FoRRRwd for NTICC 2024
29 August 2024

ZERO IS OUR GOAL
A SAFE SYSTEM IS HOW WE GET THERE

U.S. Department of Transportation
Federal Highway Administration

Focus on Reducing Rural Roadway Departures

NTICC Annual Meeting
August 29, 2024

FoRRRwD
Focus on Reducing Rural Roadway Departures

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Presenter

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Learning Objectives

By the end of this session, you should be able to:

- Describe the four pillars of the FHWA Focus on Reducing Rural Roadway Departure Crashes initiative (FoRRRwD).
- Identify technical resources for addressing roadway departure.
- Find funding opportunities for implementing roadway departure countermeasures.
- Take away strategies to apply in Tribal communities to address roadway departure crashes.

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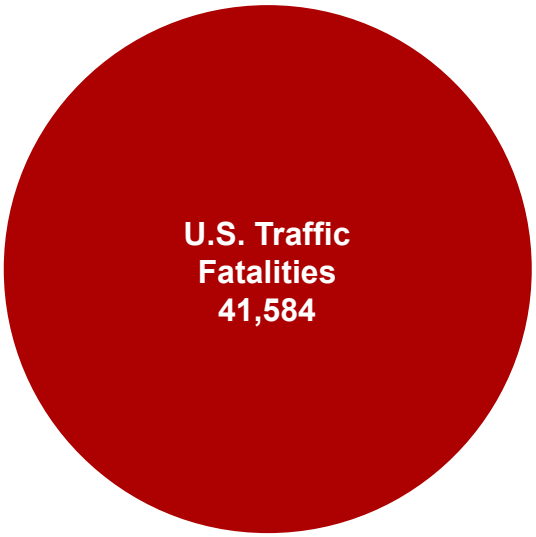
The Rural RwD Component of Traffic Fatalities



Source: NHTSA FARS (2018 – 2020 Annual Average)

FHWA Roadway Departure (RwD) Definition:
A crash in which a vehicle crosses an edge line, a center line, or otherwise leaves the traveled way.

Source: Oregon State Police

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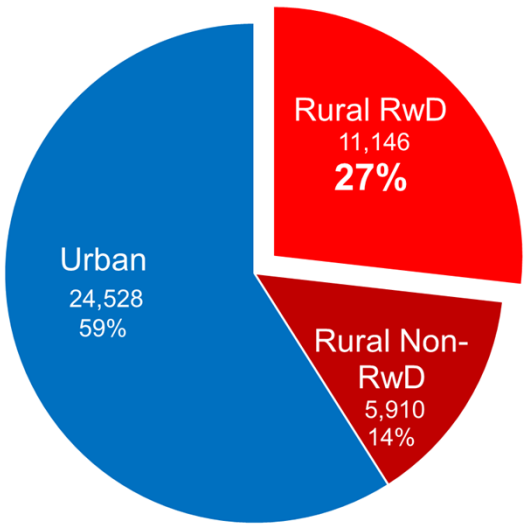
The Rural RwD Component of Traffic Fatalities



Source: NHTSA FARS (2020 – 2022 Annual Average)

FHWA Roadway Departure (RwD) Definition:
A crash in which a vehicle crosses an edge line, a center line, or otherwise leaves the traveled way.

Source: Oregon State Police

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Why do drivers leave the roadway?

- Roadway Condition
- Vehicle Component Failure
- Collision Avoidance
- Driver Error

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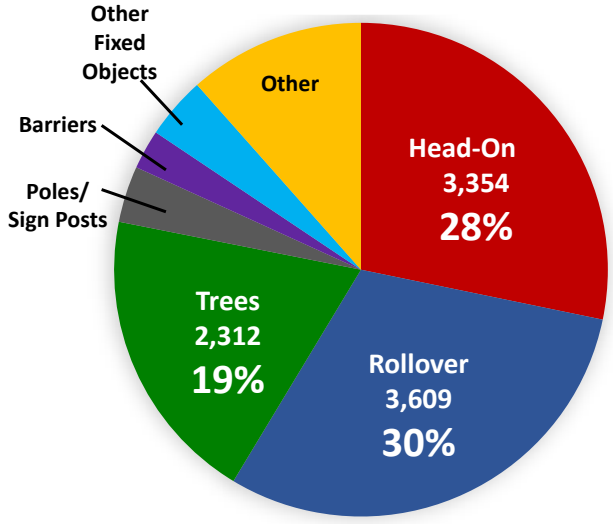
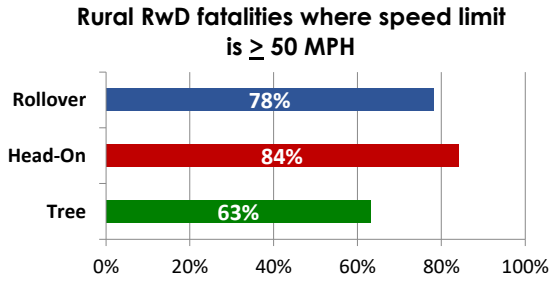
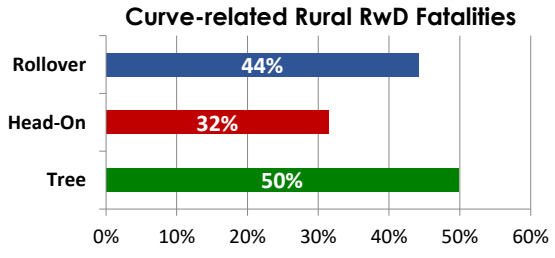
Rural Roadway Departure Fatalities by Most Harmful Event



Source: NHTSA Fars (2014-2016 Annual Average of Rural RwDs by MHE)





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The Safe System Approach

- Death/serious injury is unacceptable
- Responsibility is shared
- Humans make mistakes
- Safety is proactive
- Humans are vulnerable
- Redundancy is crucial

https://highways.dot.gov/safety/zero-deaths

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Focus on Reducing Rural Roadway Departures (FoRRRwD)

Mission - Reduce the potential for serious injury and fatal roadway departure crashes on all public rural roads by increasing the systemic deployment of proven countermeasures.

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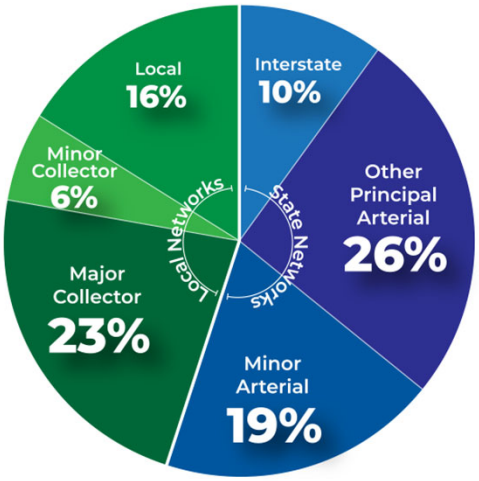
Why All Public Roads?



Roads typically maintained by states = 50% of Rural RwD fatalities

Roads typically maintained by locals = 50% of Rural RwD fatalities

Roadway departures represent 63% of all reported motor vehicle fatalities in Tribal areas

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Source: NHTSA FARS (2014-2016 Annual Average of Rural Roadway Departures by Roadway Classification) and https://irp-cdn.multiscreensite.com/7e0c8ed5/files/uploaded/TRIBAL-TRANSPORTATION-SAFETY-PLAN-web.pdf

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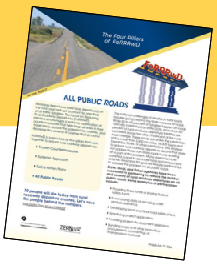
All Public Roads Example

Figure 5. Mohave Road Study Area between the towns of Parker and Ehrenberg. Source: FHWA.

Death/serious injury is unacceptable

Responsibility is shared



Transferring Funds to Improve Safety on Tribal Roads

- Arizona DOT makes HSIP funding available to all agencies that own and maintain roadways.
  - HSIP funds are transferred to the Tribal Transportation Program
  - BIA and FHWA are responsible for administering the funds
- Colorado River Indian Tribe used HSIP funds to address RwD crashes on Mohave Road by installing center lines, edge lines, rumble strips and more.

