National Center for Rural Road Safety

Est. Dec. 2014

Rural Roadway Departure Countermeasures – Part 3

Presented by: Keith Knapp, Iowa LTAP / InTrans/Safety Center

Dick Albin, FHWA

Webinar Logistics

- Duration is 11:00 AM - 12:30 PM Mountain
- Webinar – recorded and archived on website. For quality of recording, phone will be muted during presentation
- If listening on the phone, please mute your computer
- To maximize the presentation on your screen click the 4 arrows in the top right of the presentation
- At the end of each section, there will be time for Q&A
- There is a handout pod at the bottom of the screen
- Send group lists to info@ruralsafetycenter.org
- Please complete follow-up surveys; they are vital to assessing the webinar quality

Certificates of Completion/CEUs

- Survey Link –

http://survey.constantcontact.com/survey/a07efxrg8n6jpoe0rrg/start

  - Survey closes 2 weeks after webinar
  - Expect certificate/CEU form 3-4 weeks after webinar
  - Return CEU form to ContinuingEd@montana.edu **NOT** Safety Center
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National Center for Rural Road Safety
Certificate of Completion
is hereby granted to
XXX
to certify that he/she has completed to satisfaction the course
Pedestrian Treatments for Uncontrolled Locations
Granted: January 18, 2018 11:00 AM - 12:30 PM MST
Instructors: Yan Qi and Kyle Armstrong
Jaime L Sullivan
Safety Center Manager

Certificates of Completion/CEUs

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Course *cex 280717 Pedestrian Treatments for Uncontrolled Locations - Live* Location *Online*

Date *01/18/18 - 01/18/18* REGISTRATION FEE *$0.00* # OF CEU's *0.150* GENDER: M / F

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VERIFICATION OF COMPLETION

February 2, 2018

REGISTRANT: First Last
123 Main St
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ID #:		CEU	Hours
18SCEX280717	Pedestrian Treatments for Uncontrolled Locations - Live January 18, 2018	0.150	1.50
18SCEX280720	Primer on the Joint Use of the HSM and the HFG for February 13, 2018 - February 13, 2019	0.150	1.50
TOTAL:		**0.300** CEU's	**9.00** Hours

Co-Hosted by:

U.S. Department of Transportation
Federal Highway Administration

On-Ramp to Innovation
every day counts

NATIONAL ASSOCIATION COUNTY ENGINEERS
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The Voice of
County Road Officials

National
LTAP & TTAP
Association

Today's Presenters

Keith Knapp
Iowa LTAP/InTrans/Safety Center

Dick Albin
FHWA

Goals of this Webinar

Once you have completed this webinar, you will:

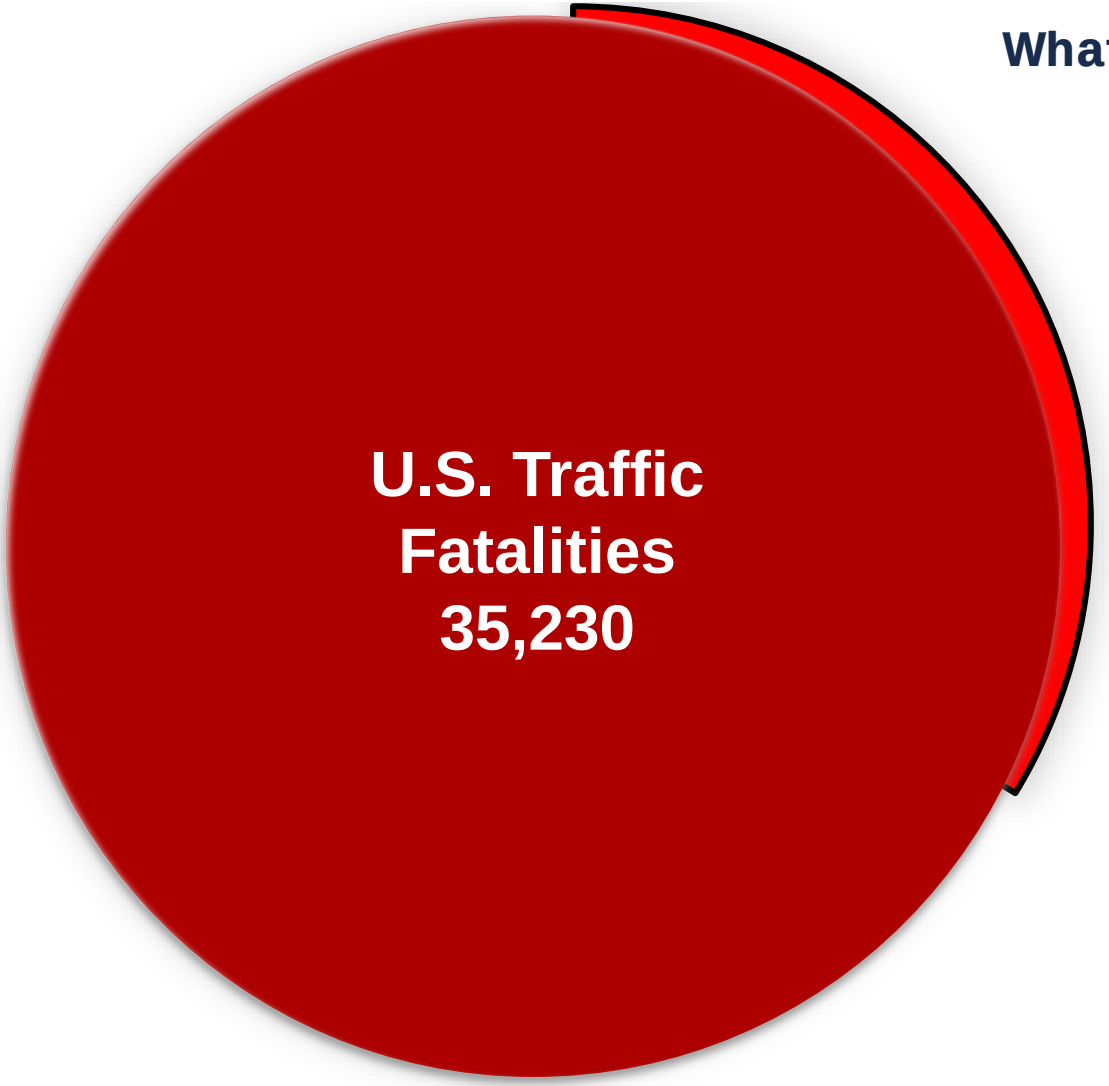
learn about clear zone treatments and crash testing of roadside hardware.

Learning Outcomes

To achieve the webinar goal, you will learn to:

- Define clear zone, it's basis, and limitations
- Describe critical, traversable, and recoverable slopes
- List some methods to reduce the potential to crash when a vehicle leaves the roadway
- Identify the criteria for determining the crashworthiness of roadside hardware
- Describe the implementation plan for MASH
- Identify hardware that has been tested to MASH

The Rural RwD Component of Fatalities



What is a Roadway Departure (RwD)?

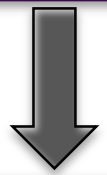
FHWA Definition: A crash in which a vehicle crosses an edge line, a center line, or otherwise leaves the traveled way.


