Module 1: Introduction

Low Cost Safety Improvements (LCSIs)

Logistics

- Health and safety (emergency exits, procedures for evacuation, etc.)
- Facility smoking policy
- Please silence cell phones/pagers
- Breaks (when, restrooms, telephones)
- Lunch arrangements
- Other site-specific issues

Session Presenters

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Goals for Today

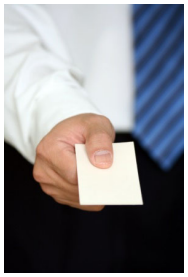
- Summarize some data that defines roadway safety in the United States
- Discuss methods to identify locations of interest for safety improvement
- Describe/discuss some potential LCSIs for:
  - Roadway Segments & Curves
  - Roadsides
  - Unsignalized Intersections
  - ~~Signalized Intersections~~
- Apply what we've learned in a real life case study

Modules Covered

- Introduction – define the problem and provide context
- Safety Data, Analysis, & Use – data use and mitigation location identification
- LCSIs and their impacts
  - Roadway segments & curves
  - Roadsides
  - Unsignalized intersections
  - ~~Signalized intersections~~
- Case study

Self Introductions

- Who you are
- Job title & Agency
- Your level of experience with safety improvements
  - Beginner
  - Intermediate
  - Expert
- Safety issue(s) you would like to know more about



Rules of Engagement

- Ask questions as you have them
- "Parking Lot" for questions to be addressed later
- We'll do some work
  - Case study
- Facilitated questioning and discussions

Introduction – Learning Outcomes

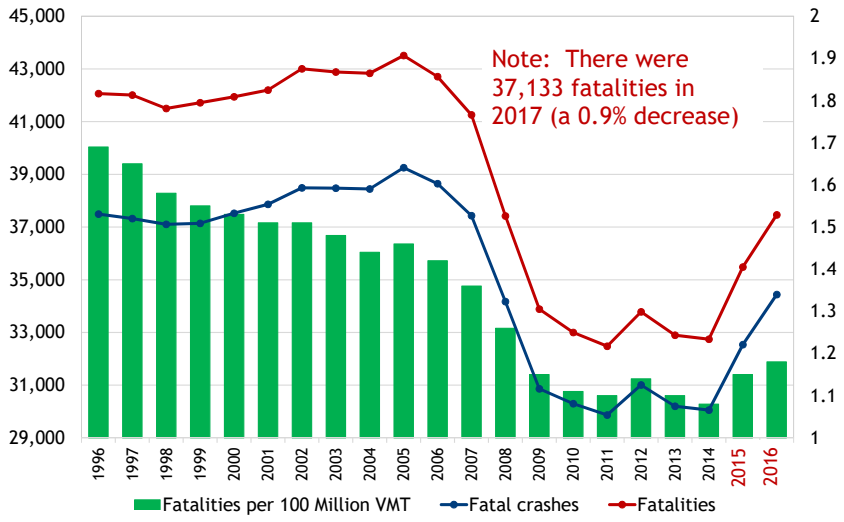
- Define and quantify roadway safety in the United States
- Describe the terminology (or context) within how you define LCSIs
- Differentiate between nominal and substantive safety

Recent Crash Experience

A quick look at:

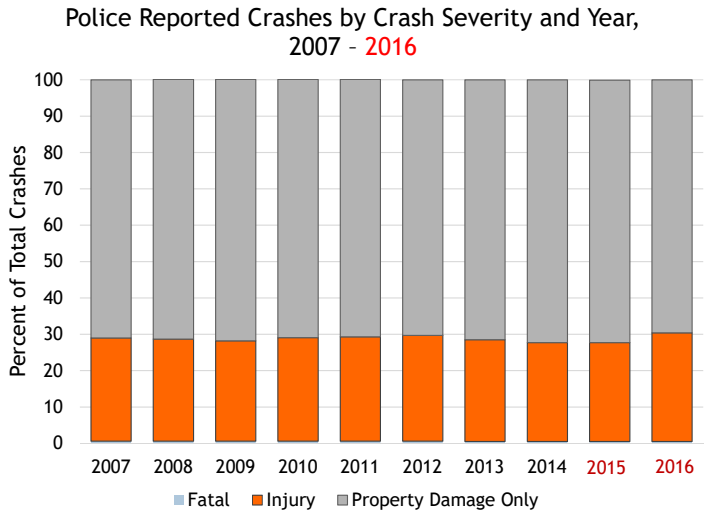
- The more relevant data
- The more recent data
  - Helps to see where we've been
  - And where we seem to be heading

Crash Fatalities in the US



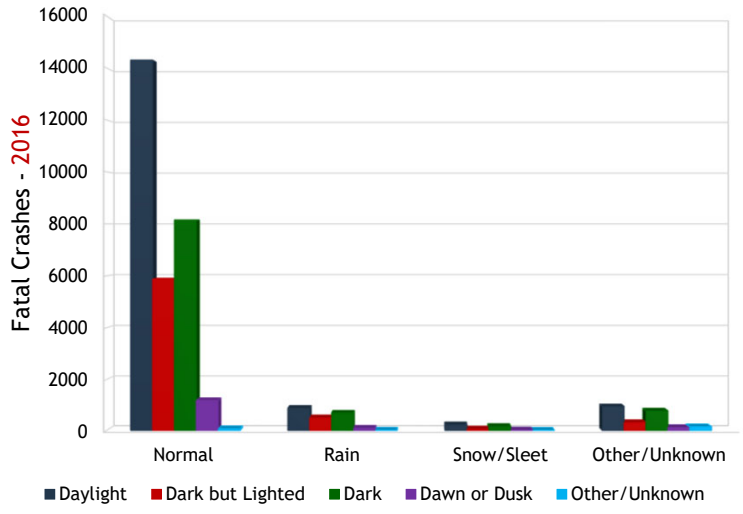
Source: National Highway Traffic Safety Administration - http://www.nhtsa.gov/FARS

Percent by Crash Severity



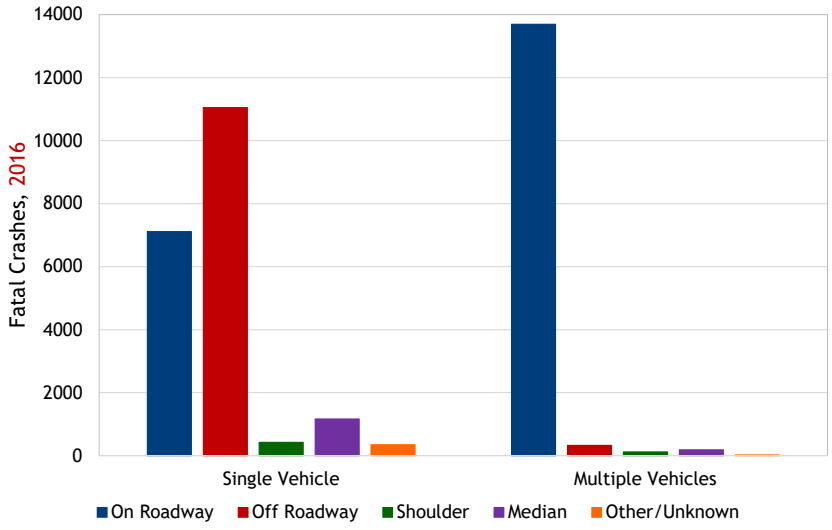
Source: NHTSA National Center for Statistics and Analysis, Traffic Safety Facts 2015 Data, Summary of Motor Vehicle Crashes (Early Edition), February 2017

Weather and Light Impacts



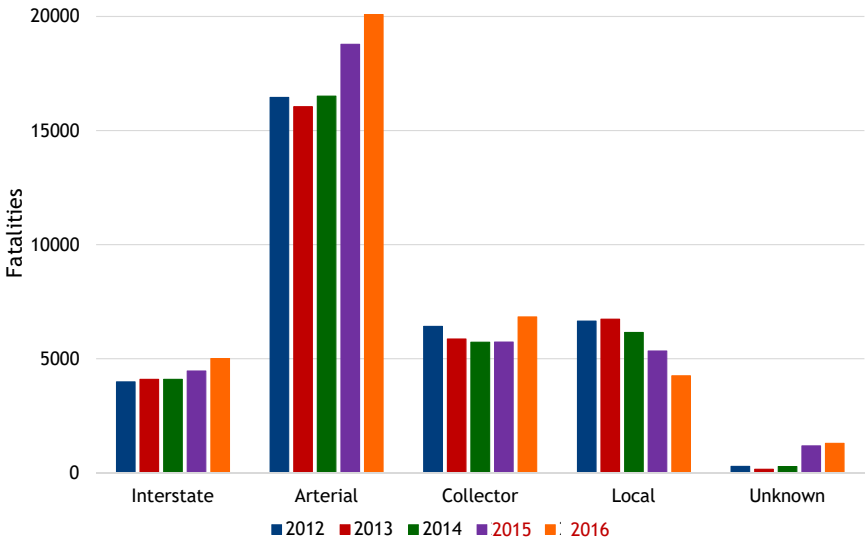
Source: National Highway Traffic Safety Administration - http://www.nhtsa.gov/FARS

Roadway or Roadside?



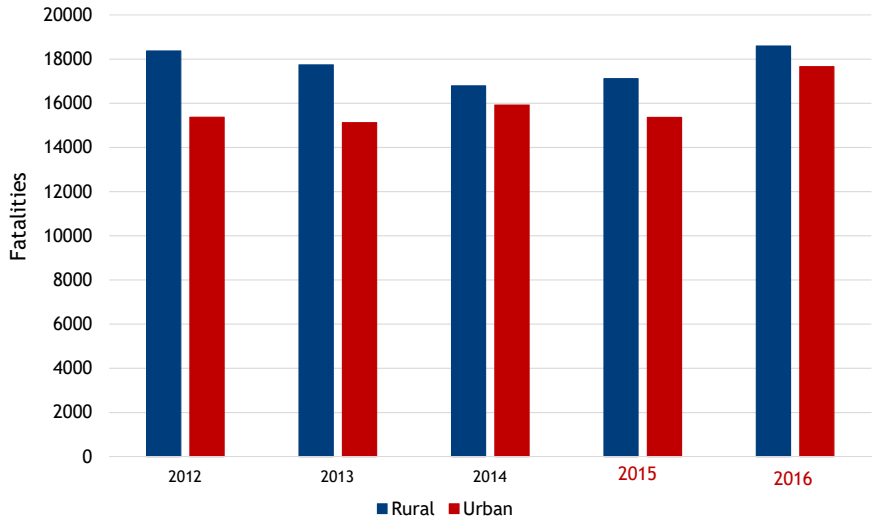
Source: National Highway Traffic Safety Administration - http://www.nhtsa.gov/FARS

Fatalities by Functional Class



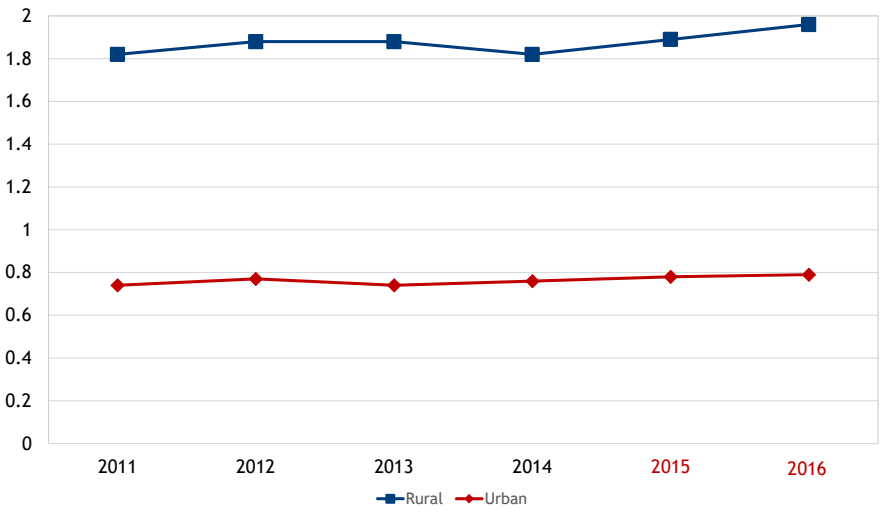
Source: National Highway Traffic Safety Administration - http://www.nhtsa.gov/FARS

Rural and Urban Fatalities



Source: NHTSA 2015 Traffic Safety Factors: Rural/Urban Comparison: https://crashstats.nhtsa.dot.gov/Api/Public/Publication/812393

Rural and Urban Fatality Rates



Source: NHTSA 2015 Traffic Safety Factors: Rural/Urban Comparison: https://crashstats.nhtsa.dot.gov/Api/Public/Publication/812393

Terminology Discussion - Part 1

Which do you use and why?

