

Low Cost Road Safety

Adam Larsen

Tribal Coordinator

Federal Highway Administration

360-619-7751

Adam.Larsen@DOT.gov



Crash
Data

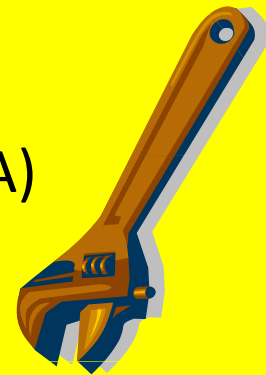


Strategic Highway Safety Plans
(SHSP)



Safety Efforts

- Countermeasures
- Education Campaigns
- Road Safety Audits (RSA)
- Targeted Enforcement
- EMS improvements
- etc...



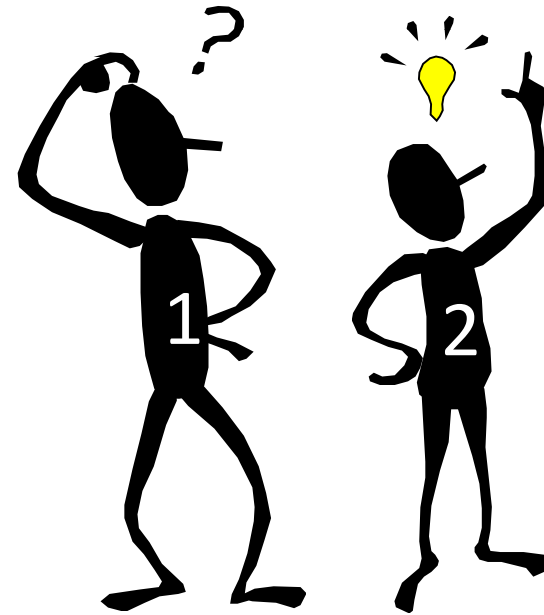
PROBLEM IDENTIFICATION



Do Not
Assume

WARNING: DO NOT Assume!

1. First ID Problems & Risks
2. Then, develop solutions



For each safety issue, the audit team may provide suggestions or possible solutions to reduce collision frequency and/or severity.

Suggestions should be:

- address the safety issue

- appropriate for stage of audit

- appropriate for all road users

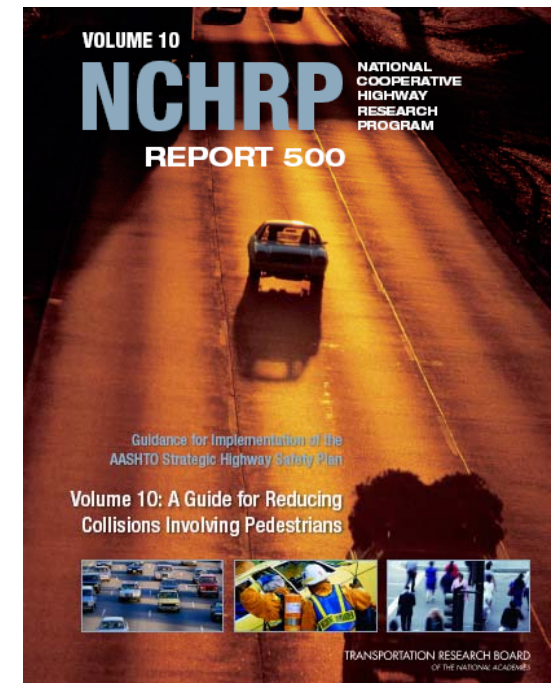
- may range between low and high cost

Crash Reduction Factor (CRF):

Represent the quantitative results from research studies, indicating the percentage reduction in crashes that can be expected after implementation of the treatment

The following slides show low cost countermeasures with CRFs

- AASHTO Roadside Design Guide
- CRFWarehouse.org
- NCHRP 500 Series
- Highway Safety Manual

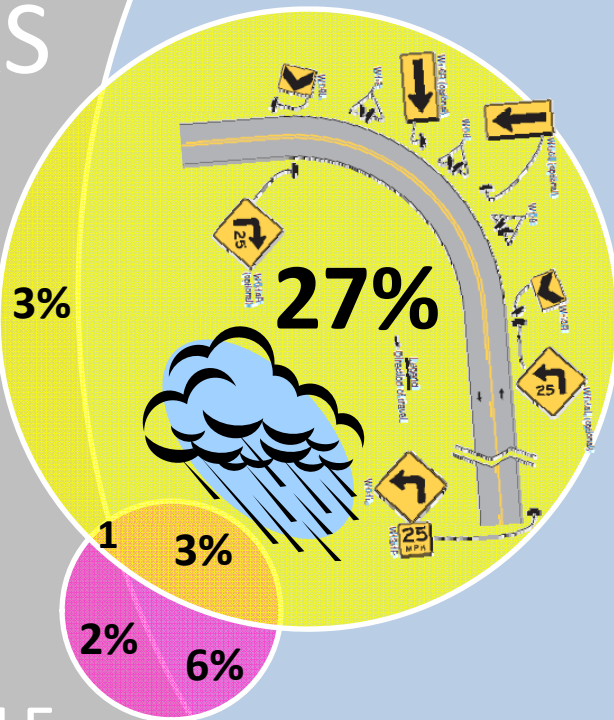


CRASH CAUSE FACTORS

HUMAN
93%

57%

ROAD
34%



VEHICLE
12%



- 1/2 at night
- 2/3 on 2-lane rural roads

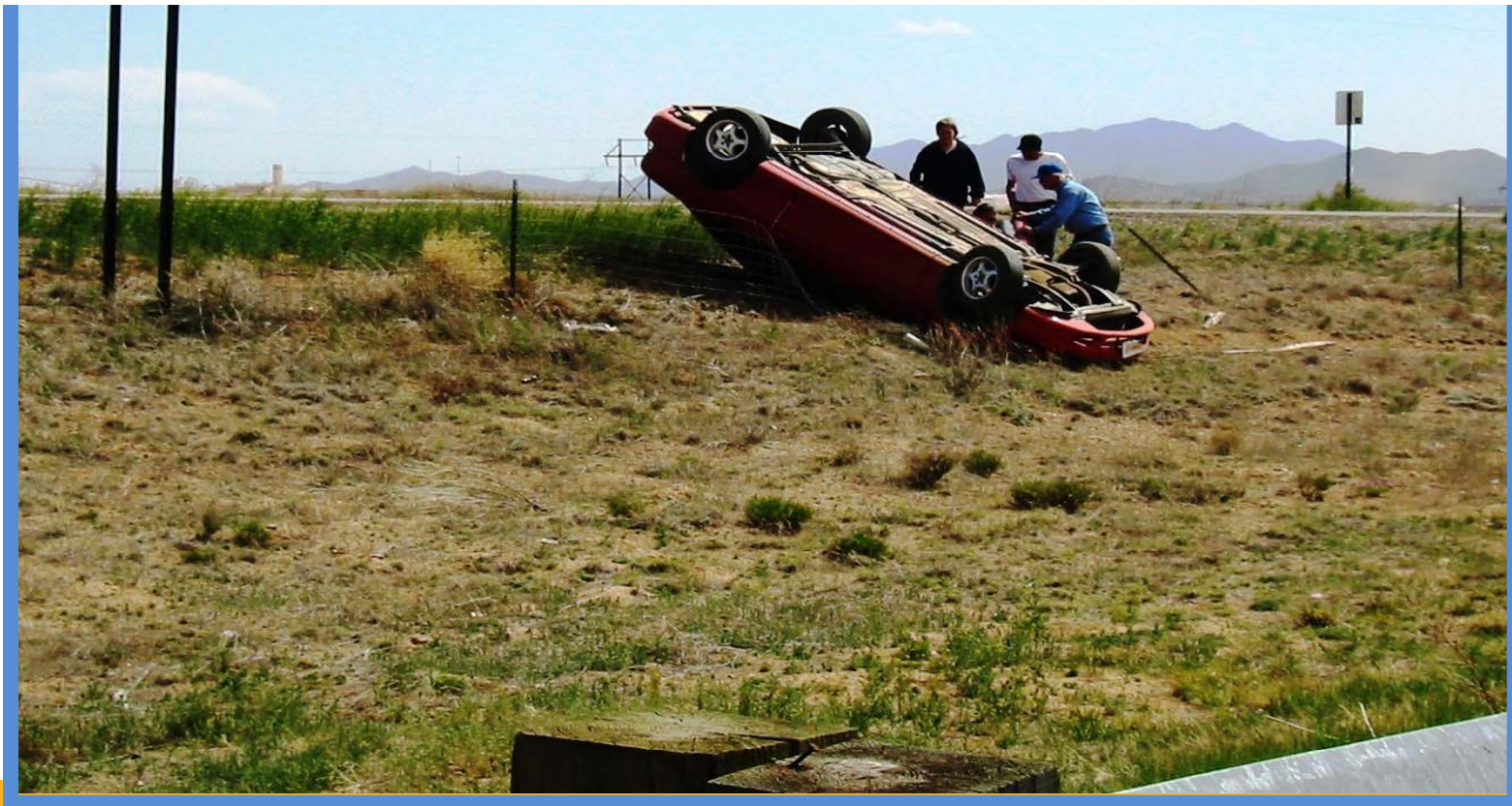
Fatal Crash Types



% of Total Fatal Crashes

Lane Departure Crash –

A non-intersection crash in which a vehicle leaves the travel lane to the left or right.



An aerial, high-angle photograph of a two-lane asphalt road winding through a green, grassy field. A red car is driving away from the viewer in the upper lane, and a white car is driving towards the viewer in the lower lane. The text 'vidman.ca' is overlaid in the bottom left corner.

