FHWA *WEBINAR*

Intersection Safety Measures for Focus State Plans

Systematic Approach to Intersection Safety

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U.S. Department of Transportation Federal Highway Administration

Federal Highway Administration RESOURCE CENTER

Safe Roads for a Safer Future
Investment in roadway safety saves lives

Webinar Resource Documents

- **Have you downloaded for Today's Webinar? (-using the file share pod)**

  -PowerPoint Handout for Today's Webinar
  -FHWA Unsignalized and Signalized Intersections Countermeasures
  -Issue Briefs Sheet #8 Toolbox of Countermeasures – Crash Reduction Factors
  - Intersection Crash Prediction Spreadsheet – Highway Safety Manual

- Before the webinar starts or after,
  to download information/files,
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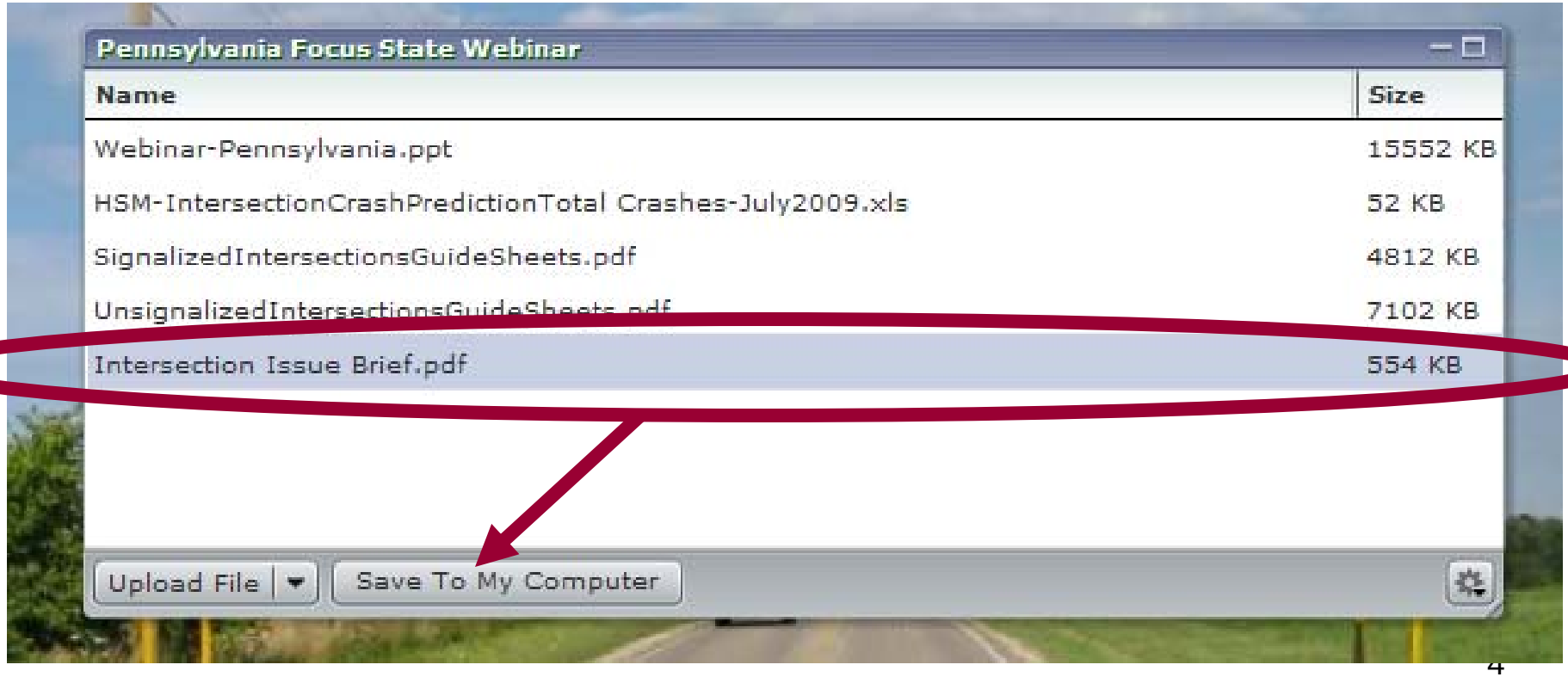


Agenda – Intersection Safety Measures for Focus State Plans

- Status of Focus State Intersection Safety Implementation Plans
- Proven Key Countermeasures for Stop Controlled Intersections
- Proven Key Countermeasures for Signal Controlled Intersections
- Proven Key Geometric Countermeasures

2006 U.S. National Total Crash Characteristics

Crash Type	Total Crashes		Fatalities + Injury Crashes	
	Number	Percent	Number	Percent
Non-Intersection	2,826,900	47%	767,820	44%
Stop and No Control Intersection	1,955,467	33%	588,618	34%
53%			**56%**	
Signalized Intersection	1,181,848	20%	391,047	22%
Total	5,964,000	100%	1,747,485	100%

Pennsylvania 2007 Traffic Fatalities

	US	Pennsylvania
TOTAL FATALITIES	42,986	1564
TOTAL INTERSECTION FATALITIES	8,657 (21% of nationwide total)	291 (20%)

Fatality Rates: Pennsylvania , U.S. and Best State

Year		Fatalities	Total Vehicle Miles Traveled (Millions)	Fatalities Per 100 Million Vehicle Miles Traveled	Total Population	Fatalities Per 100,000 Population
2004	Pennsylvania	1,490	108,070	1.38	12,335,652	12.08
	US	42,836	2,964,788	1.44	292,892,127	14.63
	Best State*			0.87		7.39
2005	Pennsylvania	1,616	108,042	1.50	12,351,881	13.08
	US	43,510	2,989,430	1.46	295,560,549	14.72
	Best State*			0.80		6.85
2006	Pennsylvania	1,525	108,278	1.41	12,388,055	12.31
	US	42,708	3,014,371	1.42	298,362,973	14.31
	Best State*			0.78		6.32
2007	Pennsylvania	1,491	108,699	1.37	12,419,930	12.00
	US	41,259	3,029,822	1.36	301,290,332	13.69
	Best State*			0.79		6.55
2008	Pennsylvania	1,468			12,448,279	11.79
	US	37,261	2,925,503	1.27	304,059,724	12.25
	Best State*					5.59

5 Year Trend For The Top 10 Counties of 2008 - Fatalities

Counties by 2008 Ranking		Fatalities					Percent of Total				
		2004	2005	2006	2007	2008	2004	2005	2006	2007	2008
1	Philadelphia County	121	99	104	125	92	8	6	7	8	6
2	Allegheny County	76	104	80	76	75	5	6	5	5	5
3	Lancaster County	54	71	63	64	66	4	4	4	4	4
4	Berks County	59	73	50	49	63	4	5	3	3	4
5	Westmoreland County	50	54	35	50	58	3	3	2	3	4
6	Bucks County	53	74	72	60	54	4	5	5	4	4
7	York County	43	50	56	54	53	3	3	4	4	4
8	Montgomery County	57	44	54	57	45	4	3	4	4	3
9	Lehigh County	37	49	41	37	42	2	3	3	2	3
10	Chester County	56	51	54	55	40	4	3	4	4	3
*Sub Total 1.**	*Top Ten Counties*	609	669	625	643	588	41	41	41	43	40
*Sub Total 2.***	*All Other Counties*	880	946	900	848	880	59	59	59	57	60
Total	*All Counties*	1,489	1,615	1,525	1,491	1,468	100	100	100	100	100

Fatalities by Crash Type

Crash Type	2004	2005	2006	2007	2008
Total Fatalities (All Crashes)*	1,490	1,616	1,525	1,491	1,468
- (1) Single Vehicle	802	888	886	843	845
- (2) Involving a Large Truck	189	183	193	194	192
- (3) Involving Speeding	661	757	675	783	718
- (4) Involving a Rollover	338	372	367	340	377
- (5) Involving a Roadway Departure	856	892	852	847	901
- (6) Involving an Intersection (or Intersection Related)	342	340	335	307	274

Systematic Approach to Intersection Safety

- Rather than focusing on only a few intersections with the highest number of crashes – “Top Down” (typical HSIP program)
- Systematic Approach focuses on the intersections with the majority of the crashes – “Bottom Up”

FOCUS STATE Intersection Safety Implementation Plans

➔ analysis of intersection crash locations typically identify 40 to 50% of the total intersection crashes in a state occur at 10 to 15% of the intersections

➔ Focus State Implementation Plans based upon the **Systematic Approach**

Systematic Approach to Intersection Safety- Example:

Table 23: Total Crashes – Missouri State Rural Roads - Signalized TCD - 2002-2007

NUMBER OF CRASHES PER INTERSECTION	NUMBER OF INTERSECTIONS	CUMULATIVE INTERSECTIONS	CUMULATIVE PERCENT	CUMULATIVE CRASHES	CUMULATIVE PERCENT
50 and greater	**8**	**8**	**1.44%**	**573**	**13.95%**
30 - 49	**23**	**31**	**5.57%**	**1,407**	**34.26%**
20 - 29	**36**	**67**	**12.03%**	**2,258**	**54.98%**
10 - 19	**56**	**123**	**22.08%**	**3,012**	**73.34%**
5 - 9	**73**	**196**	**35.19%**	**3,490**	**84.98%**
4	**31**	**227**	**40.75%**	**3,614**	**88.00%**
3	**43**	**270**	**48.47%**	**3,743**	**91.14%**
2	**77**	**347**	**62.30%**	**3,897**	**94.89%**
1	**210**	**557**	**100.00%**	**4,107**	**100.00%**
Total	557	557	100.00%	4,107	100.00%

For Missouri for 2002-2007, **73.34%** of all signalized intersection crashes occurred at 123 or **22.1%** of the total of 557state signalized intersections with 10 or more crashes

Systematic Approach to Intersection Safety- Example:

IN Signal Intersection Summary Reports

Signal Intersection - State Urban Crashes - Summary

Number of Intersections 3,264

NUMBER OF CRASHES	INDIVIDUAL		CUMULATIVE		CUMULATIVE	
	INTERSECTIONS	PERCENT	INTERSECTIONS	PERCENT	CRASHES	PERCENT
121	1	0.03%	1	0.03%	121	0.71%
120	-	0.00%	1	0.03%	121	0.71%
119	-	0.00%	1	0.03%	121	0.71%
118	-	0.00%	1	0.03%	121	0.71%
117	-	0.00%	1	0.03%	121	0.71%
116	-	0.00%	1	0.03%	121	0.71%
115	-	0.00%	1	0.03%	121	0.71%
15	19	0.58%	287	8.79%	7,541	43.99%
14	31	0.95%	318	9.74%	7,975	46.52%
13	34	1.04%	352	10.78%	8,417	49.10%
12	48	1.47%	400	12.25%	8,993	52.46%
11	49	1.50%	449	13.76%	9,532	55.60%
10	54	1.65%	503	15.41%	10,072	58.75%
9	70	2.14%	573	17.56%	10,702	62.42%

For Indiana in 2005, **58.75%** of all intersection crashes occurred at 503 or **15.4%** of the total of 3,264 state urban signalized intersections with 10 or more crashes