- Safety
- Safe
- Safer
- More safe

In general, can we make roadways “safe?”

Would you like to Play a Game?

Is This Road Safe?

Exercise

Is this road "safe?"

Exercise

Is this road "safe?"

Exercise

Is this road “safe?”

Exercise

Is this road “safe?”

Terminology Discussion - Part 2

- What is a "low cost" countermeasure?
  <$100,000?
  <$20,000?
  <$5,000?
  <$1,000?
- What factors do you think about?
- LCSIs can also be the "70%" solution until the big fix comes along

Exercise

Discussion

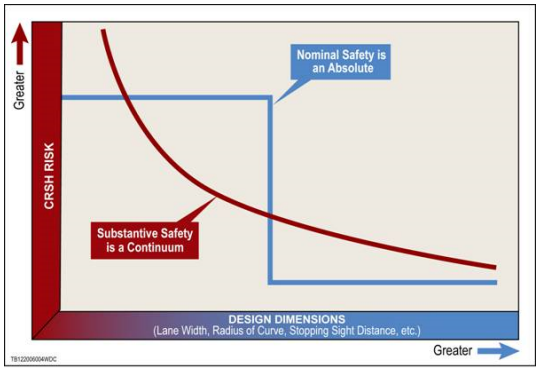
What are some LCSIs?

Terminology Discussion – Part 3

- Nominal Safety
  - Do the design or design elements meet minimum design criteria
  - National or state standards and guidance documents
- Substantive Safety
  - Safety performance of a roadway (actual or expected)
  - Evidence- or data-driven (i.e., crash frequency, rates, type, severity, etc.)

Substantive and Nominal Safety

- No direct correlation
- Roadway meeting minimum design criteria, may have higher than expected crash experience
- Roadway not meeting minimum design criteria may still function at high level of safety



Example

Nominal Safety – Advance Warning Sign + Advisory Speed Plaque

Advance Warning Sign + Advisory Speed + Chevrons = "Safer" = Substantive Safety

What's the Right Choice?

Existing Conditions

Alternative 1

Alternative 2

Alternative 3

What's the Right Choice?

At 20,000 ADT

Existing Conditions

Alternative 1

Alternative 2

Alternative 3

Review Learning Outcomes

- Define and quantify roadway safety in the United States
- Describe the terminology (or context) within how you define LCSIs
- Differentiate between nominal and substantive safety

Review Question #1

Approximately, how many times higher is the fatality rate in rural areas in comparison to that of urban areas?

2x

Review Question #2

Can a roadway have improvements that make it safer, more safe, or safe? Pick one or more.

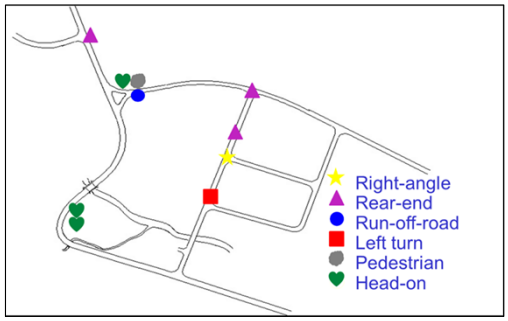
Safer and more safe

Review Question #3

This type of safety is met when all required design criteria are met?

Nominal Safety

Module 2: Safety Data, Analysis & Use



Low Cost Safety Improvements

Learning Outcomes

- Recognize the importance of quality data
- Describe the crash mitigation process
- Select appropriate crash modification factors

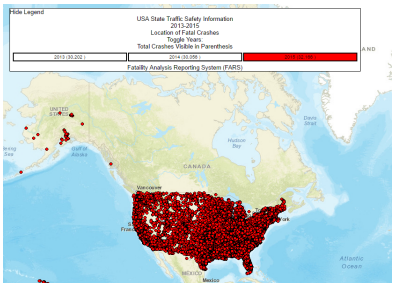
Safety Data

Name some types of data used to identify safety issues

- Crash data
- Traffic volume data
- Roadway data
- Anecdotal data

Safety Data Sources

- Statewide crash databases
- Fatality Analysis Reporting System (FARS)
- Motor Carriers Management Information System (MCMIS)
- Crash Outcome Data Evaluation System (CODES)
- NHTSA State Traffic Safety Information (STSI)



https://cdan.nhtsa.gov/stsi.htm#

Safety Data Sources

- State roadway inventory data files
- Aerial photography
- Asset management databases
- Vehicle registration databases
- Traffic volume data
- Occupant protection use surveys
- Citation and DUI tracking
- Court records

Data on Local Roads

Data on local roads can be collected by:

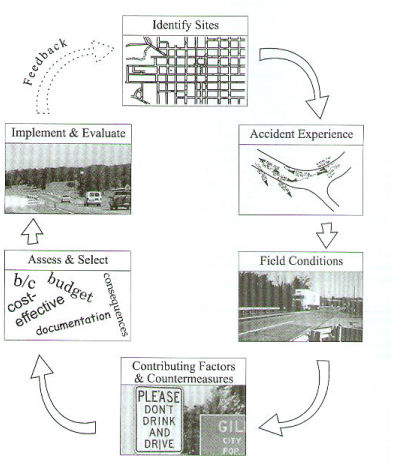
- Local law enforcement crash reports
- Maintenance/repair reports
- Observing evidence at the site
- Anecdotal from citizens
- Others?

Data Quality Measures

- Timeliness
- Accuracy
- Completeness
- Uniformity
- Integration
- Accessibility

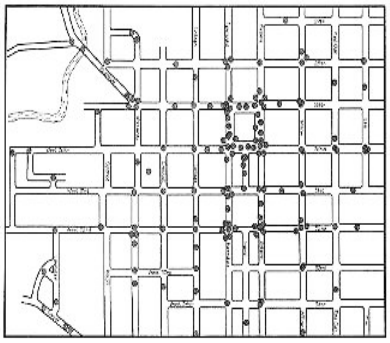
The six step crash mitigation process

1. Identify Sites
2. Collect Crash Experience
3. Gather Field Conditions
4. Identify Contributing Factors and Countermeasures
5. Assess and Select Countermeasures
6. Implement and Evaluate



Network Screening

1. Conventional Screening
2. Systemic Screening



Conventional Screening

Conventional screening identifies locations with safety issues off crash history:

- Crash frequency
- Crash rate
- Equivalent property damage only

Systemic Screening

- Evaluate entire system based on aggregate crash history to identify high-risk roadway characteristics correlated with severe crash types
- Identify improvement locations based on presence of risk factors
- Improvements are widespread implementation of low cost safety

Systemic Screening

Step 1: Identify Focus Crash Types and Risk Factors

Step 2: Screen and Prioritize Candidate Locations

Look at all locations and use a weighted scoring process incorporating risk factors

Location	ADT >1000	Skew angle	In/near curve	Lighting not present	Fatal/ Severe Injury Crashes Present	Total
A	*	*	*	*	*	5
C	*	*	*		*	4
B		*		*		2

Comparison of Screening

Conventional Screening

- Reactive
- No crashes + risk = no risk
- Uses site specific crashes

Systemic Screening

- Proactive
- No crashes ≠ no risk
- Uses crashes and surrogates (risk)

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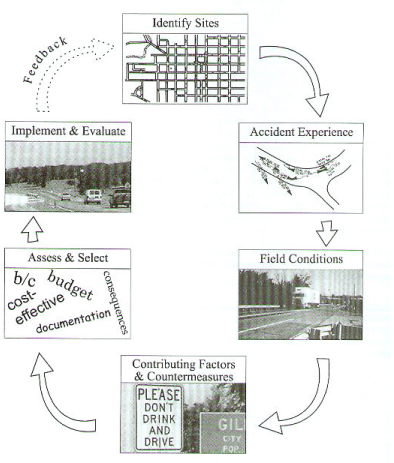
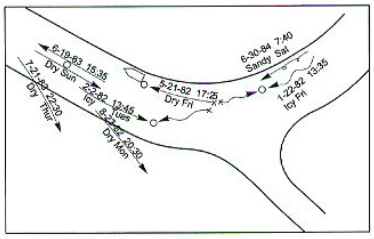
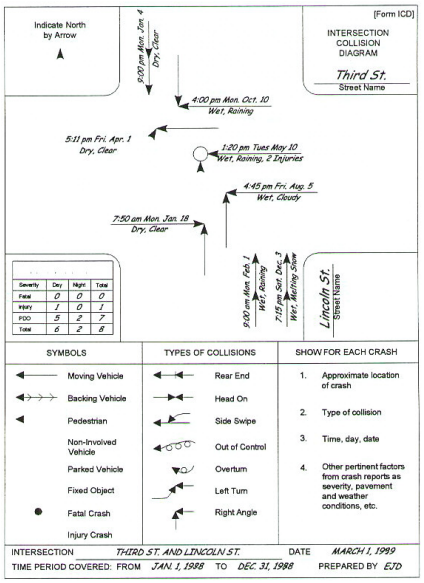


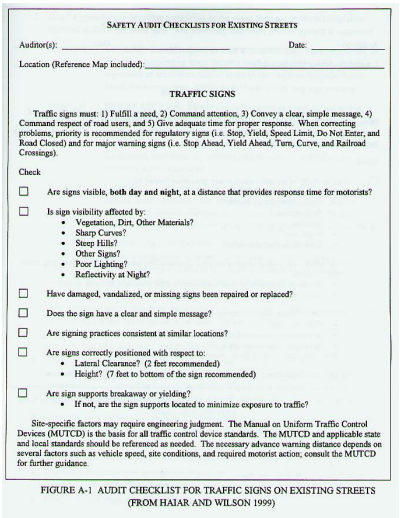
Prepare a Crash Diagram





Road Safety Audit/Assessment

- Independent team
- Observe traffic under conditions of interest
- Locate potential safety issues



SAFETY AUDIT CHECKLISTS FOR EXISTING STREETS

Auditor(s): _____ Date: _____

Location (Reference Map included): _____

TRAFFIC SIGNS

Traffic signs must: 1) Fulfill a need, 2) Command attention, 3) Convey a clear, simple message, 4) Command respect of road users, and 5) Give adequate time for proper response. When correcting problems, priority is recommended for regulatory signs (i.e. Stop, Yield, Speed Limit, Do Not Enter, and Road Closed) and for major warning signs (i.e. Stop Ahead, Yield Ahead, Turn, Curve, and Railroad Crossings).