Photo credit: Oregon State Police

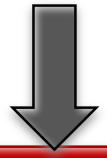
Source: NHTSA FARS (2014 – 2016 Annual Average)

Roadway Departure Objectives

1st - Keep vehicles on the road



2nd - Reduce the potential for crashes



3rd - Minimize the severity

2nd - Reduce the potential for crashes

- SafetyEdge^{SM}
- Maintained clear zones
- Traversable roadside slope

11

3rd - Minimize the severity

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

Keith Knapp,
Iowa LTAP

National Center for Rural Road Safety

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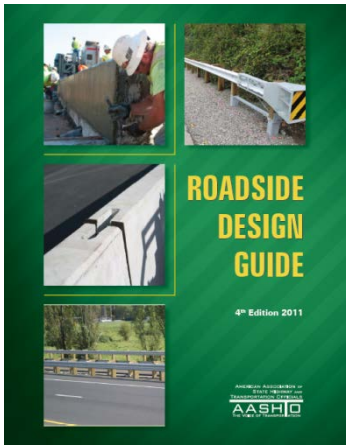
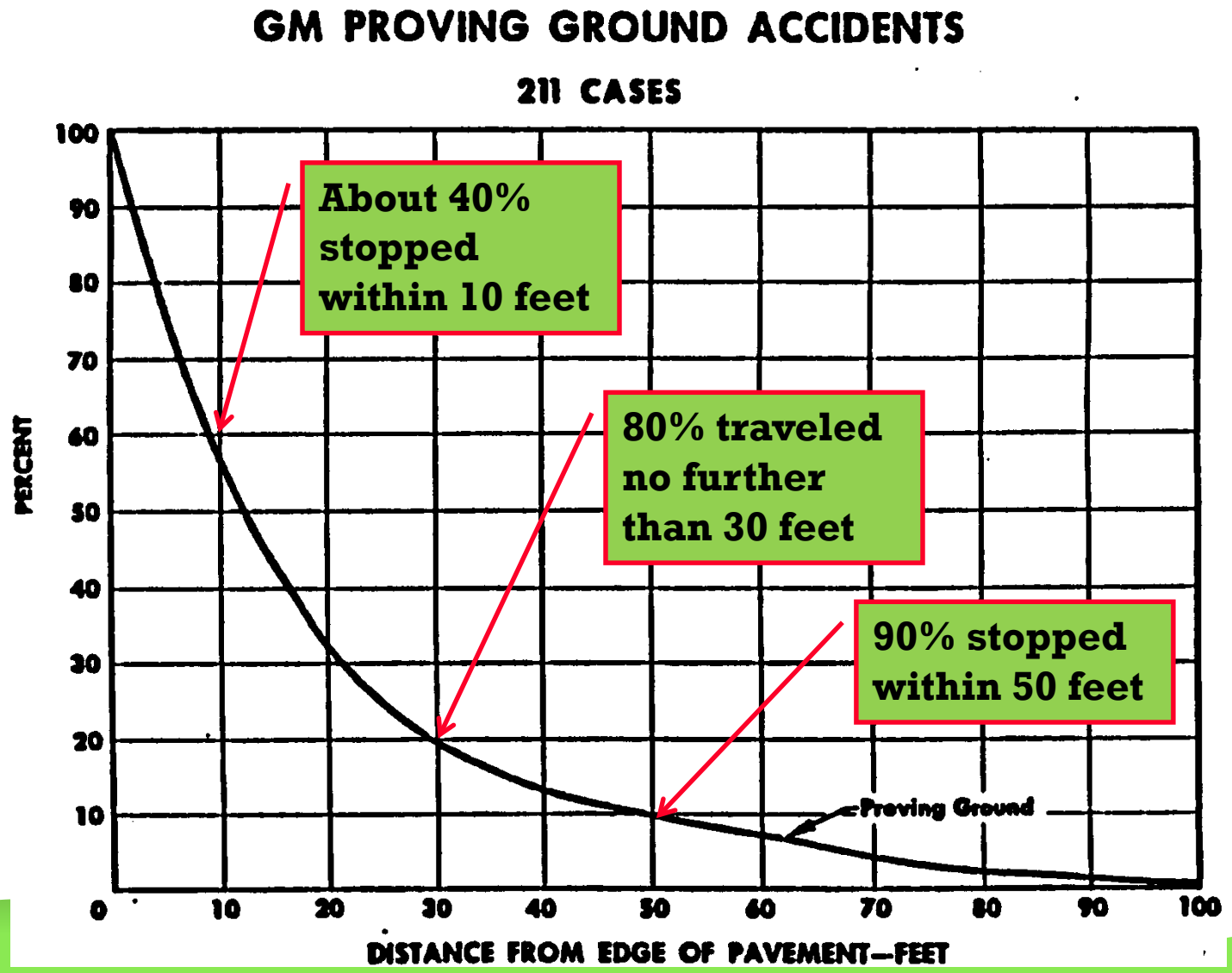
Clear Zone Defined

"The unobstructed, traversable area provided beyond the edge of the through traveled way for the recovery of errant vehicles." (RDG, 2011)



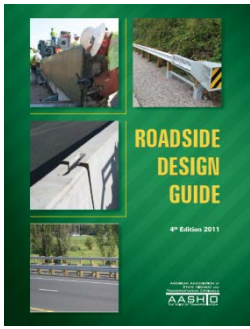
Clear Zone Origins



Clear Zone Result (RDG, 2011)

- As a result a 30' clear zone was adopted by AASHTO
- In the 1970's the 30' was adjusted to reflect speed, side slope and ADT.

Design Speed (mph)	Design ADT	Foreslopes			Backslopes		
		1V:6H or flatter	1V:5H to 1V:4H	1V:3H	1V:3H	1V:5H to 1V:4H	1V:6H or flatter
≤40	UNDER 750[c]	7–10	7–10	[b]	7–10	7–10	7–10
	750–1500	10–12	12–14	[b]	12–14	12–14	12–14
	1500–6000	12–14	14–16	[b]	14–16	14–16	14–16
	OVER 6000	14–16	16–18	[b]	16–18	16–18	16–18
45–50	UNDER 750[c]	10–12	12–14	[b]	8–10	8–10	10–12
	750–1500	14–16	16–20	[b]	10–12	12–14	14–16
	1500–6000	16–18	20–26	[b]	12–14	14–16	16–18
	OVER 6000	20–22	24–28	[b]	14–16	18–20	20–22
55	UNDER 750[c]	12–14	14–18	[b]	8–10	10–12	10–12
	750–1500	16–18	20–24	[b]	10–12	14–16	16–18
	1500–6000	20–22	24–30	[b]	14–16	16–18	20–22
	OVER 6000	22–24	26–32[a]	[b]	16–18	20–22	22–24
60	UNDER 750[c]	16–18	20–24	[b]	10–12	12–14	14–16
	750–1500	20–24	26–32[a]	[b]	12–14	16–18	20–22
	1500–6000	26–30	32–40[a]	[b]	14–18	18–22	24–26
	OVER 6000	30–32[a]	36–44[a]	[b]	20–22	24–26	26–28
65–70[d]	UNDER 750[c]	18–20	20–26	[b]	10–12	14–16	14–16
	750–1500	24–26	28–36[a]	[b]	12–16	18–20	20–22
	1500–6000	28–32[a]	34–42[a]	[b]	16–20	22–24	26–28
	OVER 6000	30–34[a]	38–46[a]	[b]	22–24	26–30	28–30



Remember

AASHTO guidance is based on assumption that 20% of vehicles will exceed the clear zone

Directing Your Questions via the Chat Pod

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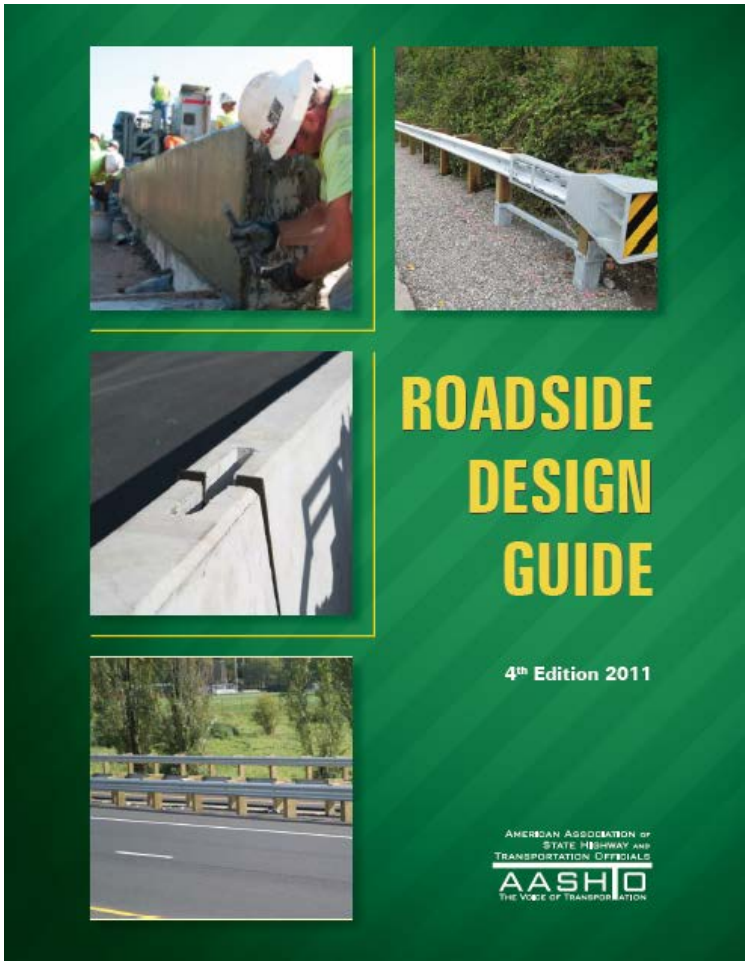
Some Typical Roadside Obstacles