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https://safety.fhwa.dot.gov/FoRRRwD/AllPublicRoads4-pager.pdf

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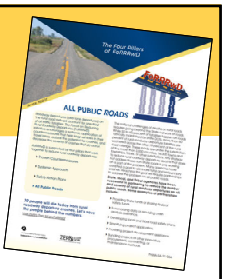
All Public Roads Example



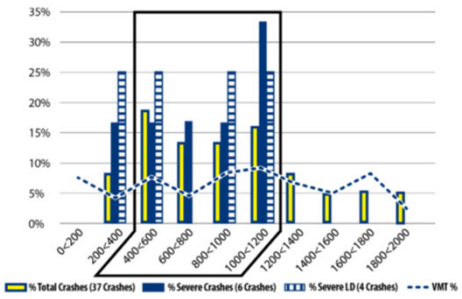


Figure 3. An example from the Cass County LRSP shows crash overrepresentation based on curve radius. Source:NDDOT.

Death/serious injury is unacceptable

Safety is proactive

FoRRRwD Thinking in North Dakota

- **North Dakota DOT realized they could not achieve zero fatalities if they did not include and address the local and Tribal road systems.**
  - **Started program to help agencies develop LRSPs**
  - **Funded program through HSIP**
- **Crash records indicated that serious injury crashes involving curves were reduced by 21 percent and lane departures were reduced by 14 percent.**

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https://safety.fhwa.dot.gov/FoRRRwD/AllPublicRoads4-pager.pdf

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Systemic Approach

- Locations identified based on risk, not solely on crash history
- Deployed on a small portion of the system with multiple risk factors
- Proactive approach
- Supplements traditional site analysis

23 USC 148 (a)(14): A "systemic safety improvement" means a proven countermeasure(s) that is **widely implemented** based on **high-risk roadway features** that are correlated with **particular severe crash types, rather than crash frequency.**

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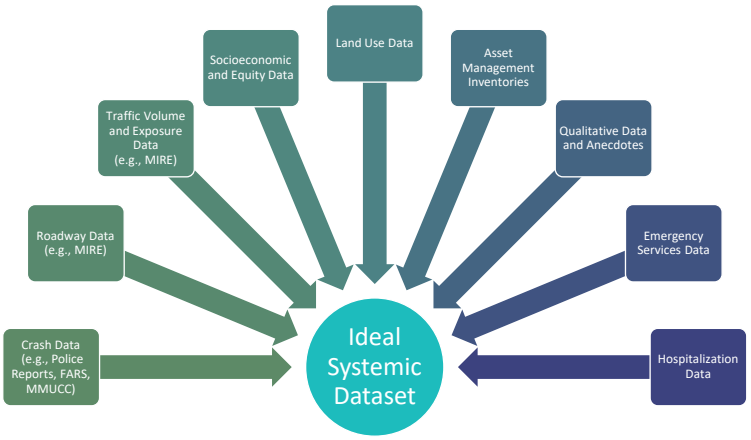
Systemic Approach Data Needs

- Integrated dataset at site level, including focus facility type system elements (e.g., horizontal curves) and features assigned to each element.
- Prepare data using spatial or tabular tools (e.g., GIS or spreadsheets).



Source: FHWA

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Identify Crash Types

EVENT	2018	2019	2020	2021	2022
Trees	25	24	19	11	19
Collision with other moving vehicle	5	4	9	6	4
Ran off Road	2	6	12	2	4
Ditch	5	5	5	6	5
Overturn (Rollover)	7	2	4	8	3
Bank or Ledge	7	2	2	5	3
Guard Rail	2	1	0	1	3
Fence or Post	1	2	1	1	1
Sign, Traffic Signal	0	2	0	2	2
Mailbox	2	1	0	1	1
Cross Centerline	0	0	4	0	0
Tunnel, Bridge, Underpass, Culvert, etc.	1	0	0	2	1
Other Non-Collision	1	1	1	0	0
Animal	0	0	1	1	0
Other Fixed Object	0	0	1	0	0
Other	0	0	1	0	0

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Identify Risk Factors

Potential Risk Factors for Roadway Departures might include:

- Number of Lanes
- Traffic Volume
- Speed Limit / Operating Speed
- Shoulder Width / Type
- Lane Width
- Median Width / Type
- Horizontal curvature
  - Superelevation
  - Delineation
  - Advance Warning Signs
  - Speed Differential
  - Visual Trap
- Pavement Condition / Friction
- Roadside features
  - Sideslope Design
  - Clear Zone
- Driveway density
- Other features
  - Rumble Strips
  - Lighting

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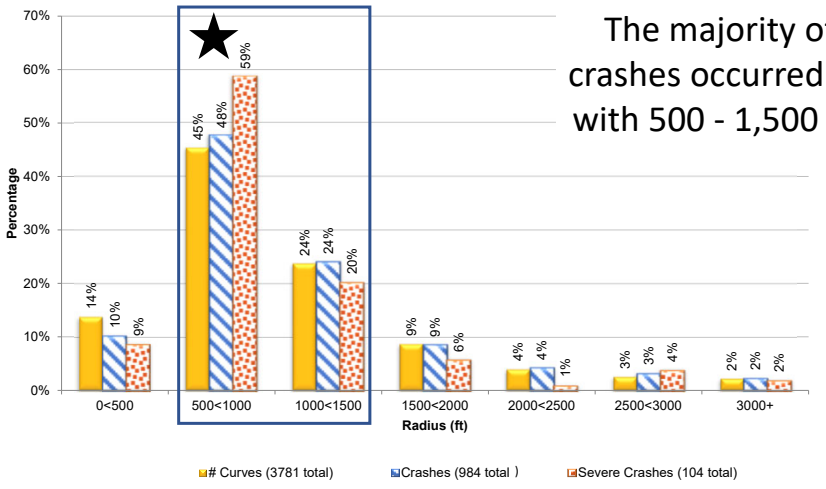
Quantitative Crash Analysis Method: Minnesota Example



The majority of severe crashes occurred on curves with 500 - 1,500 foot radii.

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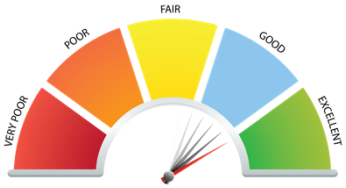
Qualitative Approach to Risk

- Use qualitative ratings when needed:
  - Good, Fair, Not-So-Good (curve radius, roadside, etc.)
  - High, Medium, Low (traffic volumes, crash frequency, etc.)
- It is important to include the risk factors that are key to your roadway network



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Qualitative Data – Presence of a Visual Trap

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Qualitative Data – Intersection in a Curve

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Prioritization – Minnesota Example

Complete census of 504 curves

Curve Count	ID	Corridor	Segment	Crashes Total	Severe	K	A	B	C	PDO	Severe RoR K	A	Radius (ft)	Length Curve (ft)	ADT	Intersection on Curve	Chevrons	Visual Trap	Rank	Proximity	Chevron Candidate
1	001A	1.01	CSAH 1	1	-	-	-	-	-	1	-	-	92	125	50	-	-	-			
2	001B	1.01	CSAH 1	-	-	-	-	-	-	-	-	-	557	422	50	-	-	-	★		
3	001C	1.01	CSAH 1	-	-	-	-	-	-	-	-	-	823	493	50	-	-	-	★		
4	001D	1.01	CSAH 1	-	-	-	-	-	-	-	-	-	379	359	50	-	-	-			
5	001E	1.01	CSAH 1	-	-	-	-	-	-	-	-	-	669	456	50	-	-	-	★		
6	001F	1.01	CSAH 1	-	-	-	-	-	-	-	-	-	270	431	50	-	-	-			
7	001G	1.01	CSAH 1	-	-	-	-	-	-	-	-	-	314	324	50	-	-	-			
8	001H	1.01	CSAH 1	-	-	-	-	-	-	-	-	-	545	239	50	-	-	-	★		
9	001I	1.01	CSAH 1	-	-	-	-	-	-	-	-	-	459	225	50	-	-	-			
10	001J	1.01	CSAH 1	-	-	-	-	-	-	-	-	-	368	274	50	-	-	-			
11	001K	1.01	CSAH 1	1	-	-	-	-	-	1	-	-	318	390	50	-	-	-			
12	001L	1.01	CSAH 1	-	-	-	-	-	-	-	-	-	267	399	50	-	Yes	-			Installed
13	001M	1.01	CSAH 1	-	-	-	-	-	-	-	-	-	1,475	345	50	-	-	-	★		
14	001N	1.01	CSAH 1	-	-	-	-	-	-	-	-	-	763	578	130	Yes	-	-	★★		
15	001O	1.01	CSAH 1	-	-	-	-	-	-	-	-	-	859	353	210	Yes	-	-	★★		
16	002A	2.02	CSAH 2	1	-	-	-	1	-	-	-	-	583	752	930	-	-	-	★★	Yes	Yes
17	002B	2.02	CSAH 2	-	-	-	-	-	-	-	-	-	584	635	930	Yes	-	-	★★★	-	Yes
18	002C	2.02	CSAH 2	-	-	-	-	-	-	-	-	-	799	665	930	Yes	-	-	★★★	-	Yes
19	002D	2.02	CSAH 2	-	-	-	-	-	-	-	-	-	963	626	930	-	-	-	★★	Yes	Yes
20	002E	2.02	CSAH 2	-	-	-	-	-	-	-	-	-	1,234	584	930	-	-	-	★★	Yes	Yes
21	002F	2.02	CSAH 2	-	-	-	-	-	-	-	-	-	1,188	719	930	-	-	-	★★	Yes	Yes
22	002G	2.02	CSAH 2	1	1	1	-	-	-	-	1	-	938	556	930	-	-	-	★★★	-	Yes
23	002H	2.02	CSAH 2	-	-	-	-	-	-	-	-	-	1,199	402	930	-	-	-	★★	Yes	Yes
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
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502	249ZH	249.01	CR 249	-	-	-	-	-	-	-	-	-	432	301	275	Yes	-	-		Yes	Yes
503	249ZI	249.01	CR 249	-	-	-	-	-	-	-	-	-	814	344	275	-	-	-		Yes	Yes
504	249ZJ	249.01	CR 249	-	-	-	-	-	-	-	-	-	800	685	275	-	-	-	★	Yes	Yes