Check

- ☐ Are signs visible, **both day and night**, at a distance that provides response time for motorists?
- ☐ Is sign visibility affected by:
  - Vegetation, Dirt, Other Materials?
  - Sharp Curves?
  - Steep Hills?
  - Other Signs?
  - Poor Lighting?
  - Reflectivity at Night?
- ☐ Have damaged, vandalized, or missing signs been repaired or replaced?
- ☐ Does the sign have a clear and simple message?
- ☐ Are signing practices consistent at similar locations?
- ☐ Are signs correctly positioned with respect to:
  - Lateral Clearance? (2 feet recommended)
  - Height? (7 feet to bottom of the sign recommended)
- ☐ Are sign supports breakaway or yielding?
  - If not, are the sign supports located to minimize exposure to traffic?

Site-specific factors may require engineering judgment. The Manual on Uniform Traffic Control Devices (MUTCD) is the basis for all traffic control device standards. The MUTCD and applicable state and local standards should be referenced as needed. The necessary advance warning distance depends on several factors such as vehicle speed, site conditions, and required motorist action; consult the MUTCD for further guidance.

FIGURE A-1 AUDIT CHECKLIST FOR TRAFFIC SIGNS ON EXISTING STREETS (FROM HAIAR AND WILSON 1999)

The six step crash mitigation process

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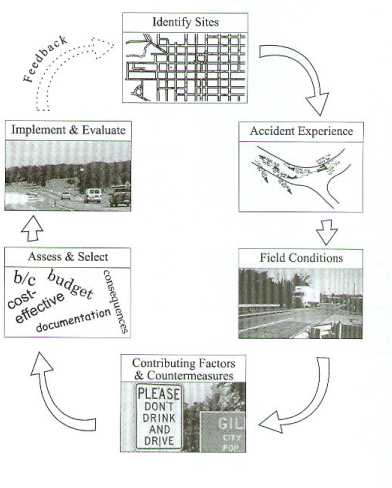


Gather Field Conditions

ON-SITE OBSERVATION REPORT [Form OSOR-1]

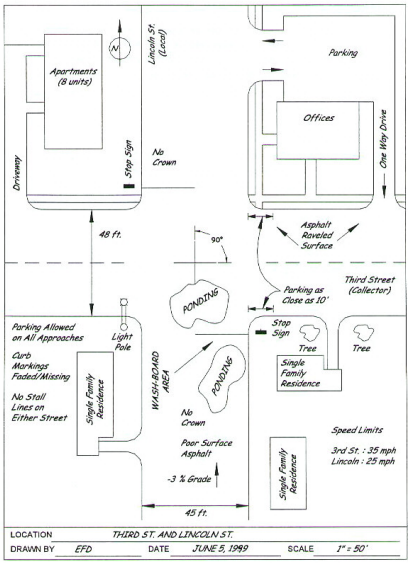
LOCATION	Third St. and Lincoln St.	CONTROL DEVICES	2-way stop
OBSERVE	EJD	DAY	Tues.
		DATE	June 5, 1999
TIME	4:30 pm	WEATHER	Occasional Rain

PHYSICAL CHECKLIST:	CHECK ITEM IF PROBLEM EXISTS
1. Obstructions block view of traffic control devices at or near the location?	
2. Obstructions block view of opposing or conflicting traffic?	
3. The legal parking layout restricts sight distances?	X
4. Traffic signs are satisfactory as to number, size, message, placement, reflectivity, and visibility? (see MUTCD)	X
5. Traffic signals are satisfactory as to number, lense size, placement, visibility, and timing? (see MUTCD)	
6. Pavement markings are satisfactory as to location, size, message, color, and visibility? (see MUTCD)	X
7. Channelization devices, such as islands, are adequate for:	
A. Reducing traffic conflict areas?	
B. Defining traffic movement paths?	
C. Separating traffic flows?	
8. Curb radii are adequate for turning vehicles?	
9. Roadway horizontal curves too sharp?	
10. Approach grades at intersection too steep?	
11. Pavement has proper crown and superelevation?	X
12. Lane and street widths are adequate?	
13. The pavement surface condition is satisfactory? (Consider potholes, rutting wash board, edge drop-offs, raveling, bleeding surface, cracking, and poor drainage.)	X
14. The roadside is clear of hazardous objects?	
15. Driveways are properly placed and designed?	
16. Pedestrian crosswalks are properly placed and designed?	
17. Street lighting is satisfactory?	
18. Advertising signs or lights reduce driver visual capability?	

- Traffic Volume – Turning Movement, ADT
- Spot Speeds
- Traffic Conflict Study
- Sight Distance Evaluation

Prepare a Condition Diagram

- Roadway geometry
- Non-motorized facilities
- Traffic control devices
- Land use
- Roadside features
- Sight distance issues



The six step crash mitigation process

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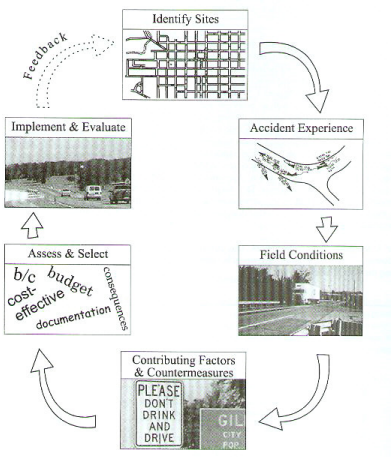
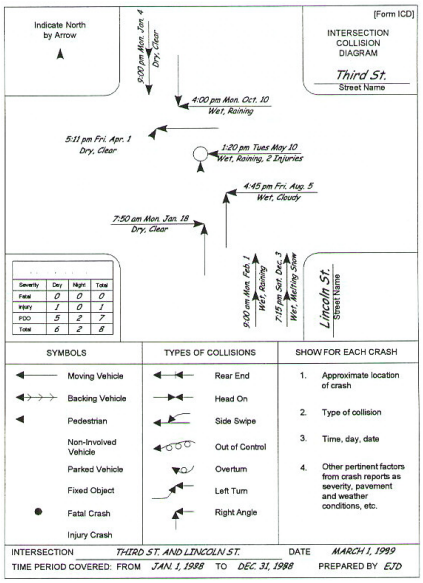
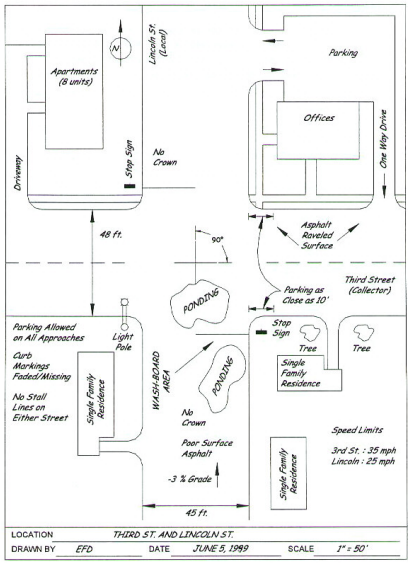


Identify Contributing Factors - Example





Countermeasure selection

- Crash type
- Location type
- Best practices

Countermeasure sources

- Research
- FHWA and NCHRP publications
- FHWA Office of Safety Website
- Proven Safety Countermeasures
- CMF Clearinghouse

TABLE 12 Potential countermeasures for roadway accidents

TYPE OF ROADWAY ACCIDENT Contributing Factor Potential Countermeasure	
LEFT TURNS	**SIDESWIPE ACCIDENTS (INCLUDING OPPOSITE- AND SAME-DIRECTION SIDESWIPE ACCIDENTS)**
Large Volume of Left Turns Add two-way left-turn lane Add turn bays at selected locations **Restricted Sight Distance** Remove sight obstruction Install or improve warning signs Reduce speed limit if justified by a study Provide turn lane **Excessive Speed** Reduce speed limit if justified by a study **Lack of Adequate Gaps** Provide stop sign (see *MUTCD*) Improve roadway lighting Provide traffic signal (see *MUTCD*)	**Roadway Design** Widen lanes Provide turn bays Install advanced route or street signs Install/improve pavement lane lines Prohibit parking Install median barrier Install rumble strips Upgrade or widen roadway shoulder Provide turn lane Install acceleration or deceleration lane Repair road surface **Inadequate Signing/Marking** Install illuminated street name sign Install advance guide sign Improve or install pavement markings
RIGHT TURNS **High Approach Speed** Reduce speed limit if justified by a study Install rumble strips **Roadway Design** Increase curb radii Install acceleration or deceleration lane	**HEAD-ON ACCIDENTS** **Roadway Design** Widen lanes Provide turn bays Install/improve pavement lane lines Remove parking Install median barrier/rumble strips
REAR END **Driver Not Aware of Intersection** Install/improve warning signs Reduce speed limit if justified by a study **Large Numbers of Turning Vehicles** Create left- or right-turn lanes Prohibit turns Increase curb radii Install acceleration or deceleration lane **Excessive Speed** Reduce speed limit if justified by a study **Inadequate Roadway Lighting** Improve roadway lighting	

The six step crash mitigation process

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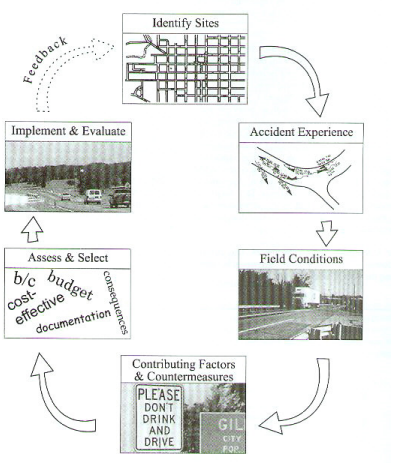


What is a Crash Modification Factor?

A CMF is a multiplicative factor that indicates the proportion of crashes that would be expected after implementing a highway safety countermeasure.

- Value < 1.0 -- lower crash frequency
- Value > 1.0 -- increased crash frequency

Crash Modification Factor Example

A rural curve had 4 nighttime crashes per year and the engineer is thinking of installing chevrons.

- CMF = 0.75

How many crashes are expected in the year following installation?

$$4 \times 0.75 = 3 \text{ crashes per year}$$

Difference Between a CMF and CRF

- Crash Reduction Factors (CRF's) are generally referred to as a % reduction that might be expected
- CRF's and CMF's are related as follows:

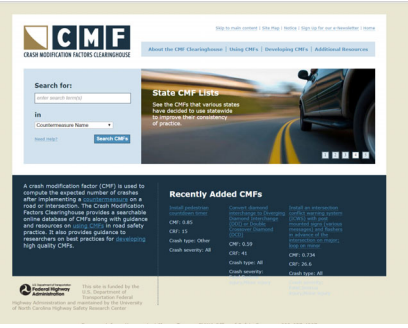
  CRF = 1 – CMF x 100

- *A CRF of 10% = CMF of 0.90*

How is a CMF used?