FOCUS STATE Intersection Safety Implementation Plans

Workshops conducted in 10 states to date:

- ➔ Indiana
- ➔ Tennessee
- ➔ Georgia
- ➔ Louisiana
- ➔ Florida
- ➔ Arizona
- ➔ Louisiana
- ➔ South Carolina
- ➔ Mississippi
- ➔ Missouri

Systematic Approach to Intersection Safety by the States:

- **8** states have developed Implementation Plans for Systematic Approach to Intersection Safety
- **7** states are actively reviewing the identified intersections and conducting engineering field reviews.
- **7** states have revised their engineering standards to provide for enhanced low cost signing and marking and for signal head per lane with back plates
- **2** states have let contracts for the first year annual element for systematic improvement

FOCUS STATE Intersection Safety Implementation Plans

Implementation Plans approved in 5 states to date:

- ➔ Louisiana
- ➔ Florida
- ➔ South Carolina
- ➔ Missouri
- ➔ Mississippi

FOCUS STATE Intersection Safety Implementation Plans

2 states have let/are letting contracts for Systematic Improvement:

- ➔ Louisiana
- ➔ South Carolina

FOCUS STATE Intersection Safety Implementation Plans

South Carolina's Systematic Approach:

- **Estimated 194,000 intersections in South Carolina**
- **44% of the intersection crashes occurred at 1.3% of the intersections (5 or more crashes in 5 years)**

FOCUS STATE Intersection Safety Implementation Plans

South Carolina:

Results for the first 91 intersections improved (2004) 3 years of “after” intersection crash data compared to 3 years of before crash data:

- ➔ Total crash reduction of 54.7%
- ➔ Severity Index reduction of 54.5%
- ➔ Injuries reduced by 34.8% and
- ➔ Fatalities reduced by 75%
- ➔ Average Benefit to Cost ratio of 385

FOCUS STATE Intersection Safety Implementation Plans

South Carolina:

➔ will complete statewide replacement of traffic signal heads with LED's + Backplates this year

➔ let a contract for improvement of 2,200 intersections in June as the first year of a 3 year Implementation plan

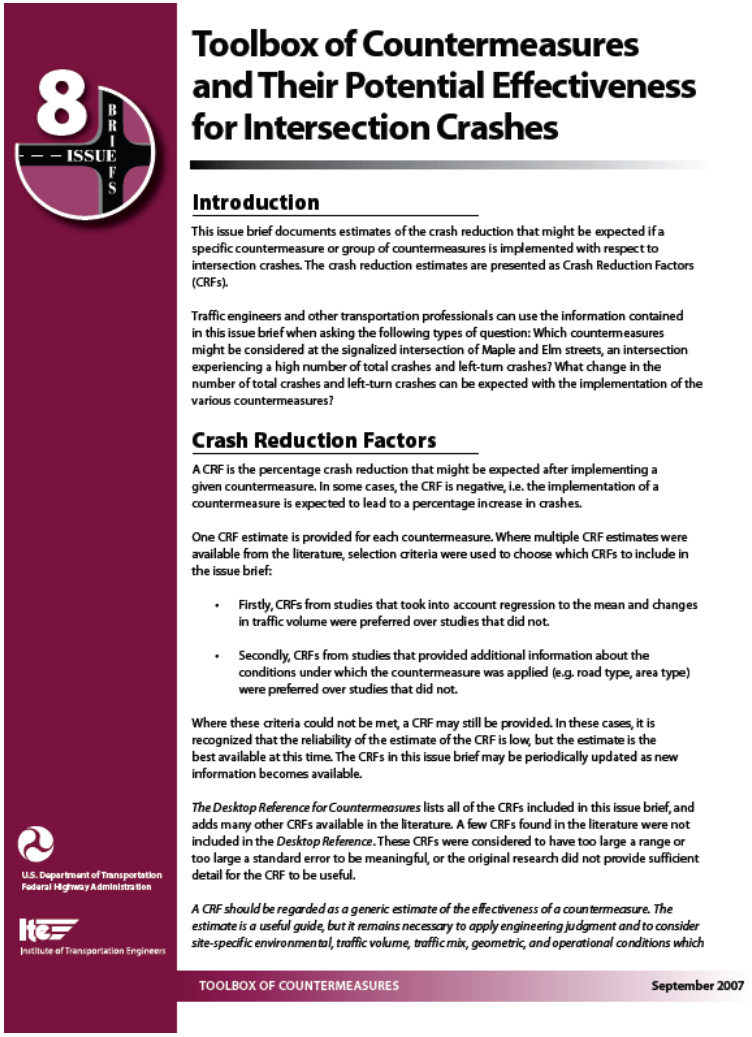
FOCUS STATE
Intersection Safety Implementation Plans

Questions?

Intersection Safety Countermeasures

Appendix: FHWA

Intersection Safety Issues Briefs #8 – Toolbox of Countermeasures



8 ISSUE BRIEFS

U.S. Department of Transportation
Federal Highway Administration

ite
Institute of Transportation Engineers

Toolbox of Countermeasures and Their Potential Effectiveness for Intersection Crashes

Introduction

This issue brief documents estimates of the crash reduction that might be expected if a specific countermeasure or group of countermeasures is implemented with respect to intersection crashes. The crash reduction estimates are presented as Crash Reduction Factors (CRFs).

Traffic engineers and other transportation professionals can use the information contained in this issue brief when asking the following types of question: Which countermeasures might be considered at the signalized intersection of Maple and Elm streets, an intersection experiencing a high number of total crashes and left-turn crashes? What change in the number of total crashes and left-turn crashes can be expected with the implementation of the various countermeasures?

Crash Reduction Factors

A CRF is the percentage crash reduction that might be expected after implementing a given countermeasure. In some cases, the CRF is negative, i.e. the implementation of a countermeasure is expected to lead to a percentage increase in crashes.

One CRF estimate is provided for each countermeasure. Where multiple CRF estimates were available from the literature, selection criteria were used to choose which CRFs to include in the issue brief:

- Firstly, CRFs from studies that took into account regression to the mean and changes in traffic volume were preferred over studies that did not.
- Secondly, CRFs from studies that provided additional information about the conditions under which the countermeasure was applied (e.g. road type, area type) were preferred over studies that did not.

Where these criteria could not be met, a CRF may still be provided. In these cases, it is recognized that the reliability of the estimate of the CRF is low, but the estimate is the best available at this time. The CRFs in this issue brief may be periodically updated as new information becomes available.

The Desktop Reference for Countermeasures lists all of the CRFs included in this issue brief, and adds many other CRFs available in the literature. A few CRFs found in the literature were not included in the *Desktop Reference*. These CRFs were considered to have too large a range or too large a standard error to be meaningful, or the original research did not provide sufficient detail for the CRF to be useful.

A CRF should be regarded as a generic estimate of the effectiveness of a countermeasure. The estimate is a useful guide, but it remains necessary to apply engineering judgment and to consider site-specific environmental, traffic volume, traffic mix, geometric, and operational conditions which

TOOLBOX OF COUNTERMEASURES September 2007

Unsignalized and Signalized Intersection Safety Strategies

UNSIGNALIZED INTERSECTION SAFETY STRATEGIES

Federal Highway Administration

Implement Driveway Closures/Relocations

WHERE TO USE
Unsignalized intersections with high crash frequencies related to driveways adjacent to the intersection. Generally, driveways within 250 feet of the intersection are the greatest concern.

Photo by: TTI

While this photo depicts driveways closed by guardrail, permanent curb and gutter is the preferred countermeasure design.

DETAILS

Effective access management is key to improving safety at and adjacent to unsignalized intersections. Highway agencies are increasingly using access management techniques on urban and suburban arterials.

A key element of access management is closure or relocation of driveways adjacent to intersections. Access points within 250 feet upstream and downstream of an intersection are generally undesirable. Strategies for mitigating safety problems that may arise from a driveway located too close to an unsignalized intersection are to close the driveway (if other access to the adjacent property already exists) or to relocate the driveway (if no other appropriate access is available). It is desirable to relocate access points from the major road to the minor road (away from the intersection), or (where practical) to another street or frontage road. Where there is access from the minor road, a side street, or a frontage road, relocating the driveway to the major road farther from the intersection may be considered.

KEY TO SUCCESS

Agencies should work with onwners of adjacent properties to assure them that some restriction of access to their properties will improve safety and will not affect their ability (or, in the case of a retail business, their customers' ability) to reach their properties. Where practical, these strategies should be implemented as part of a comprehensive corridor access management plan.

NCHRP Report 500 / Volume 5: A Guide for Addressing Unsignalized Intersection Collisions STRATEGY A1

Intersection Safety Strategies

- Individual Strategy Sheets for each of the 49 Unsignalized Intersection Strategies
- **from NCHRP 500 – Volume 5: A Guide for Addressing Unsignalized Intersection Collisions**
- Individual Strategy Sheets for each of the 28 Signalized Intersection Strategies

Systematic Approach to Intersection Safety

Application of low cost measures:

- Signing and
- Marking and
- Minor Signal Visibility measures

- Rather than high cost geometric reconstruction of intersections

The Two Overall Principles for Design and Operation of Intersections:

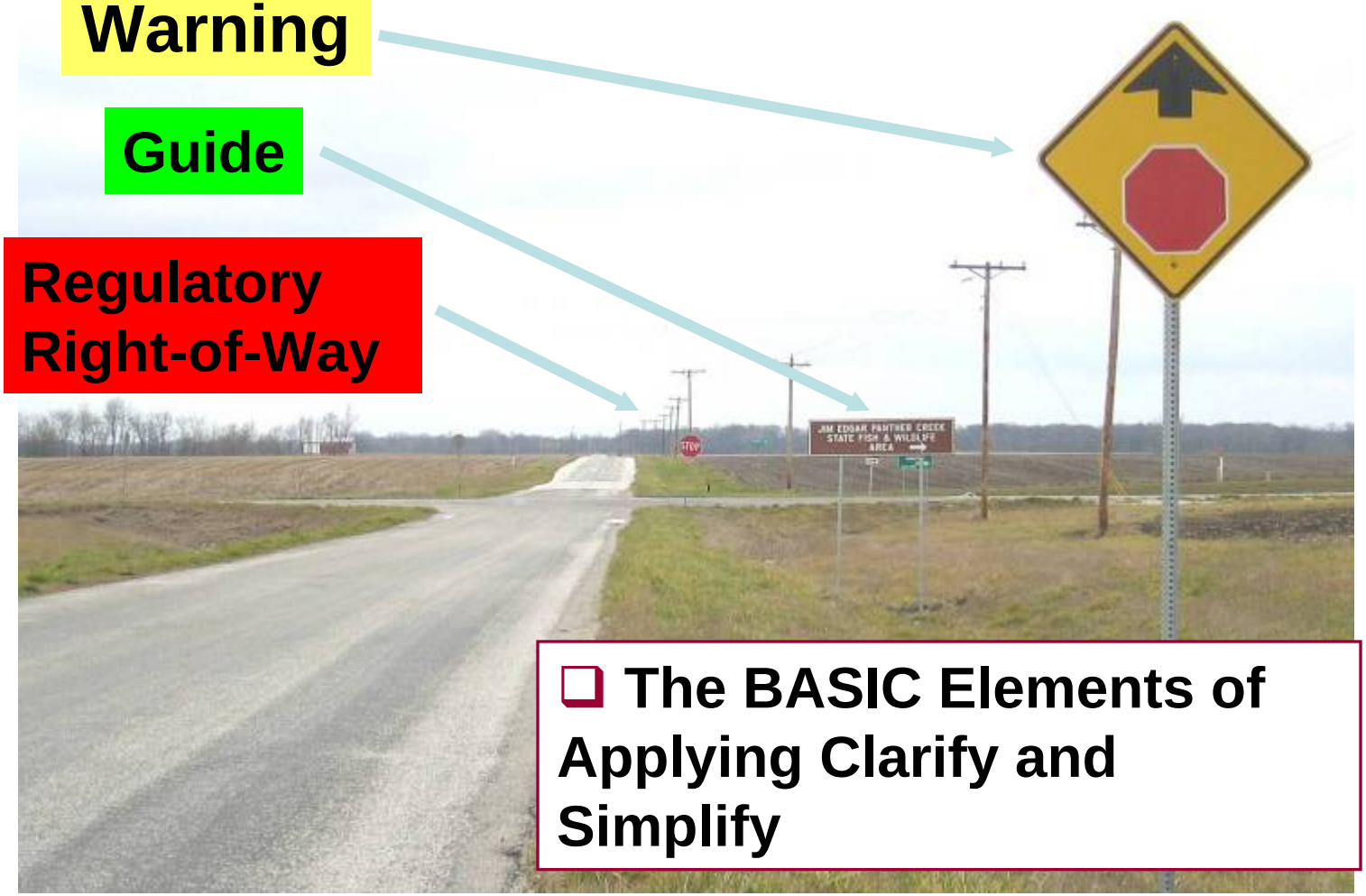
- **Clarify**
- **Simplify**

Systematic Approach to Improving Intersection Safety

Warning

Guide

Regulatory
Right-of-Way



- **The BASIC Elements of Applying Clarify and Simplify**

Applying “Clarify” and “Simplify”:

➔ Provide info in advance of where it is needed (warning + navigation)

➔ “Spread” decisions

➔ Keep workload at “medium” level

➔ Maximize **visibility** of warning and Stop signs + beacons

Clarify and Simplify Example:

- **Signal Control of 2 rural State Highways**

Clarify and Simplify Example:

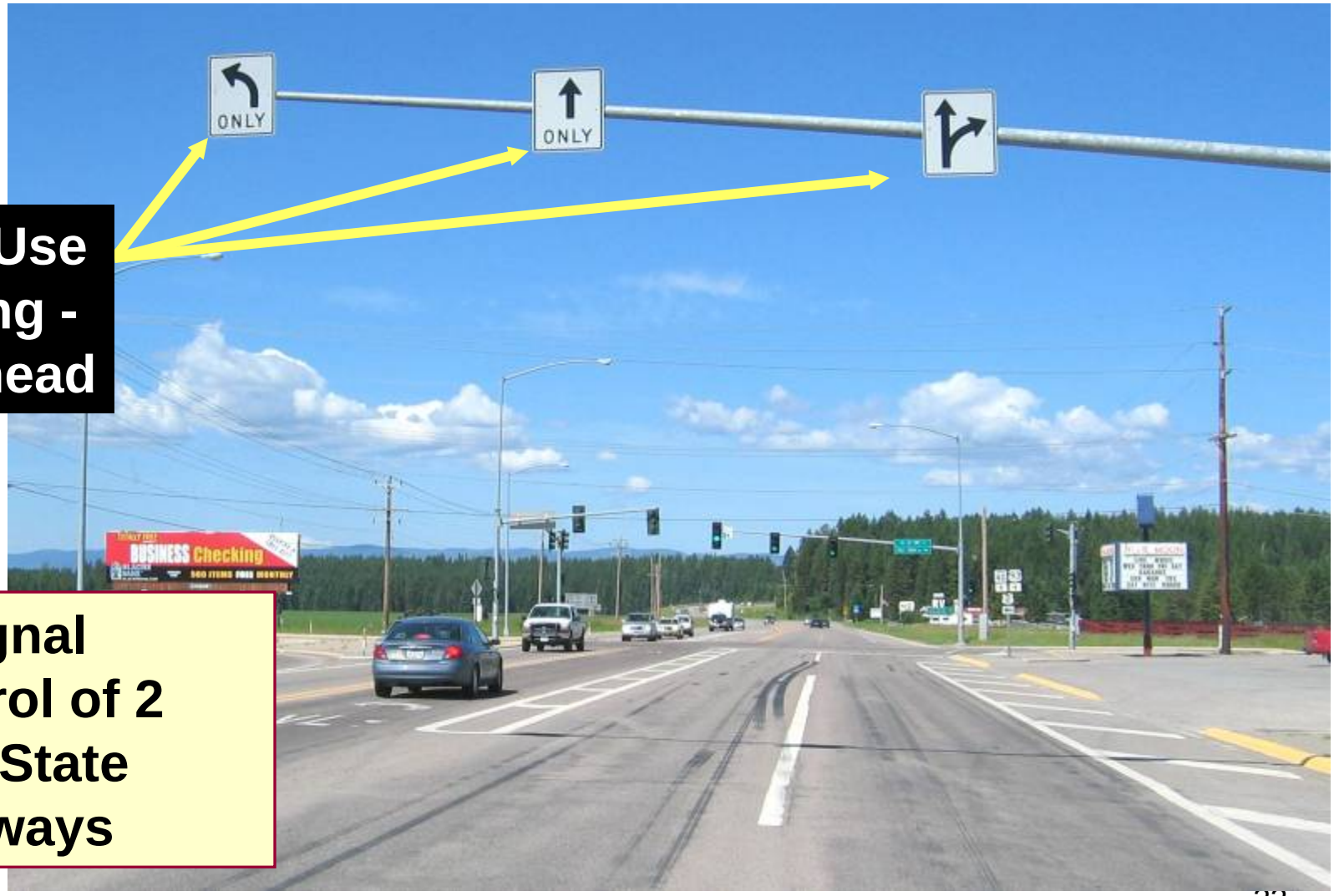
Guide

- **Signal Control of 2 rural State Highways**

Clarify and Simplify Example:

- **Signal Control of 2 rural State Highways**

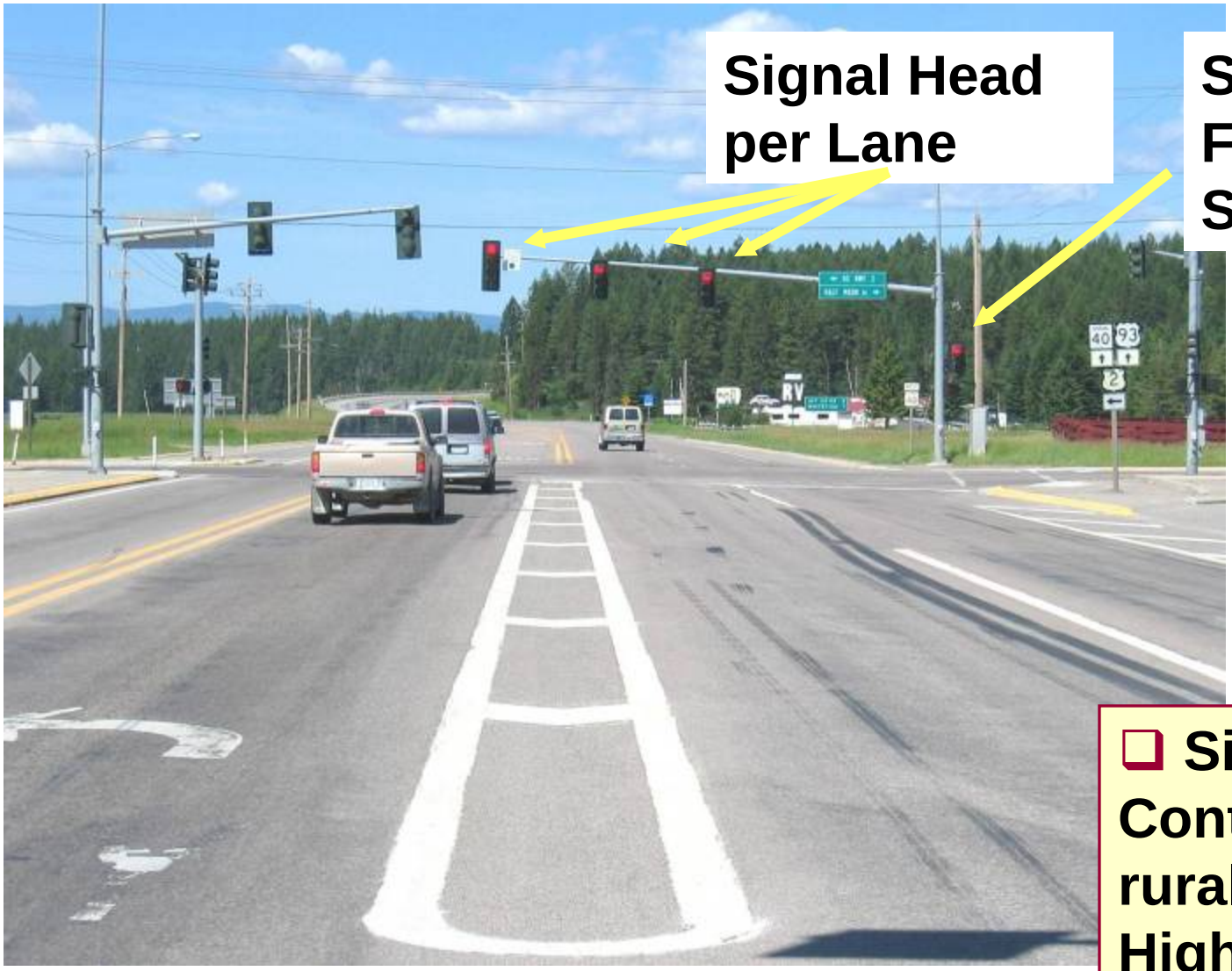
Clarify and Simplify Example:



Lane Use Signing - Overhead

- **Signal Control of 2 rural State Highways**

Clarify and Simplify Example:



- **Signal Control of 2 rural State Highways**

Low Cost Signing Example:

Low Cost Signing Example:

Low Cost Signing Example:

Guide

Greenwood, SC

Low Cost Signing Example:

Greenwood, SC

Applying Clarify and Simplify

Questions and Discussion

Warning Signing Countermeasures:

1.A Advance Warning Signs

Purpose: …to call attention to **unexpected** conditions and to situations that might **not be readily apparent** to road users

"**ALERTing**" Drivers - Warning Signs for Stop Controlled Intersections:

1. **Advance Warning Signing**
   - **A. for Unexpected Conditions**
   - **B. for Intersections**
   - **C. Enhanced Advance Warning**
   - **D. for Right-of-Way Controls**
   - **E. Flashers for Intersection Warning**