Stars	#	%	Chevrons in Place #	Chevrons in Place %
★★★★★	0	0%	0	0%
★★★★	7	1%	2	0%
★★★	25	5%	4	1%
★★	108	21%	1	0%
★	250	50%	2	0%
-	114	23%	5	1%
	504	100%	14	3%

32 High Priority Curves (6%)

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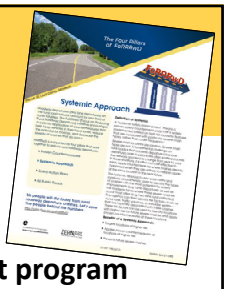
Systemic Approach Example



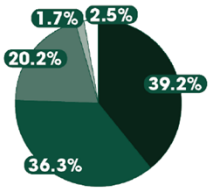


Figure 5. Injury Crash Types, 2009-2018. Source: recreated from SWO Tribal Transportation Safety Plan.

Improving Safety in Tribal Areas

- **Sisseton-Wahpeton Oyate Tribe participated in a safety improvement program through the WY T2/LTAP and NPTTAP.**
- **Analyzed crash data and field evaluation of:**
  - **general roadway conditions**
  - **Intersections**
  - **signage and pavement markings**
  - **fixed objects**
  - **shoulder/ right-of-way**
- **Received grant to install 31 miles of edge line rumble strips.**

Safety is proactive

Humans make mistakes

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https://safety.fhwa.dot.gov/FoRRRwD/Systemic4-pager.pdf

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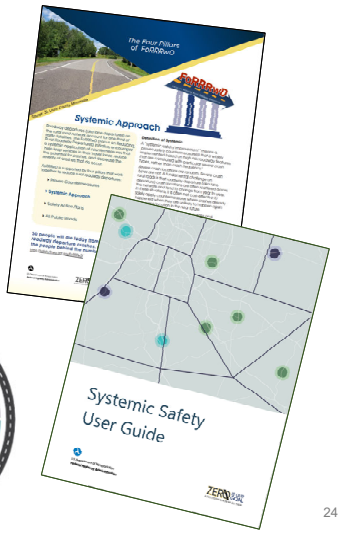
Systemic Approach Resources

- Resources
  - FHWA Systemic Approach to Safety Website
  - Systemic Analysis Infographic – How Healthy is Your Road System?
  - Systemic Approach Potential Risk Factors
  - FHWA Systemic Safety User Guide



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Local Road Safety Plans (LRSP)

- Framework for identifying, analyzing, and prioritizing safety improvements
- Engages multiple stakeholders
- Uses data-driven approach
- Results in a list of issues, risks, actions, and improvements
- LRSP Do-It-Yourself website

VIDEO

Source: FHWA

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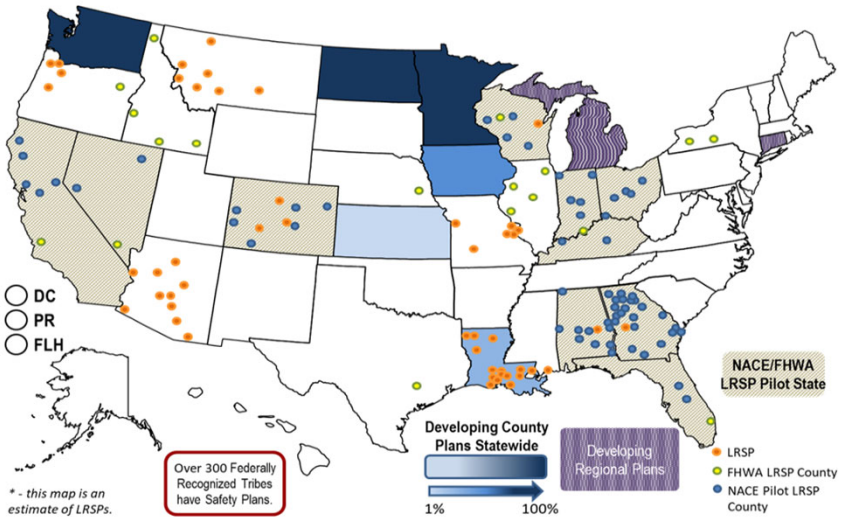
Local Road Safety Plans - 2020



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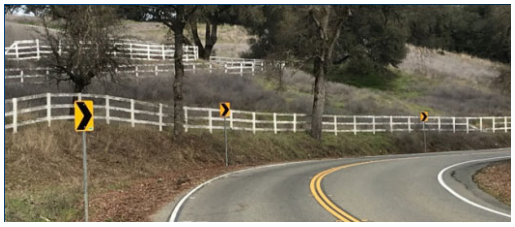
Effectiveness

- 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.
  - **35% reduction** in severe curve crashes in Thurston County, WA.



Source: Nevada County (CA)

Source: Elmore County (AL)

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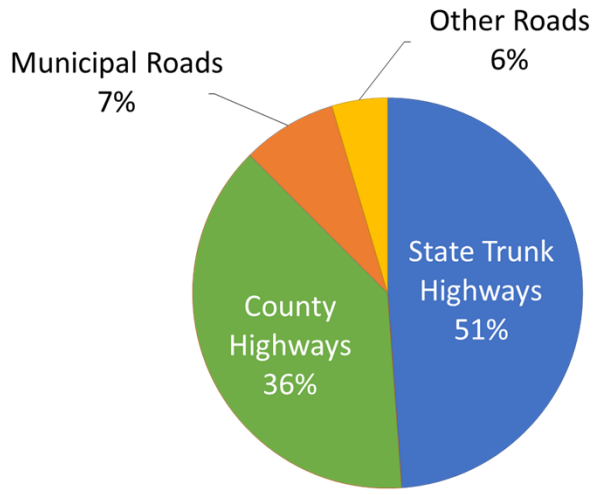
Minnesota Example



2015 Fatalities by Roadway in Minnesota

- State provides 50% of HSIP to local agencies
- State provided safety plans for all counties
- State streamlined the process for projects that were in the plans
- Counties have found efficiency in bundling projects across county lines

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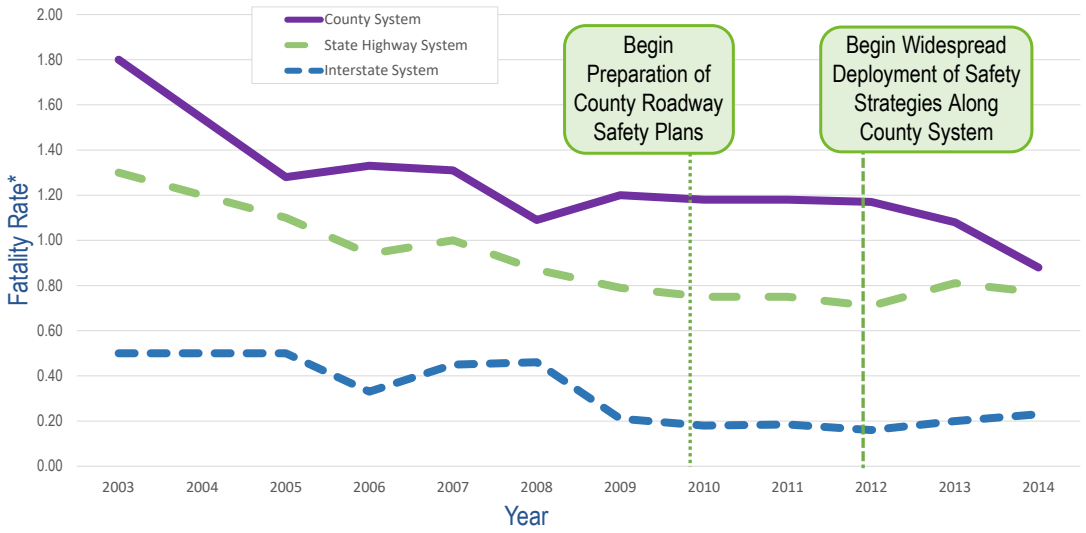
Minnesota Results



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Source: Mark Vizecky, MnDOT

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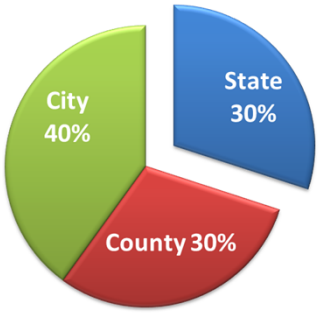
Washington State Example



Percent Fatal & Serious Collisions

- State provides 70% of HSIP to local agencies
- State provided training and crash data
- 33 of 39 counties developed safety plans
- **ALL** the plans were completed by county staff

The fatal crash rate is 2X higher on county roads than on state highways.