vidman.ca

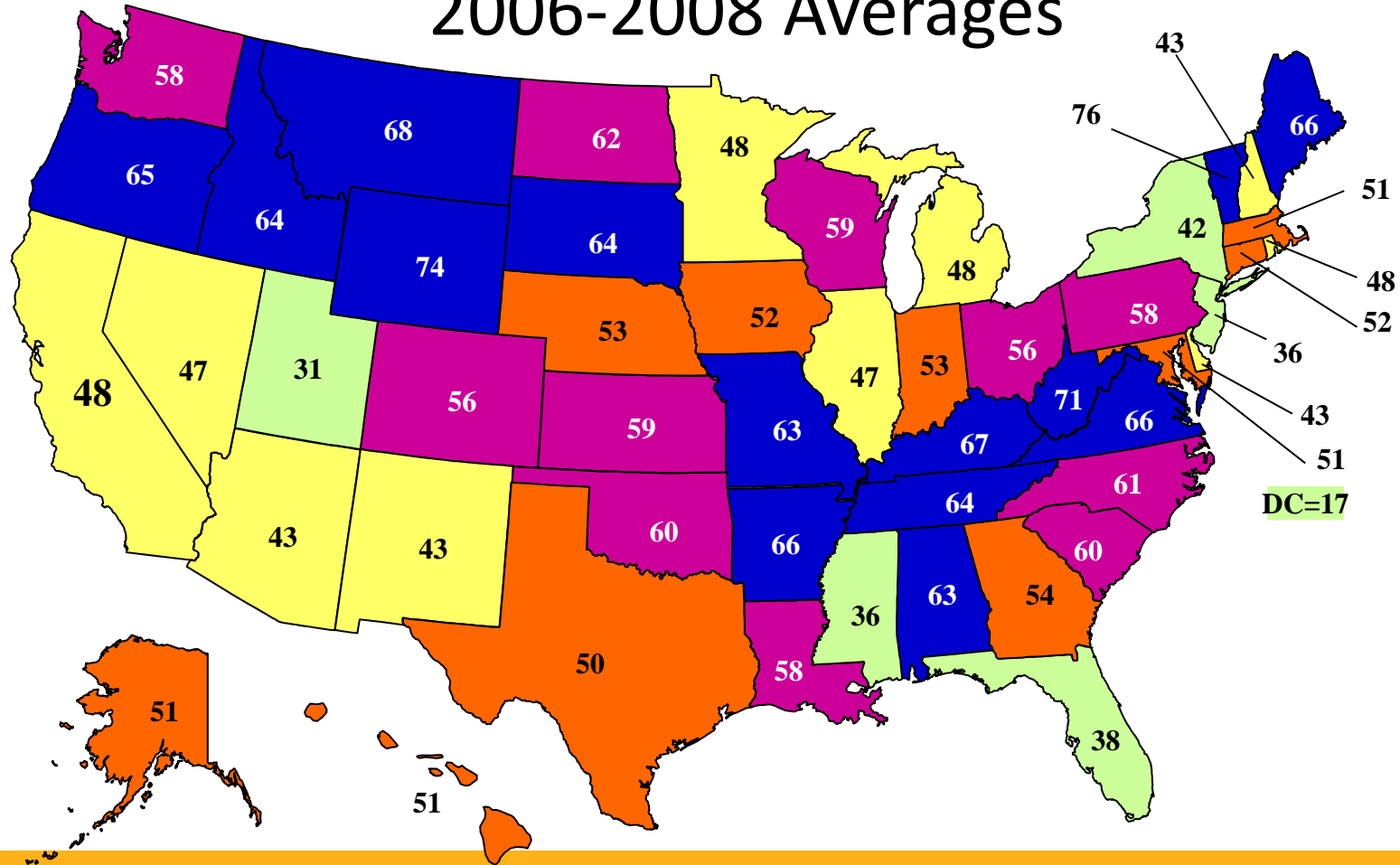
Lane Departure

- 53% of all Road Fatalities Nationwide
- 48% in California



Roadway Departure Percent of Fatal Crashes

2006-2008 Averages



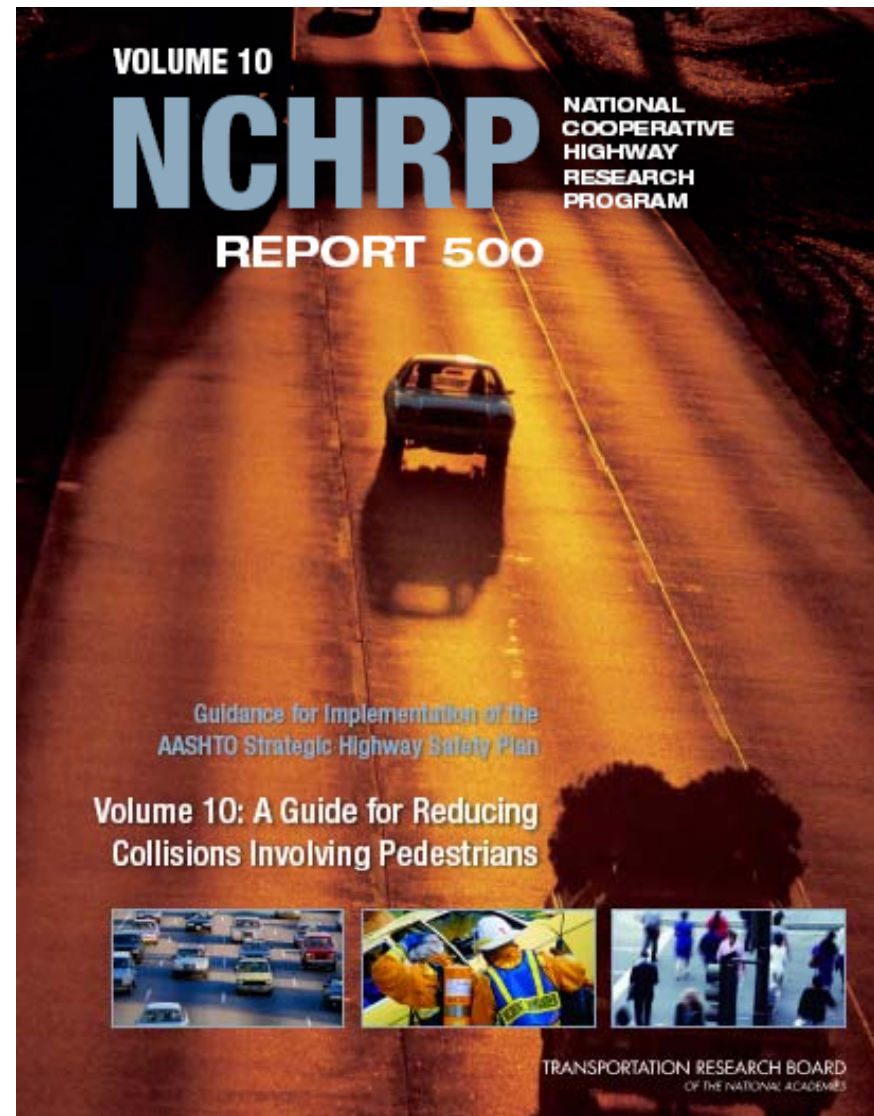
Why do drivers leave the road?

- **Road Condition**
- **Collision Avoidance**
- **Vehicle Component Failure**
- **Driver Error**
- **Driver Impairment**
- **Human Factors Violations**



NCHRP 500 Volume 6

Guide for Addressing Run-Off-Road Collisions



Addressing Risk Factors

Enforcement/Education
actions to keep vehicles
on roadway:

- Change driver behavior
(DUI, speeding, fatigue, distractions)
- Spot enforcement
- Targeted education efforts



Addressing Risk Factors

- **Engineering Strategies for Road Departure**
- **Keep on Road**
- **Lessen Severity After Departure**



Keep Vehicles on Road – Higher Cost

- High friction overlays
- Wider travel lanes
- Paved shoulders
- Provide new super elevation

- Oil & Chip Gravel Roads
- Widen shoulders
- Flatten curves (increase radius)
- Maintenance of Superelevation

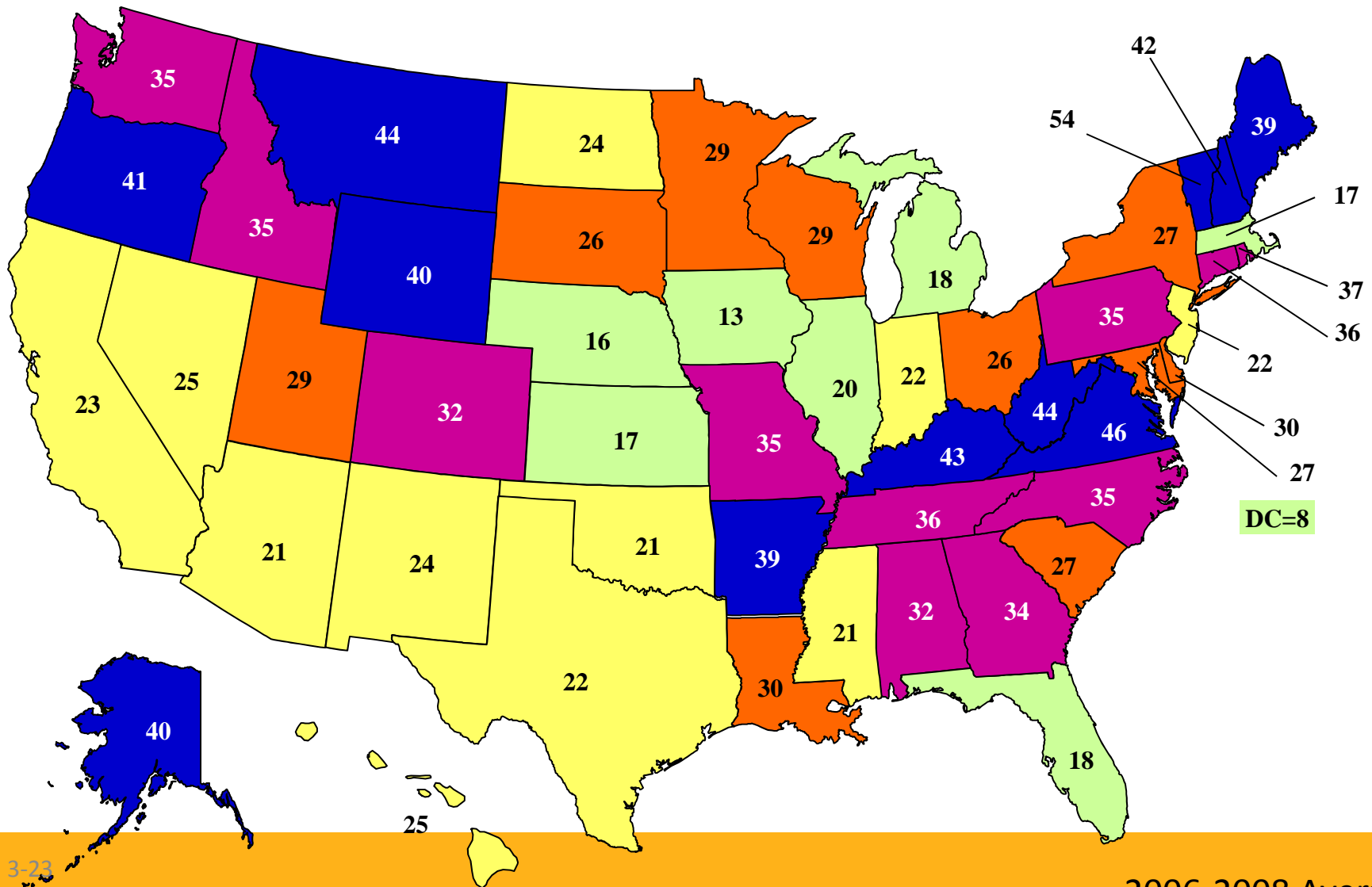


Keep vehicles on Road – Low Cost

- Pavement Markings
- Pavement Rumble Strip(e)s
- Safety Edge

- Signs
- Delineators
- Adequate sight distance for alignment changes
- Curves: delineation, warning, super-elevation
- Clear Zones

Percent Curve Crashes



Friction Treatment



Curve/Hill Combinations

- Combination of vertical/horizontal alignment
- Horizontal curve after miles of tangent

Delineation
Warning Signs
Widening
Realignment

Low Cost: Signs & Delineation



<http://MUTCD.FHWA.DOT.GOV>

2009 MUTCD on Curves

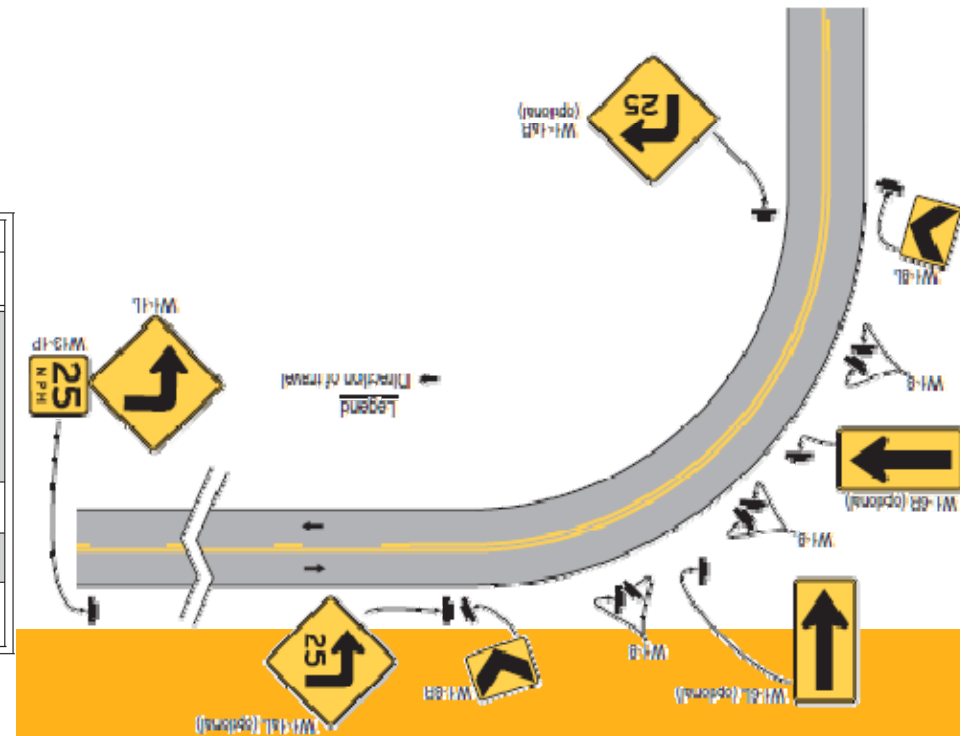
- **Compliance Date 12/31/2019**
- **2009 MUTCD Table 2C-5**
- **Not required for roads with <400 ADT**