- Compare safety consequences among various alternatives
- Capture the greatest gain with limited funds
- Compare results of new analyses with existing CMFs to check reasonableness
- Check validity of assumptions in cost-benefit analyses

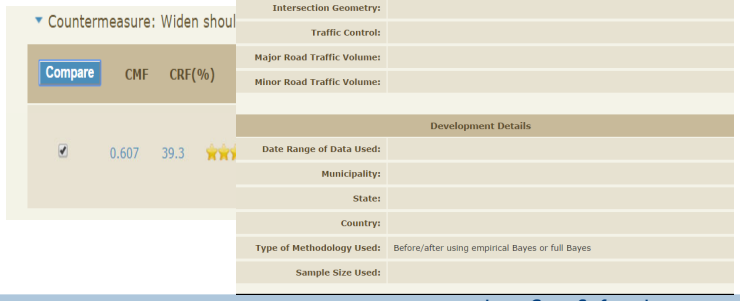
CMF Clearinghouse



- Structured but subjective process
- Star quality rating criteria (excellent, fair, poor)
  1. Study design
  2. Sample size
  3. Standard error
  4. Potential bias
  5. Data source

Assessing and Choosing CMFs

- Stars
- Area type
- Crash type
- Crash severity
- Study specifics



Assessing CMFs

Urban 2 lane site where we want to pave outside shoulder

Which CMF would one choose?

Countermeasure: Widen shoulder

Compare	CMF	CRF(%)	Quality	Crash Type	Crash Severity	Area Type	Reference	Comments
☑	0.771	22.9	★★★★☆	All	All	Rural	Park et al., 2014	Before condition shoulder width between ... [read more]
☑	0.688	31.2	★★★★☆	All	Fatal,Serious injury,Minor injury	Rural	Park et al., 2014	Before condition shoulder width between ... [read more]
☑	0.95	5	★★★☆☆	All	All	Urban	Dixon et al., 2016	CMF applies to increasing left ... [read more]
☑	0.91	9	★★★☆☆	All	All	Urban	Dixon et al., 2016	CMF applies to increasing right ... [read more]

Multiple countermeasures

What to do if considering multiple countermeasures:

- Look for combination on clearinghouse
- Multiple CMFs together

$$CMF_{combined} = CMF_1 \times CMF_2$$

CRFs Presented Today

- Highway Safety Manual
- CMF Clearinghouse
- Additional sources for those not ranked, newer material

Using CMF/CRF to Assess Countermeasures

Contributing factor: Poor delineation at night

Site: Rural curve with no signing and regular pavement markings

Countermeasure	CRF	Crash Type	Crash Severity
Chevrons	25%	Nighttime, non intersection	All
Raised Pavement Markings	19%	Nighttime	All

Which countermeasure would you choose?

The six step crash mitigation process

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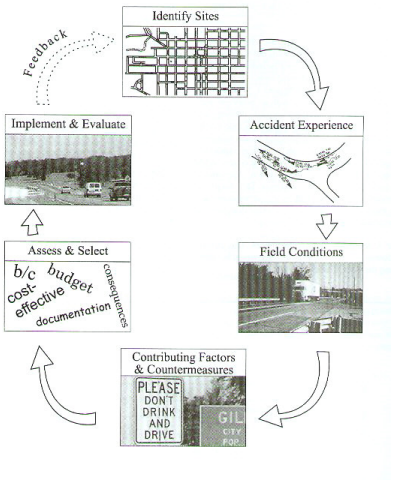
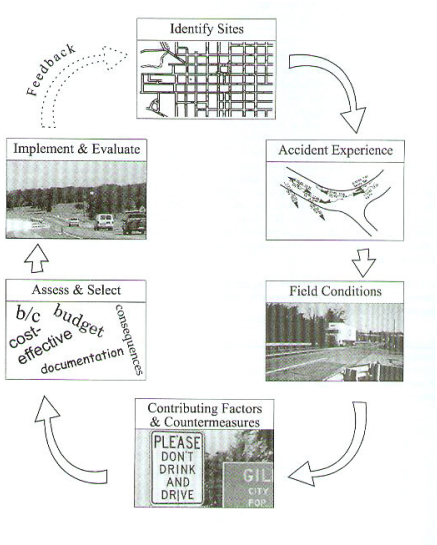


Step 6: Implement and Evaluate

- Implement based on available funds
- Evaluate effectiveness
  - Economic Analysis
  - Crash study
  - Speed study

Summary



Review Learning Outcomes

- Recognize the importance of quality data
- Describe the crash mitigation process
- Select appropriate crash modification factors

Review Question 1

Which of the six steps in the crash mitigation process involves a site visit?

3. Gather Field Conditions

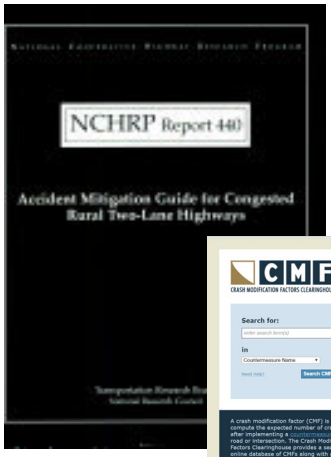
Review Question 2

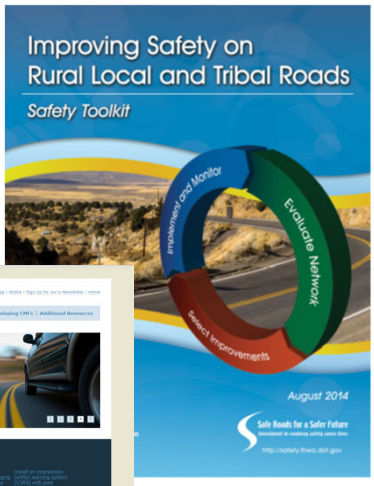
True or False?

The CMF with the highest star ranking is always the best to use.

False

Some Resources





Some Resources

- FHWA, Systemic Safety Project Selection Tool
- FHWA, Proven Safety Countermeasures
- FHWA, Road Safety Audit Guidelines
- FHWA, Road Safety Audit Guidelines – Prompt Lists
- FHWA, Tribal Road Safety Audits
- FHWA, Road Safety Audits (RSA)
- Manual of Uniform Traffic Control Devices

Module 3: Roadway Curve and Segment Safety Improvements

Low Cost Safety Improvements

Learning Outcomes

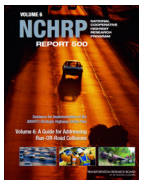
- Define roadway curve and tangent safety in the U.S.
- Identify/describe some signing and marking safety improvements for curves and tangents
- Interpret and apply signing and marking safety improvement crash reduction factors (CRFs)

Roadway Crash Experience

- In 2017:
  - 61.1 % (20,942) of total fatal crashes occurred on the roadway
  - 56.7% (11,874) not at an intersection
- 53% of all traffic fatalities from 2014-2016 were roadway departure (vehicle crosses an edge line, a center line or leaves traveled way)
- Approximately 25% of fatalities on curves

Strategies

- Keep vehicles from encroaching into the opposite lane
- Keep vehicles from encroaching on the roadside
- Minimize the likelihood of crashing into an oncoming vehicle
- Reduce likelihood of a vehicle leaving its lane at a curve
- Improve the roadway and driving environment to better accommodate an aging population
- Reduce the severity of the crash



Treatment Categories

Signing

Pavement Markings

Miscellaneous

Signing Treatments

- Dynamic speed feedback sign
- Curve warning sign with/without advisory speed
- Doubling up curve warning signs
- Fluorescent sheeting
- Curve warning sign with flashing beacon
- Post mounted delineators
- Reflective barrier delineation
- Arrow signs at horizontal curves
- Traditional and sequential dynamic chevrons

Marking Treatments

- Optical speed bars
- In lane pavement markings
- Edgelines
- Centerlines
- Wider lines
- Wet reflective markings
- Raised pavement markings
- Centerline rumble strips
- Bike lanes

Miscellaneous Treatments

- Improve friction/skid resistance
- Lighting

Signing

Dynamic Speed Feedback Signs

Flash or display message when driver is exceeding pre-set threshold

Description	CRF	Crash type	Crash severity	Area Type	Quality
Install dynamic speed feedback sign***	5%	All	All	Rural Curve	★★★★★

Dynamic Speed Feedback Signs

Use on tangents:

- Mean speed reduced 0.6 – 5.9 mph
- Saw significant decreases in those traveling ≥ 10 & 15 mph over speed limit

Curve Warning Signs

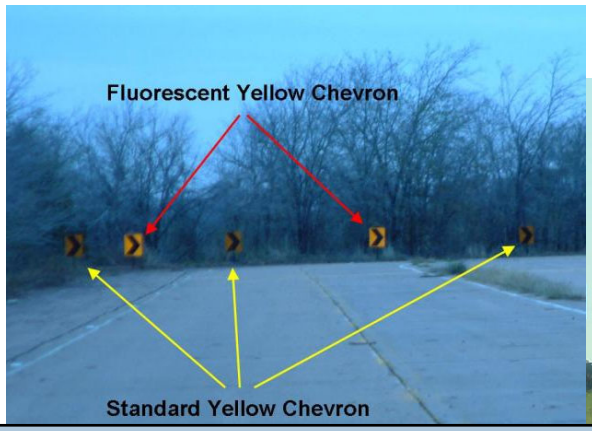
Countermeasure	CRF	Crash type	Crash severity	Area Type	Quality
Advance static curve warning signs***	30%	All	Serious Injury, Minor Injury	Not Specified	★★★★★

Curve Warning Sign with Advisory Speed

Countermeasure	CRF	Crash type	Crash severity	Area Type	Quality
Install combination horizontal alignment/ advisory speed signs	13%	All	Serious Injury, Minor Injury	Not Specified	★★★★☆

Doubling Up Curve Warning Signs

Fluorescent Sheeting on Signs



Countermeasure	CRF	Crash type	Crash severity	Area Type	Quality
Install new fluorescent curve signs or upgrade existing curve signs to fluorescent sheeting***	18%	Head on, Non-intersection, Run off road, sideswipe	All	Rural	★★★★☆

Curve Warning Sign with Flashing Beacons

Countermeasure	CRF	Crash type	Crash severity	Area Type	Quality
Install flashing beacons as advance warning***	30%	All	All	Not Specified	Not rated

Delineation Countermeasures

- Define the roadway operating area
- Define direction and sharpness of curves

- Types of crashes treatments address:
  - Run off road
  - Head on
  - Sideswipe

Post Delineators & Post Mounted Delineators

Mixed results on effectiveness

Reflective Barrier Delineation

Install Arrow Signs at Horizontal Curves

Chevrons

Countermeasure	CRF	Crash type	Crash severity	Area Type	Quality
Install chevron signs on horizontal curves***	6%	Head on, Non-intersection, Run off road, Sideswipe	All	Rural	★★★★☆
	22%	Nighttime Head on, Non-intersection, Run off road, Sideswipe	All	Rural	★★★★☆

Sequential Dynamic Chevrons System

- LED lights illuminate as the vehicle passes through curve
- 58% crash reduction in rural areas