- Edge drop off
- Trees
- Utility and light poles
- Sign posts and mailboxes
- Rocks and boulders
- Ditches
- Drainage features and facilities
- Steep slopes
- Others

Methods to Address Obstacles

- Remove
- Redesign
- Relocate
- Reduce severity
- Shield
- Delineate



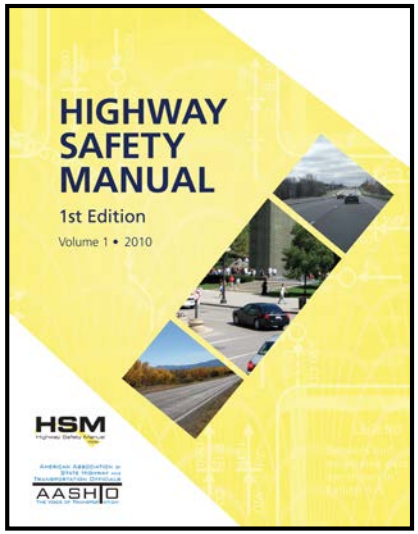
Shoulder Widening

The shoulder is where vehicle recovery begins!

Shoulders are most critical on horizontal curves

Shoulder Widening

CMF for shoulder width on 2 lane rural roads



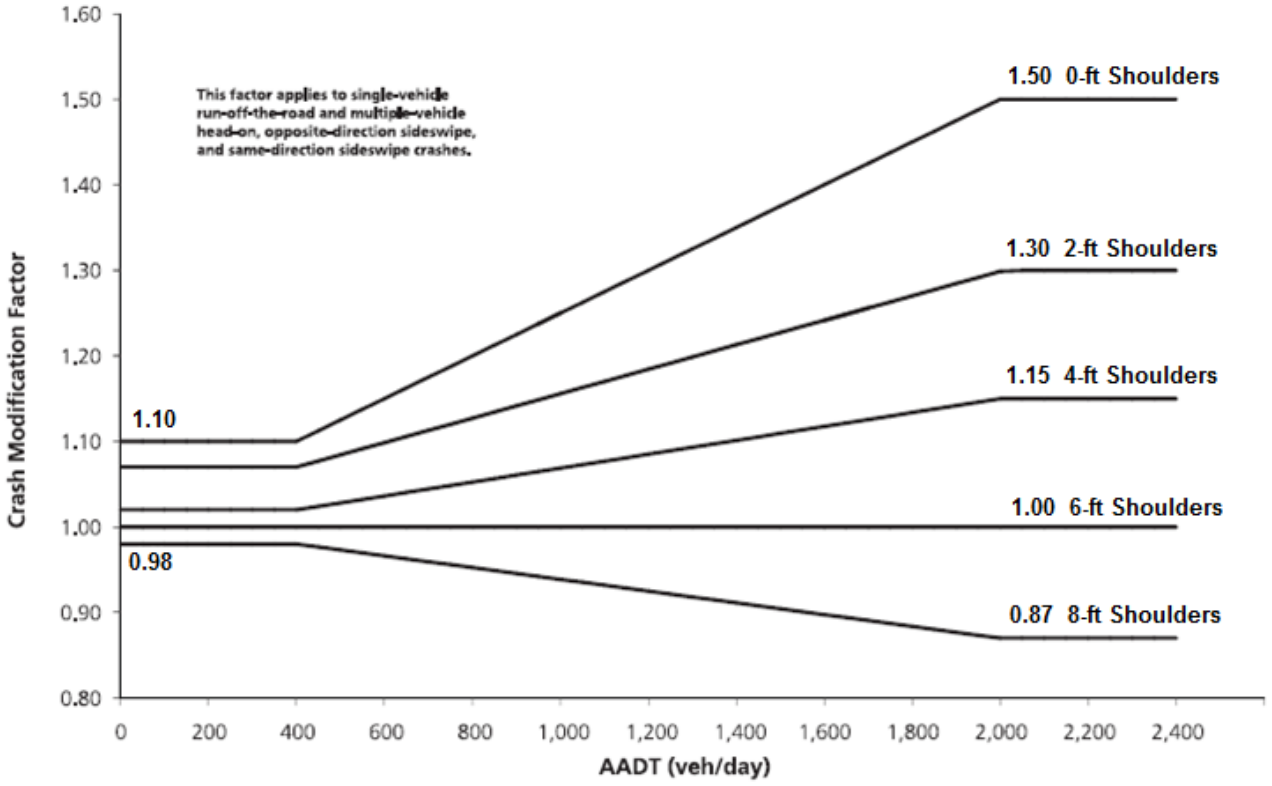


Figure 10-8. Crash Modification Factor for Shoulder Width on Roadway Segments

Reduce Edge Drop

- **AAA Study (2006) suggests drop off becomes problematic between 2.25 and 2.5 inches.**
- **Matches well with typical 2 inch maintenance thresholds**
- **May be a relationship below this height but not detected in this study**

Safety Edge$_{SM}$

- Consolidating the pavement edge into 30° shape during paving to provide stability for vehicles recovering from a roadway departure
- CMF = 0.94 for total crashes (HSIS Report)
- B/C range: 4 to 63
- Implement as a standard practice for paving and resurfacing projects

Increased Edge Compaction

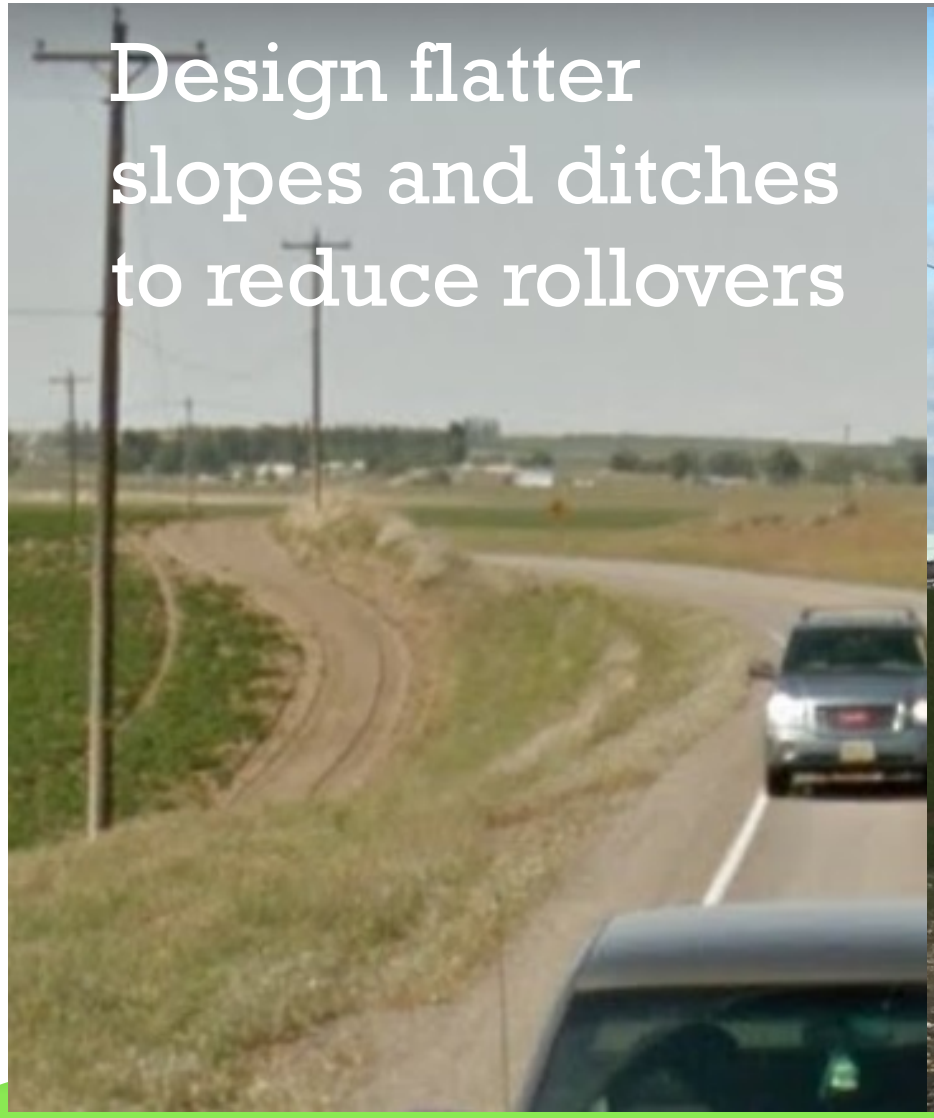
With Safety Edge$_{SM}$

Without Safety Edge

After Shoulder is Pulled Back

Flattening Slopes

Design flatter slopes and ditches to reduce rollovers



Roadside Slopes (RDG, 2011)