Table 2C-5. Horizontal Alignment Sign Selection

Type of Horizontal Alignment Sign	Difference Between Speed Limit and Advisory Speed				
	5 mph	10 mph	15 mph	20 mph	25 mph or more
Turn (W1-1), Curve (W1-2), Reverse Turn (W1-3), Reverse Curve (W1-4), Winding Road (W1-5), and Combination Horizontal Alignment/Intersection (W10-1) (see Section 2C.07 to determine which sign to use)	Recommended	Required	Required	Required	Required
Advisory Speed Plaque (W13-1P)	Recommended	Required	Required	Required	Required
Chevrons (W1-8) and/or One Direction Large Arrow (W1-6)	Optional	Recommended	Required	Required	Required
Exit Speed (W13-2) and Ramp Speed (W13-3) on exit ramp	Optional	Optional	Recommended	Required	Required

Note: Required means that the sign and/or plaque shall be used, recommended means that the sign and/or plaque should be used, and optional means that the sign and/or plaque may be used.

See Section 2C.06 for roadways with less than 1,000 ADT.



2009 MUTCD Option for fluorescent colors

- Florescent Yellow Chevrons on high risk curves
- 20% reduction in crashes (Iowa DOT)



Rumble Strips

- Injury crash reduction
 - 18% on rural two-lane highways.
 - 17% on rural multi-lane divided highways.
- Reduction in run-off-road crashes of 38% on freeways.

LANE DEPARTURE



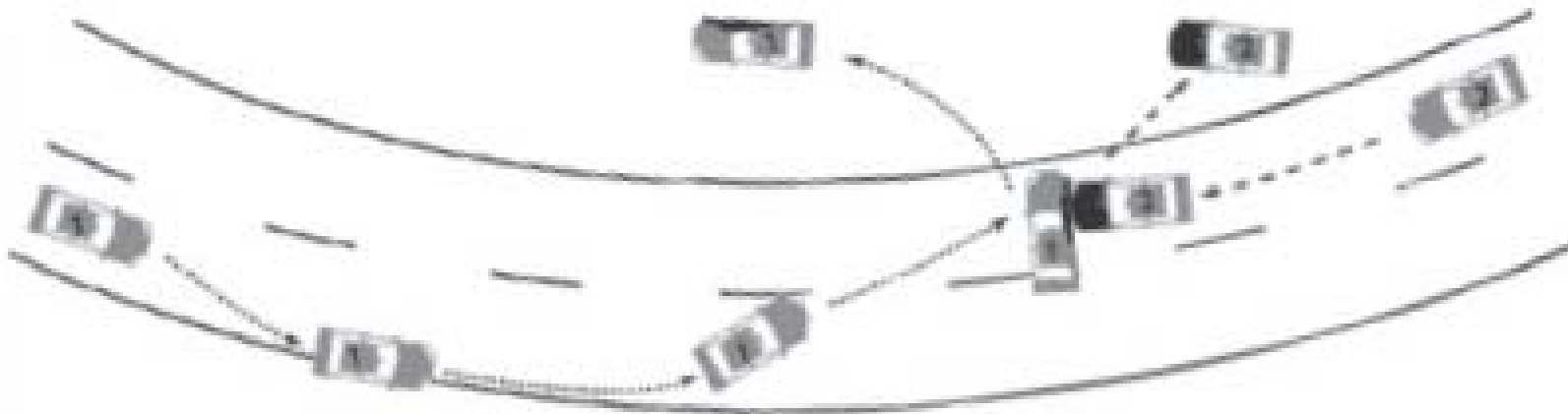
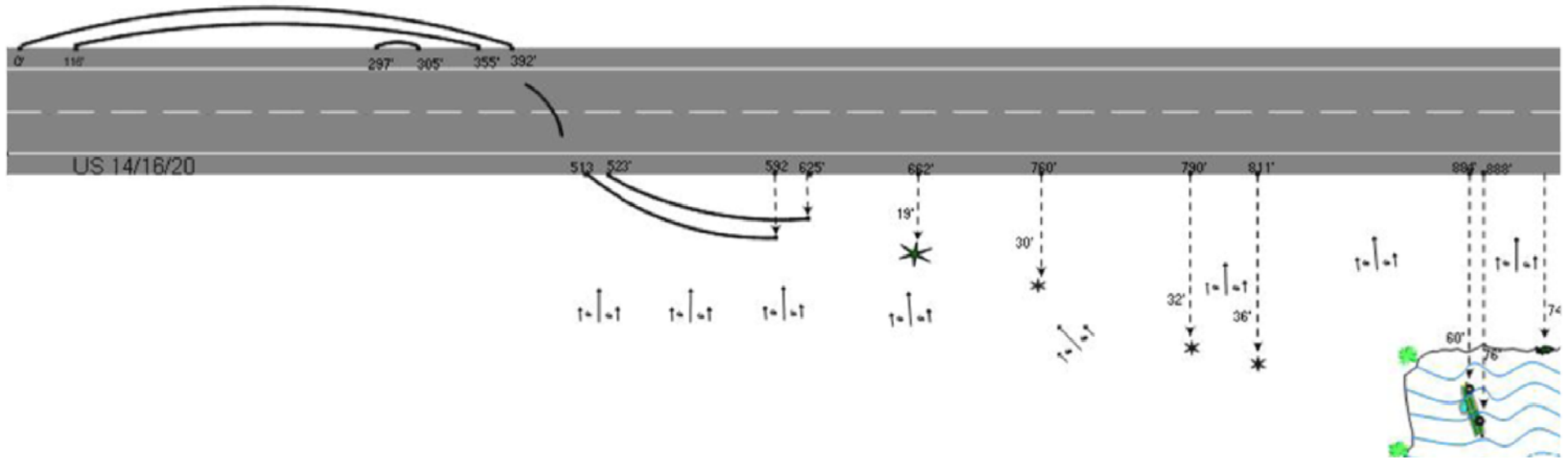
Edge Rumble Stripes



Edge Drop-Off

Safety Edge

Overcorrecting – a fatal mistake



Safety Edge



Safety Edge

- **Saves Lives**
- **Improves Compaction**
- **Reduces Maintenance Expense**
- **Adds Less than 1% to Pavement Resurfacing**



“Safety Edge”



FHWA Loaner Shoe

However, some drivers will still leave the road and...



...the consequences can be severe.

After Departure

Strategy to minimize severity:

Effectiveness

1. Remove / Redesign
2. Relocate Hazards
3. Protect / Reduce Severity
4. Delineate Hazards

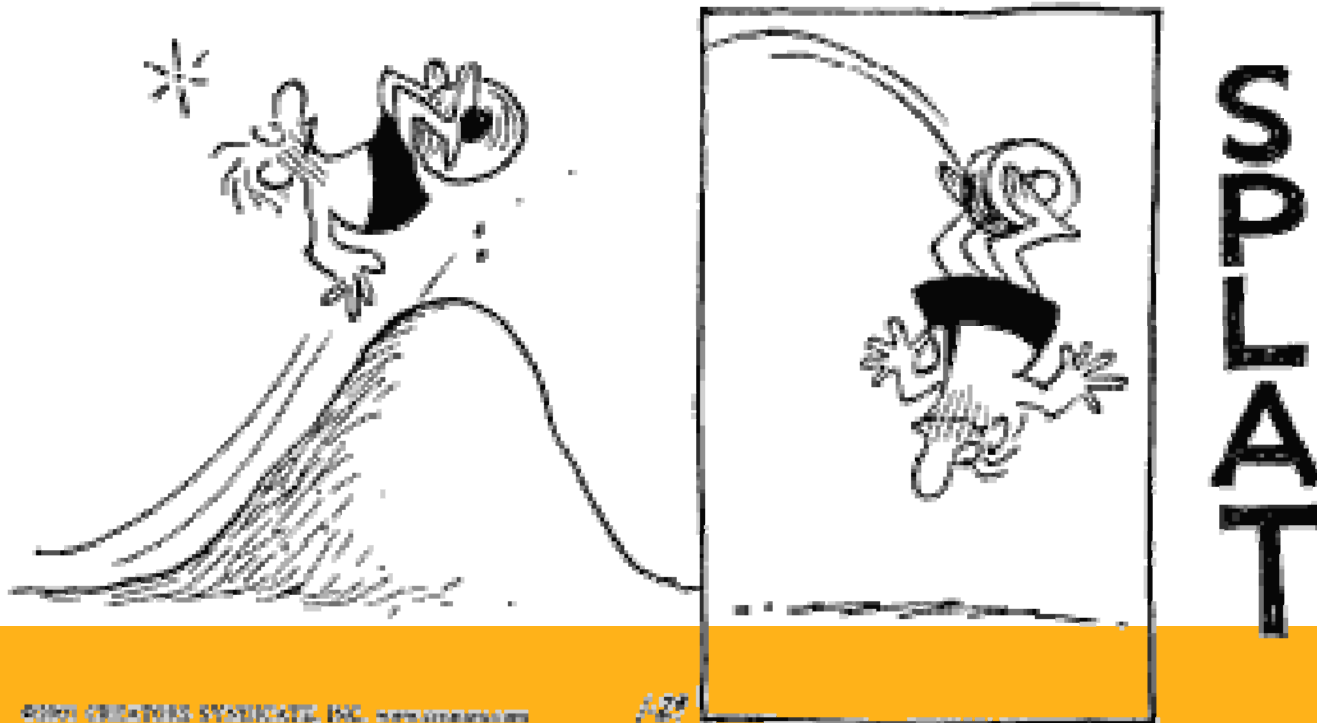


Clear Zone

10 to 35 feet *minimum*
depending on speed and slope.
(See AASHTO Roadside Design Guide)



- **Slopes & Embankments**
 - Recoverable: $\leq 4H:1V$
 - Traversable: $4H:1V$ to $3H:1V$
 - Unrecoverable: $> 3H:1V$