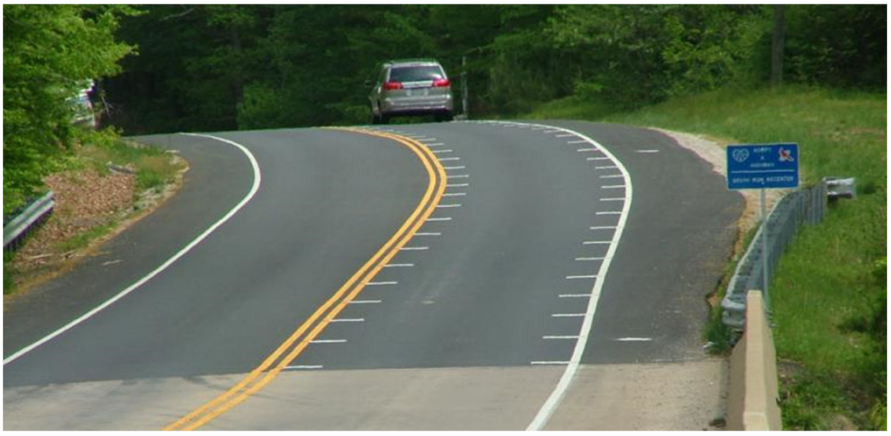
Additional Signing Countermeasures

- Oversized signs
- Icy curve warning systems
- Full-post reflective treatment to chevron post
- Sign maintenance

Pavement Markings

Use of Optical Speed Bars

- Mean, median and 85th percentile speed reductions have been seen (Katz, 2004)



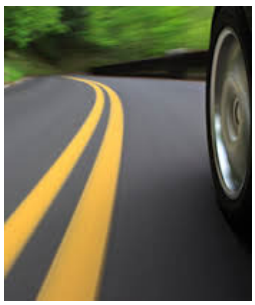
In Lane Pavement Markings

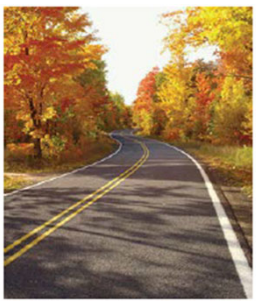
Have been found to reduce speeds by 4 mph at rural curves (Chrysler and Schrock, 2005).

Install Edgeline Markings

Description	CRF	Crash type	Crash severity	Area Type	Quality
Install edgelines (tangent)***	6.1%	All	All	Rural	★★★★☆
Install edgelines (curves)***	25.9 %	All	All	Rural	★★★★☆

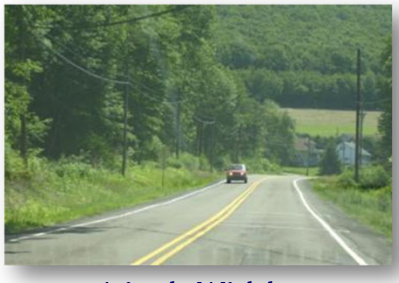
Install Centerline Markings





Description	CRF	Crash type	Crash severity	Area Type	Quality
Place centerline markings	1.0%	All	Serious injury, Minor injury	Rural	★★★★☆
Place edgeline and centerline markings	24.0%	All	Fatal, Serious injury, Minor injury	Rural	★★★★☆

Install Wider Striping



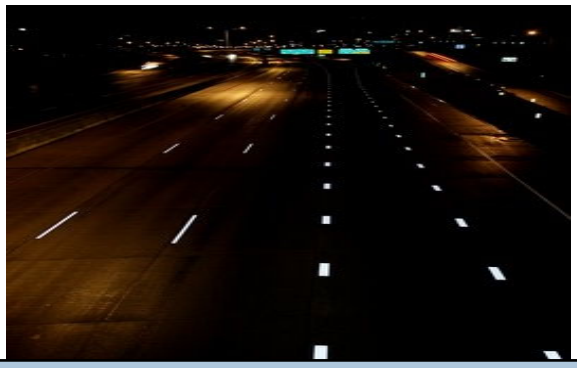
4-inch Width

6-inch Width

Description	CRF	Crash type	Crash severity	Area Type	Quality
Install wider edgelines (4 in to 6 in)***	36.5%	All	Fatal, Serious injury, Minor injury	Rural	★★★★★
Install wider edgelines (4 in to 5 in)***	37.7%	All	Fatal, Serious injury, Minor injury	Rural	★★★★☆
Place wide (8 inches) edgeline markings	-5%	All	Serious Injury, Minor Injury	Rural	★★★★☆

Upgrade to Wet-reflective Pavement Markings

- Paint, tape, or thermoplastic material
- Improve level of retroreflectivity during wet road surface conditions



Description	CRF	Crash type	Crash severity	Area Type	Quality
Upgrade existing markings to wet-reflective markings***	31.5%	Wet Road	All	Not specified	★★★★☆

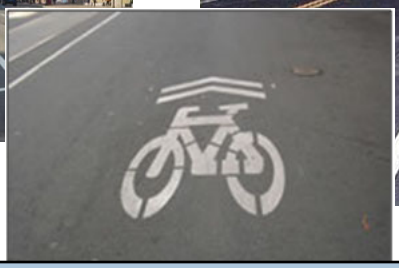
Install Raised Pavement Markers

Description	CRF	Crash type	Crash severity	Area Type	Quality
Install raised pavement markers***	19%	Nighttime	All	Rural	★★★★★
Install snowplowable, permanent raised pavement markers	-13%	Nighttime	All	Rural	★★★★★

Install Centerline Rumble Strips

Description	CRF	Crash type	Crash severity	Area Type	Quality
Install centerline rumble strips	21.0%	Head on, Sideswipe	Serious injury, Minor injury	Rural	★★★★★
Install centerline rumble strips***	37.0%	Head on, Sideswipe	All	Rural	★★★★★

Bike Lanes



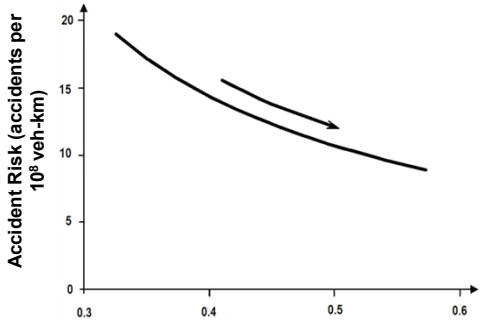
Description	CRF	Crash type	Crash severity	Area Type	Quality
Install cycle tracks, bike lanes or on-street cycling***	73%	Vehicle/bicycle	Serious, minor or possible injury	Urban	★★★★☆
Install bicycle lanes***	60%	Vehicle/bicycle	Fatal, serious, minor or possible injury	Urban	★★★★☆
Install bicycle lanes***	-5%	All	All	Urban	★★★★☆

Additional Marking Countermeasures

- Profiled thermoplastic markings
- Narrow painted median
- Smooth lane narrowing
- High visibility crosswalks

Miscellaneous

Improved Friction/ Skid Resistance



- Not necessarily high friction
- May be epoxy-based or chip seals

Description	CRF	Crash type	Crash severity	Area Type	Quality
Improve pavement friction (increase skid resistance)***	65.4	Wet road	All	Rural	★★★★☆
Improve pavement friction (HFS - High Friction Surface)***	51.9	Wet road	All	All	★★★★☆

Lighting

Description	CRF	Crash type	Crash severity	Area Type	Quality
Provide highway lighting	28%	Nighttime	Serious/Minor Injury	All	★★★★☆
Install lighting ***	49%	Nighttime	Fatal	All	★★★★☆

Review Learning Outcomes

- Define roadway curve and tangent safety in the U.S.
- Identify/describe some signing and marking safety improvements for curves and tangents
- Interpret and apply signing and marking safety improvement crash reduction factors (CRFs)

Review Question #1

Which of these crash types do delineation countermeasures target?

a) Run off road
b) Sideswipe
c) Head on
d) All of the above

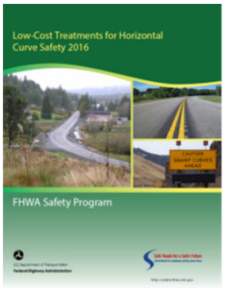
Review Question #2

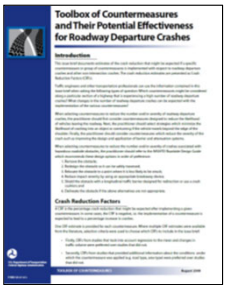
Name at least one countermeasure that can help improve safety during wet conditions.

- Improving friction/skid resistance
- Raised pavement markings
- Wet reflective pavement markings

Resources #1

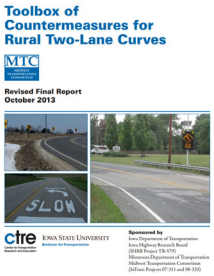
- Manual on Uniform Traffic Control Devices (MUTCD)
- FHWA Office of Safety Website
- FHWA, Low Cost Treatments for Horizontal Curve Safety
- FHWA, Roadway Departure Safety – A Manual for Local Road Owners
- Toolbox of Countermeasures and their Potential Effectiveness for Roadway Departure Crashes

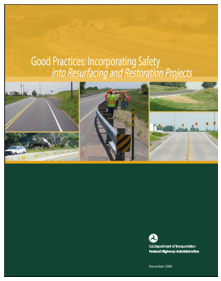




Resources #2

- Toolbox of Countermeasure for Rural Two Lane Curves (CTRE)
- Speed Management Toolbox for Rural Communities (CTRE)
- FHWA, Good Practices: Incorporating Safety into Resurfacing and Restoration Projects
- ATTSA and NACE – Low Cost Local Road Safety Solutions





Module 4: Roadsides

Low Cost Safety Improvements

Learning Outcomes

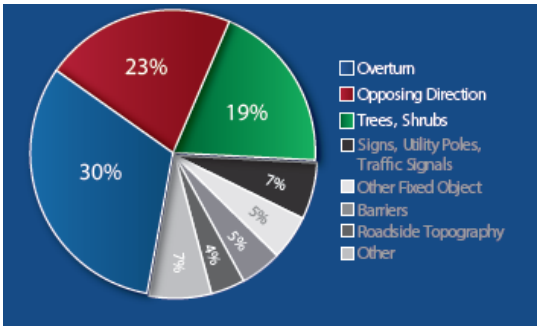
- Define the scope of the roadway departure safety issue in the U.S.
- Identify/describe some safety improvements and strategies that address roadside safety
- Interpret and apply the crash reduction potential of different treatment strategies related to roadside safety

Scope of the Issue

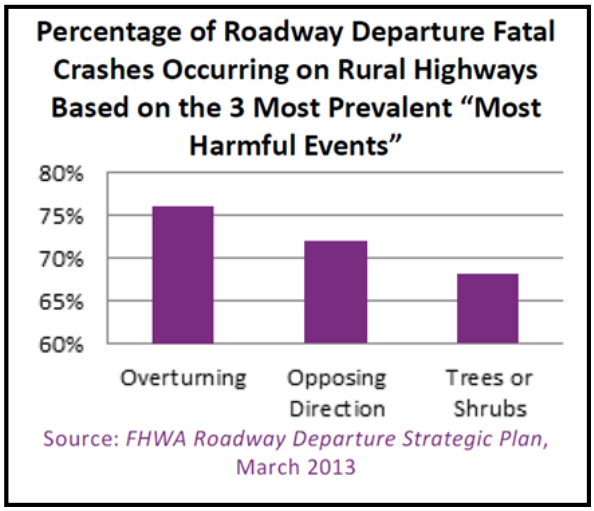
- Roadway departure crashes typically account for more than 50% of all roadway fatalities
- Average of 18,779 (53% of total) roadway departure fatalities from 2014-2016

Some Reasons for Roadway Departure

- Adverse roadway conditions
- Collision avoidance
- Vehicle malfunction
- Driver error
- Distractions
- Others?