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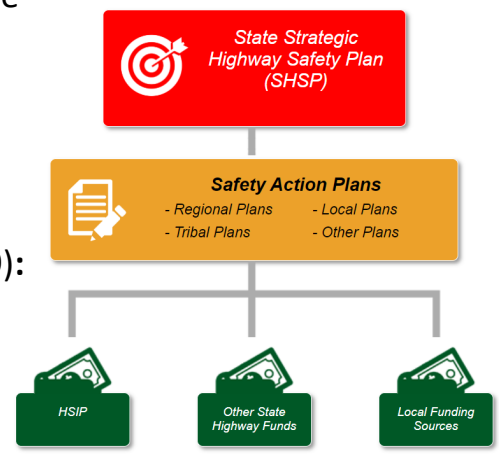
Opportunity for Widespread Deployment

- Approximately **75 percent of rural roads** are owned by local agencies**.**
- While **local roads** are less traveled than State highways, they have a much **higher rate of fatal and serious injury crashes.**
- **Native Americans are disproportionally represented in traffic fatalities** (2015-2019): **of 145 deaths per 100,000 compared to 55.2 for total population per 100,000**.



Source: FHWA

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Safety Action Plan Example

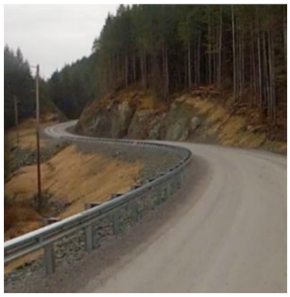

Figure 3. Guardrail installed in front of a steep slope on Kasaan Road. Source: FHWA.

Strategic Tribal Transportation Safety Plan

- **Organized Village of Kasaan (OVK) developed a Safety Plan through Tribal Transportation Program Safety Funds (TTPSF).**
- **Plan included need to address roadway departure improvements along Kasaan Road.**
  - **Guardrail locations were identified.**
  - **TTPSF grant awarded to install guardrail.**
  - **Other countermeasures (such as realignment of "Killer Hill") will be implemented in the future.**

Safety is proactive

Responsibility is shared

https://safety.fhwa.dot.gov/FoRRRwD/ActionPlans4-pager.pdf

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Case Studies and Resources

- Case Studies
  - Caltrans – dedicated $18 million for local agency safety improvements, including $8 million to assist agencies developing LRSPs
  - North Dakota DOT – allocated 50% of the HSIP funding to proactively assisted local and tribal agencies with implementation of LRSPs
    - 14% reduction in lane departure severe injury crashes on local roads
    - 21% reduction in curve crashes on local roads
- Resources
  - LRSP Do-It-Yourself website
  - Local agency insights video
  - Informational video on LRSPs
  - FHWA Local and Rural Safety Resources Webpage

Source: Marin County (CA)

Source: North Dakota DOT

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Proven Safety Countermeasures

Speed Management

- Appropriate Speed Limits for All Road Users
- Speed Safety Cameras
- Variable Speed Limits

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

Intersections

- Backplates with Retroreflective Borders
- Corridor Access Management
- Dedicated Left- and Right-Turn Lanes at Intersections
- Reduced Left-Turn Conflict Intersections
- Roundabouts
- Yellow Change Intervals
- Systemic Application of Multiple Low-Cost Countermeasures at Stop-Controlled Intersections

Pedestrian/Bicyclist

- Bicycle Lanes
- Crosswalk Visibility Enhancements
- Leading Pedestrian Interval
- Pedestrian Hybrid Beacons
- Rectangular Rapid Flashing Beacons (RRFB)
- Road Diets (Roadway Reconfiguration)
- Walkways
- Medians and Pedestrian Refuge Islands in Urban and Suburban Areas

Crosscutting

- Lighting
- Local Road Safety Plans
- Road Safety Audit
- Pavement Friction Management

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Identifying and Selecting PSCs

WHAT IS A CRASH MODIFICATION FACTOR (CMF)?

A CMF is an estimate used to quantify the change in crashes expected after the implementation of a countermeasure and whether it is a decrease in crashes (CMF below 1.0), an increase in crashes (CMF over 1.0), or no change in crashes (CMF of 1.0).

Example

CMF = 0.8 or 20% reduction in crashes

Proven =

- Comprehensive literature and Clearinghouse review
- Effectiveness in reducing fatalities and serious injuries
- Supported by data and research
  - High-quality CMFs = 4 and 5 stars
  - Extensively studied and documented

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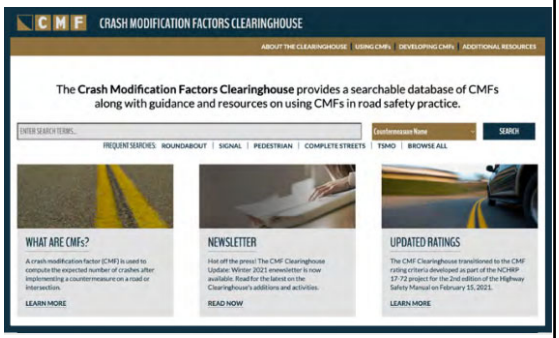
CMF Clearinghouse

- Repository of over 8,000 CMFs
- CMF Criteria
  - Based on crash data
  - Quantify the safety effect of an infrastructure characteristic, feature, or modification
  - Explicitly present CMF values
- Provides CMF Data
- Educates CMF Users
- Facilitates CMF Research
- Rigorous review and update process



Source: CMF Clearinghouse

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https://www.cmfclearinghouse.org/

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Roadway Departure Objectives

1st - Keep vehicles on the road

2nd - Reduce the potential for crashes

3rd - Minimize the severity

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1st - Keep vehicles on the road

- Improved curve delineation (including wider edge lines)
- Friction treatments in curves and other spot locations
- Edge line, shoulder & center line rumble strips

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Enhanced Delineation for Horizontal Curves

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

- Considerations
  - Review signing practices and policies for compliance with the MUTCD
  - Use the systemic approach to identify and treat curves
  - Incremental approach is beneficial to avoid excessive costs

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Effectiveness

- In-Lane Curve Warning Pavement Markings
  - Up to **35-38% reduction** in all crashes (CMF IDs 10312 and 9167)
- New Fluorescent Curve Signs or Upgrade Existing Curve Signs to Fluorescent Sheeting
  - Up to **18% reduction** in non-intersection, head-on, run-off-road, and sideswipes in rural areas (CMF IDs 2431 and 2432)

Source: FHWA

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Effectiveness of Chevron Signs

- Chevron Signs
  - Up to **25% reduction** in nighttime crashes (CMF ID 2439)
  - Up to **16% reduction** in non-intersection fatal and injury crashes (CMF ID 2438)
- Oversized Chevron Signs
  - Up to **15% reduction** in fatal and injury crashes (CMF ID 8978)

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Opportunity for Widespread Deployment

Over **10 million curves** along **two-lane highways** in the U.S.

One quarter of crash fatalities occur **on curves** in the U.S.