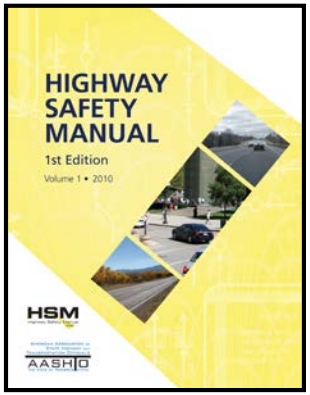
- **Foreslope, Backslope, Transverse Slope, & Drainage Channels**
- **Parallel Foreslope Definitions**
  - **Recoverable: 1V:4H or flatter (generally stop or slow and return)**
  - **Non-Recoverable: Between 1V:3H and 1V:4H (traversable, but most can not stop or return easily)**
  - **Critical: Steeper than 1V:3H (likelihood of overturn)**

Table 13-18. Potential Crash Effects on Total Crashes of Flattening Sideslopes (15)

Treatment	Setting (Road Type)	Traffic Volume	Crash Type (Severity)
Flatten Sideslopes	Rural (Two-lane road)	Unspecified	All types (Unspecified)

Base Condition: Existing sideslope in *before* condition.

NOTE: Standard error of the CMF is unknown.



CMF

Sideslope in Before Condition	Sideslope in After Condition			
	1V:4H	1V:5H	1V:6H	1V:7H
1V:2H	0.94	0.91	0.88	0.85
1V:3H	0.95	0.92	0.89	0.85
1V:4H		0.97	0.93	0.89
1V:5H			0.97	0.92
1V:6H				0.95

Always Consider What's at the Bottom of the Slope

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Drainage Features

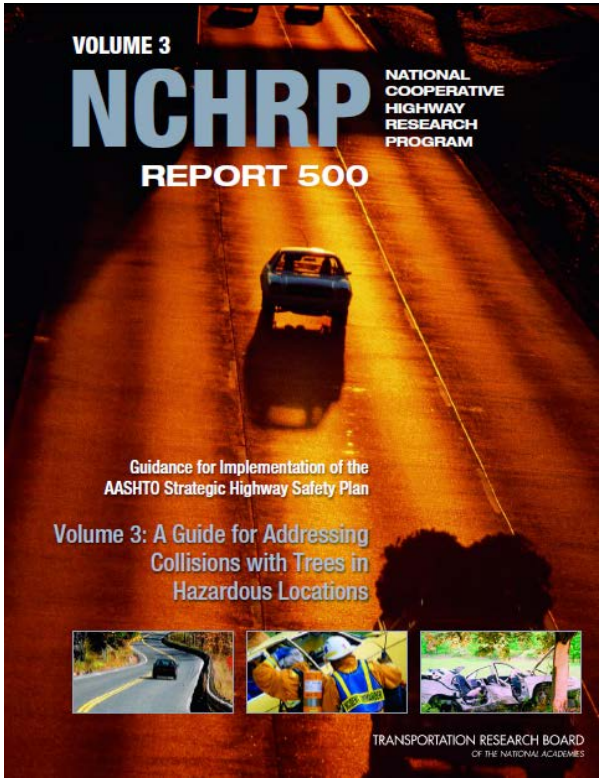
Cross drainage features

Parallel drainage features

Make them Traversable (See RDG, 2011 for details)

Tree Strategies

- Avoid Placing Trees in High Risk Locations
- Remove Trees in High Risk Locations
- Shield Motorists from striking Trees in high risk locations
- Delineate Trees in High Risk Locations



High Risk Locations

- Close to travelled way
- Outside of curves
- On non-recoverable slopes

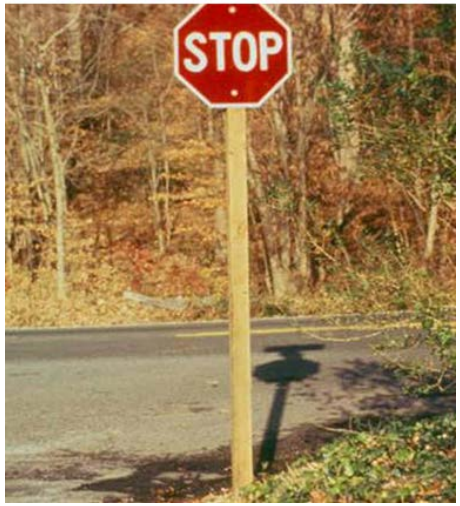
Don’t forget the stumps

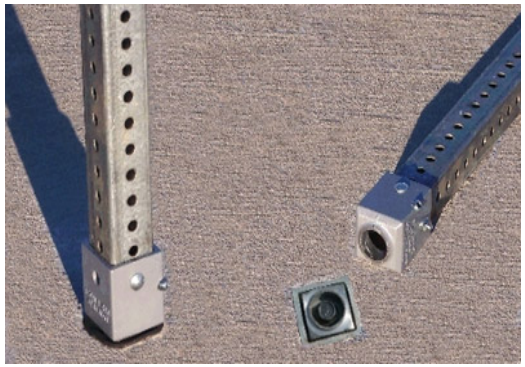
Some Resources

- NCHRP 500 Volume 3: A Guide for Addressing Collisions with Trees in Hazardous Locations
- Noteworthy Practices: Roadside Tree and Utility Pole Management (2016)
- Highway Safety and Trees: The Delicate Balance (Video and brochure)

Mailboxes

Sign Supports





Breakaway sign supports, mailboxes and delineators that have a FHWA Eligibility Letter are on the FHWA Office of Safety website

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FHWA

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Roadway Departure Objectives