Rural Percentages of Top Three



Driver Limitations

Driver's make mistakes because of human physical, perceptive, and cognitive limitations

FACTORS THAT AFFECT THE DIFFERENT COMPONENTS OF PERCEPTION-REACTION TIME

Activity	Factor	Explanation
Seeing/ Perceiving	Low contrast (e.g., night)	Drivers take longer to perceive low-contrast objects.
	Visual glare	Objects are perceived less quickly in the presence of glare.
	Older age	Older drivers are less sensitive to visual contrast and are more impaired by visual glare (e.g., oncoming headlights).
	Object size/height	Smaller objects/text require drivers to be closer to see them.
	Driver expectations	Drivers take substantially longer to perceive unexpected objects.
	Visual complexity	Drivers take longer to perceive objects "buried" in visual clutter.
	Driver experience/familiarity	PRT to objects and situations will generally be faster with increased experience and/or familiarity.
Cognitive Elements	Older age	Older drivers require more time to make decisions.
	Complexity	Drivers require more time to comprehend complex information or situations and to initiate more complex or calibrated maneuvers.
Initiating Actions	Older age	Older drivers require more time to make vehicle control movements and their range of motion may be limited.

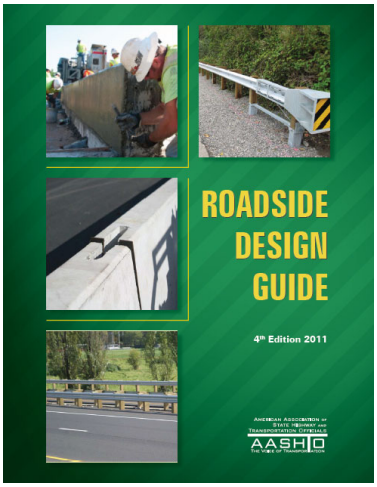
Some Typical Roadside Hazards

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

Examples

General Methods to Address Hazards

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



Some Treatments We Will Discuss

- Reduce edge drop
- Add a safety edge
- Paved shoulders
- Shoulder rumble strips and edgeline stripes
- Clear zone
- Flattening slopes
- Clear/relocate/replace obstacles
  - Hazardous trees
  - Utility poles
  - Non-crashworthy sign supports and mailboxes
- Adjust drainage features
- Change/install guardrail
- Sidewalks

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

Add a Safety Edge

Helps errant vehicles to maintain stability, and more reliably gain re-entry

Countermeasure	CRF	Crash type	Crash severity	Area Type	Quality
Install safety edge treatment***	6.5%	All	All	Rural	★★★★☆
Install safety edge treatment***	9.1%	Run off road	All	Rural	★★★★☆

Paved Shoulders

Table 6. Percent change in crashes relative to providing a 6-foot shoulder on rural two-lane roadway segments (Modified from HSM Table 13-7).

Shoulder Width	Percent change in crashes in comparison to roads with 6-foot shoulders		
	Average Annual Daily Traffic (AADT) (vehicles/day)		
	< 400	400-2,000	> 2,000
0 ft	+ 10%	Between +10% and +50%, depending on AADT	+ 50%
2 ft	+ 7%	Between +7% and +30%, depending on AADT	+ 30%
4 ft	+ 2%	Between +2% and +15%, depending on AADT	+ 15%
6 ft	0%	0%	0%
8 ft or more	- 2%	Between -2% and -13%, depending on AADT	– 13%

** Crash types: Single vehicle run-off-road, multiple vehicle head-on, opposite direction sideswipe, and same-direction sideswipe.*

Low-Cost Treatments for Horizontal Curve Safety - 2016

Countermeasure	CRF	Crash type	Crash severity	Area Type	Quality
Pave shoulder***	18%	Fixed object, head on, run off road, sideswipe	Serious injury, minor injury	Rural	★★★★☆

Install Shoulder Rumble Strips

Countermeasure	CRF	Crash type	Crash severity	Area Type	Quality
Install shoulder rumble strips***	16%	Run off road	All	Rural	★★★★★
Install shoulder rumble strips***	36%	Run off road	Fatal, Serious Injury, Minor Injury	Rural	★★★★★

Rumble Stripes (Edgeline)

Countermeasure	CRF	Crash type	Crash severity	Area Type	Quality
Install edgeline rumble strips***	33%	Run off road	Fatal, Serious Injury, Minor Injury	Rural	★★★★★
Install edgeline rumble strips on roadways with a shoulder width less than 5 feet***	47%	Run off road	Fatal, Serious Injury, Minor Injury	Rural	★★★★★

Rumble Stripes (Combo)

Countermeasure	CRF	Crash type	Crash severity	Area Type	Quality
Install shoulder rumble stripe, widen shoulder from 0 to 2 feet, and pavement resurface***	12.3%	Head on, run off road	All	Rural	★★★★★
Install shoulder rumble stripe, widen shoulder from 0 to 2 feet, and pavement resurface***	27.1%	Head on, run off road	Fatal, Serious Injury, Minor Injury	Rural	★★★★★

Clear Zone - General

The unobstructed, traversable area provided beyond the edge of the through traveled way for the recovery of errant vehicles.

Countermeasure	CRF	Crash type	Crash severity	Area Type	Quality
Increase distance to roadside features (3.3 to 16.7 ft)	22%	All	All	Rural	★★★★★
Increase distance to roadside features (16.7 to 30.0 ft)	44%	All	All	Rural	★★★★☆

Flatten Slopes

Traversable Slope

Countermeasure	CRF	Crash type	Crash severity	Area Type	Quality
Flatten slopes from 1V:3H to 1V:4H***	42%	All	Serious injury, minor injury	Rural	★★★★★
Flatten slopes from 1V:4H to 1V:6H***	22%	All	Serious injury, minor injury	Rural	★★★★★

Flatten Slopes

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

Treatment	Setting (Road Type)	Traffic Volume	Crash Type (Severity)	CMF				
				Sideslope in Before Condition	Sideslope in After Condition			
					1V:4H	1V:5H	1V:6H	1V:7H
Flatten Sideslopes	Rural (Two-lane road)	Unspecified	All types (Unspecified)	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

Base Condition: Existing sideslope in *before* condition.

NOTE: Standard error of the CMF is unknown.

Clearing/Relocating Obstacles

Table 40 Percent reductions in specific types of obstacle accidents due to clearing/relocating obstacles farther from the roadway *(93)*

Increase in Obstacle Distance (I.O.D.), m (ft)	Trees (%)	Mailboxes, Culverts, & Signs (%)	Guardrails (%)	Fences/Gates (%)
0.9 (3)	22	14	36	20
1.5 (5)	34	23	53	30
2.4 (8)	49	34	70	44
3.1 (10)	57	40	78	52
4.0 (13)	66	N.F.	N.F.	N.F.
4.6 (15)	71	N.F.	N.F.	N.F.

Notes:
N.F. = generally not feasible to relocate obstacles to specified distances.
I.O.D = amount of increase in obstacle distance from roadway.
This table is appropriate for obstacle distances of 9.1 m (30 ft) or less and only on two-lane rural roadways.

Remove Hazardous Trees

- 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)

Relocate Utility Poles #1

- Two 3-Star CMFs exists for change in:
  - lateral offset of utility poles***
  - longitudinal density of utility poles***
- CMFs vary by the offset and density change
- Study concluded that offset impacts are larger than spacing

Relocate Utility Poles #2

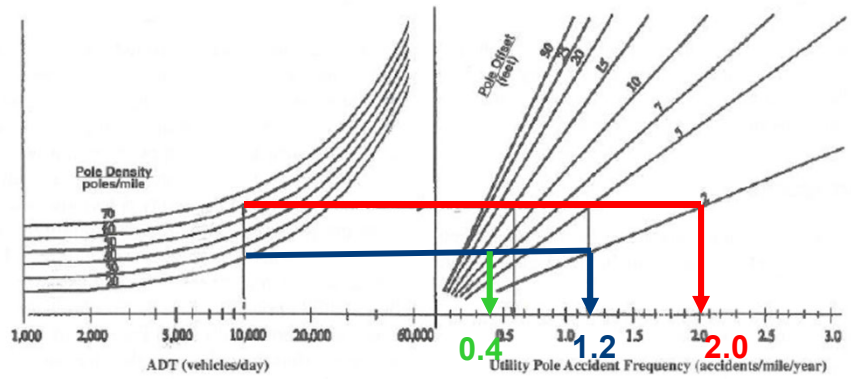


Figure 18. Nomograph for predicting utility pole accident frequency (96).

Source – NCHRP 440 (originally Zegeer and Parker, 1984)

Replace/Relocate Non-Crashworthy Sign Supports

Bad Example

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

Replace/Relocate Mailboxes

Adjust Drainage Features #1

Cross drainage features

Parallel drainage features

Adjust Drainage Features #2

Change/Install Guardrail

Used to shield roadside hazards

Countermeasure	CRF	Crash type	Crash severity	Area Type	Quality
Change Barrier along Embankment to Less Rigid Type	32%	Run off Road	Serious injury, minor injury	Not specified	★★★★★
New Guardrail along Embankment***	47%	Run off Road	Serious injury, minor injury	Not specified	★★★★★
Install W-Beam Guardrail***	11%	Run off Road	Fatal, serious injury, minor injury	Rural	★★★★½

Sidewalks

- Help to separate pedestrians and vehicles
- Survey of State DOTs found they used a reduction in vehicle/pedestrian crashes of 65-89%.

Learning Outcomes Revisited

- Define the scope of the roadway departure safety issue in the U.S.
- Identify/describe some safety improvements and strategies that address roadside safety
- Interpret and apply the crash reduction potential of different treatment strategies related to roadside safety

Review Question 1

What are the six options the Roadside Design Guide generally provides to address roadside obstacles?

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

Review Question 2

What are some of the roadside features that can present a hazard to vehicles if they have left the roadway?