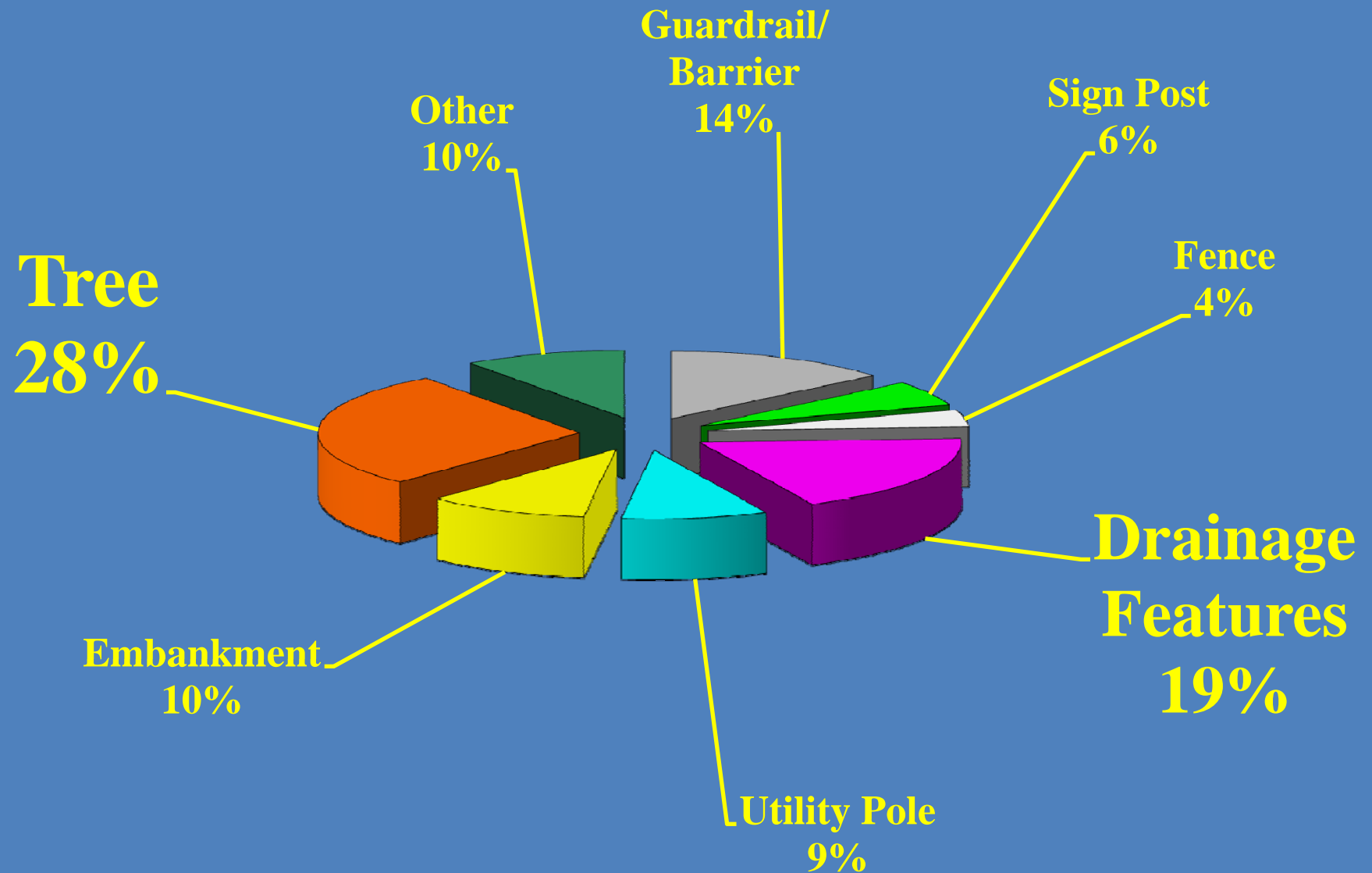
Remove Hazards

- **Fixed Objects**
 - Cattle Grates
 - Trees / Vegetation
 - (>4" diam.)
 - Non-breakaway posts
 - Fences, especially with top rail
 - Non-crashworthy barrier
 - Drainage structures
 - Boulders
 - Monument Mailboxes



40% reduction in Fatal/Inj crashes

Roadside Hazard Fatalities



Crashworthy –

Term to describe device that have passed crash testing standards.



Crash Test Standards –

NCHRP-350

MASH



- Moving hazards out of the “clear zone” lessens the likelihood that they will be involved in a crash.
- Crashes outside the clear zone are likely to be less severe than if the object was right off the shoulder.



Protect / Shield

- Protect objects
 - Slopes
 - Fixed objects

- Grading to lessen severity
 - Drainage structures
 - Crossroads & Driveways



- Crashworthy
 - NCHRP 350
 - MASH
- Deflection
- End Treatments
- Installation Standards



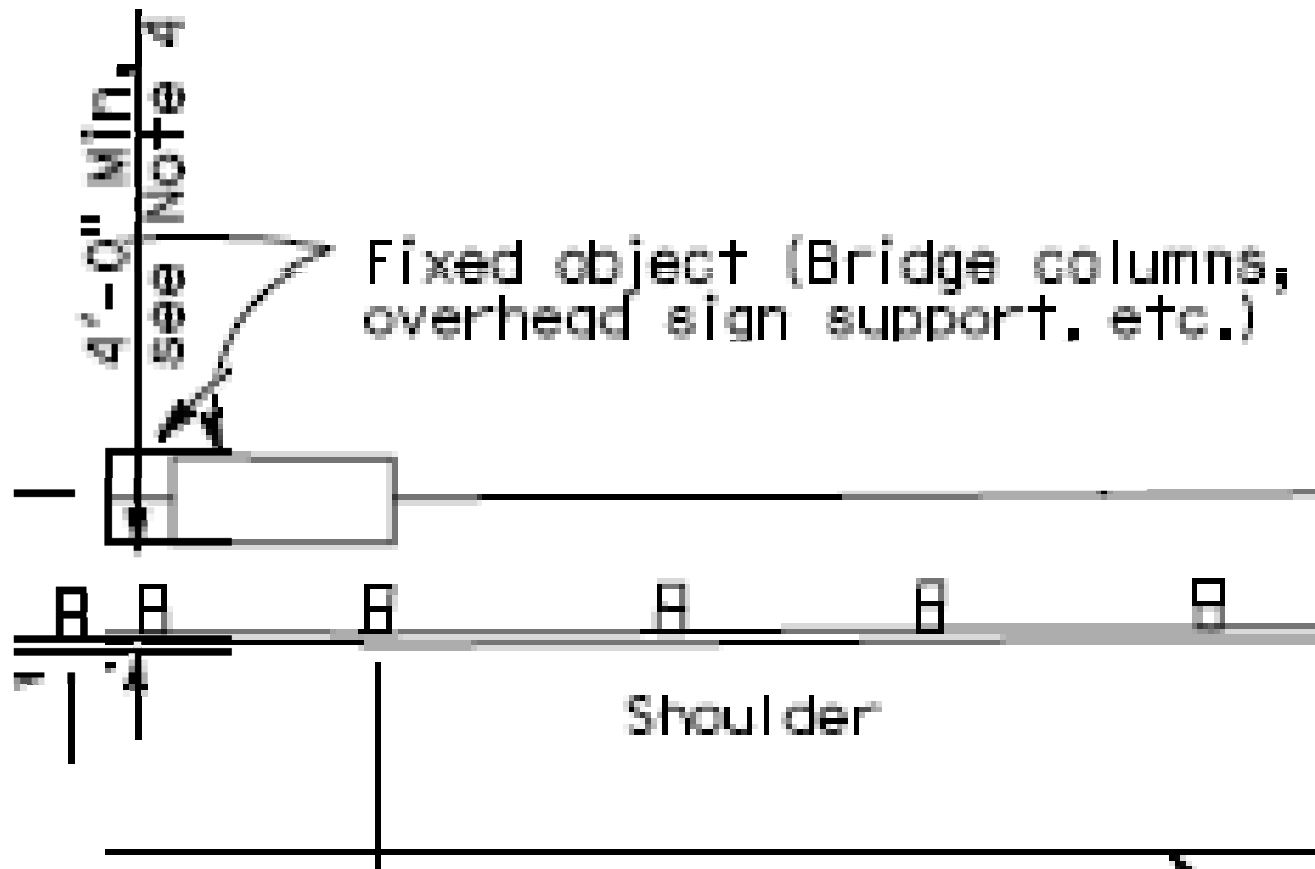
Longitudinal Barriers



TL-3 62 mph 820kg Car; 2000kg Pickup



Guardrail Deflection



Crashworthy End Terminals

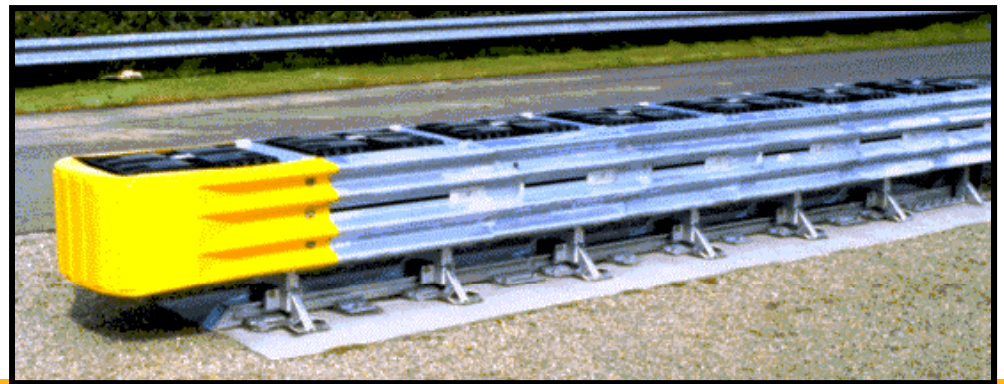
BCT



SAND BARRELS



ADIEM II



QUADGUARD

Dangerous Guardrail Ends

Blunt Ends

Turn Down Terminals

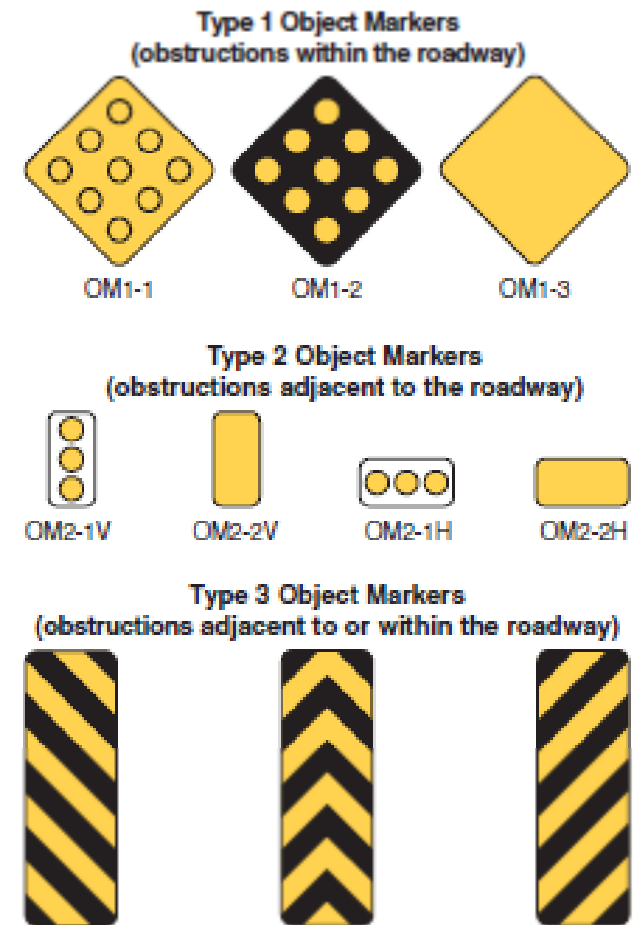


Delineate – Last Resort

- Objects
- Adverse / unexpected alignment
- Non-traversable slopes



Figure 2C-13. Object Markers




Prevent Lane Departure:

- Combat Distracted, Drowsy, Impaired Driving
- Correct Geometric Deficiencies

After Roadway Departure:

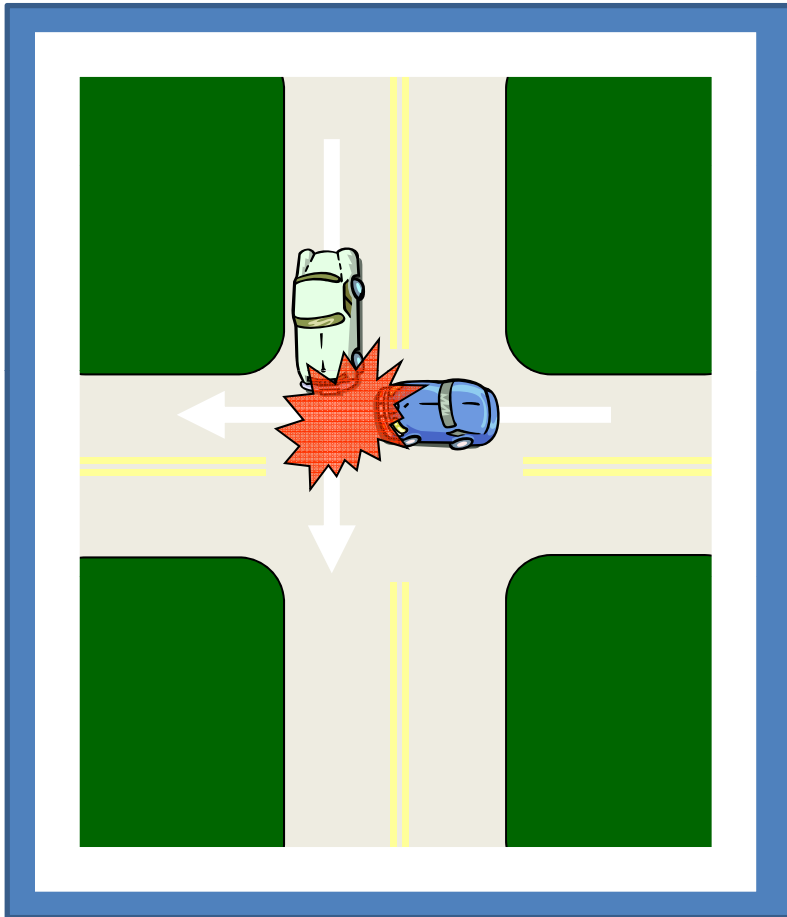
Effectiveness



1. Remove
 2. Relocate
 3. Protect / Shield
 4. Delineate
- 

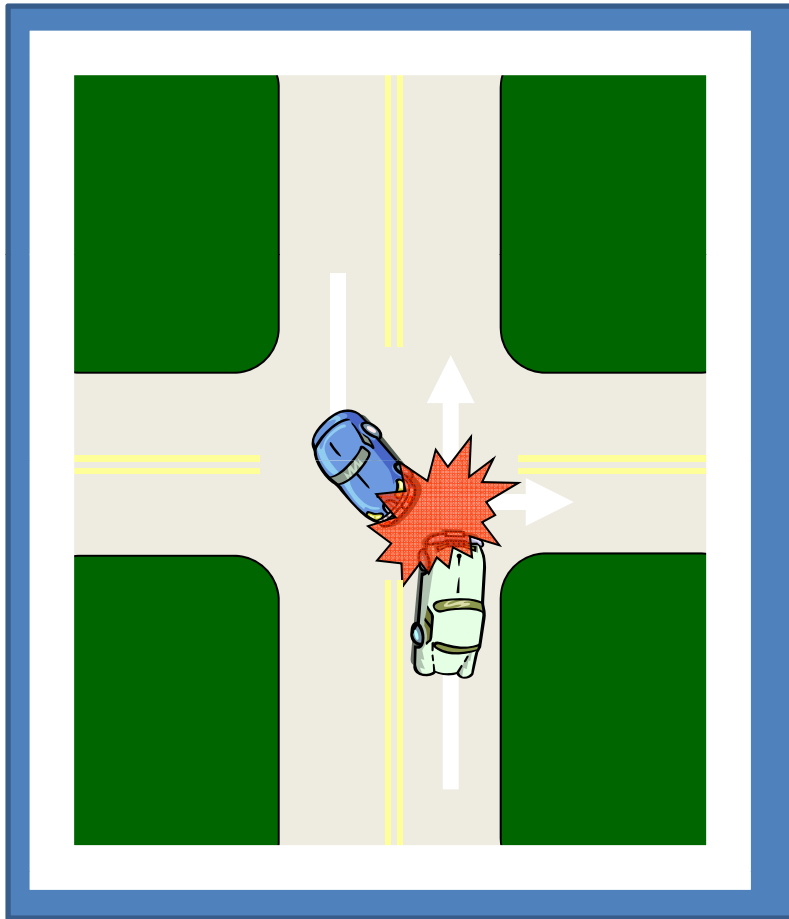


Intersection Safety Facts



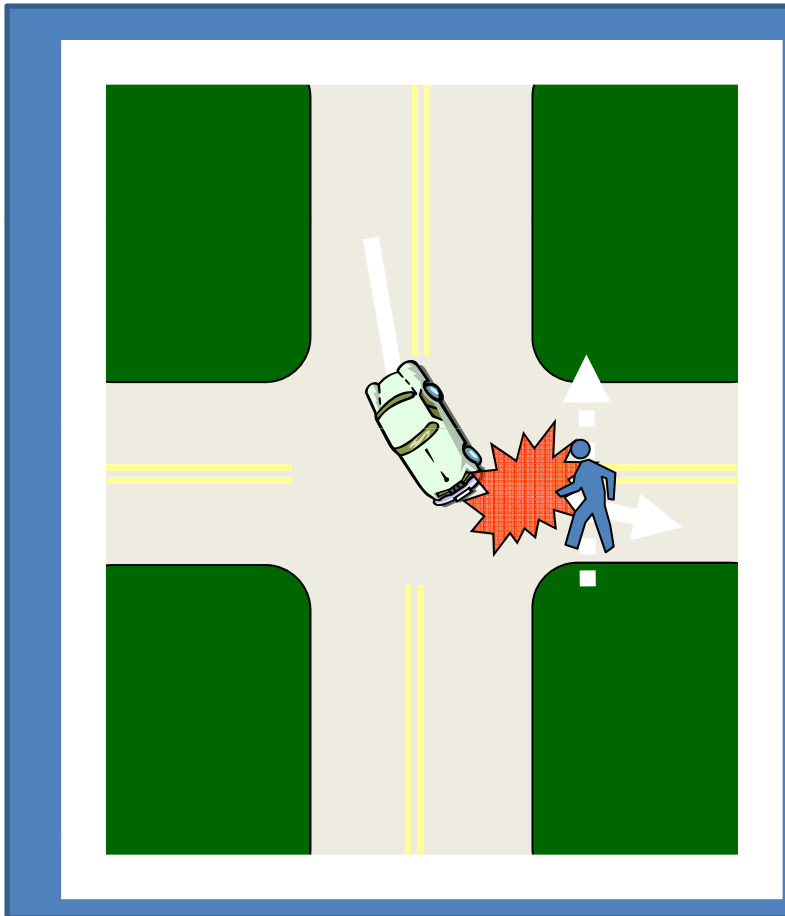
**Angle crashes account
for over 40% of fatal
crashes at
intersections**

Intersection Safety Facts



**Left turn crashes
account for over 20% of
fatal crashes at
intersections**

Intersection Safety Facts



**Ped/Bike crashes
account for 25% of fatal
crashes at signalized
intersections**

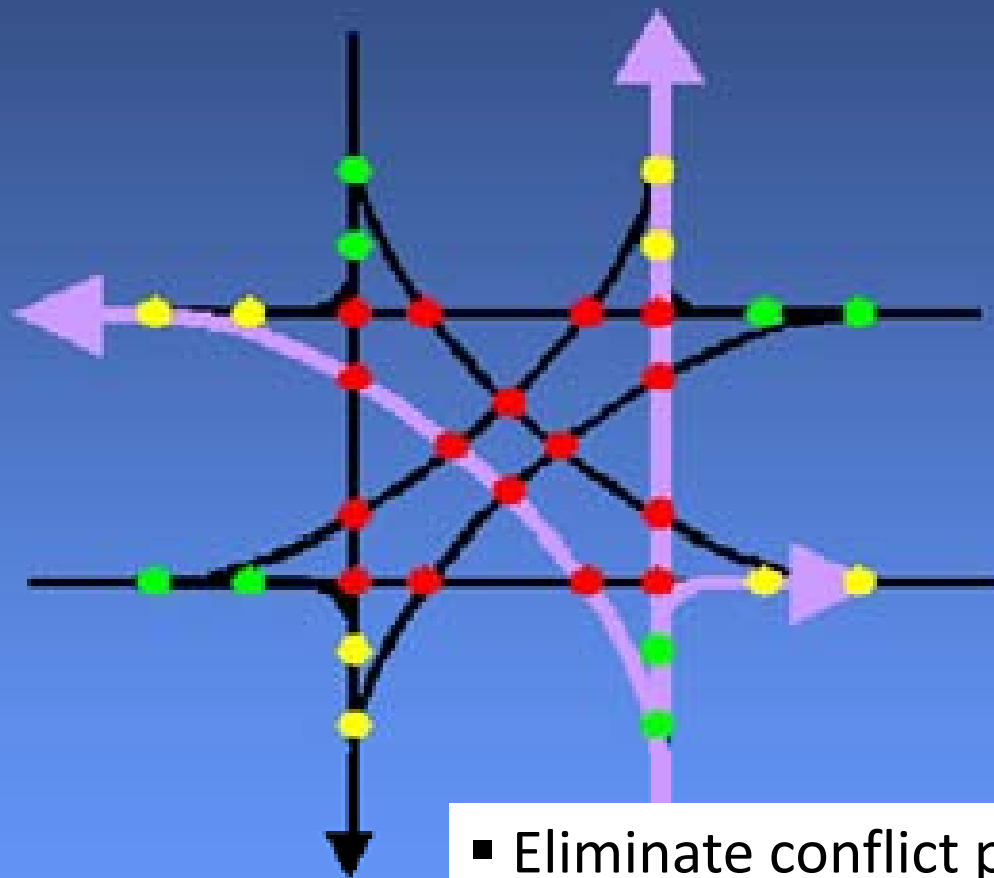
Keys to Intersection Safety

- Manage conflict points
- Adequate sight distance
- Provide advance warning & navigation
- Increase intersection conspicuity
- Minimize road user delay