Source: PennDOT

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Case Studies and Resources

- Case Studies
  - Bonner County (ID) – improved visibility at higher-risk rural horizontal curves by installing edge lines and delineators
  - Ohio DOT – Township Safety Sign Grant Program
    - 67 percent reduction in fatalities and 33 percent drop in serious injuries in the 2 years after deployment
- Resources
  - FHWA Horizontal Curve Safety Webpage
  - Curve Safety Solutions
  - Low-Cost Treatments for Horizontal Curve Safety
  - Reducing Roadway Departure Crashes at Horizontal Curve Sections on Two-lane Rural Highways
  - Instructional Video for Chevron Sign Spacing

Source: Bonner County (ID)

Source: Franklin County (OH)

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Wider Edge Lines

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Wider Edge Lines

- MUTCD Section 3A.04
  - Wider Edge Lines – when the marking width is increased from the minimum normal line width of 4 inches to the maximum normal line width of 6 inches
- Increase drivers' perception of travel lane edge
- Durable marking material may have lower life cycle cost
- Installing over rumble strips (i.e., rumble stripes) can improve marking longevity and visibility in areas with snowplow operations
- May provide better guidance to automated vehicles

Source: Thurston County, WA

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Effectiveness of Wider Edge Lines

- Up to **37% reduction** in fatal and injury non-intersection crashes on rural, two-lane highways (CMF ID 4737)
- Up to **22% reduction** in fatal and injury crashes on rural freeways
- 25:1 B/C ratio for fatal and serious injury crashes on two-lane rural roads

Source: Thurston County, WA

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Opportunity for Widespread Deployment

- **Over half** of fatalities in U.S. are **roadway departures**.
- **Improves detection and tracking for cameras** for connected and automated vehicles.
- **Benefit-Cost**: 15% more in cost, but $1 spent amounts to $33 to $55 in benefits.

Source: Texas Transportation Institute

Source: FHWA

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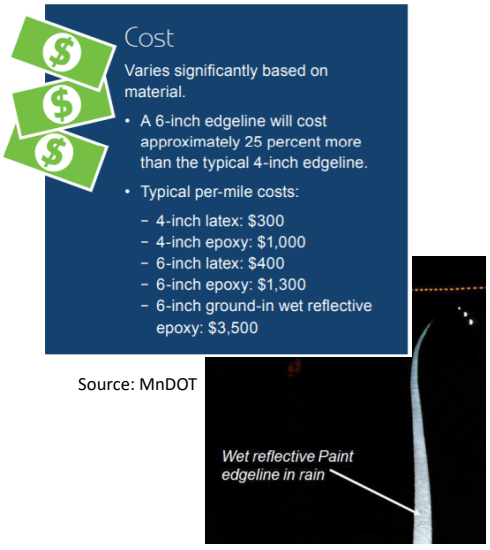
Case Studies and Resources

- Case Studies
  - Minnesota - Enhanced Edge Lines
    - Systemic Application of 6-inch edge lines on local roads
    - Tool to prioritize markings on low-volume roads
  - Michigan
    - Included on Common Safety Countermeasures for Local Agencies list
    - Benefits of wider edge lines in reducing crashes on rural two-lane highways
      - 15-38% reduction in fatal and injury crashes
      - 15-30% reduction in total crashes
      - 33-55:1 benefit cost ratio for fatal and injury crashes
- Resources
  - FHWA Pavement Markings Webpage



Source: MnDOT

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Pavement Friction Management

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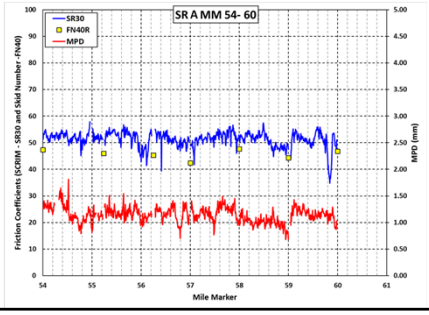
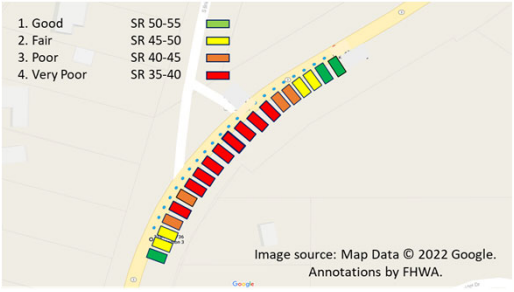
Pavement Friction Management

- Continuous Pavement Friction Measurement (CPFM)
  - Provides a comprehensive picture of how friction varies across pavement segments
  - Measures friction continuously at highway speeds
  - Provides both network and project level data
  - Analyzes friction, crash, and roadway data better than traditional methods
  - Enable deployment of pavement related countermeasures





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Pavement Friction Management – High Friction Surface Treatment

- High Friction Surface Treatments (HFST)
  - Durable, anti-abrasion, and polish-resistant aggregate (i.e. calcined bauxite) over thermosetting polymer resin binder
  - Applications:
    - Horizontal curves
    - Interchange ramps
    - Intersections and approaches
    - Crosswalk approaches
    - Locations with history of rear-end, failure to yield, wet-weather, or red-light-running crashes

Source: FHWA

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Effectiveness of HFST

- Up to **72% reduction** for run off road crashes at **horizontal curves** (CMF ID 10334)
- Up to **48% reduction** for injury crashes at **horizontal curves** (CMF ID 10333)
- Up to **31% reduction** for head-on crashes at **horizontal curves** (CMF ID 10336)

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Opportunity for Widespread Deployment

28 percent of traffic fatalities in the U.S. occur at horizontal curves

Over 10 million curves on two-lane roads

21 states with less than 10 HFST locations

Only 3 states with CPFM programs

Source: St. Louis County (MN)

Source: FHWA

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Case Studies and Resources

- Case Studies
  - Maricopa County (AZ) – first pilot of HFST at two locations
    - Pre-installation - 35 total crashes, 7 severe injuries
    - Post-installation – 1 total crash, no injuries
  - South Dakota DOT – pilot project on four curves
    - 80% reduction in total crashes
    - Led to expansion of HFST at 15 locations (66% crash reduction)
  - PennDOT – over 500 HFST locations
    - Analysis of 47 locations – 63% reduction in injury crashes, and went from 8 fatalities down to 0
  - Florida DOT – signalized intersection applications
    - Crosswalk incursions decreased 11-31% after HFST application
- Resources
  - FHWA Pavement Friction Webpage
  - Pavement Friction for Road Safety: Primer on Friction Measurement and Management Methods
  - HFST Site Selection and Installation Guide
  - HFST Resources

Source: Maricopa County (AZ)

Source: South Dakota DOT

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Longitudinal Rumble Strips and Stripes on Two-Lane Roads

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Longitudinal Rumble Strips and Stripes on Two-Lane Roads

- Rumble Strips
  - Milled or raised elements on the pavement intended to alert drivers through vibration and sound that their vehicle has left the travel lane
- Rumble Stripes
  - Rumble strips that coincide with centerline or edgeline pavement markings


Source: FHWA


Source: Missouri DOT

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Effectiveness

- Center Line Rumble Strips
  - Up to **44-64% reduction** in head-on fatal and injury crashes on two-lane rural roads (CMF IDs 3358 and 3356)
- Shoulder Rumble Strips
  - Up to **13-51% reduction** in single vehicle, run-off-road fatal and injury crashes on two-lane rural roads (CMF IDs 3425 and 3648)
- Low-Cost – B/C Ratios exceeding 100:1


Source: FHWA


Source: FHWA

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Opportunity for Widespread Deployment

Over half of fatalities in U.S. are **roadway departures**.

46 States use shoulder rumble strips

36 States use center line rumble strips

Source: FHWA

Source: FHWA

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Case Studies and Resources

- Case Studies
  - Mercer County (NJ) – implemented 6 miles of center line rumble stripes across 18 roads after successful pilot projects
  - Sisseton-Wahpeton Oyate (SWO) Tribe – secured a Tribal Transportation Program Safety Fund grant to develop a Strategic Safety Plan and implement 30.6 miles of rumble strips identified in their systemic analysis
- Resources
  - FHWA Rumble Strips and Rumble Stripes Webpage
  - Decision Support Guide for the Installation of Shoulder and Center Line Rumble Strips on Non-Freeways
  - Sweet Sound of Safety informational video

Source: Mercer County

Source: SWO Tribe/FHWA

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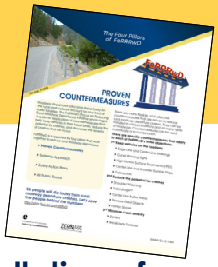
Proven Countermeasures Example

Figure 1. Edge lines and delineators improve visibility on horizontal curves. Source: Matt Mulder, Bonner County, Idaho.