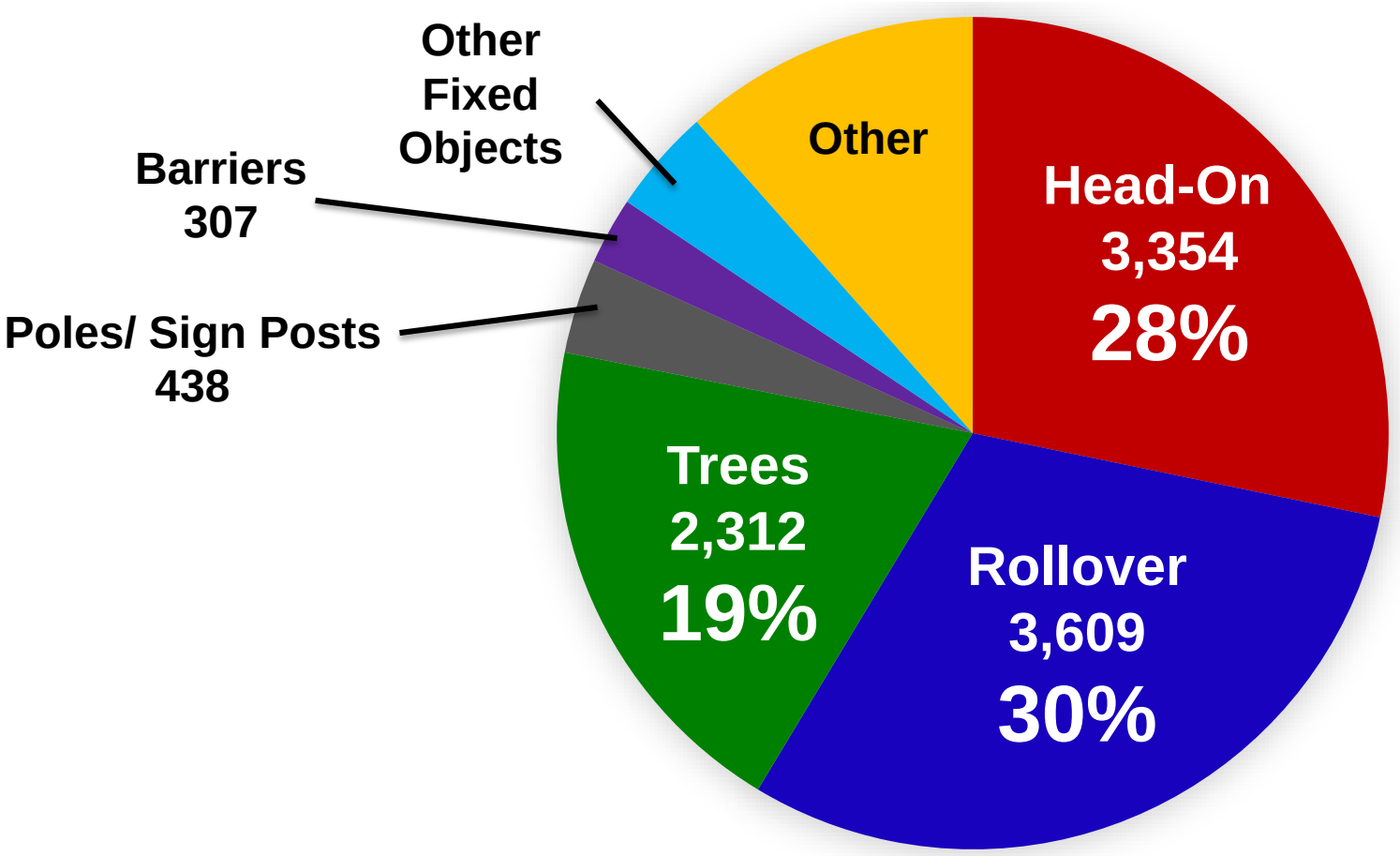
1st - Keep vehicles on the road

2nd - Reduce the potential for crashes

3rd - Minimize the severity

Rural RwD Fatalities by Most Harmful Event

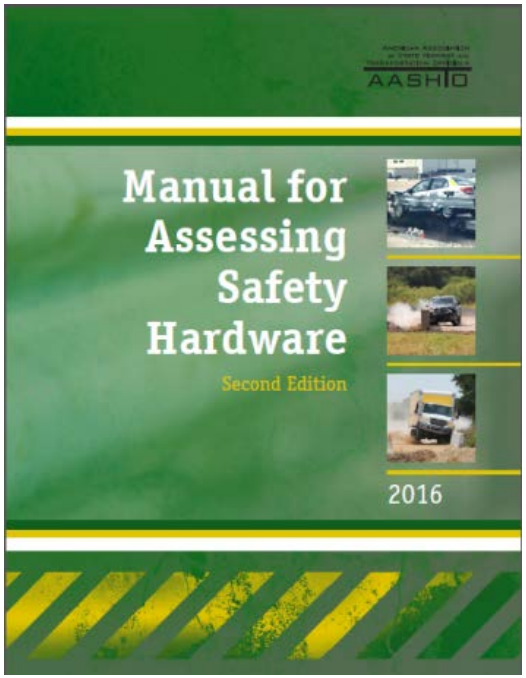
(FARS 2014-2016 - average annual)



Roadside Hardware

Crashworthy Roadside Safety Hardware

- Barriers
- Terminals & Crash Cushions
- Breakaway Sign Posts
- Work Zone Devices



3rd - Minimize the severity

MASH Overview

- Specifies tests for roadside hardware devices
- Worst Practical Conditions
- Includes 6 unique Test Levels for longitudinal barriers
- Test matrices for terminals, crash cushions, sign supports, and work zone devices

Test Vehicles

Majority of hardware tested with 2 passenger vehicles:

- 2420 # Small Car
- 5000 # Pick-up Truck

Test Vehicles

TL-4

22000 lb - SU Truck

TL-5

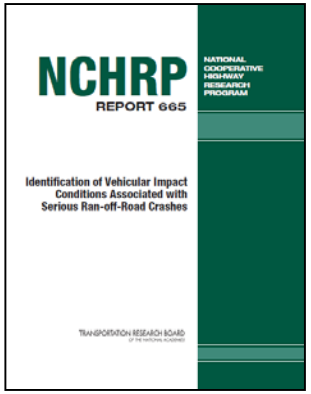
80,000 lb Tractor-Trailer

TL-6

80,000 lb Bulk Fluid Tanker

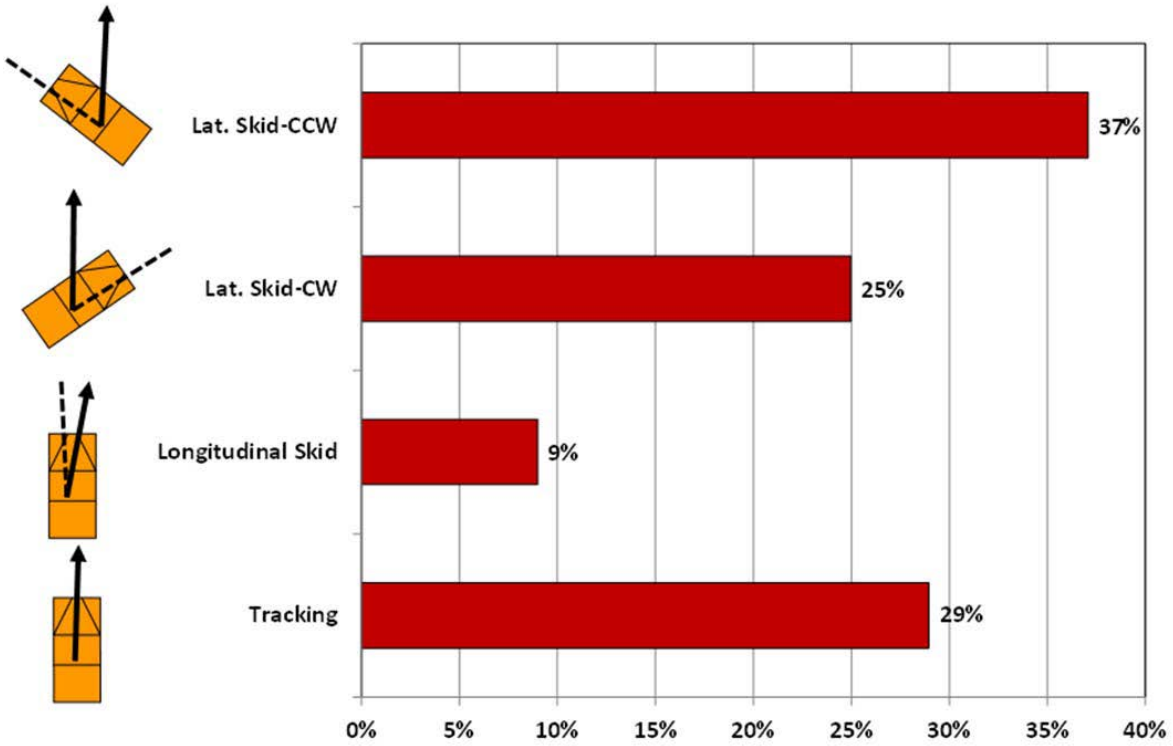
Test Levels

TEST LEVEL	*Vehicle*	*IMPACT SPEED*
TL-1	**Car, PU**	**31 MPH**
TL-2	**Car, PU**	**44 MPH**
TL-3	**Car, PU**	**62 MPH**
TL-4	**TL3 + 22,000# SU**	**56 mph**
TL-5	**TL3 + 80,000# Semi**	**50 mph**
TL-6	**TL3 + 80,000# Tanker**	**50 mph**



Limitations of Crash Testing

- Vehicle may impact device differently (speed, angle, not tracking)



Source: NCHRP 17-22

Limitations of Crash Testing

- Vehicle size, weight, center of gravity may vary

VS

Limitations of Crash Testing

- Site conditions may vary (slopes, curbs, grade, curve, soil conditions)
- Device may be installed differently

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2016 MASH Implementation Plan

Existing Hardware

- Agencies are urged to establish a process to replace existing highway safety hardware that has not been successfully tested to NCHRP Report 350 or later criteria.
- Agencies are encouraged to upgrade existing highway safety hardware to comply with the 2016 edition of MASH either when it becomes damaged beyond repair, or when an individual agency's policies require an upgrade to the safety hardware.

https://design.transportation.org/mash-implementation/

2016 MASH Implementation Plan

New Installations

- Utilization of MASH 2016-compliant hardware will be required on new permanent installations and full replacements for projects on the **NHS** let after the dates below:
  - **December 31, 2017:** W-beam barrier and cast-in-place concrete barrier
  - **June 30, 2018:** W-beam terminals
  - **December 31, 2018:** Cable barrier, cable barrier terminals, and crash cushions
  - **December 31, 2019:** Bridge rails, transitions, all other longitudinal barriers (including portable barriers installed permanently), all other terminals (W-beam & others), sign supports, and all other breakaway hardware

https://design.transportation.org/mash-implementation/

2016 MASH Implementation Plan

What is included in the December 31, 2017, sunset date in the AASHTO/FHWA Joint Implementation Agreement?