- Pavement edge or shoulder drop off
- Slopes
- Trees
- Utility poles
- Mailboxes
- Non-Crashworthy sign supports
- Drainage features

Some Resources

- Roadside Design Guide (2011)
- Highway Safety Manual (2010)
- CMF Clearinghouse (www.cmfclearinghouse.org)
- State of The Practice for Shoulder and Center Line Rumble Strip Implementation on Non-Freeway Facilities (2017)
- NCHRP 440 – Accident Mitigation Guide for Congested Rural Two-Lane Highways (2000)
- NCHRP 500 – Volumes 3 (trees, 2003)), 6 (run-off-the-road, 2003), and 8 (utility poles, 2004)
- Low-Cost Treatments for Horizontal Curve Safety 2016

Module 5: Unsignalized Intersections

Low Cost Safety Improvements

Learning Outcomes

- Define unsignalized intersection safety in the U.S.
- Identify/describe some safety improvements for unsignalized intersections
- Interpret and apply unsignalized intersection safety improvement crash reduction factors (CRFs)

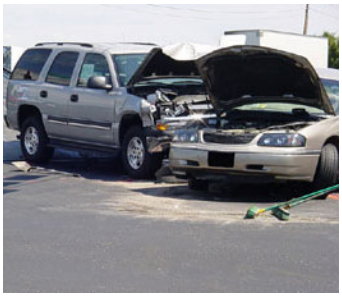
U.S. Fatalities - 2016

- 37,461 total fatalities in U.S.
- 10,267 total intersection fatalities (27.4%)
- 7,122 unsignalized intersection fatalities (69% of all intersection fatalities)
  - 985 pedestrian fatalities
  - 200 bicyclist fatalities
- About 19% of all roadway fatalities happened at unsignalized intersections (2016)

Source: 2014 Fatal Accident Reporting System (FARS)

Predominant Crash Types

- Rear end
- Angle and turning
- Sideswipe
- Pedestrian/bicyclist



General Characteristics

- Complex locations
  - Crossing movements
  - Turning movement
  - Merging/diverging movements
- Multiple users
  - Autos/Trucks/Buses
  - Pedestrian
  - Bicyclists
- Traffic control
  - Uncontrolled
  - Yield
  - Stop (two-way and all-way)
- Configurations: Three, four, and more legs

Configurations and Crashes

- Collision rates at 4-leg intersections are 1.2 to 1.6 times those at 3-leg
- Safety of offset 3-leg intersection increases as minor road traffic increases

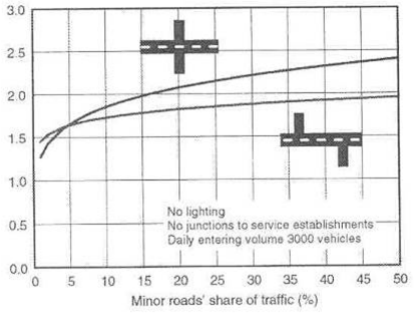
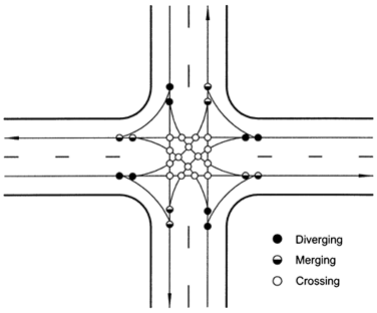
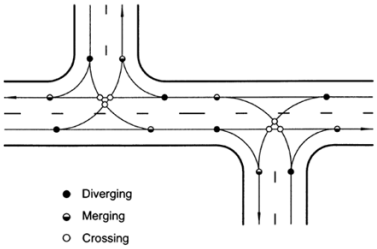


Figure 20.1
Expected number of injury collisions in 5 years

Converting a 4-Leg to Two 3-Leg Intersections





In the HSM the CMF for this conversion is related to the Minor Street Traffic

Expected safety improves as the percentage of minor street traffic increases

Countermeasure	CRF	Crash type	Crash severity	Area Type	Quality
Convert 4-leg intersection into two 3-leg intersections	25.0%	All	Serious injury, Minor injury	Urban	★★★★☆

Other Treatments We Will Discuss

- Minor road to all way stop control
- Roundabouts
- Reduced Left Turn Conflict Intersections
- Turn lanes
- Change skew angle
- Oversized stop signs
- Double stop signs
- Enhanced signing and delineation
- Increase stop sign retroreflectivity
- Flashing LED stop sign
- Flashing beacons
- Intersection collision warning systems
- Transverse rumble strips
- Intersection lighting
- Improve sight distance
- Pedestrian Refuge

Convert Minor Road to All-Way Stop Control

- Can reduce right-angle and turning crashes
- Suitable at moderate volumes and relatively balanced volume intersections
- Be selective, look at crash patterns, and consider delay impact

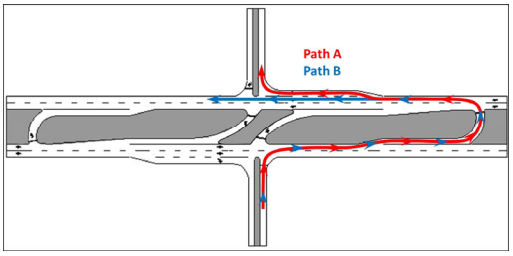
Countermeasure	CRF	Crash type	Crash severity	Area Type	Quality
Minor road stop to all-way stop	75.0%	Angle	All	Urban	★★★★★
Minor road stop to all-way stop	48.0%	All	All	Rural	★★★★★

Roundabouts

Countermeasure	CRF	Crash type	Crash severity	Area Type	Quality
Convert intersection with minor-road stop control to modern roundabout	71.0%	All	All	Rural	★★★★★
Convert intersection with minor-road stop control to modern roundabout	82.0%	All	Serious injury, Minor injury	Rural	★★★★★
Convert high speed rural*** intersection to roundabout	87.0%	All	Serious injury, Minor injury	Rural	★★★★½

Reduced Left Turn Conflict Intersections #1

- Restricted Crossing U-turn (RCUT) aka J Turn or superstreet intersection

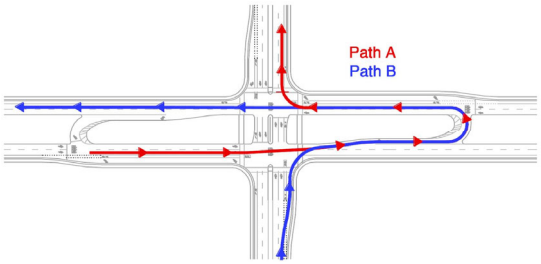



Example of RCUT intersection.

Countermeasure	CRF	Crash type	Crash severity	Area Type	Quality
Install J-Turn intersection***	34.8	All	All	Rural	★★★★★
Install J-Turn intersection***	53.7	All	Major injury, minor injury, possible injury	Rural	★★★★☆

Reduced Left Turn Conflict Intersections #2

- Median U-Turn aka Michigan left or Thru-Turn Intersection
  - 30% reduction in injury related crashes (Jagannathan 2007)



Left Turn Lanes

- Reduce conflicts between turning vehicle and following vehicles
- Can reduce rear-end (major road), right-angle, and opposing left turn crashes

Countermeasure	CRF	Crash type	Crash severity	Area Type	Quality
Provide a left-turn lane on one major-road approach	44%	All	All	Rural	★★★★☆
Provide a left-turn lane on both major-road approaches	48%	All	All	Rural	★★★★★

Right Turn Lanes

- Provide storage and deceleration area
- Reduce conflicts between turning vehicle and following vehicles
- Improve operational performance

Countermeasure	CRF	Crash type	Crash severity	Area Type	Quality
Install right-turn lane on one major road approaches	14%	All	All	All	★★★★☆
Install right-turn lane on both major road approaches	26%	All	All	All	★★★★☆

Offset Left Turn lanes

- Improves intersection sight distance (left-turn)
- Can help with gap judgement

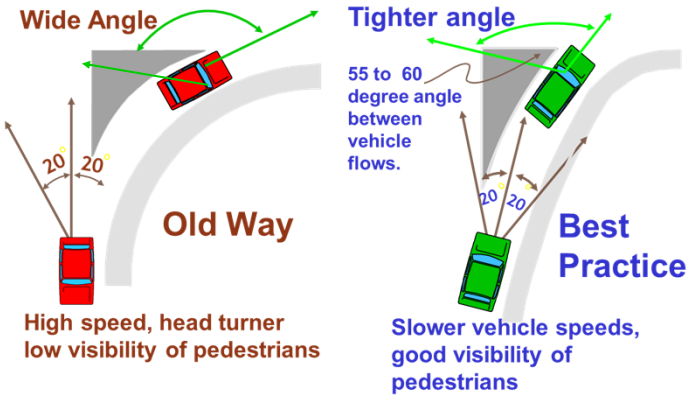
Countermeasure	CRF	Crash type	Crash severity	Area Type	Quality
Install positive offset left turn lanes***	78%	Left-turn, Rear end	All	Rural	★★★★★
Install positive offset left turn lanes***	50%	All	All	Rural	★★★★★

Offset Right Turn lanes

Improve minor street traffic sight distance

Countermeasure	CRF	Crash type	Crash severity	Area Type	Quality
Install offset right-turn lane***	69.0%	Angle	All	Rural	★★★★★

Improve Turn Lane Angle



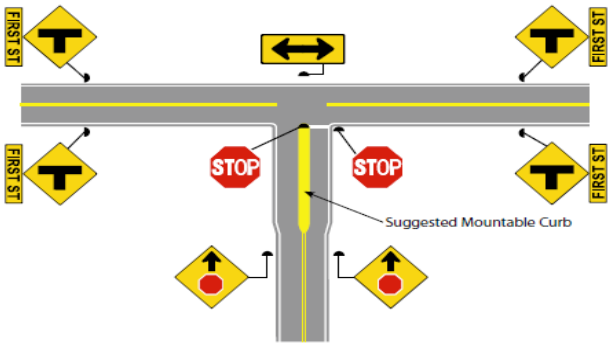
Countermeasure	CRF	Crash type	Crash severity	Area Type	Quality
Improve angle of channelized right turn lane***	60.3%	Right turn, Other	All	Not specified	★★★★☆
Improve angle of channelized right turn lane***	44.2%	All	All	Not specified	★★★★☆

Change Skew Angle

CMF Varies with Difference in Angle

Countermeasure	CMF	Crash type	Crash severity	Area Type	Quality
Change intersection skew angle	$e^{0.0054(\Delta_{skew\ angle})}$	All	All	Rural	Cannot be rated (HSM)

Enhanced Signing and Delineation



Countermeasure	CRF	Crash type	Crash severity	Area Type	Quality
Implement systemic signing and marking improvements at stop-controlled intersections***	10.1%	All	Fatal, Major Injury, Minor Injury, & Possible Injury	All	★★★★☆
	14.7%	Nighttime	All	All	★★★★☆

Oversized Stop Sign

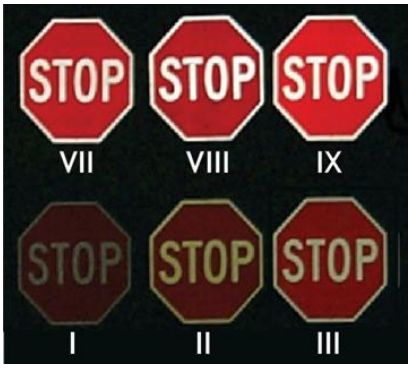
A study based on surveys of DOTs found a crash reduction of 19%

Double Stop Sign

11% reduction in all crashes (FHWA Issue Brief #8) but can't be ranked

Countermeasure	CRF	Crash type	Crash severity	Area Type	Quality
Install double stop signs***	55%	Angle	All	Urban	★☆☆☆☆

Increased Retroreflectivity



Countermeasure	CRF	Crash type	Crash severity	Area Type	Quality
Increase retroreflectivity of stop signs***	7.6%	Angle	All	All	★★★★☆
Increase retroreflectivity of stop signs***	17.5%	Rear end	All	All	★★★★☆

Flashing Beacons

- Reinforce driver awareness of the stop sign
- May help to mitigate patterns of right-angle crashes related to stop sign violations

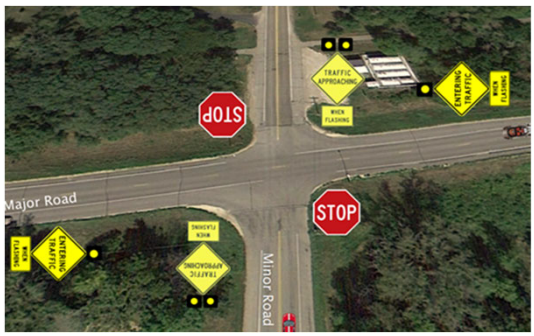
Countermeasure	CRF	Crash type	Crash severity	Area Type	Quality
Flashing beacon at stop controlled intersection	16%	Angle	All	Rural	★★★★☆

LED Stop Signs

Figure 1: Example of stop sign with embedded LEDs and solar unit.