Edge Lines and Delineators at Horizontal Curves

- **Bonner County, ID prioritized installation of edge lines and delineators on horizontal curves**
  - **Used Local Highway Safety Improvement Program funds to improve visibility at curves on 31 roadways**
  - **Edge lines are durable pavement marking**
  - **Anecdotal evidence indicates positive reception with requests for more installations**

Humans are vulnerable | **Humans make mistakes** | **Redundancy is crucial**

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https://safety.fhwa.dot.gov/FoRRRwD/Countermeasure4-pager.pdf

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2nd - Reduce the potential for crashes

- SafetyEdge^{SM}
- Roadside Design Improvements at Curves
  - Shoulders
  - Maintained clear zones
  - Traversable roadside slopes

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SafetyEdge^{SM}

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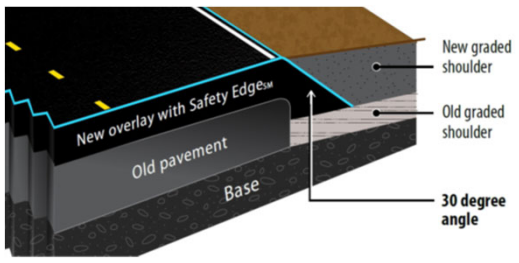
SafetyEdge^{SM}

- Shapes the pavement edge to approximately 30 degrees from the pavement cross slope during paving
- Eliminates vertical drop-off at pavement edge
- Improves durability – reduces edge raveling
- Many commercially available devices
- After paving, adjacent graded material should be brought flush with pavement surface
- Target systemwide implementation via standards for all new paving and resurfacing projects



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Effectiveness

- Up to **11% reduction** in fatal and injury crashes (CMF ID 9205)
- Up to **21% reduction** in run-off-road crashes (CMF ID 9211)
- Up to **19% reduction** in head-on crashes (CMF ID 9217)
- Low-Cost – B/C Ratios between 700:1 to 1,500:1

Source: PennDOT

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Opportunity for Widespread Deployment

- Approximately **2,850,000 miles** of paved roadways in the U.S.
- For some States, pavement edges were cited in up to **25% of rural run-off-road crashes** on paved roads with unpaved shoulders.
- Less than **1%** of additional asphaltic material required for implementing SafetyEdge[SM] into new projects.
- **Less deterioration** than a regular pavement edge (based on 6-year test section).

Source: FHWA

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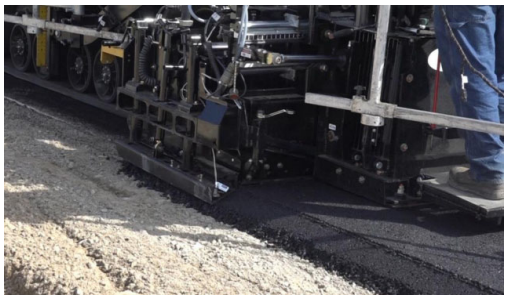
Case Studies and Resources

- Case Studies
  - Pavement and Maintenance | FHWA (dot.gov) Field Reports
  - Design and Construction | FHWA (dot.gov) Field Reports
- Resources
  - FHWA SafetyEdge^{SM} Webpage
  - SafetyEdge^{SM} Your Angle for Reducing Roadway Departure Crashes video

Source: FHWA



Source: FHWA

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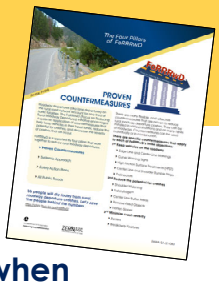
Proven Countermeasures Example

Figure 6. Paving a Delaware roadway with SafetyEdge^{SM}. After paving, a graded shoulder will become flush with top of the pavement, covering the sloped edge. Source: FHWA.



SafetyEdge^{SM}

- **Delaware DOT (DelDOT) first implemented the SafetyEdge^{SM} when resurfacing a narrow rural collector in 2010.**
- **In 2018, DelDOT included it in their standard detail to be implemented systematically into paving on all State roads.**

Humans are vulnerable

Humans make mistakes

Redundancy is crucial

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https://safety.fhwa.dot.gov/FoRRRwD/Countermeasure4-pager.pdf

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Roadside Design Improvements at Curves

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Roadside Design Improvements at Curves – Clear Zone

- Clear Zone
  - "Unobstructed, traversable area provided beyond the edge of the through travel way for the recovery of errant vehicles and Includes shoulders, bike lanes, and auxiliary lanes, except those auxiliary lanes that function like through lanes."
  - Allows a driver stop safely or regain control of a vehicle that has left the roadway.
  - Remove, relocate, or redesign roadside obstacles or features in the clear zone.
  - See AASHTO's Roadside Design Guide for clear zone widths and the clear zone adjustment factors for horizontal curves.

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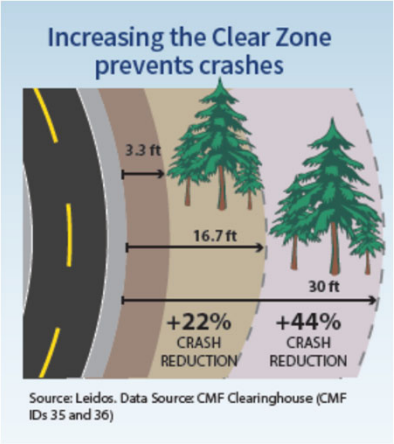
Effectiveness of Improved Clear Zone

- Increase the distance to roadside features from 3.3 ft to 16.7 ft
  - Up to **22% reduction** for all crashes (CMF ID 35)
- Increase the distance to roadside features from 16.7 ft to 30 ft
  - Up to **44% reduction** for all crashes (CMF ID 36)
- Increase the distance to tree line on rural two-lane highways
  - By 5 to 8 ft: Up to **35-49% reduction** in total crashes (NCHRP Report 440)
  - By 10 to 13 ft: Up to **57-66% reduction** in total crashes (NCHRP Report 440)



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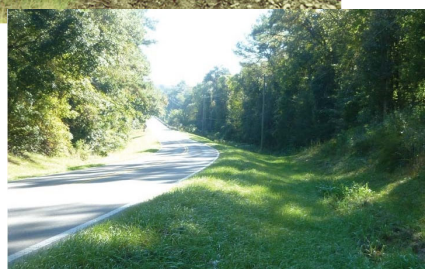
Roadside Design Improvements at Curves – Slope Flattening

- Slope Flattening
  - Reduce the steepness of the sideslope to increase drivers' ability to keep the vehicle stable, regain control of the vehicle, and avoid obstacles
  - Slopes of 1V:4H or flatter are considered recoverable
  - Slopes between 1V:3H and 1V:4H are generally considered traversable, but non-recoverable



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Effectiveness of Flattening Slopes

- Flatten side slope from 1V:3H to 1V:4H
  - Up to **42% reduction** in injury crashes on rural roads (CMF ID 26)
- Flatten side slope from 1V:4H to 1V:6H
  - Up to **22% reduction** in injury crashes on rural roads (CMF ID 29)

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Roadside Design Improvements at Curves – Shoulders

- Adding or Widening Shoulders
  - Provide recovery area to regain control in the event of a roadway departure

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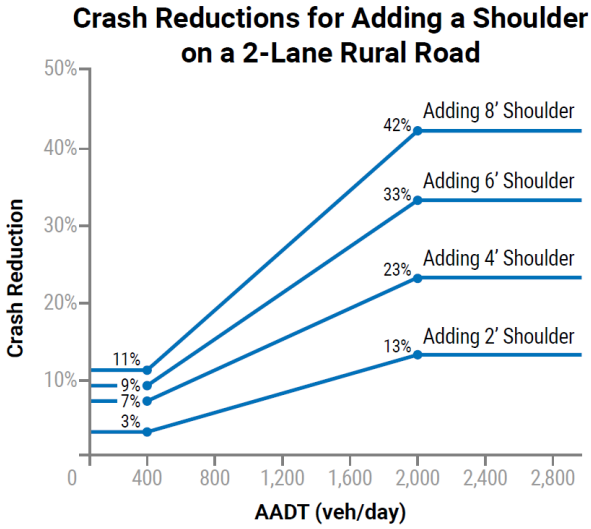
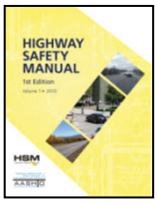
Effectiveness of Shoulder Widening





Adapted from the AASHTO Highway Safety Manual (HSM) for 2 lane rural roads with no existing shoulder.

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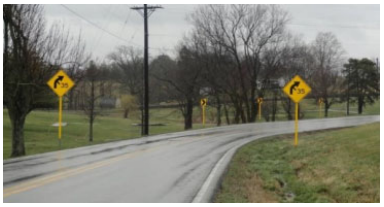
Opportunity for Widespread Deployment

- **27%** of all crashes occur on horizontal curves
  - ↳ **80%** of those crashes involve roadway departures.