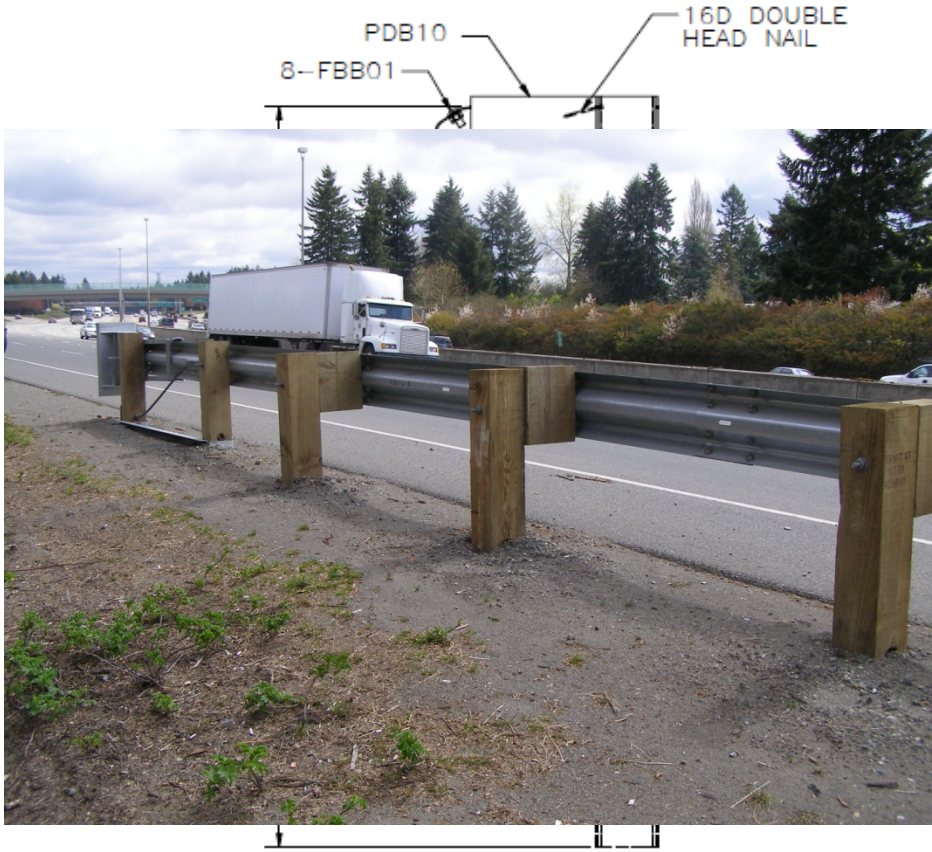
…This sunset date is intended to cover standard installations. Special applications of these devices, such as barriers utilizing reduced post spacing, barriers installed on a flare, barriers mounted behind curbs, and barriers located at bridge ends in restricted areas, are included in the December 31, 2019, sunset date for “transitions" and "all other longitudinal barriers."

https://design.transportation.org/mash-implementation/

Midwest Guardrail System (MGS)

MGS uses

- Same w-beam rail
- Same 6’ posts
- Top Rail height = 31”
- 12” deep blockout
- Rail Splices between posts



Eligibility Letter B-133 & 212

MGSMASH Video

Midwest Guardrail System (MGS)

The MGS has been tested to MASH:

- with steel and wood posts
- with 12” & 8” blocks, and a couple designs have also been tested with no blocks
- with long spans (leaving out up to 3 posts)
- In front of 2:1 slopes
- with curbs

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Concrete Barriers

Shapes tested

- Safety Shaped
  - New Jersey Shape
  - F-Shape
- Single Slope
- Vertical Wall

MASH NJ Concrete Barriers Video

Barriers for Large Trucks

- TL3 – Passenger Vehicles (Car and PU)
  - 32” based on NJ shape testing
- TL4 – Single Unit Truck (22,000#)
  - 36” based on Single Slope testing
- TL5 Tractor Trailer (80,000#)
  - 42” based on Vertical Wall testing

Note – No national criteria for when to use TL-4, 5, or 6

MASH Implementation
Guardrail Terminals

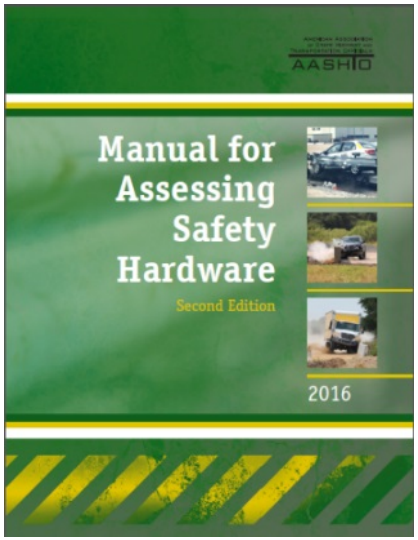
What is included in the June 30, 2018, sunset date in the AASHTO/FHWA Joint Implementation Agreement?

- …This sunset date covers tangent terminals. Other applications, such as double-sided or median terminals, flared terminals, and terminals installed on a flare, are included in the December 31, 2019, sunset date for “all other terminals.”

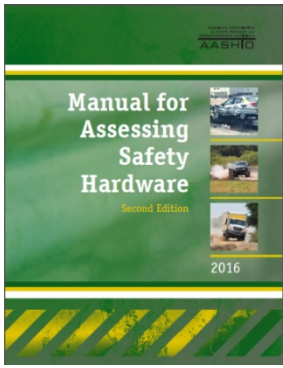
https://design.transportation.org/mash-implementation/