2. **Advance Transverse Rumble Strips**

Warning Signing Countermeasures:

1.B Advance Intersection Warning Signs

Tried

CRF = 30% Urban

CRF = 40% Rural

*NCHRP 500, Objective 17.1 E1 – Improve Visibility of Intersections by providing enhanced signing

Warning Signing Countermeasures:

1.B Advance Intersection Warning Signs

*NCHRP 500, Objective 17.1 E1 – Improve Visibility of Intersections by providing enhanced signing

Supplemental Plaques and Auxiliary Signs

- **Advisory Speed Plaques**
- **Street Name Signs**
- **Unexpected Conditions**

Warning Signing Countermeasures:

1. C. Enhanced Countermeasures for Intersections on Curves

- Add Location of Side Roads

Advance Warning Countermeasures:

Section 2A.15 Enhanced Conspicuity for Signing – January 2, 2008 Notice of Proposed Rule Making

A. **Increasing the size**
B. **Doubling-up of a standard regulatory, warning, or guide sign by adding a second identical sign on the left-hand side of the roadway.**
C. **Adding a solid yellow or fluorescent yellow rectangular "header panel" above a standard sign**
D. **Adding a NEW plaque (see Section 2C.67) above a new standard regulatory or warning sign, for a period of time determined by engineering judgment, to call attention to the new sign.**
E. **Adding one or more red flags (cloth or retroreflective sheeting) above a sign**
F. **Adding a solid red or fluorescent red strip of retroreflective sheeting at least 75 mm (3 in) wide around the perimeter of a standard regulatory sign.**

Advance Warning Countermeasures:

Section 2A.15 Enhanced Conspicuity for Signing – January 2, 2008 Notice of Proposed Rule Making

G. Adding a solid yellow, a solid fluorescent yellow, or a diagonally striped black and yellow (or black and fluorescent yellow) strip of retroreflective sheeting at least 75 mm (3 in) wide around the perimeter of a standard warning sign.

H. Adding a warning beacon (see Section 4L.03) to a standard regulatory (other than a STOP or a Speed Limit sign), warning, or guide sign.

I. Adding a speed limit sign beacon (see Section 4L.04) to a standard Speed Limit sign.

J. Adding a stop beacon (see Section 4L.05) to a STOP sign.

K. Adding light emitting diode (LED) units within the symbol or legend of a sign or border of a standard regulatory, warning, or guide sign

L. Using other methods that are specifically allowed for certain signs as described elsewhere in this Manual.

Warning Signing Countermeasures:

1.C Enhanced Warning Signing

Fluorescent Yellow

*NCHRP 500, Objective 17.1 E1 – Improve Visibility of Intersections by providing enhanced signing

Warning Signing Countermeasures:

1.C Enhanced Warning Signing

*NCHRP 500, Objective 17.1 E5 – Install larger warning signs at Intersections

- Increasing Size of Sign 36” x 36” rather than 30” x 30”

Warning Signing Countermeasures:

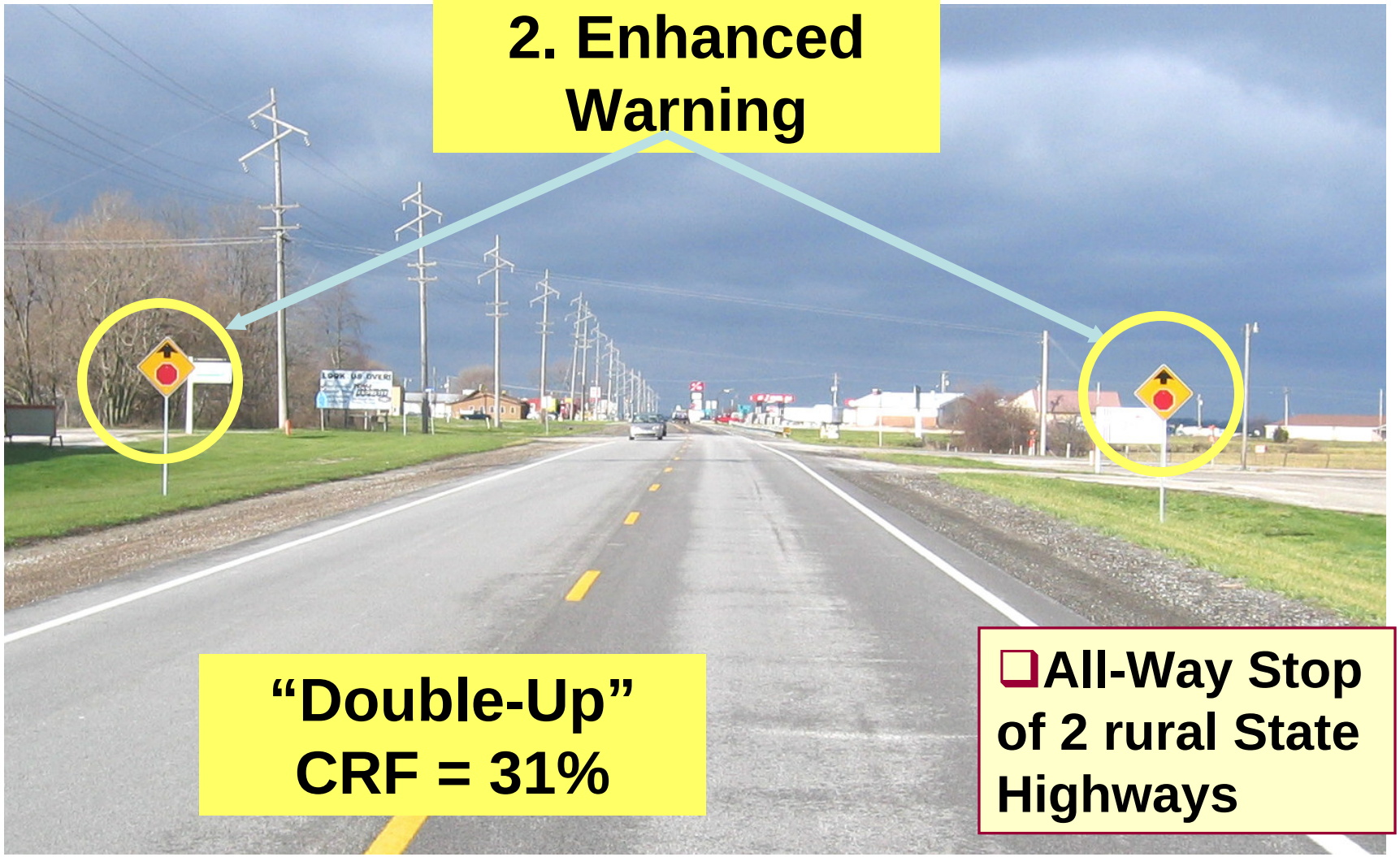
1.C Enhanced Warning Signing

- Increasing Size of Sign by Mounting or Large Background

NCHRP 500, Objective 17.1 E5 – Install larger warning signs at Intersections

Enhancing Clarify & Simplify

Enhancing Clarify & Simplify



Enhancing Clarify & Simplify

Doubled-Up Stop Aheads

Enhancing Clarify & Simplify

Enhanced Advance Warning Signing for Right-of-Way Controls – “Doubling-Up”

2 Pairs of Doubled up Stop Aheads

Enhancing Clarify & Simplify

Flashers for Intersection Warning Signs

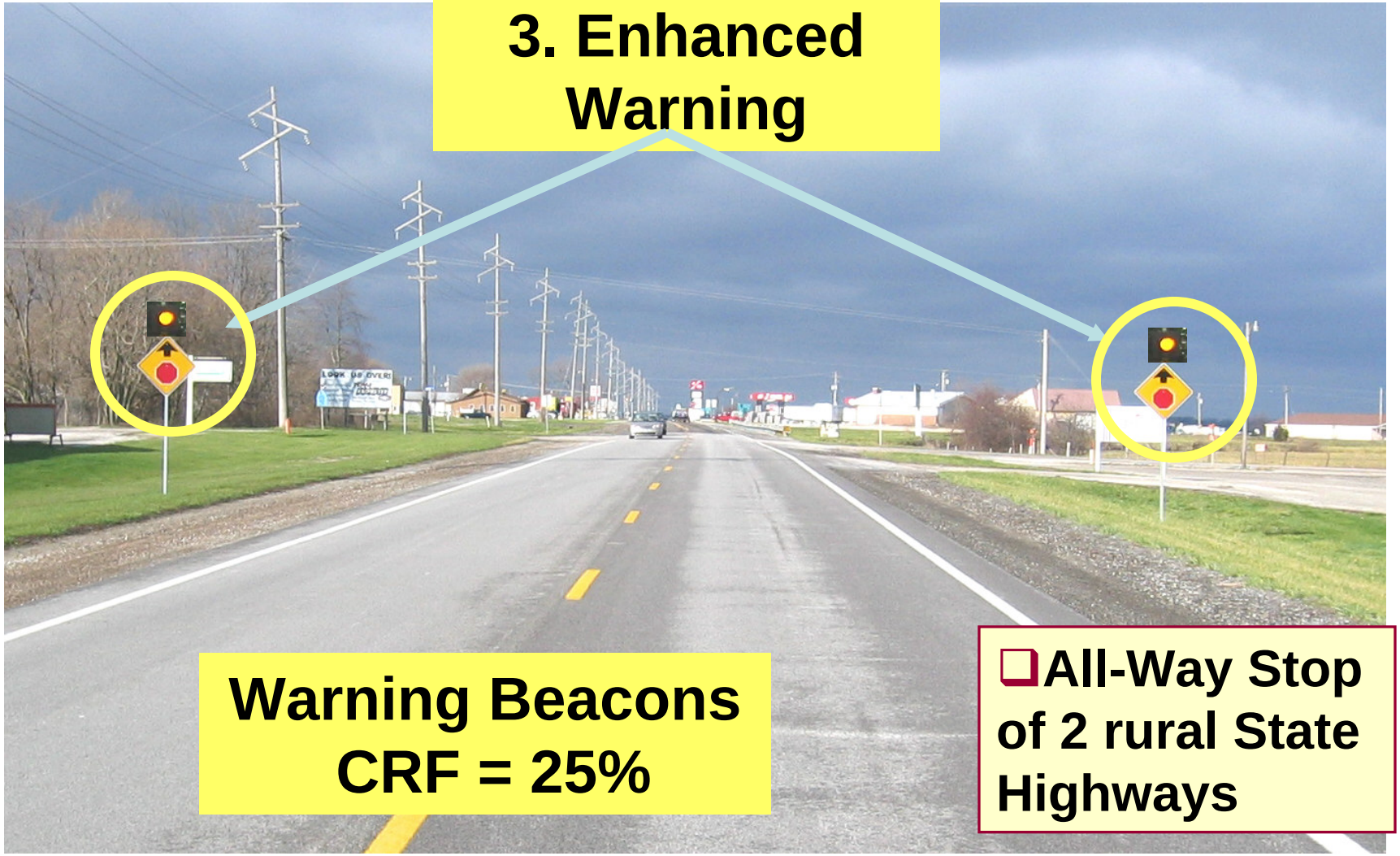
Stop Ahead
with Flasher

Tried

CRF= 25%

All Crashes

Enhancing Clarify & Simplify



Enhancing Clarify & Simplify

1.D STOP AHEAD Pavement Markings

CRF = 15%

Enhancing Clarify & Simplify

2. Enhanced Warning

- **Add Advance Transverse Rumble CRF = 28%**

- **All-Way Stop of 2 rural State Highways**

Warning Sign Countermeasures:

Questions?