Source: FHWA



Source: FHWA

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Case Studies and Resources

- Case Studies
  - Lapeer County Road Commission – Tree Removal Program
    - Proactive tree removal and trimming
- Resources
  - Rural Roadway Departure Countermeasure Pocket Guide
  - FHWA Clear Zones Webpage
  - Noteworthy Practices Roadside Tree and Utility Pole Management
  - Low-Cost Treatments for Horizontal Curve Safety

Source: Lapeer County (MI)

Source: FHWA

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3rd - Minimize the severity

- Breakaway Features
  - Signs and luminaire supports
  - Utility poles
- Barriers to shield obstacles including:
  - Trees and shrubbery
  - Other fixed objects
  - Slopes

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Roadside Design Improvements at Curves – Barriers

- Roadside Barriers
  - Shield unmovable objects or steep slopes with roadside barriers
    - Bodies of water
    - Large culverts
    - Embankments

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Barrier Systems

Barrier systems include:

- Standard Sections
- End Treatments
- Transitions

It is important to ensure tension continuity throughout the system!

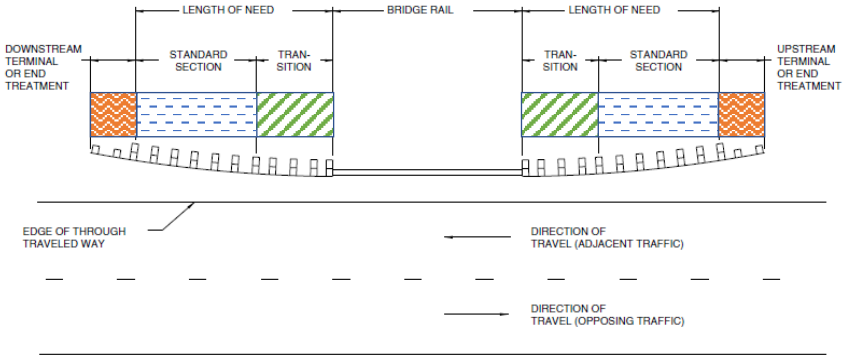

Figure 5-4. Definition of Roadside Barriers

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MASH Test Levels

TEST LEVEL	VEHICLE	IMPACT SPEED	IMPACT ANGLE
TL-1	Car, PU	31 mph	25 degrees
TL-2	Car, PU	44 mph	25 degrees
TL-3	Car, PU	62 mph	25 degrees
TL-4	TL3 + 22,000# SU	56 mph	15 degrees
TL-5	TL3 + 80,000# Semi	50 mph	15 degrees
TL-6	TL3 + 80,000# Tanker	50 mph	15 degrees

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Barrier Context

- Roadside Barriers
- Median Barriers
- Bridge Railings

Barrier must be less severe than the area of concern.

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Barrier Systems

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Barrier Comparison Video

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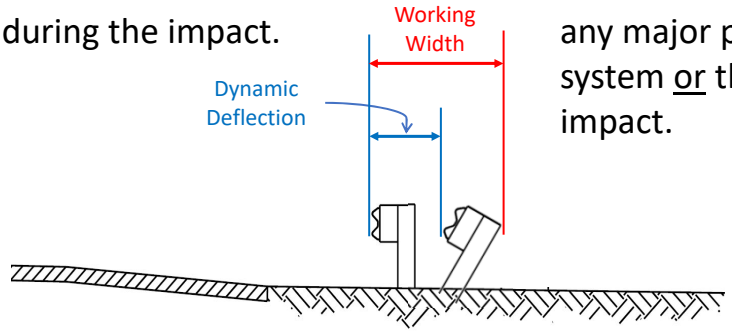
Dynamic Deflection / Working Width

Dynamic Deflection – the maximum lateral displacement of the test article on the traffic side that occurs during the impact.



Working Width – the distance between the barrier face before impact and the maximum lateral position of any major part of the system or the vehicle after impact.

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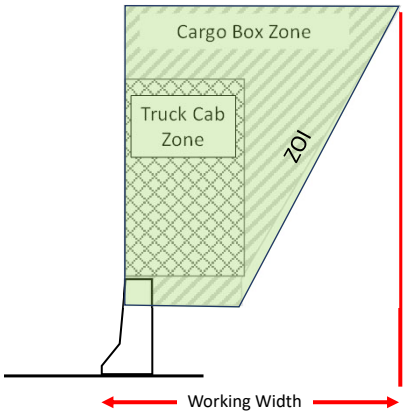
Working Width / Zone of Intrusion

- Working Width – the distance between the barrier face before impact and the maximum lateral position of any major part of the system or the vehicle after impact
- Zone of Intrusion (ZOI) – the region measured above and behind the face of a barrier system where an impacting vehicle or any major part of the system may extend during an impact



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Types of End Treatments

- Anchors
- Terminals – A crashworthy end treatment for flexible or semi rigid barriers
- Crash Cushions – A crashworthy end treatment for concrete barriers, bridge rails, or point objects

Note: While most Terminals and Crash Cushions provide anchorage, not all Anchors are crashworthy for head-on impacts.

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Guardrail Anchors

- Used to develop tension in barrier which affects the deflection and redirection capabilities
- Usually the trailing end of a barrier on a one-way roadway
- May be used when crashworthy end is not required

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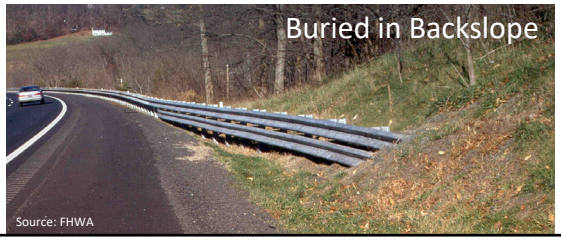
Guardrail Terminals

- Tangent versus Flared
- Energy Absorbing versus
  Non-Energy Absorbing
- Compression versus Tension



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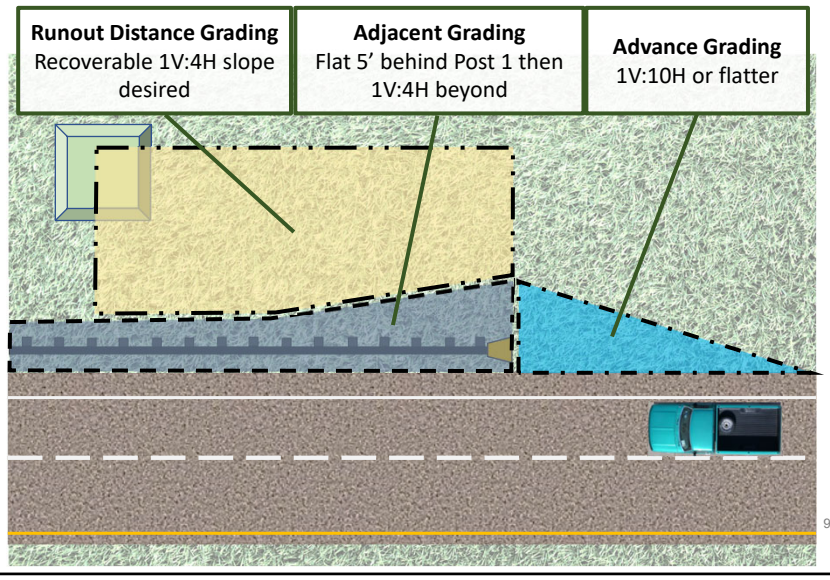
Terminal Site Grading Considerations



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Proven Countermeasures Example

Figure 3. A high-tension cable barrier preserves views of the landscape while shielding vehicles from a steep drop-off. Source: FHWA.