Intersection Conflict Points

Conventional intersection



Conflict Types

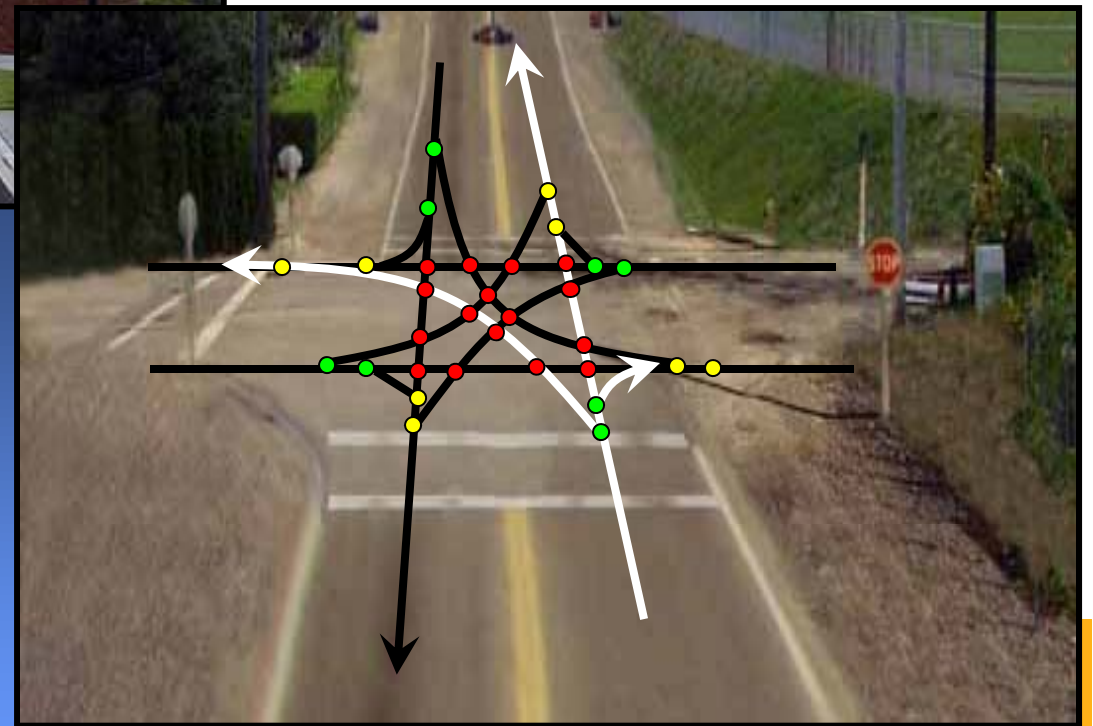
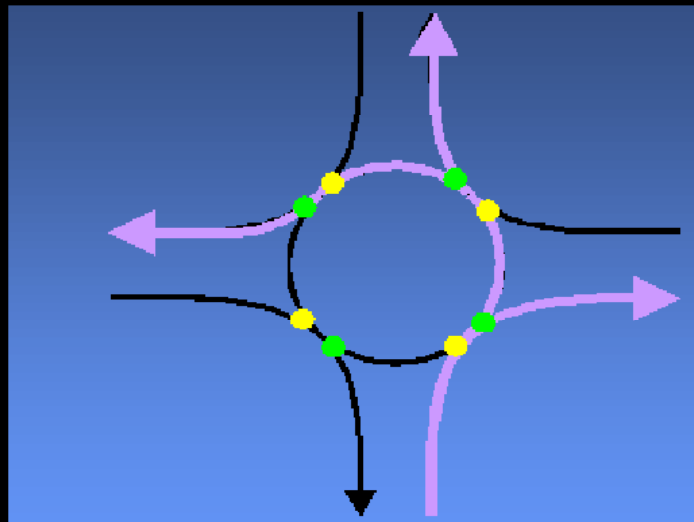
● Diverge:	8
● Merge:	8
● Crossing:	16
<hr/>	
Total:	32

- Eliminate conflict points
- Separate conflicts in space or time
- Control the type/severity of conflict

Conventional vs. Roundabout



Conflict Points:
Conventional Intersection 32
Roundabouts 8



NEW

NCHRP

REPORT 672

**Roundabouts:
An Informational Guide**
Second Edition

TRANSPORTATION RESEARCH BOARD
OF THE NATIONAL ACADEMIES

NATIONAL
COOPERATIVE
HIGHWAY
RESEARCH
PROGRAM

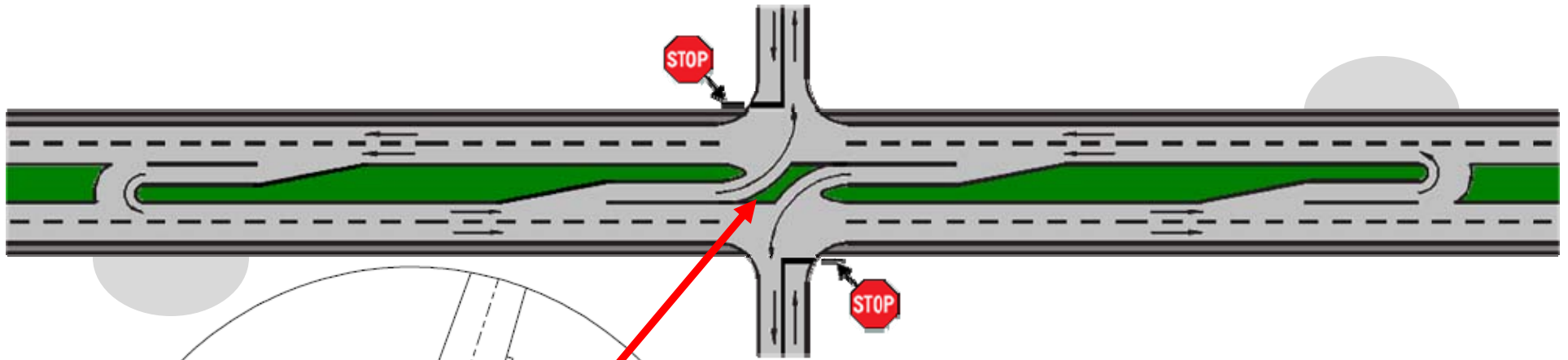
In cooperation with



U.S. Department
of Transportation
Federal Highway
Administration

- ▶ Public Outreach
- ▶ Legal issues
- ▶ Planning
- ▶ Operations
- ▶ Safety
- ▶ Design
- ▶ Construction

J-Turn Intersection



Separate conflicts

Can provide sight distance

Works for large vehicles

Jug Handle Intersection

Separate conflicts

Improves signal operations
by eliminating left turns



Access Control



**MODERATE ACCESS
CONTROL**



**NO ACCESS
CONTROL**

Photo: T. Welch

Consolidate Conflict Points with Access Control.

Improve safety, operations of road.

Install Traffic Signal



Magic Bullet?

Increase

Rear end crashes by 50%

Decrease

Angle crashes by 65%

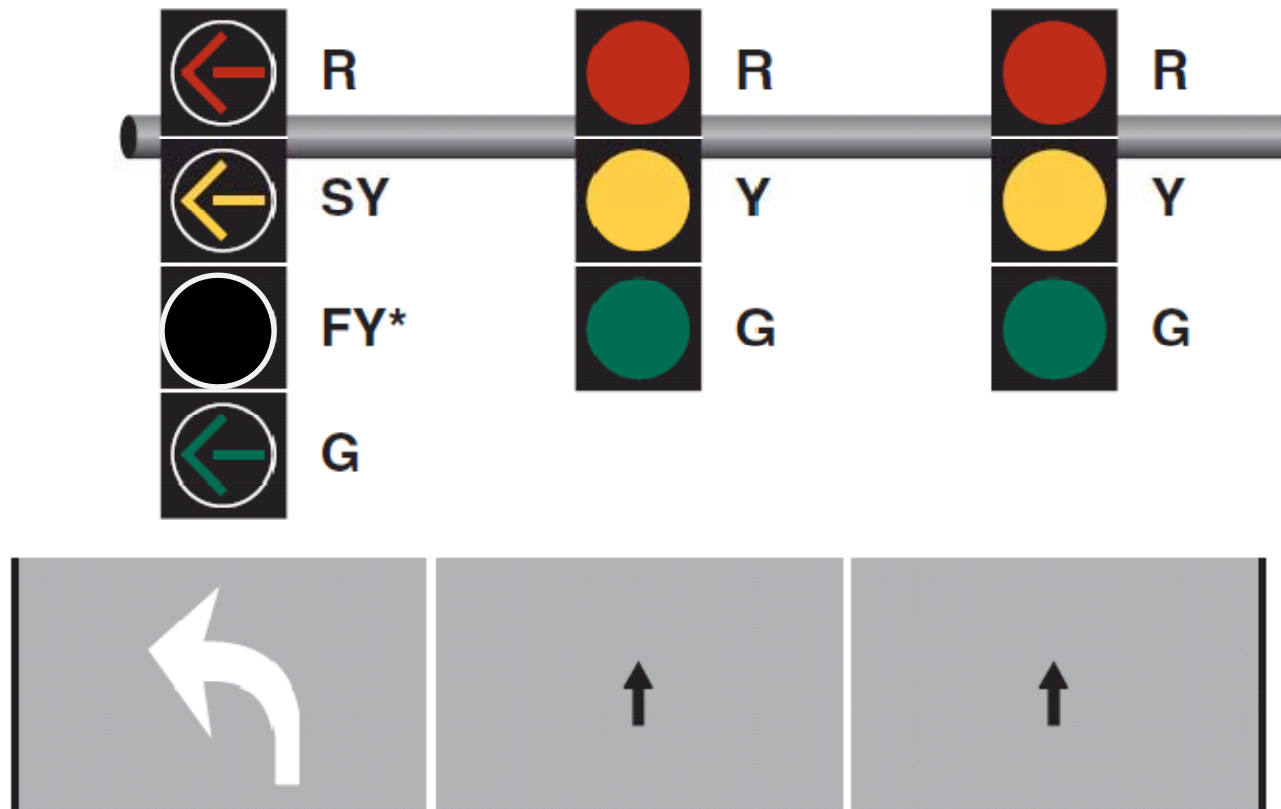
INTERSECTIONS



Change Permissive LT Phase to Protected-Only LT Phase:
CRF 97% (Left-Turning Crashes)

Flashing Yellow Arrow

Flashing yellow arrow for permissive turns
~20% CRF for Fatal & Injury Crashes



INTERSECTIONS



Enhance Traffic Signal Visibility:

Replace Post-mounted w/ Mast Arms:

CRF 25% to 32% (All Crashes)¹

Increase Head Diameter from 8" to 12":

CRF 33% to 47% (Angle Crashes)²

1. Winston-Salem NC Study

⁶⁹2. ITE RLR Handbook (Iowa, Kansas City MO study locations)

INTERSECTIONS



Enhance Traffic Signal Visibility - One Signal Head per Lane:
CRF 22% (All Crashes) CRF 47% (Angle Crashes)

ICBC, Winston-Salem NC

INTERSECTIONS



Enhance Traffic Signal Visibility – Supplemental Heads
CRF 15% (All Crashes) CRF 47% (Angle Crashes)

INTERSECTIONS



Enhance Traffic Signal Visibility – Add Backplates:
CRF 2% to 24% (All Crashes) CRF 32% (Angle Crashes)
CRF 50% (Red Light Running Frequency)



Enhance Traffic Signal Visibility – Retroreflectorized Border:
CRF 24% (All Crashes) CRF 16% (Injury/Fatal Crashes)

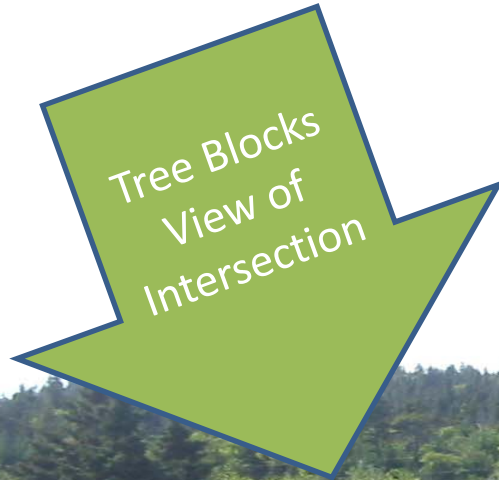
- Benefits color blind individuals at night
- Improved safety during power outages