STOP Control Intersection Countermeasures:

1. Increase Size
2. Add Retroreflective Sleeves to posts
3. Double-Up
4. Enhance Visibility (stop sign on island)
5. Overhead Placement
6. Stop Beacons

STOP Control Intersection Countermeasures:

1. Increase Size

- **Oversized STOP Signs**

*NCHRP 500, Objective 17.1 E5 – Install larger regulatory signs

STOP Control Intersection Countermeasures:

- **"Oversize" Stop Sign**

STOP Control Intersection Countermeasures:

2. Retroreflective sleeves and flags

"Flagging"

Sleeve

STOP Control Intersection Countermeasures:

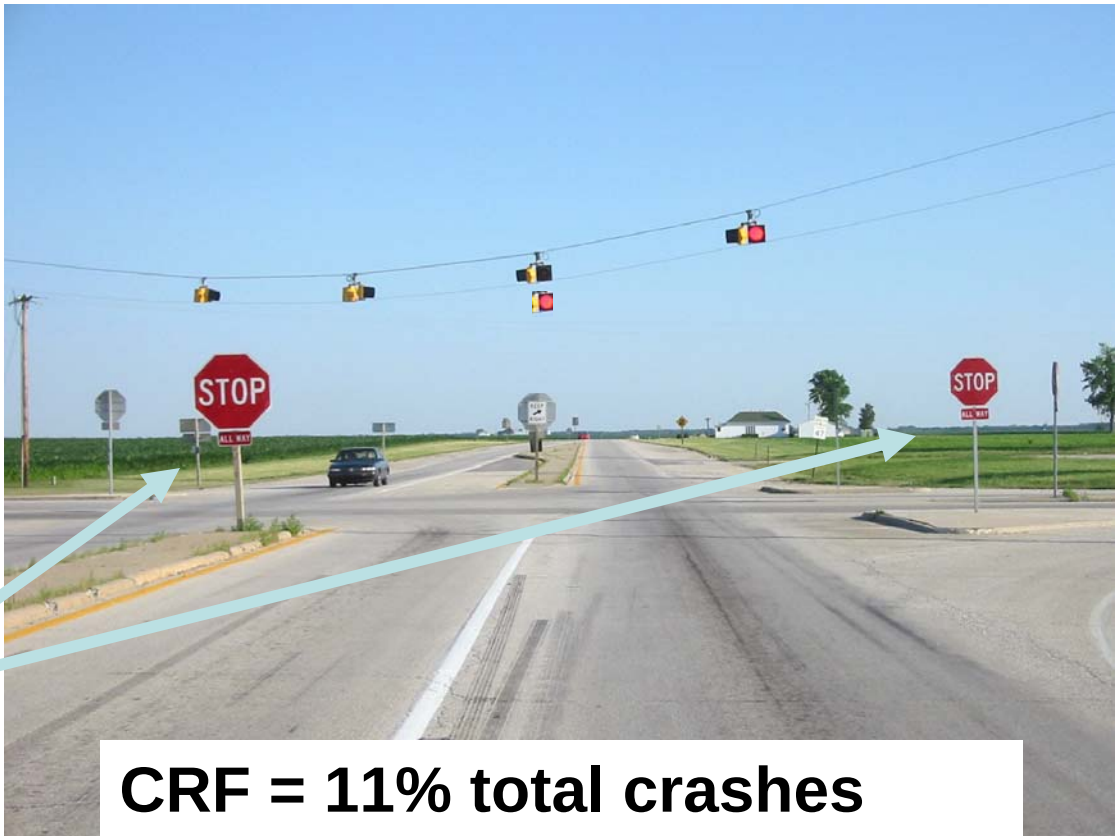
3. “Double-Up”

“Doubled up” Stop Signs – Left and Right Hand Side of Two-Lane Road

CRF = 11% total crashes
CRF = 55% Rt Angle Crashes

STOP Control Intersection Countermeasures:

3. "Double-Up"



"Doubled up"
Stop Signs

CRF = 11% total crashes
CRF = 55% Rt Angle Crashes

STOP Control Intersection Countermeasures:

- **Position the Stop on an Island closer to the Driver's approach**

IL 123 & IL 97, IL

STOP Control Intersection Countermeasures:

4. Enhance visibility

(Stop Sign in Island)

Two Stop Signs

NCHRP 500, Strategy 17.1 E3 – Install Splitter Islands on Minor Road Approaches

STOP Control Intersection Countermeasures:

4. Enhance Visibility (Supplemental Stop Sign in Island)

***NCHRP 500, Strategy 17.1 E3 – Install Splitter Islands on Minor Road Approaches**

STOP Control Intersection Countermeasures:

5. Overhead Mounted Stop Signs

*NCHRP 500, Strategy 17.1 E8 – Overhead Mounted Stop Signs

STOP Control Intersection Countermeasures:

6. Stop Beacons

STOP Beacon Mounted on Top of Stop Sign

CRF = 30%

*NCHRP 500, Strategy 17.1 E11 – Flashing Beacons at Stop-Controlled Intersections

STOP Control Intersection Countermeasures:

6. Stop Beacons

Overhead
Simultaneous
Flashing Stop
Beacons

-Most
Effective
Application

Applying Clarify and Simplify

- Stop Sign on outside of large right turn radius is too far out of center attention window of driver

Applying Clarify and Simplify

- Add Stop Sign on Island to Enhance Visibility CRF = 11% + Right Hand Supplementary Stop Sign

Applying Clarify and Simplify

- **Add Stop Beacon**

CRF = 30%

- **All-Way Stop of 2 rural State Highways**

Low Cost Marking Measures:

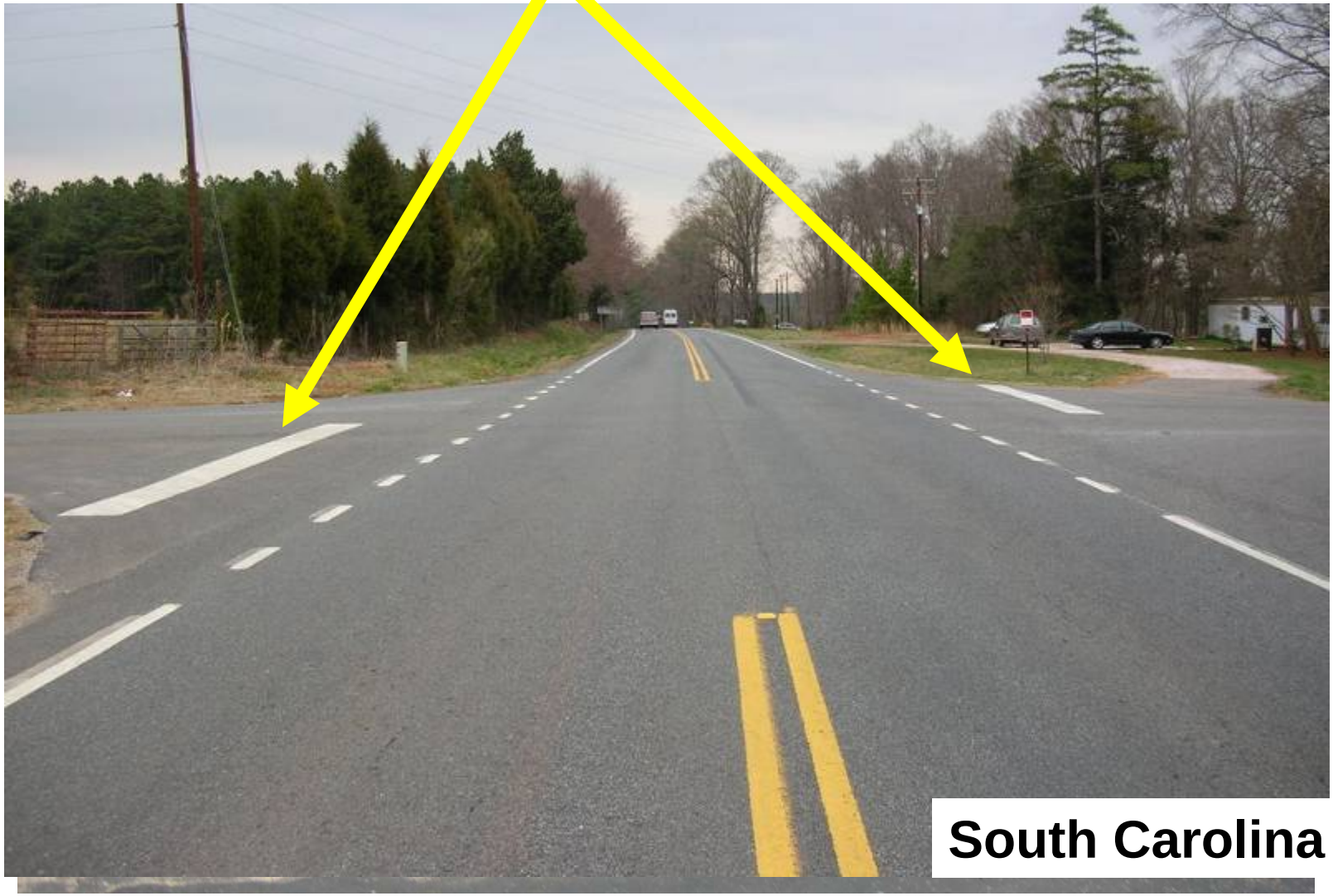
Low Cost Marking Measures:

Sight Obstruction

Pond Branch & Nelly Wingard, SC

Low Cost Marking Measures:

- Move Stop Bars Forward



STOP Control Intersection Countermeasures:

Questions?