Cable Barrier

- **Gunnison County CO partnered with Central Federal Lands (CFL) and the National Forest to identify a potential solution to shield vehicles from the drop-off toward the river.**
- **The cable barrier allows for:**
  - **Unobstructed views of the landscape**
  - **Snow can be plowed over and through it**
  - **More usable roadway width for bicyclists and RVs**

Humans are vulnerable | **Humans make mistakes** | **Responsibility is shared**

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https://safety.fhwa.dot.gov/FoRRRwD/Countermeasure4-pager.pdf

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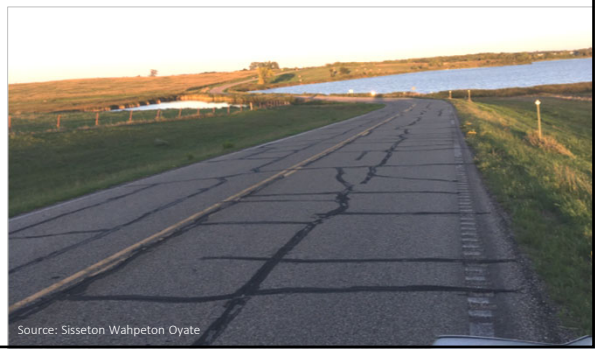
Funding for Tribal Roadway Departure Projects

- Roadway Departure is involved in 2 out of every 3 fatal crashes in Tribal areas
- Tribal Transportation Program Safety Fund has a 25% funding goal for Roadway Departure projects (about $5-million)
- Reduced application burden
- Only specific countermeasures eligible
- Can submit multiple applications



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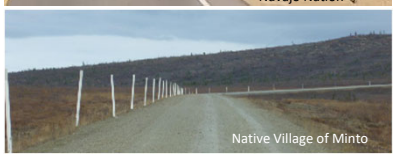
Eligible Improvements

- Curve warning signs
- Delineators
- New center/edge striping
- Edge rumbles
- Center line rumbles
- Mitigation of roadside hazards



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Mitigation of Roadside Hazards

- Install object markers
- Remove fixed objects
- Widen/Establish clear zone
- Replace roadside hardware with crashworthy devices
- Install or upgrade roadside barrier

Apply to the Infrastructure Improvement Category for higher-cost mitigations like shoulder widening and roadside grading.

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How to Get Funding? – Step 1

- Use this form!
  - Enter location information

Systemic Roadway Departure Countermeasure Request Form

Click to Add Photo (optional)

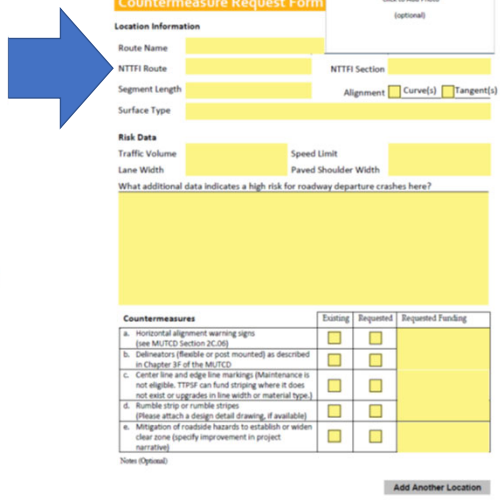
Location Information

Route Name

NTTFI Route | NTTFI Section

Segment Length | Alignment ☐ Curve(s) ☐ Tangent(s)

Surface Type



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How to Get Funding? – Step 2

- Explain why location is high risk

Risk Data

Traffic Volume | Speed Limit

Lane Width | Paved Shoulder Width

What additional data indicates a high risk for roadway departure crashes here?

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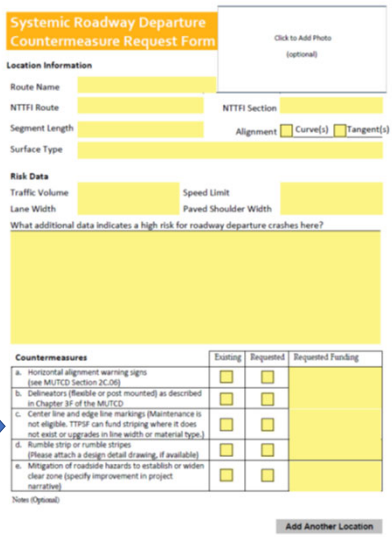
How to Get Funding? – Step 3

- Select existing low-cost countermeasures
- Select requested countermeasures
- Note requested funding

Countermeasures	Existing	Requested	Requested Funding
a. Horizontal alignment warning signs (see MUTCD Section 2C.06)	☐	☐	
b. Delineators (flexible or post mounted) as described in Chapter 3F of the MUTCD	☐	☐	
c. Center line and edge line markings (Maintenance is not eligible. TTPSF can fund striping where it does not exist or upgrades in line width or material type.)	☐	☐	
d. Rumble strip or rumble stripes (Please attach a design detail drawing, if available)	☐	☐	
e. Mitigation of roadside hazards to establish or widen clear zone (specify improvement in project narrative)	☐	☐	

Notes (Optional)

Add Another Location



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Tribal Transportation Program Safety Fund Completed Projects

(xxviii) A physical infrastructure safety project…

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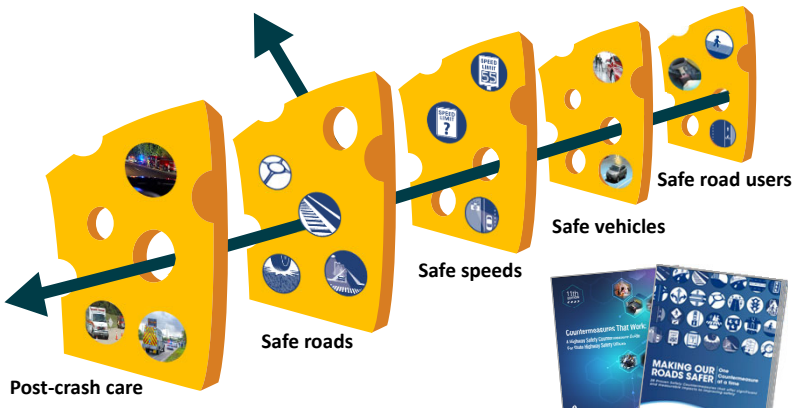
PSCs Support the Safe System Approach

Source: FHWA

The "Swiss Cheese Model" of redundancy creates layers of protection



Adapted from James Reason's model for analyzing accident causation
https://royalsocietypublishing.org/doi/10.1098/rstb.1990.0090

Source: NHTSA, FHWA.

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Learning Objectives

You now should be able to:

- Describe the four pillars of the FHWA Focus on Reducing Rural Roadway Departure Crashes initiative (FoRRRwD).
- Identify technical resources for addressing roadway departure.
- Find funding opportunities for implementing roadway departure countermeasures.
- Know strategies to apply in Tribal communities to address roadway departure crashes.

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FoRRRwd for NTICC 2024
29 August 2024

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FoRRRwD Resources

FoRRRwD Promotional Materials and Tools

Rural Roadway Departure Countermeasure Pocket Guide

FoRRRwD Countermeasures Poster

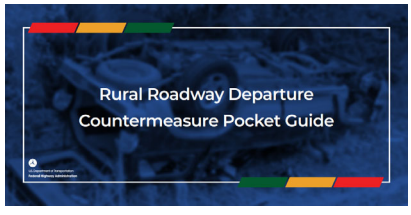
The Four Pillars of FoRRRwD Brochures:

- Safety Action Plans
- All Public Roads
- Proven Countermeasures
- Systemic Approach

Printable Trading Cards

FHWA Crash Tree Diagram Tool

Local Road Safety Plans Infographic – LRSPs Your Map to Safer Roadways



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FoRRRwD Resources

Videos

[FoRRRwD Overview Video]
[Driving FoRRRwD to a Safe System]

Proven Countermeasures

[Low Cost Safety Improvements: Longitudinal Pavement Markings]
[Low Cost Safety Improvements: Unpaved Roads]
[Rumble Strips: The Sweet Sound of Safety]
[Curve Signing Overview]
[Curve Signing: Proper Chevron Spacing]
[Curve Signing: Proper Placement in the Field]
[High Friction Surface Treatment (HFST) on Local Roads]
[Continuous Pavement Friction Measurement]

Systemic Approach

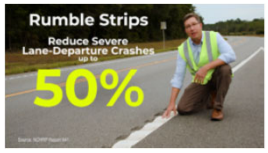
[Systemic Analysis: How Healthy is your Road System?]
[3 Approaches to Address Severe Roadway Crashes]

Safety Action Plans

[Local Road Safety Plan Overview]
[Local Road Safety Plans – a California Case Study]

All Public Roads

[FoRRRwD on All Public Roads: Our Path to Zero]



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Proven Safety Countermeasures Resources

- [PSC Factsheets]
- [PSC Booklet]
- [PSC Search and Filter Tool]
- [PSCs in Rural Communities] Informational Guide
- Videos
  - [SSCs in School Zones]
  - [Lighting: A Florida Case Study on a PSC]
- [NCHRP Synthesis: 20-05/Topic 55-10] (Implementation of the FHWA Proven Safety Countermeasures)
- [Safe System Roadway Design Hierarchy]

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NTICC 2024
Thank You!
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FoRRRwD
Focus on Reducing Rural Roadway Departures
ZERO IS OUR GOAL
A SAFE SYSTEM IS HOW WE GET THERE
Federal Highway Administration
RESOURCE CENTER
Office of Innovation Implementation

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