Provide & Maintain Intersection Sight Distance



Provide & Maintain

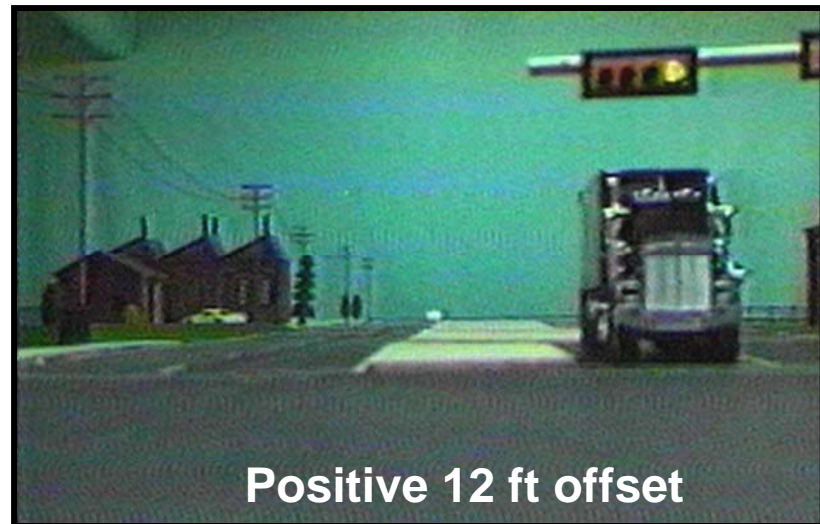
Intersection Sight Distance



Intersection Sight Distance



Provide Sight Distance



Provide Sight Distance



20-26%
Crash
Reduction



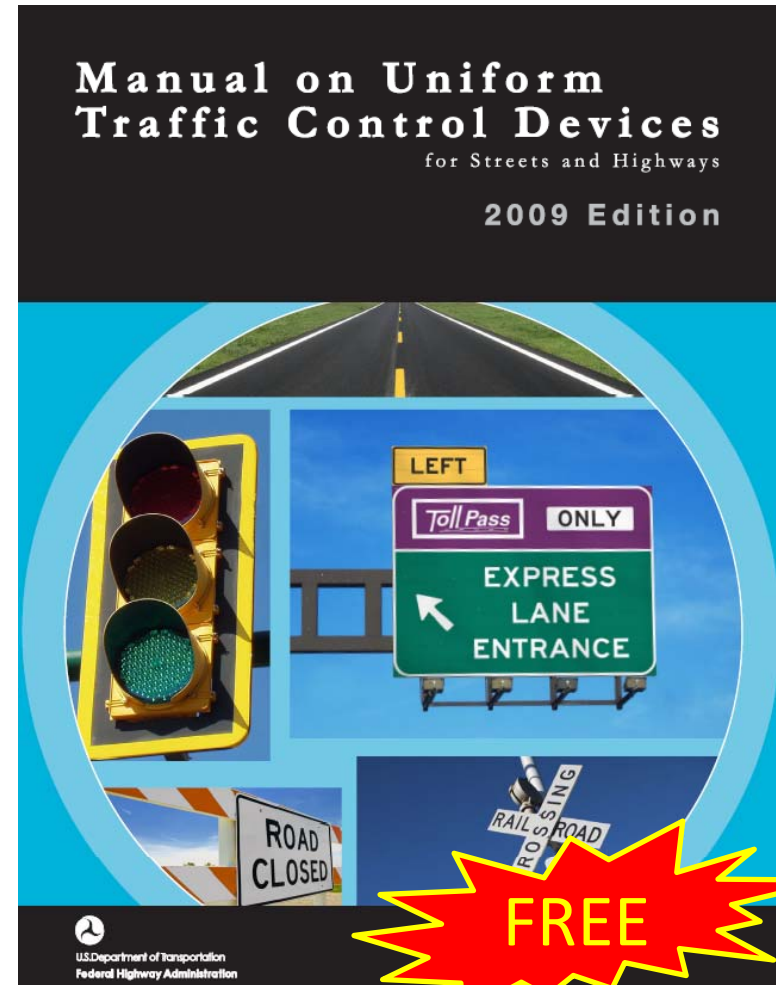
Offset Right-turn Lane



For correct decision making, a driver must:

1. Receive a message.
2. Understand the message.
3. Have time to react.

**Standard symbols convey
a recognized message**



www.MUTCD.FHWA.DOT.GOV

Advance Warning Signs 40% Crash Reduction



MUTCD 2C-46

www.MUTCD.FHWA.DOT.GOV

Increased Sign Conspicuity

A – W16-15P plaque above a regulatory or warning sign if the regulation or condition is new



B – Red or orange flags above a regulatory, warning, or guide sign



C – W16-18P plaque above a regulatory sign



D – Solid yellow, solid fluorescent yellow, or diagonally striped black and yellow (or black and fluorescent yellow) strip of retroreflective sheeting around a warning sign



E – Vertical retroreflective strip on sign support



F – Supplemental beacon



MUTCD Section 2A.15

12-58% Reduction in Angle Crashes

Increased Sign Conspicuity



Enhanced TCDs - Doubled-Up Signs: CRF 31% (All Crashes)

Winston, NC Study of Supplementary Signage



Advance Lane Assignment Signs: CRF 15% (All Crashes)



In advance of STOP or YIELD Sign
Place Rumbles AT the advance warning sign

Intersection Conspicuity



Lighting
CRF 38%
for Dark lighting crashes.

INTERSECTION CONSPICUITY



Provide Stop Bars: CRF 10% to 25% (All Crashes)

NCHRP 500 Volume 6 “Guide for Addressing Unsignalized Intersection Collisions”

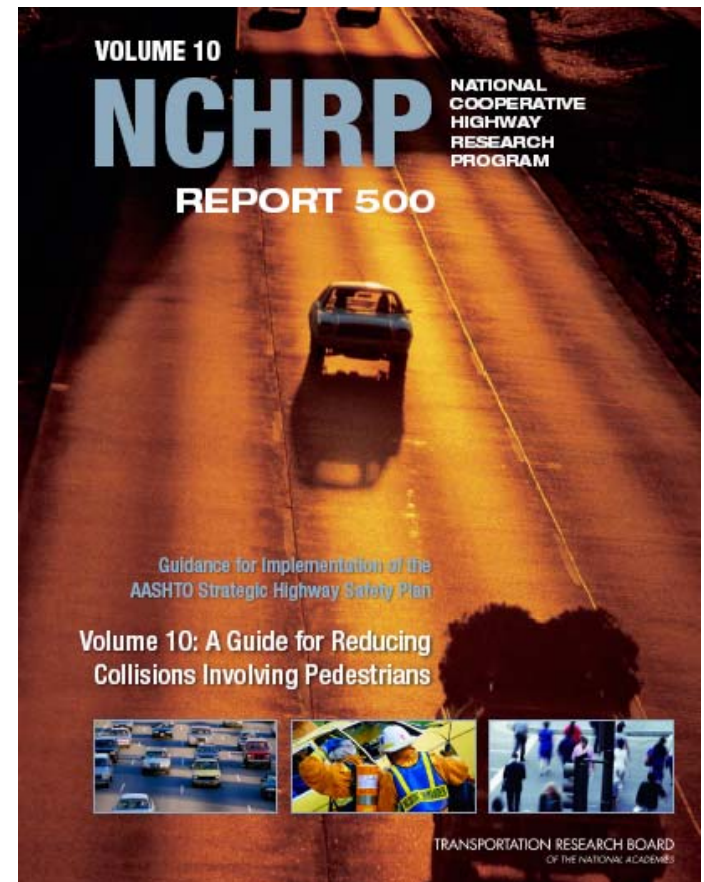
Pedestrians

- 4,654 Pedestrians Killed/year (~12 % of all traffic fatalities)
 - 58% are adults
 - 23% are older citizens
 - 19% are children
- A pedestrian is killed or injured every 4 minutes



NCHRP 500 Volume 10

- Separate conflicts in time and space
- Reduce Pedestrian duration of conflicts.
- Improve sight distance – see & be seen
- Reduce Vehicle Speed how & when appropriate
- Improve Pedestrian Safety Awareness / Education

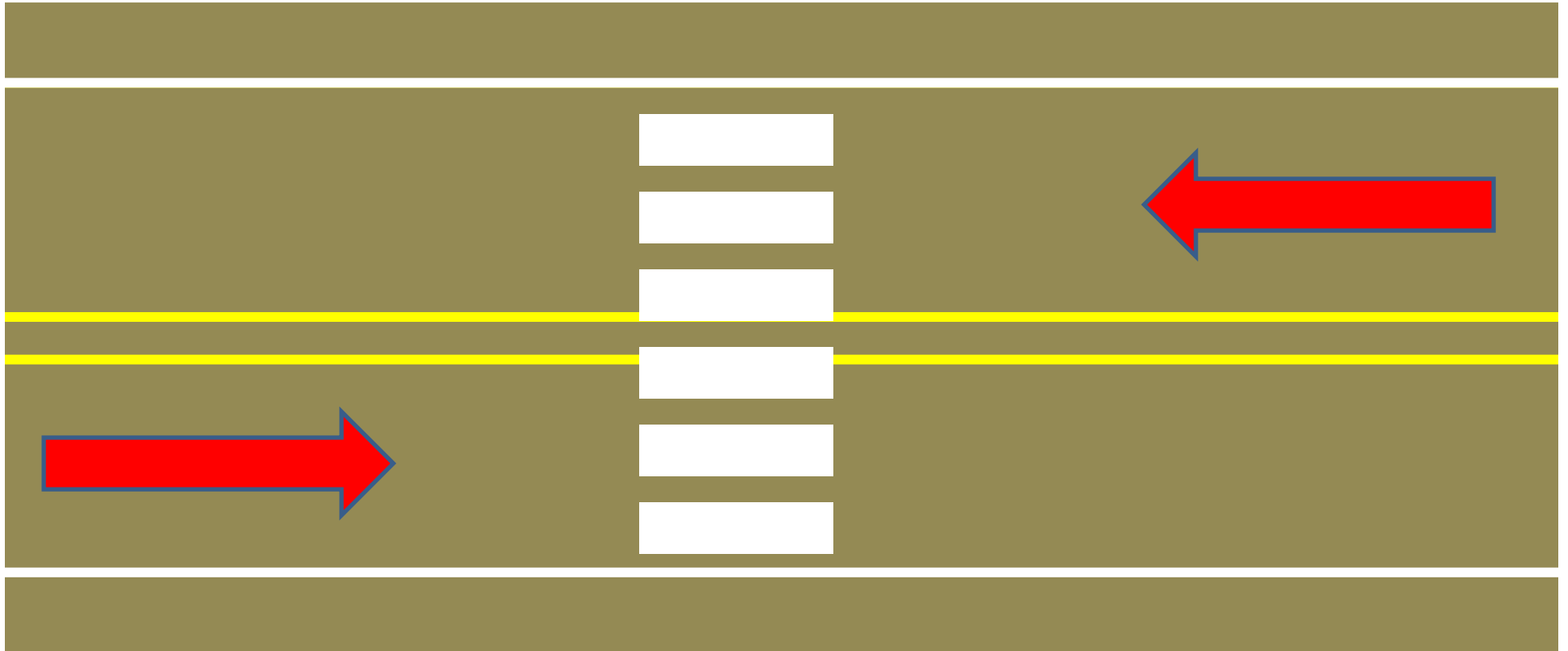


Countermeasures



“with a sidewalk being a crash site was 88 percent lower risk”