Low Cost Intersection Safety Measures:

- Install Splitter Islands on the Minor Road Approach to an Intersection

***NCHRP 500, Strategy 17.1 E3 – Install Splitter Islands on Minor Road Approaches**

Injury Crashes
CRF = 45% – 3 approaches
CRF = 40% – 4 approaches

Low Cost Intersection Safety Measures

Concept 1 – Narrow travel lanes by striping on Main highway

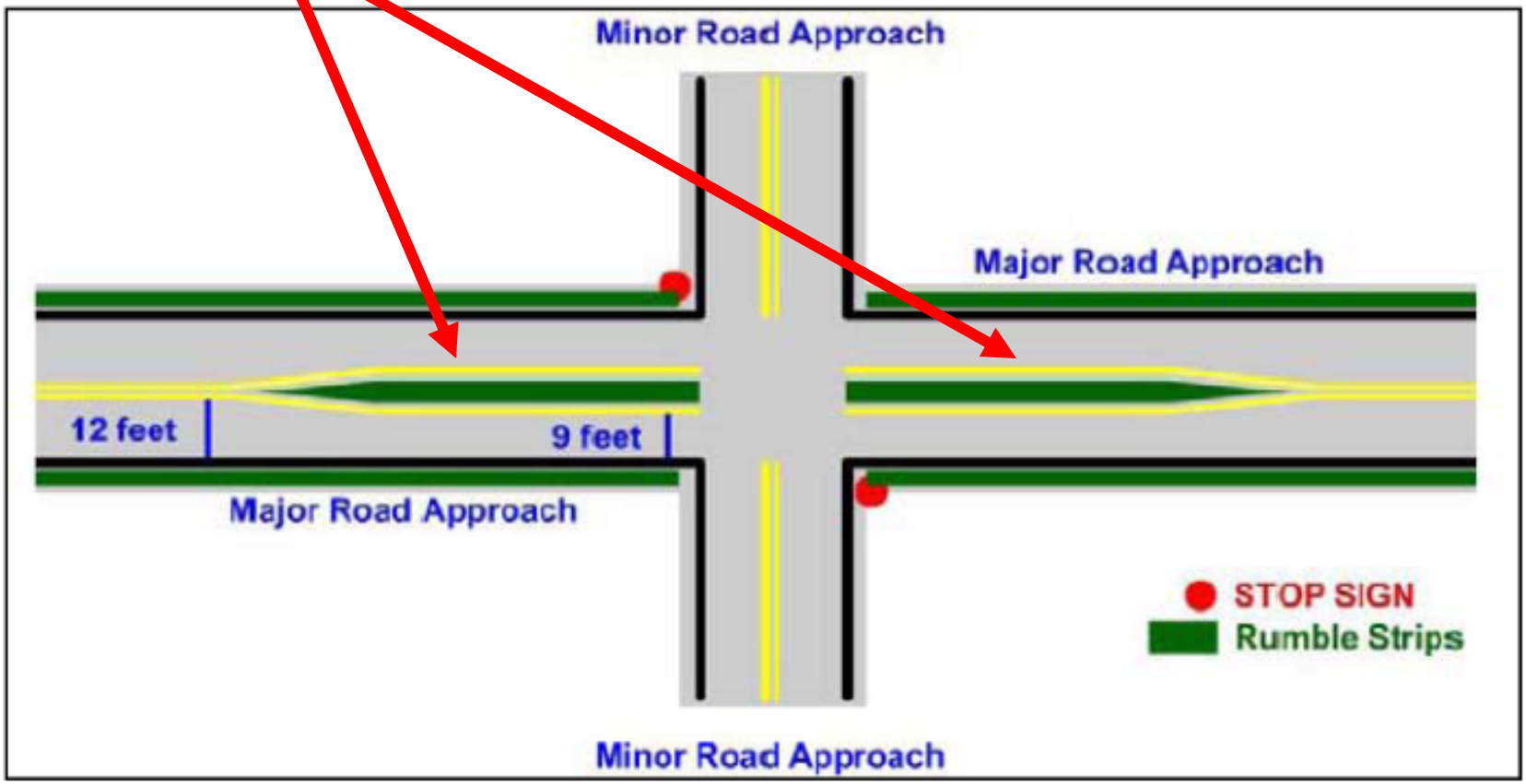


Figure 1. Illustration of Concept 1

Low Cost Intersection Safety Measures

Concept 1 – Narrow travel lanes by striping on Main highway

Figure 7. Example 1a of Concept 1 in Pennsylvania.

Low Cost Intersection Safety Measures

Concept 1 – Narrow travel lanes by striping on Main highway

Table 3. Speed Reductions for All Vehicles

Sites	Posted Speed Limit (mph)	Approach Lane Width within rumble strips	Number of Observations	All Speeds			85th Percentile Speeds		
				Reduction After Treatment (mph)		95% Confidence Interval	Reduction After Treatment (mph)		95% Confidence Interval
				Mean	S.D.		Mean	S.D.	
Site 1	55	10'	352	1.8	0.32	(1.00, 2.60)	4.2	0.23	(3.63, 4.78)
Site 2	50	10'	317	2.6	0.34	(1.75, 3.45)	4.1	0.17	(3.68, 4.53)
Site 3	55	9'	428	3.9	0.42	(2.85, 4.95)	4.1	0.19	(3.63, 4.58)
Site 4	55	10.5'	408	2.9	0.25	(2.28, 3.53)	4.5	0.28	(3.80, 5.20)
Site 5	55	10'	535	4.3	0.31	(3.53, 5.08)	4.9	0.25	(4.28, 5.53)
Site 6	55	10'	376	4.6	0.29	(3.88, 5.33)	5.2	0.21	(4.68, 5.73)
Site 7	50	10'	487	3.8	0.41	(2.78, 4.83)	4.3	0.33	(3.48, 5.13)
Site 8	55	10.5'	356	3.7	0.61	(2.12, 5.23)	4.4	0.23	(3.83, 4.98)
Site 9	55	10'	423	3.4	0.33	(2.58, 4.23)	4.5	0.30	(3.75, 5.25)
All			**3,682**	**3.5**	**0.36**	**(2.61, 4.42)**	***4.5***	**0.25**	**(3.88, 5.08)**

Low Cost Intersection Safety Measures

Concept 1 – Narrow travel lanes by striping on Main highway

Table 6. Crash Data Summary for Concept 1 Implementations

Site	Period (years)		Crash Rate (crashes per MEV per year)		Percent Change in Crash Rate (minus indicates a reduction)			
	Before	After	Before	After	Total Crashes	Fatal + Injury Crashes	Angle Crashes	Rear-end Crashes
PA 1	5.25	1.08	3.23	1.02	-69%	-64%	-76%	--
PA 2	5.25	1.08	1.46	1.01	-30%	-1%	-18%	-100%
PA 3	Concept 1 removed after 6 months; therefore, PA 3 was not included in crash analysis.							
PA 4	6.00	1.92	1.36	0.23	-83%	-79%	-100%	-100%
KY 1	5.75	1.17	2.13	1.48	-30%	-31%	-28%	39%
KY 2	5.00	1.50	1.52	2.04	34%	-24%	-13%	87%
MO 1	6.92	0.99	2.15	2.47	15%	116%	-59%	906%
MO 2	6.92	0.99	1.32	0.90	-32%	-20%	-46%	-100%
MO 3	6.92	0.99	2.31	2.05	-11%	26%	-47%	144%
FL 1	4.50	1.50	1.36	1.05	-23%	11%	68%	4%
Combined	**52.51**	**11.22**	**1.85**	**1.27**	**-31%**	**-20%**	**-42%**	**54%**

Note: MEV = million entering vehicles

Low Cost Intersection Safety Measures

Concept 2 – Add splitter Island on side road approaches

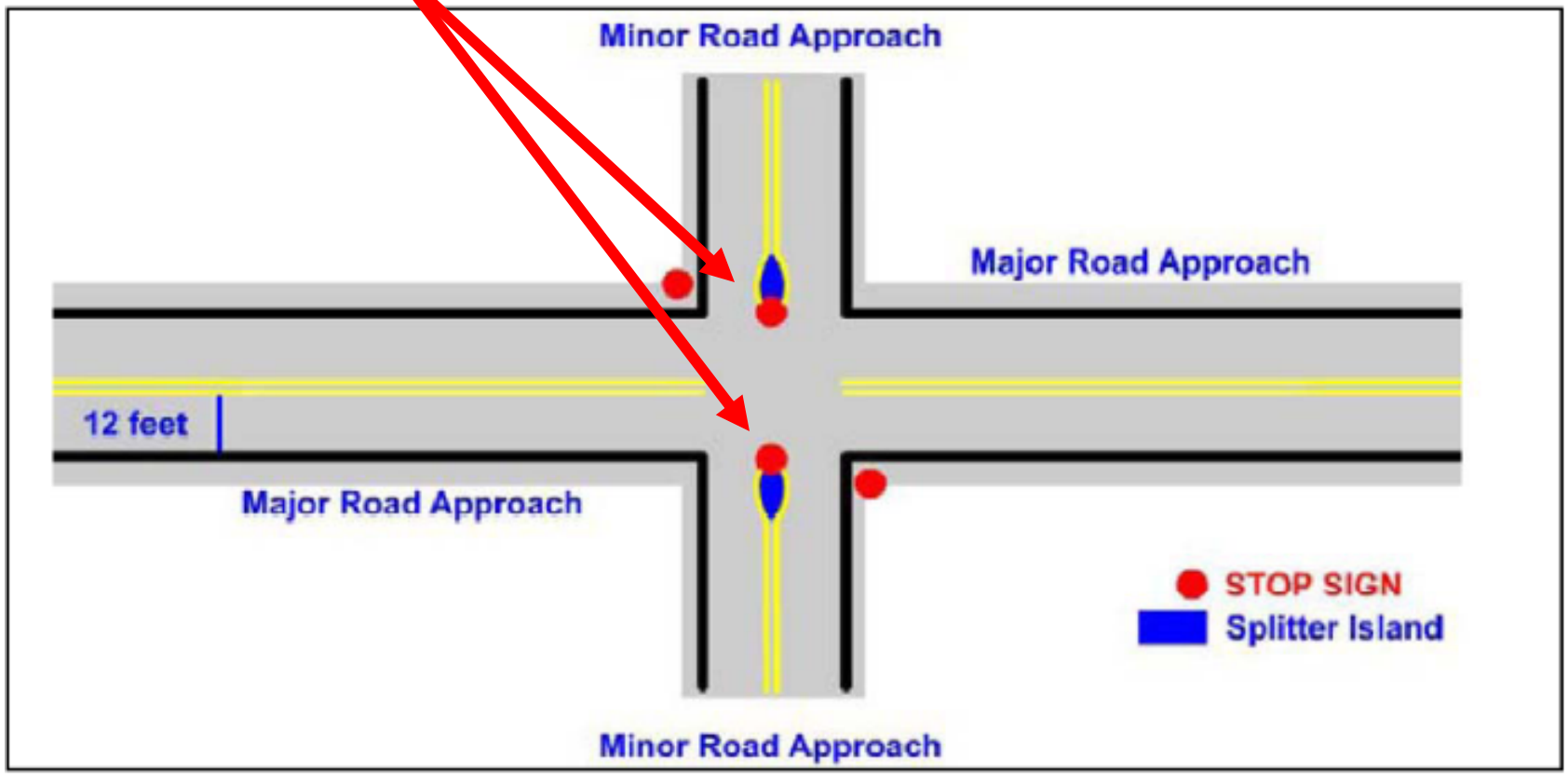


Figure 2. Illustration of Concept 2.

Low Cost Intersection Safety Measures

Concept 2 – Add splitter Island on side road approaches

Figure 13. Example implementation of Concept 2 in Virginia.

Low Cost Intersection Safety Measures

Concept 2 – Add splitter Island on side road approaches

Figure 14. Example implementation of Concept 2 in Maryland.

Low Cost Intersection Safety Measures

Concept 2 – Add splitter Island on side road approaches

Table 7 Crash Data Summary for Concept 2 Implementation

Site	Period (years)		Crash Rate (crashes per MEV per year)		Difference in Crash Rate			
	Before	After	Before	After	Total Crashes	Fatal + Injury Crashes	Angle Crashes	Rear-end Crashes
1 VA	4.00	1.92	2.59	0.82	-68%	-74%	-74%	-100%

Note: MEV = million entering vehicles

Low Cost Intersection Safety Measures:

Questions?