Countermeasure	CRF	Crash type	Crash severity	Area Type	Quality
Replace standard stop sign with flashing LED stop sign***	41.5%	Angle	All	Not specified	★★★☆☆

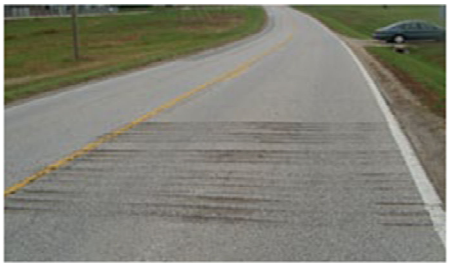
Intersection Conflict Warning Systems



Warns drivers on minor or major road that traffic is approaching the intersection on other approaches when sign is flashing

Countermeasure	CRF	Crash type	Crash severity	Area Type	Quality
Install ICWS for two-lane at two-lane intersection***	27%	All	All	Rural	★★★★★
Install ICWS for two-lane at two-lane intersection***	30%	All	Serious Injury, Minor injury	Rural	★★★★★
Install ICWS for two-lane at two-lane intersection***	20%	Angle	All	Rural	★★★★★

Transverse Rumble Strips



- Appropriate on stop-controlled approaches to rural intersections where crash data show control is not currently being recognized
- 2015 study found reductions of 37% (3 leg) and 29% (4 leg) for fatal and injury crashes. Greatest reduction seen for rear end crashes.

Countermeasure	CRF	Crash type	Crash severity	Area Type	Quality
Install transverse rumble strips on stop control approaches in rural areas***	21.5%	All	Fatal, Serious injury	Rural	★★★★★
Install transverse rumble strips on stop control approaches in rural areas***	-19.1%	All	PDO	Rural	★★★★☆

Intersection Lighting

Minnesota DOT

- Install at intersections with a pattern of nighttime crashes
  - rear-end
  - right-angle
  - turning crashes

Countermeasure	CRF	Crash type	Crash severity	Area Type	Quality
Provide intersection illumination	38%	Nighttime	Serious injury, minor injury	Not specified	★★★★★
Provide intersection illumination	42%	Nighttime, Vehicle/Pedestrian	Serious injury, minor injury	Not specified	★★★★★
Install intersection lighting***	11.9%	Nighttime	All	Not specified	★★★★★

Improve Sight Distance

- Remove obstructions and maintain sight triangles
- Past work experts indicated 5% decrease in crashes for fixing each deficient quadrant

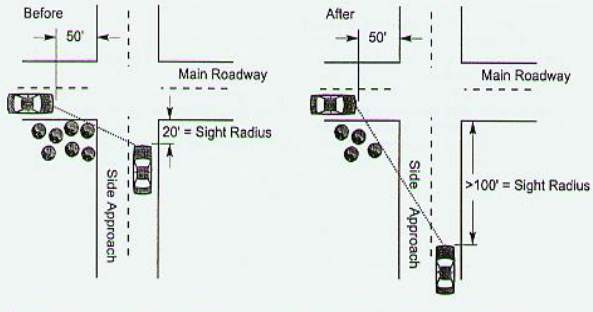


Figure 23. Example of increased sight radius on accident reduction (112).

NCHRP Research Report 875

Guidance for Evaluating the Safety Impacts of Intersection Sight Distance (2018)

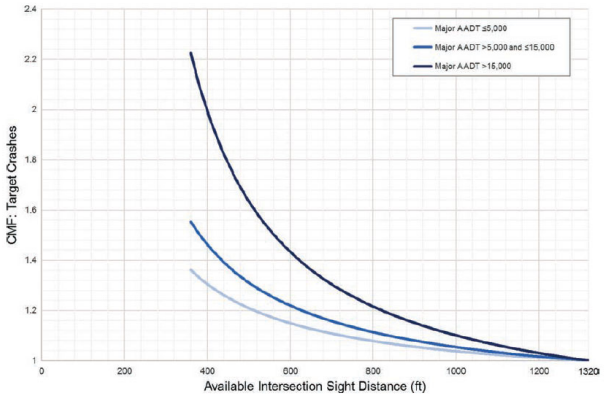


Chart A-5. CMFs for target crashes when posted speed equals 55 mph.

Pedestrian Refuge

Countermeasure	CRF	Crash type	Crash severity	Area Type	Quality
Install raised median with marked crosswalk (uncontrolled)***	46%	Vehicle/ Pedestrian	All	Urban and suburban	★★★☆☆
Install raised median with or without marked crosswalk (uncontrolled)***	31.5%	Vehicle/ Pedestrian	All	Urban and suburban	★★★☆☆
Install raised median with or without marked crosswalk (uncontrolled)***	25.9%	Rear end, sideswipe	All	Urban and suburban	★★★★☆

Some Other Treatments

- Sign maintenance
- Access management
- Advanced warning signs
- Stop bar addition and location
- Pavement marking messages
- Addition of splitter islands on minor approach
- Turn acceleration lanes
- Eliminate turning maneuvers
- Convert 3-Leg offset intersections to 4-leg
- Shoulder widening

Learning Outcomes Revisited

- Define unsignalized intersection safety in the U.S.
- Identify/describe some safety improvements for unsignalized intersections
- Interpret and apply unsignalized intersection safety improvement crash reduction factors (CRFs)

Review Question 1

About what percentage of fatalities occur at unsignalized intersections?

20%

Review Question 2

Name 3 treatments that might be used to make the driver more aware of the need to stop?

- LED stop sign
- Increase retroreflectivity
- Double up stop signs
- Install oversized stop sign
- Transverse rumble strips

Resources #1

- Highway Safety Manual – Chapter 14 (2010)
- Crash Modification Factors Clearinghouse
- Intersection Safety, A Manual for Local Rural Road Owners (2011)
- Manual for Selecting Safety Improvements on High Risk Rural Roads (2014)
- Low-Cost Safety Enhancements for Stop-Controlled and Signalized Intersections (2009)

Resources #2

- Unsignalized Intersection Information Guide (www.ite.org/uiig/)
- NCHRP Report 500 / Volume 5: A Guide for Addressing Unsignalized Intersection Collisions (2003)
- Issue Brief #8 – Toolbox of Countermeasures and Their Potential Effectiveness for Intersection Crashes (2009)
- Objectives and Strategies for Improving Safety at Unsignalized and Signalized Intersections

Module 6: Unsignalized Intersection Exercise

Low Cost Safety Improvements

Learning Outcomes

At the end of this lesson, you will be able to:

1. Analyze crash and visual data
2. Evaluate unsignalized intersections for safety concerns
3. Evaluate potential low cost safety improvement(s) to improve unsignalized intersection safety.

Background Information on Site

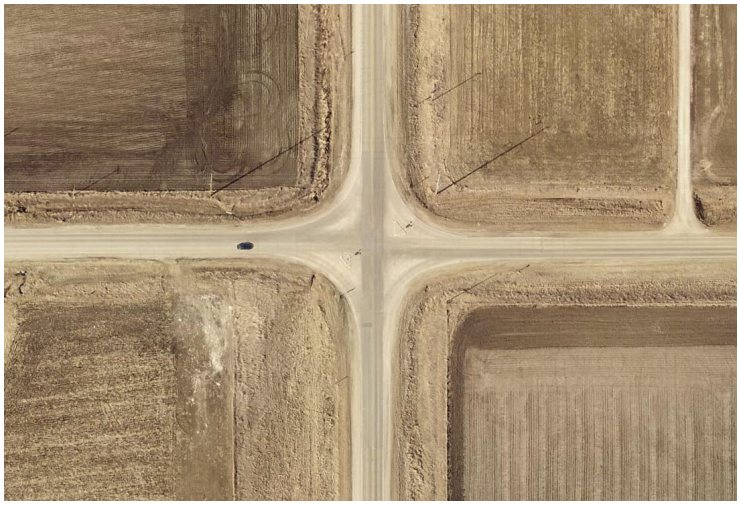
- Two-way stop controlled intersection
- History of intersection related crashes during the last 5 years

Exercise Goals

Utilize aerial views, approach views, crash diagram and crash summaries to:

1. Determine the types of crashes that are most typical at the unsignalized intersection
2. Determine potential safety issues at the unsignalized intersection
3. Determine additional data that may be helpful in identifying issue
4. List potential low cost safety improvement(s) which may be appropriate to help address the safety issue(s)
5. Discuss how you might prioritize the low cost safety improvement(s) suggested

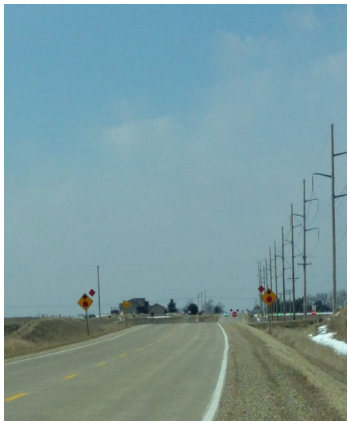
Aerial View



West Approach to Intersection

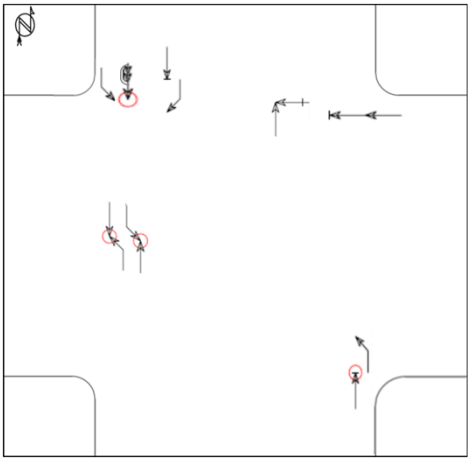
North Approach to Intersection

East Approach to Intersection



South Approach to Intersection

Crash Diagram



Straight
Stopped
Unknown
Backing
Overtaking
Sideswipe
Parked
Erratic
Out of control
Right turn
Left turn
U-turn

Pedestrian
Bicycle
Injury
Fatality
Nighttime
DUI

Fixed objects:
General
Signal
Tree
Pole
Curb
Animal

3rd vehicle
Extra data

Crash History

Manner of Impact		
Rear-end	3	42.85%
Angle, oncoming left turn	2	28.55%
Broadside (front to side)	1	14.3%
Sideswipe, same direction	1	14.3%

Major Cause		
FTYROW: Making left turn	2	28.55%
Crossed centerline (undivided)	1	14.3%
Followed too close	1	14.3%
Swerving/Evasive Action	2	28.55%
Other	1	14.3%

Crash Severity		
Minor Injury	3	42.85%
Possible Injury	1	14.3%
Property Damage Only	3	42.85%

Surface Condition		
Dry	6	85.7%
Wet	1	14.3%

Alcohol Involved		
No	7	100%
Yes	0	0%

Questions to answer

1. What are the most prevalent types of crashes?
2. What safety issues may be leading to these types of crashes?
3. What other data would be helpful to have?
4. What low cost safety improvement(s) might help address these issues?
5. How might you prioritize the different countermeasures?

Review Learning Outcomes

1. Analyze crash and visual data
2. Evaluate unsignalized intersection for safety concerns
3. Evaluate potential low cost safety improvement(s) to improve unsignalized intersection safety.