Pedestrian Conflict Zones



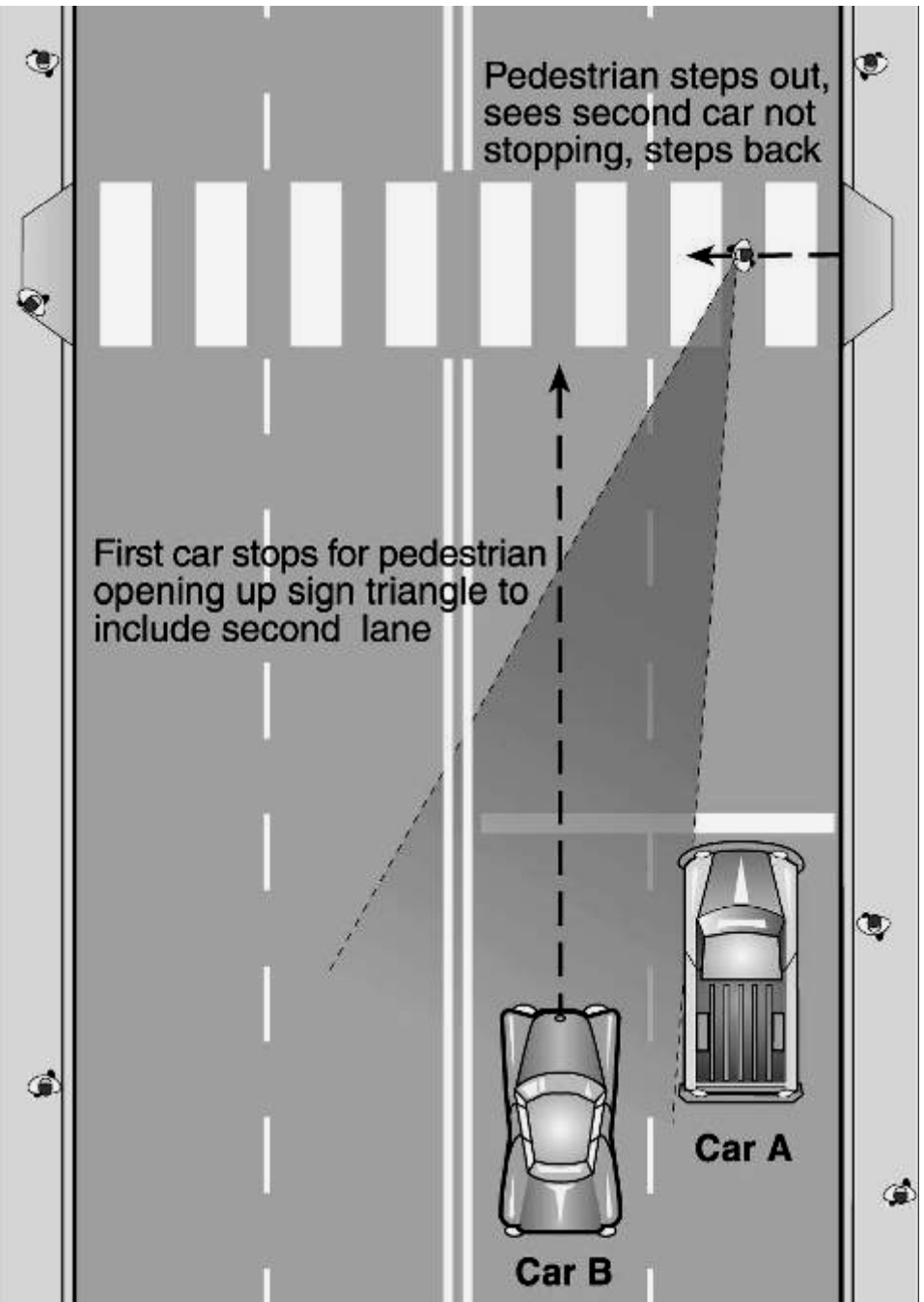
Reduce, Eliminate, and Separate

Multiple threat crash solution

Advance stop/yield line

1st car stops further back

1st car no longer masks 2nd car, which
can be seen by pedestrian



Traffic Calming



A curb extension at a mid-block crosswalk



A median island with a raised mid-block crosswalk



Ped Countermeasures

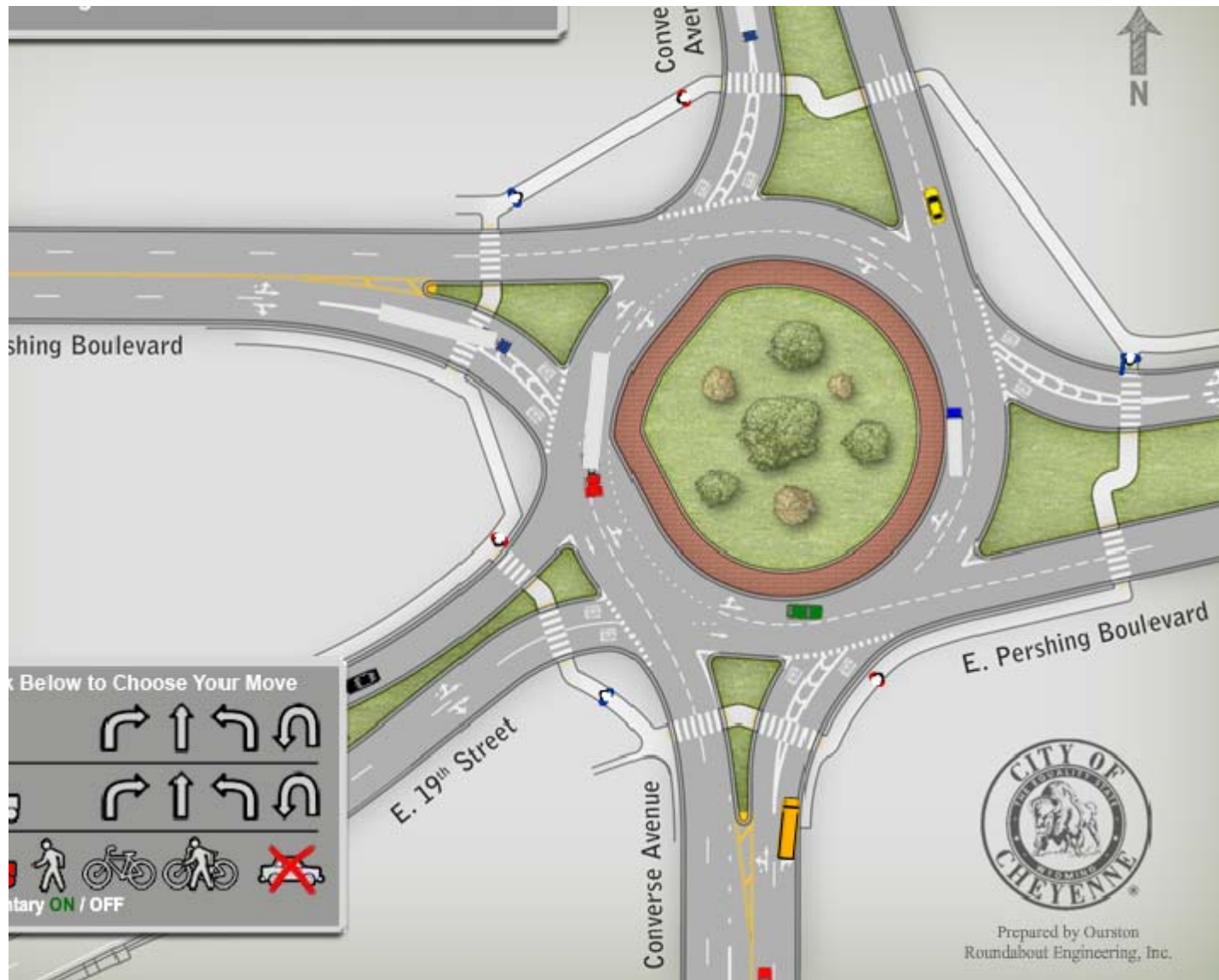


Reduce Crossing Distance

Bulb Outs



Roundabouts & Peds



Road Diet (Orlando FL)

**Shorten Crossing Distance,
Reduces the number of conflicts,
& Provides opportunity for refuge.**

(Also reduces rear-end & sideswipe crashes related to turning vehicles.)



Before



Concept

Before



Reclaiming road space creates room for ped islands

Concept



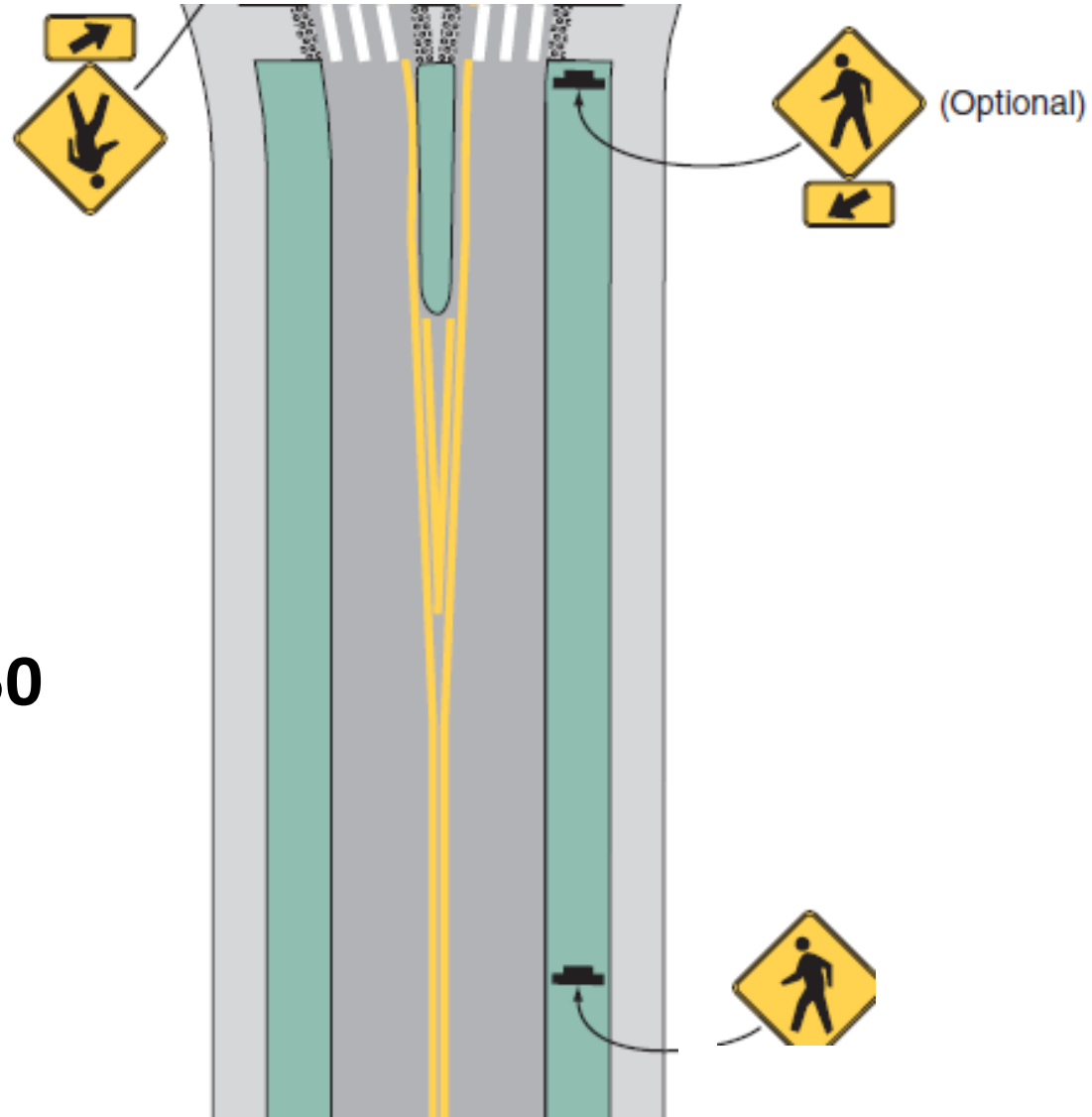
Reclaiming road space creates room for ped islands

After



Reclaiming road space creates room for ped islands

MUTCD 2C-50



Extra Signing



R1-5



R1-5a



R1-5b



R1-5c



R1-9



R1-9a

* The legend STATE LAW is optional. A fluorescent yellow-green background color may be used instead

Ped Activated Beacons



Accessibility



Obstructions / Sight Distance



Night pedestrian crashes





Questions?