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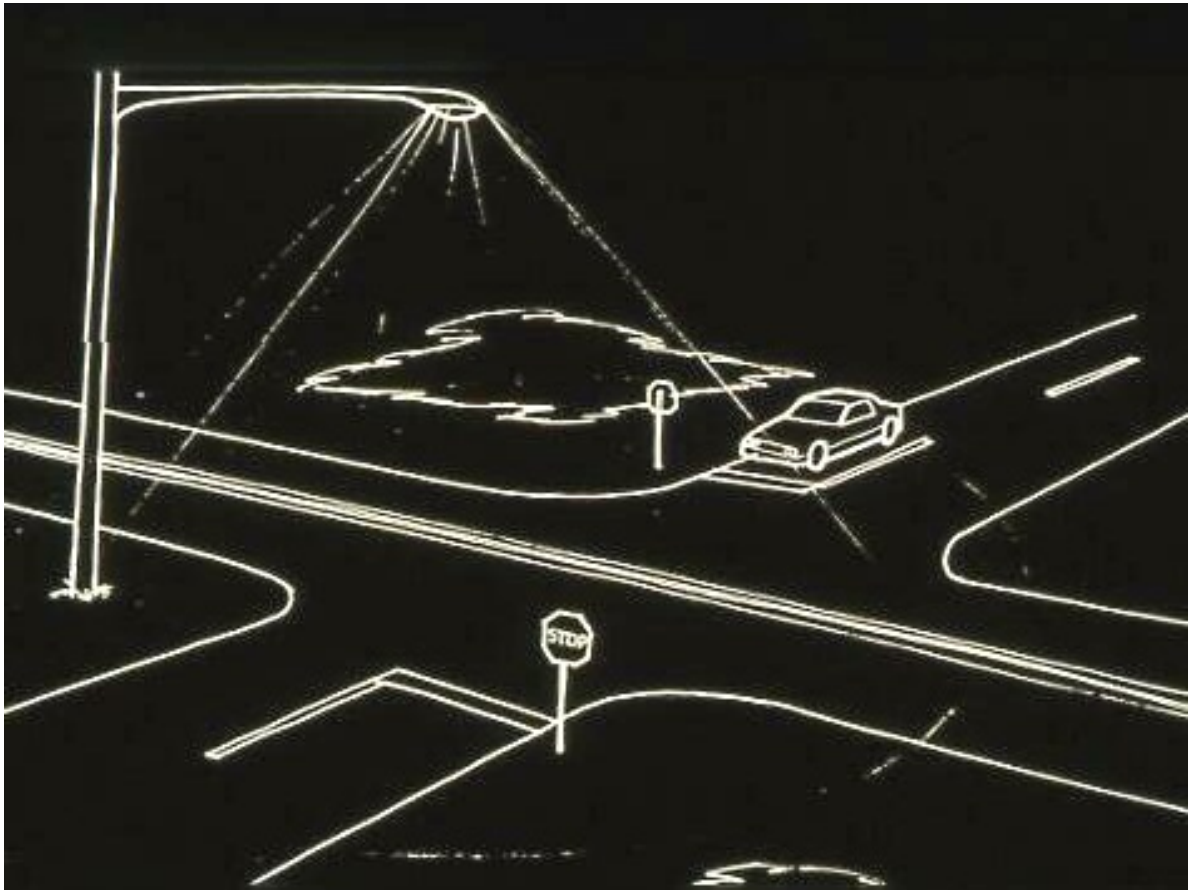
Intersection Lighting Countermeasures



Lighting and Safety

- **27% of total traffic crashes occur under dark conditions**
- **45% of traffic fatalities under dark conditions**
- **Nighttime fatality rate is 3 times the daytime rate**
- **Nighttime crash rate is 1.6 times the daytime rate**

Intersection Lighting Countermeasures

-37% of all intersection fatalities occur nighttime yet travel during nighttime is only 27%

- nighttime intersection fatalities are out of proportion to exposure

NCHRP 500, Strategy 17.1 E2-Improve Visibility of Intersection by Providing Lighting (P)

Intersection Lighting Countermeasures

-Installation of lighting of rural intersections reduced crashes **by 25 to 50%** (MN study)

- **CRF = 30% (Elvik & Vaa)**
- **unlighted** rural intersection had **twice the number of crashes** vs. lighted intersections (Iowa CTRE 2008 study)

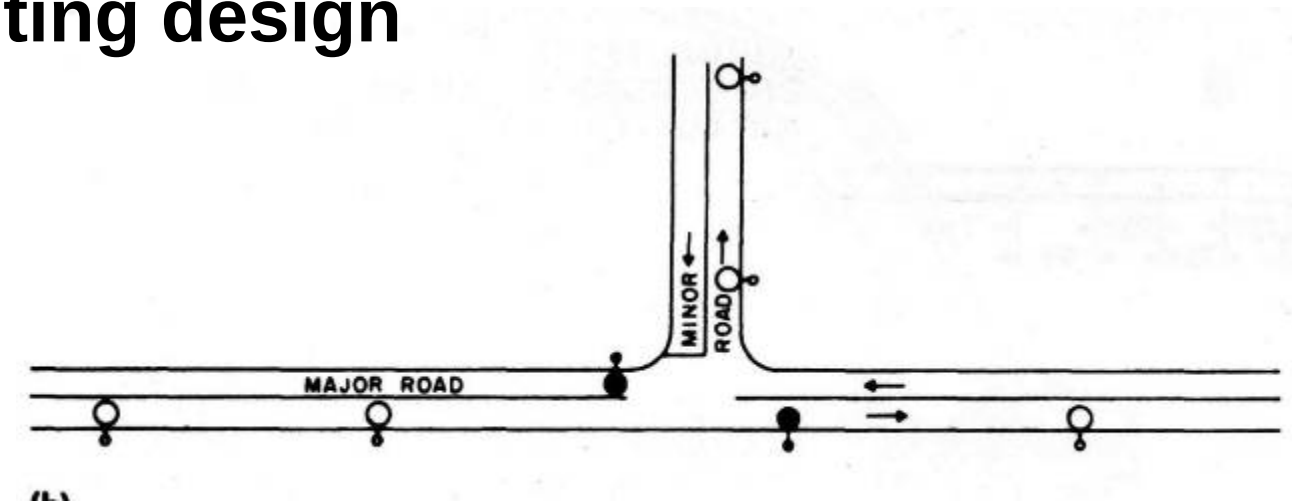
NCHRP 500, Strategy 17.1 E2-Improve Visibility of Intersection by Providing Lighting (P)

Intersection Lighting Countermeasures

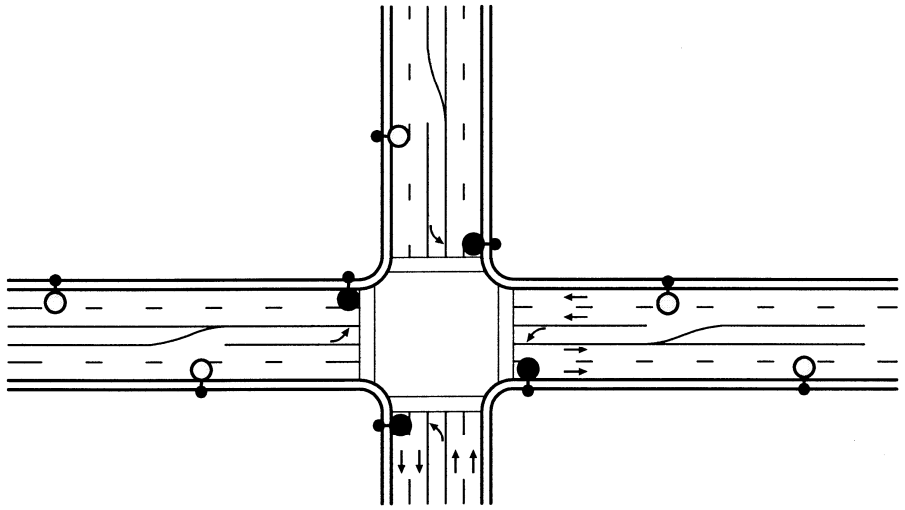
-Iowa CTRE study of 232 rural unsignalized Intersections found the **night to day crash ratio** for lighted intersections was **0.39 vs. 0.61** for unlighted intersections

Intersection Lighting Countermeasures

RP-8-00 lighting design examples



-Lighting of Intersection Approaches reduces twice the crashes as does just lights at Intersection



Improving Safety of Intersections with Lighting:

Questions?

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Signalized Intersection Countermeasures

Signalized Intersection Countermeasures:

ITE Traffic Engineering Handbook

1. Update Yellow Clearance Interval

Yellow Time

All-Red Time

NY study: 9% decrease in multi-vehicle crashes

*NCHRP 500, Objective 17.2 A2 – Optimize Clearance Intervals

Table 13–2 Formula to Calculate Change + Clearance Interval Time

Metric Values
English Values in [ ]

$$CP = t + \frac{V}{2a} + \frac{V}{20\,[64.4]g} + \frac{W+L}{V}$$

where:

- CP = non-dilemma change period (Change + Clearance Intervals)
- t = perception-reaction time (nominally 1 sec)
- V = approach speed, m/s [ft/s]
- g = percent grade (positive for upgrade, negative for downgrade)
- a = deceleration rate, m/s^2 (typical 3.1 m/s^2) [ft/s^2 (typical 10 ft/s^2)]
- W = width of intersection, curb to curb, m [ft]
- L = length of vehicle, (typical 6 m) [ft (typical 20 ft)]

Source: *Determining Vehicle Signal Change and Clearance Intervals*, Publication IR-073, Washington, D.C.: Institute of Transportation Engineers, 1994.

