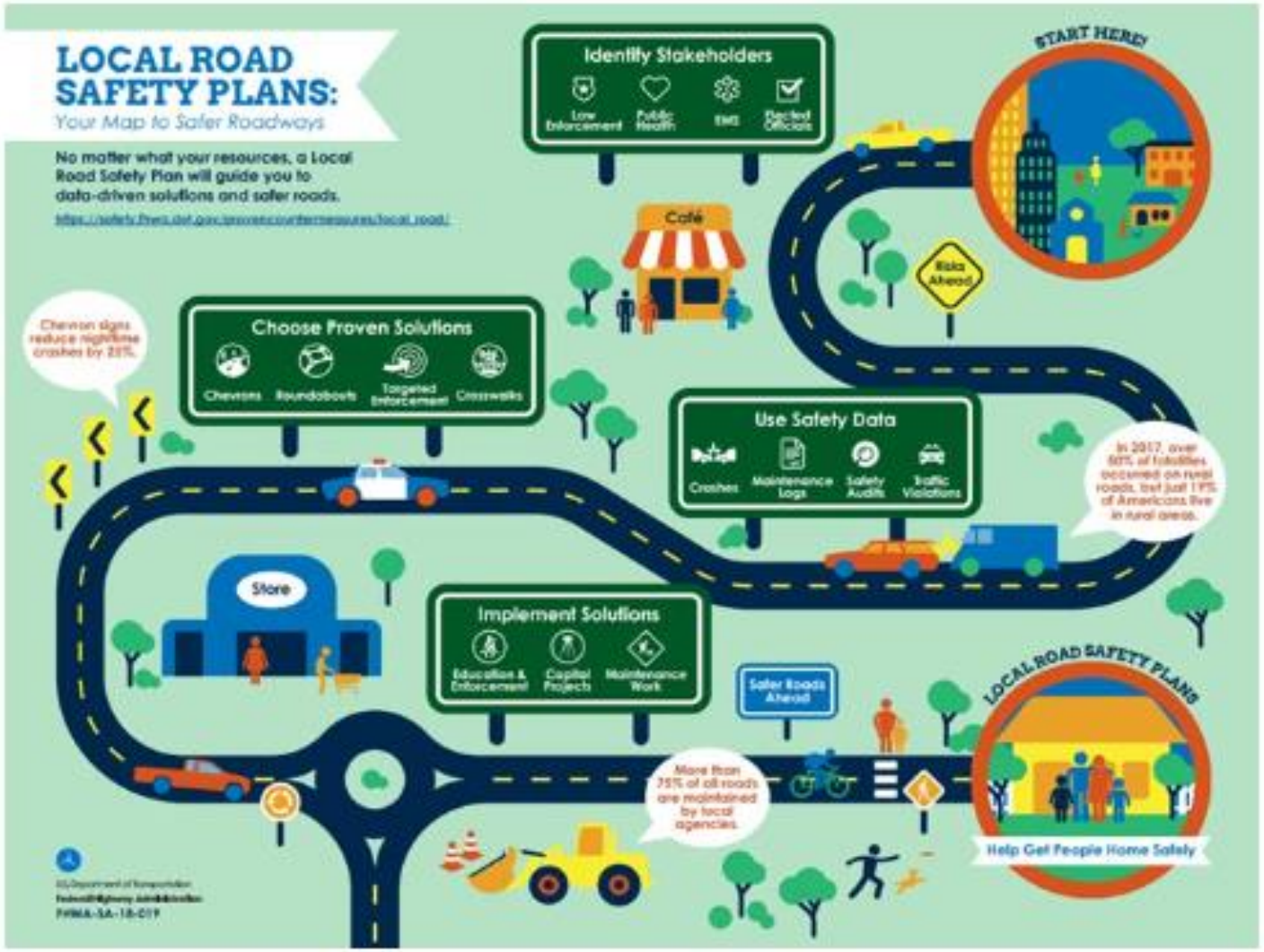
Lighting can reduce crashes up to:

42%
for nighttime injury pedestrian crashes at intersections.[1]

33-38%
for nighttime crashes at rural and urban intersections.[2,1]

28%
for nighttime injury crashes on rural and urban highways.[1]

Crosscutting: Local Road Safety Plans



Infographic showing the LRSP process. Source: FHWA

Safety Benefits:

Agencies have experienced the following benefits after LRSP implementation:

25%

reduction in county road fatalities in Minnesota.

17%

reduction in fatal and serious injury crashes on county-owned roads in Washington State.

35%

reduction in severe curve crashes in Thurston County, WA.

Crosscutting: Pavement Friction Management

- Applications
  - Horizontal curves
  - Interchange ramps
  - Intersection approaches
    - Higher-speed signalized and stop-controlled intersections
    - Steep downward grades
  - Locations with a crash history of rear-end, failure to yield, wet-weather, or red-light running crashes
  - Crosswalk approaches
- Considerations
  - Applied to existing pavement
  - If poor pavement quality, the life cycle will be shortened

Safety Benefits:

HFST can reduce crashes up to:

63%

for injury crashes at ramps.[2]

48%

for injury crashes at horizontal curves.[2]

20%

for total crashes at intersections.[3]

Crosscutting: Road Safety Audit

- Benefits
  - Reduced number of severity crashes
  - Reduced costs from early identification and mitigation of safety issues before projects are built
  - Increased opportunities to integrate multimodal safety strategies and proven safety countermeasures
  - Ability to consider human factors throughout design
  - Increased communication and collaboration among stakeholders

Source: FHWA

Sources

- FHWA's Office of Safety
  - https://highways.dot.gov/safety
- FHWA's Proven Safety Countermeasures
  - https://highways.dot.gov/safety/proven-safety-countermeasures
- FHWA's Crash Modification Factors (CMF) Clearinghouse
  - https://cmfclearinghouse.fhwa.dot.gov
- FHWA's Evaluation of Low-Cost Safety Improvements Pooled Fund Study (ELCSI-PFS)
  - https://highways.dot.gov/research/safety/evaluations-low-cost-safety-improvements-pooled-fund-study/studies-elcsi-pfs
  - https://highways.dot.gov/research/safety/evaluations-low-cost-safety-improvements-pooled-fund-study/publications

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