MASH Tangent Terminals

- Soft Stop
- MSKT
- Max-Tension



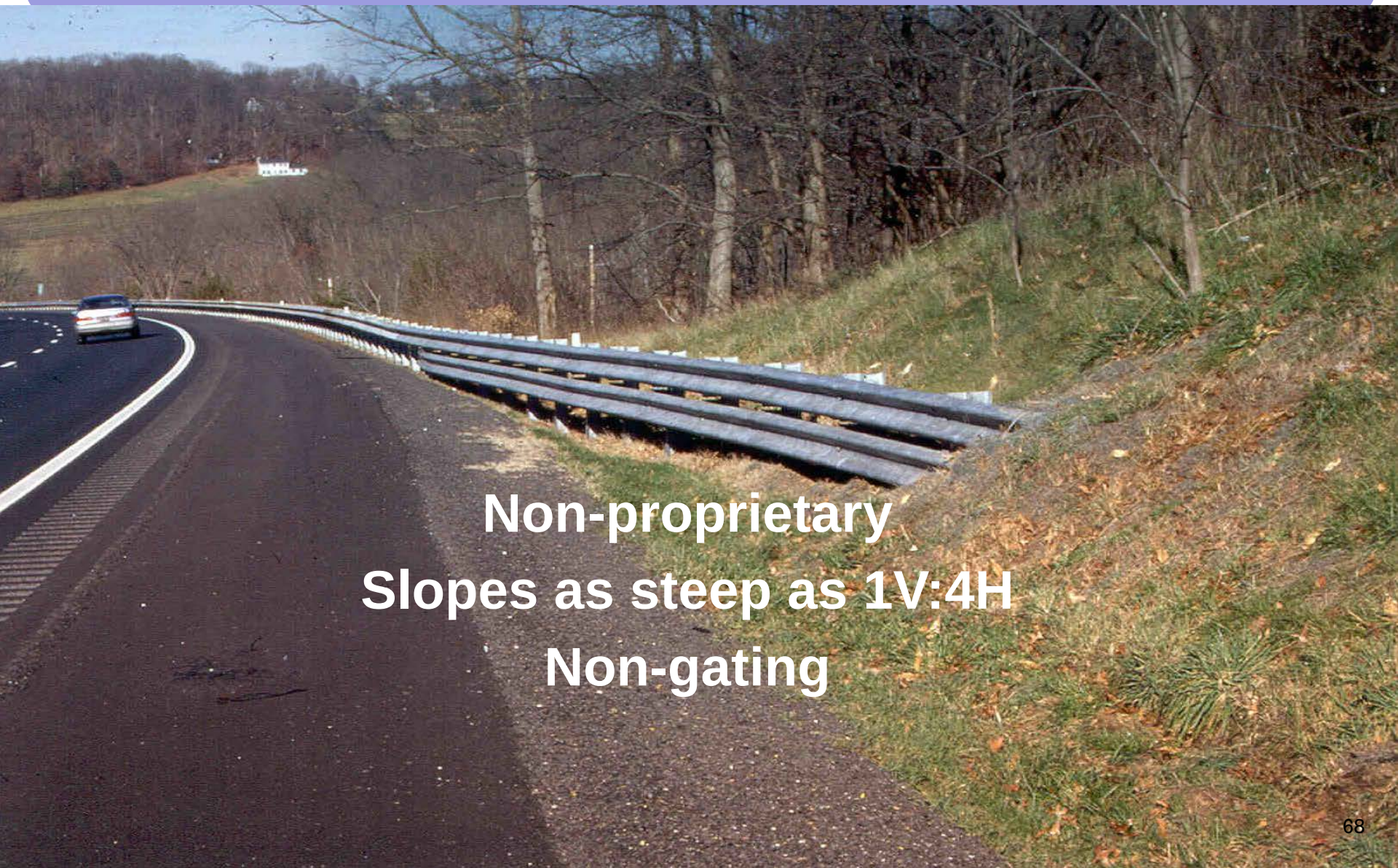
Flared Terminal



Note: While the SRT M10 has been issued a MASH eligibility letter, the manufacturer is not producing this design. The SRT 350 is still available.

Eligibility Letters CC-140

Buried-In-Backslope



Non-proprietary

Slopes as steep as 1V:4H

Non-gating

MASH Implementation
Cable Barriers and Crash Cushions

What is included in the December 31, 2018, sunset date in the AASHTO/FHWA Joint Implementation Agreement?

- The AASHTO/FHWA Joint Implementation Agreement is amended for contracts on the National Highway System such that new permanent installations and full replacements of cable barriers and cable barrier terminals must be MASH 2016-compliant by the December 31, 2019, sunset date for "all other longitudinal barriers" and "all other terminals." New permanent installations and full replacements of crash cushions will still require compliance with MASH 2016 by December 31, 2018.

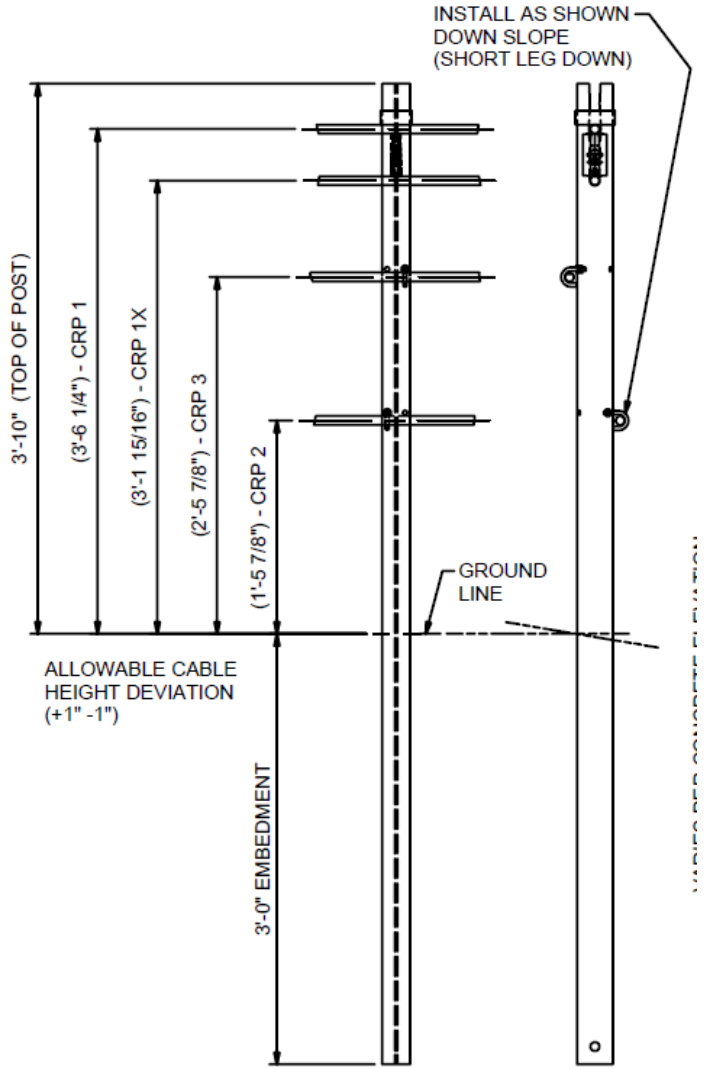
https://design.transportation.org/mash-implementation/

Cable Barrier

Cable systems tested to MASH 2009

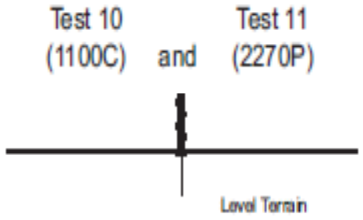
https://design.transportation.org/mash-implementation/

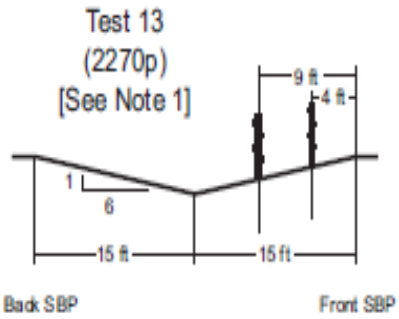
Greater Range in Cable Heights Provides More Flexibility

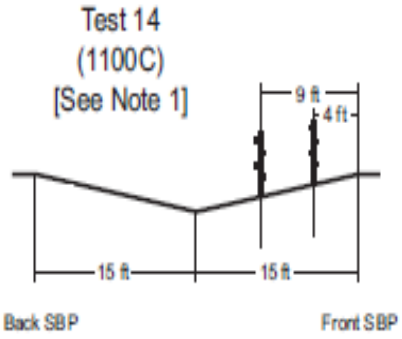


Eligibility Letter B-232

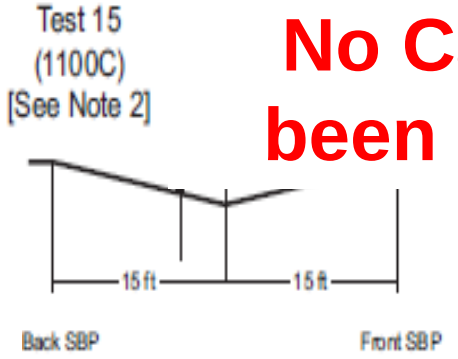
MASH 2016
Tests for Cable Median Barrier

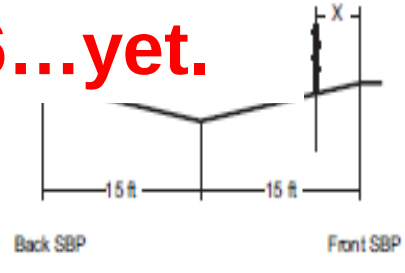


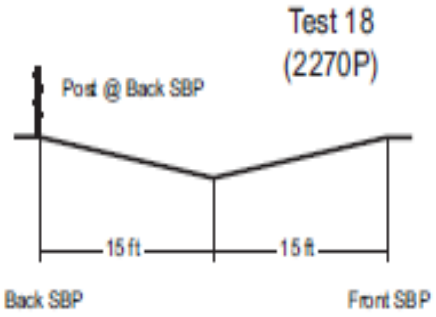




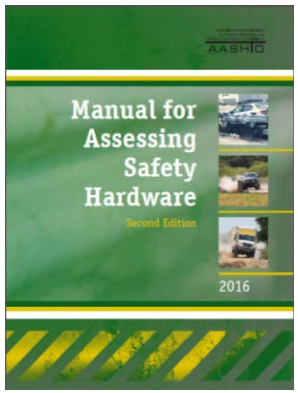
No Cable Median Barriers have been tested to MASH 2016…yet.







The most significant changes in the 2nd edition of MASH is for testing of cable medain barrier



Crash Cushions

- Utilization of MASH 2016-compliant Crash Cushions will be required on new permanent installations and full replacements for projects let after **December 31, 2018**

Crash Cushions tested to MASH:

- QuadGuard
- SCI
- TrafFix Big Sandy Sand Barrels

Note – no significant difference in MASH 2016

Bridge Rails

Several Tested to MASH

- Concrete (same shapes as rigid barriers)
- Steel
- Combination (concrete parapet with metal rail)

Bridge Rails

NCHRP 20-07 (Task 395) MASH Equivalency of NCHRP Report 350-Approved Bridge Railings

- Assessed 22 Bridge rails for
  - stability
  - rail geometrics
  - strength
- Found 12 to be satisfactory

Table 4.32 List of Similar or Less Critical Rails.

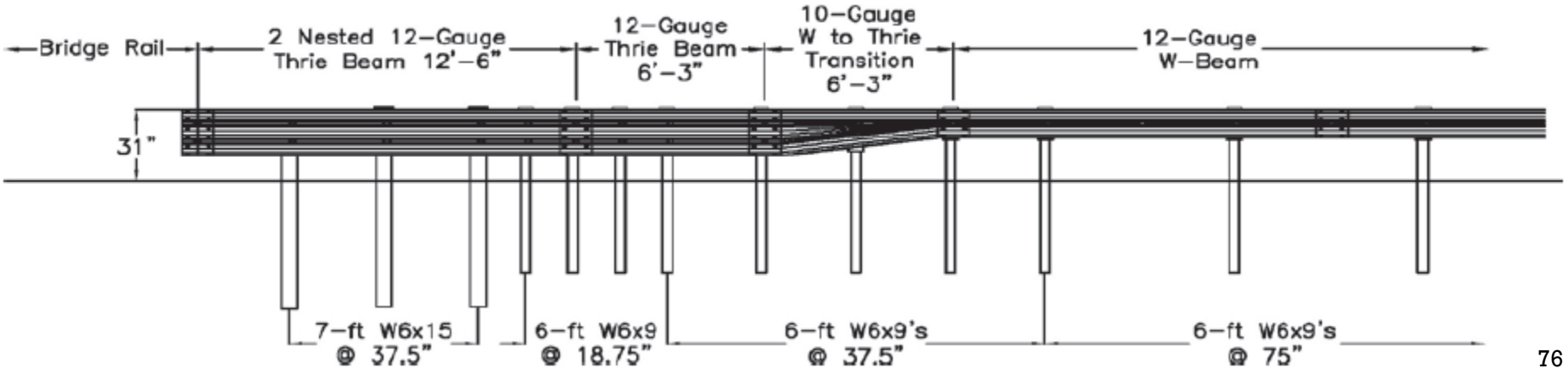
System Name	MASH Equivalency Assessment	Similar or Less Critical Rails
Alaska Multi-State Bridge Rail -32.5" (AK)	Satisfactory TL-3	Alaska Multi State Bridge Rail (ND) Two-Tube Bridge Rail (Federal Lands) 2-Tube Curb Mount Rail (OR) PA Type 10M Bridge Barrier (PA) Type 10M (CO)
S-352series, Bridge Railing, Galvanized Steel Tubing /Concrete Combination (VT)	Satisfactory TL-4	PS-1 (IN) Bridge Railing, Aesthetic Parapet Tube (MI) Bridge Sidewalk Railing with Concrete Barrier (OH)
Type A42 Metal Bridge Railing (NM)	Satisfactory TL-4	N/A
Bridge railing, Aesthetic Parapet Tube (B-25-J) (MI)	Satisfactory TL-4	S-352 Galvanized Steel Tubing Concrete Combination Rail (VT)
Concrete Parapet with Structural Tubing STD-11-1 (TN)	Satisfactory TL-3	C402 (TX)
42" F-Shape (WV)	Satisfactory TL-5	42" F-Shape (PA, VA, OK, MD, MA)
45" F-Shape (IN)	Satisfactory TL-5	N/A
32" F-Shape (WV)	Satisfactory TL-3	32" F-Shape (PA, VA, LA, OR, MA, ME, FL, WS, TX)
42" F-Shape (ME)	Satisfactory TL-4	42" F-Shape (FL, WS)
42" Single Slope (WV)	Satisfactory TL-4	42" Single Slope (PA, VA, LA, OK, MD, MA)
36" Single Slope (TX)	Satisfactory TL-4	36" Single Slope (TN)

NCHRP 22-35 Evaluation of Bridge Rail Systems to Confirm AASHTO MASH Compliance (on-going)

Transitions

Several Designs Tested

- TL2
- TL3 (shown)
- TL3 with curb



Portable Concrete Barriers

Several Designs Tested

- Free Standing
- Stiffened
- Anchored

Sign Supports

Tested Designs

- Flanged U-Channel Post
- Multiple Wood supports
- Steel supports with slip base

2016 MASH Implementation Plan

Work Zone

- Temporary work zone devices, including portable barriers, manufactured after December 31, 2019, must have been successfully tested to the 2016 edition of MASH. Such devices manufactured on or before this date, and successfully tested to NCHRP Report 350 or the 2009 edition of MASH, may continue to be used throughout their normal service lives.

https://design.transportation.org/mash-implementation/

Work Zone Devices

This Category includes:

- Temporary Sign Supports
- Barricades
- Barriers

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Roadside Safety Pooled Fund

https://www.roadsidepooledfund.org/mash-implementation/search/

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- Implementation Dates
- General Information
- Research Needs List
- Testing Needs List
- FHWA MASH Implementation Agreement Q&A

Hardware Tested

The information provided in this database is for reference only. It is the responsibility of the user/designer to verify that the selected system meets current Federal eligibility and safety requirements. To filter available hardware devices, select the type of device, test level, eligibility letter, and if the device is proprietary/non-proprietary. If there are options available for the device selected they will appear to the right. Results are displayed below and can be selected for more information.

Device Types: -Guardrails

Test Level: 3

FHWA Eligibility Letter: Yes

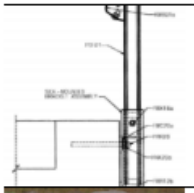
Proprietary/Non-proprietary: All

Guardrail Options

Rail Type: ☐ Box-Beam ☐ Thrie Beam ☑ W-Beam

Post Material: ☐ Steel ☐ Wood ☐ Wood and Steel

Blockout Type: ☐ Composite ☐ Steel ☐ Wood ☐ None

	Title	Description	Proprietary/ Non proprietary	FHWA Eligibility Letter
	Side-Mounted Weak-Post Guardrail Attached to Culvert	It is an adaptation of the weak-post MGS bridge rail that allows for attachment to the outside face of the culvert headwalls.	Non-proprietary	B-264
	Non-Blocked Steel-Post MGS for Wire-Faced, MSE Walls	31" tall non-blocked steel-post MGS. For use on wire-faced, MSE walls	Non-proprietary	B243A

Directing Your Questions via the Chat Pod

1. Chat pod is on left side of screen between attendees pod & closed caption pod

3. Answers will appear here unless addressed verbally

2. Type your question or comment here

Learning Outcomes

In this webinar, you have learned to:

- Define clear zone, it's basis, and limitations
- Describe critical, traversable, and recoverable slopes
- List some methods to reduce the potential to crash when a vehicle leaves the roadway
- Identify the criteria for determining the crashworthiness of roadside hardware
- Describe the implementation plan for MASH
- Identify hardware that has been tested to MASH

SC Upcoming 2018 Webinars

- Framework for Bikeway Designation on Rural Roads

  Jan. 31st, 11:00 AM to 12:30 PM Mountain

RRwD Archived Webinars

- EDC5 Reducing Rural Roadway Departures Webinar

https://connectdot.connectsolutions.com/p19821 15wf44/?proto=true

- Rural Roadway Departure Countermeasures – Part 1 and Part 2

https://ruralsafetycenter.org/training-education/safety-center-trainings/archived-safety-center-trainings/

Reducing Rural Roadway Departures

https://www.fhwa.dot.gov/innovation/everydaycounts/edc_5/roadway_departures.cfm

Contact Information

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Dick Albin - Dick.Albin@dot.gov

Or contact the National Center for Rural Road Safety Help Desk at:

(844) 330-2200 or info@ruralsafetycenter.org

http://ruralsafetycenter.org/