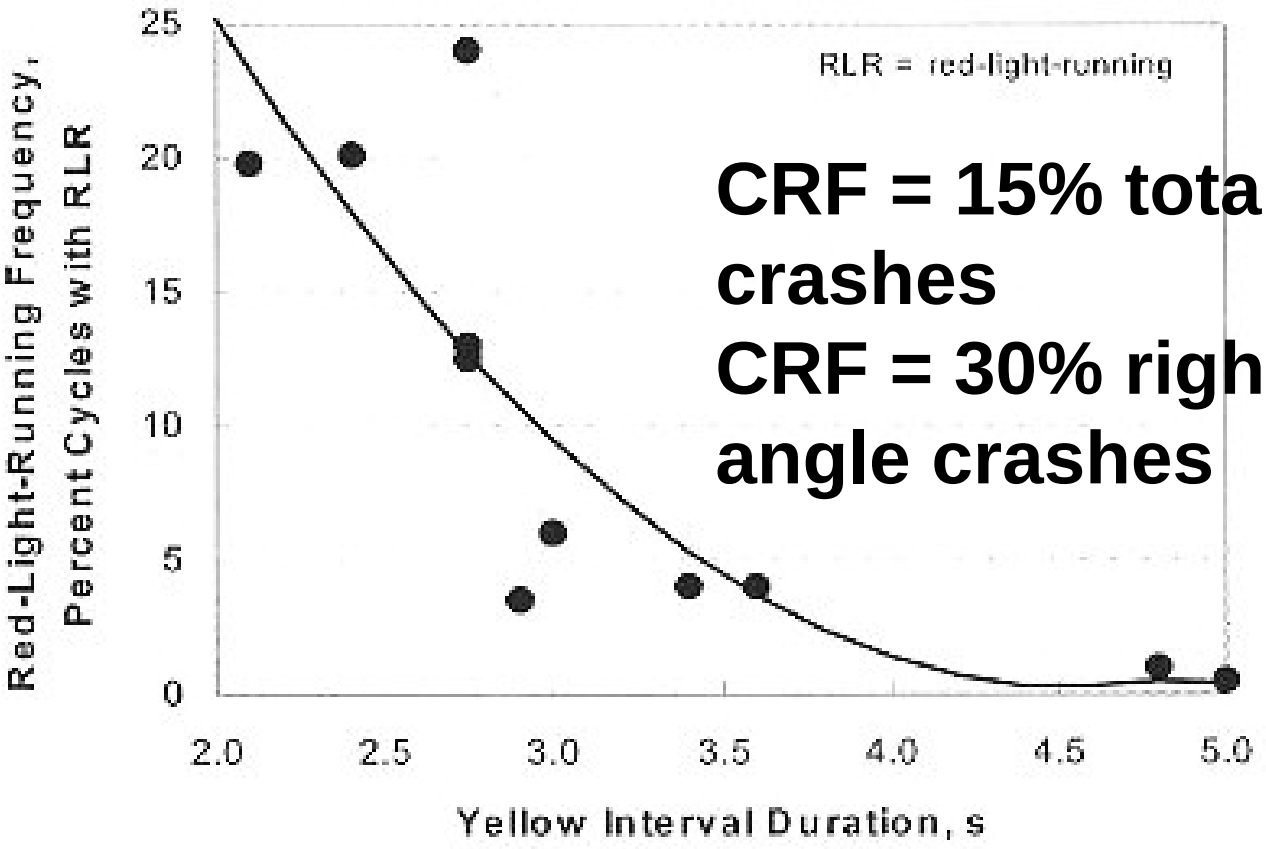
NY study: CRF =8% total crashes CRF = 12% injury crashes CRF = 39% ped crashes

Signalized Intersection Countermeasures:

1. Update Yellow Clearance Interval

*TTI, Bonneson, 2003

*NCHRP 500, Objective 17.2 A2 – Optimize Clearance Intervals



CRF = 15% total crashes
CRF = 30% right angle crashes

Signalized Intersection Countermeasures:

2. Advance Detection

Advanced Dilemma Zone Detection for Rural High Speed Approaches

Field Test Results

- **Before-After Study**
  - *Based on five intersections*

	Reduction Factors
– *Delay:*	*14%*
– *Stop Frequency:*	*9%*
– *All Red-Light Violations:*	*58%*
– *Truck Red-Light Violations:*	*80%*
– *Severe crashes:*	*39%*

Transportation Institute

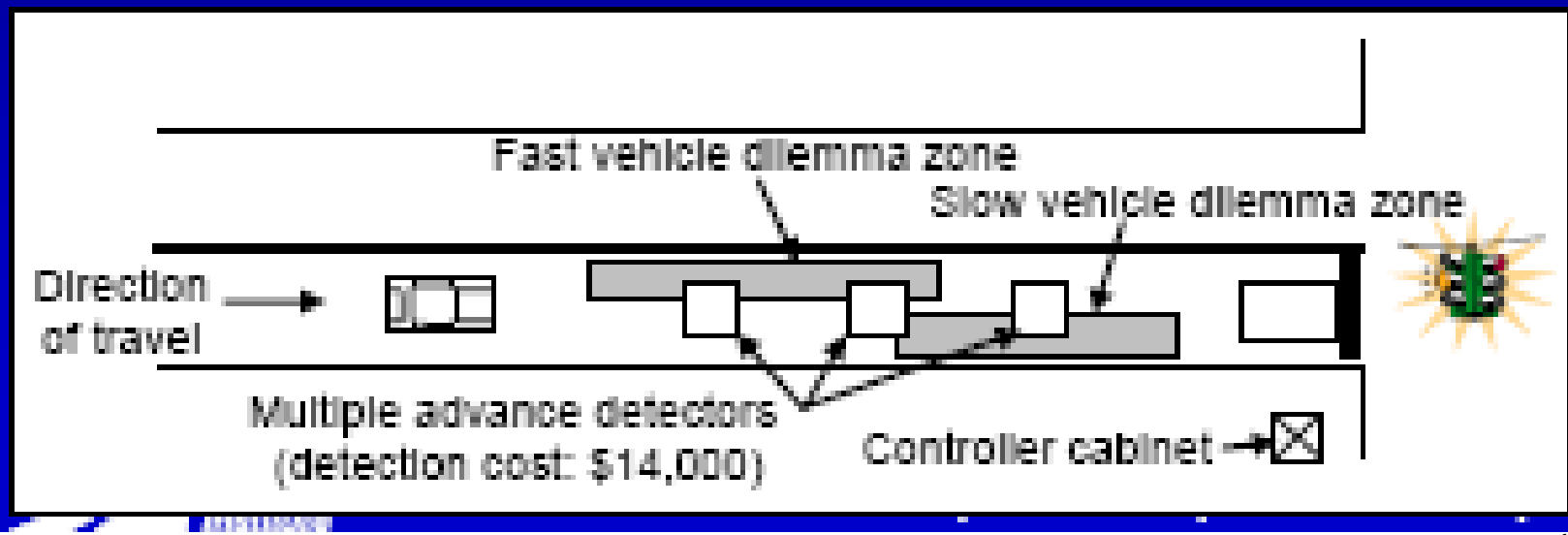
Transportation Operations Group

CRF = 39% Injury Crashes

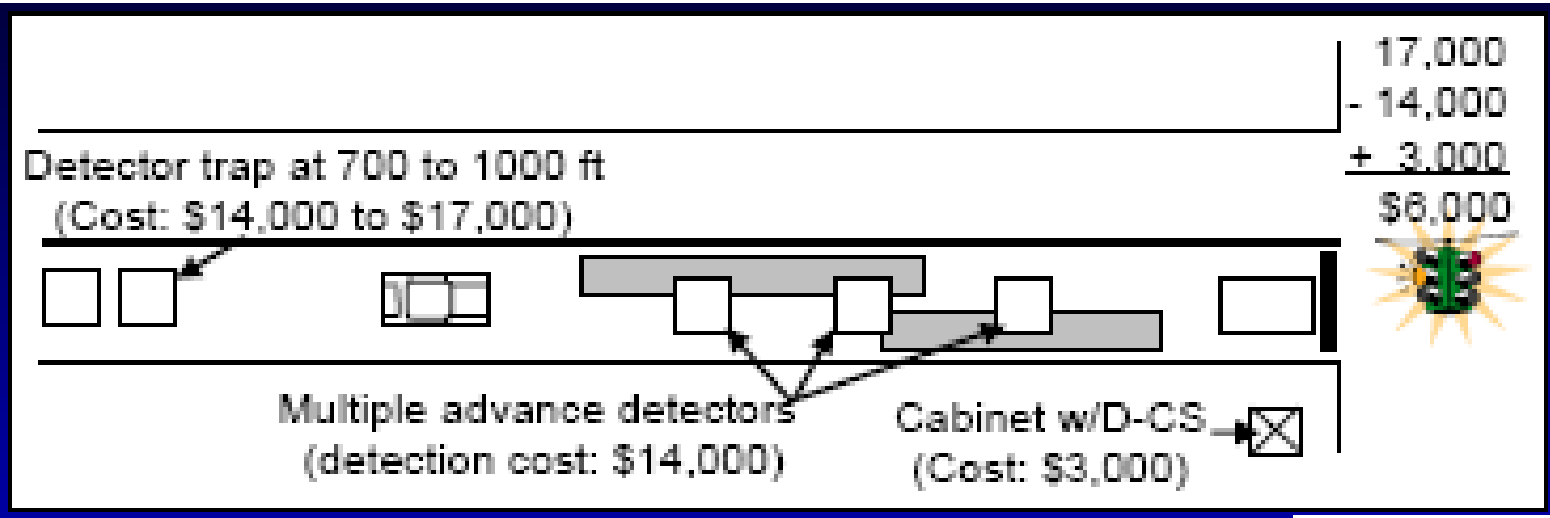
Advanced Dilemma Zone Detection for Rural High Speed Approaches:

- **Frequent Crashes Due to Phase Change**
- **Dilemma Zone**
  - *Driver population is collectively indecisive*
  - *Typically, 2.5 to 5.5 s travel time from stop line*
- **Traditional Detection Design**

*Bonneson, TTI, 2005



Advanced Dilemma Zone Detection for Rural High Speed Approaches:



- **Detection-Control System (D-CS)**
  - *Eliminate traditional advance loops*
  - *Add one speed trap beyond the dilemma zone*
  - *Predict when each vehicle is in dilemma zone*
  - *Provide priority to trucks*

*Bonneson, TTI, 2005

Texas Transportation Institute

Transportation Operations Group

Signalized Intersection Countermeasures:

3. Improve Visibility (12” Indications, Supplemental heads)

CRF = 49% for change from pedestal position to mast arm position

Increasing indications from 8” to 12”

CRF = 11% total crashes

CRF = 46% right angle crashes

*NCHRP 500, Strategy 17.2 D2: Improve Visibility of Signals

Signalized Intersection Countermeasures:

3. Improve Visibility (Additional Primary Head)

CRF = 28% total crashes

CRF = 35% right angle crashes

CRF = 28% rear end crashes

*NCHRP 500, Strategy 17.2 D2: Improve Visibility of Signals

Signalized Intersection Countermeasures:

3. Improve Visibility (Signal Head per Lane)

1 head for 1 Lt lane

4 heads for 4 lanes

1 head for 1 Rt lane

CRF = 7% total crashes

CRF = 46% right angle crashes

*NCHRP 500, Strategy 17.2 D2: Improve Visibility of Signals

Signal Visibility – Example

Signal Visibility Example

Systematic Approach to Intersection Safety – Signal Visibility:

States with Policy of Signal Head per Lane:

- **Florida (July 1, 2009)**
- **South Carolina**
- **Mississippi**
- **Louisiana**
- Missouri
- **Indiana**
- Minnesota
- Illinois
- Ohio

Signalized Intersection Countermeasures:

5. Add Back Plates

CRF = 13% total crashes

CRF = 50% right angle crashes

Signalized Intersection Countermeasures:

5. Add Back Plates

-50% reduction in RLR
*** Bonneson**

Systematic Approach to Intersection Safety – Signal Visibility:

Columbia, SC

- ❑ **Signal Head per lane**
- ❑ **Backplates**
- ❑ **LED Indications**

❑ **SC dot in a series of projects is improving every traffic signal to LED indications with Backplates**

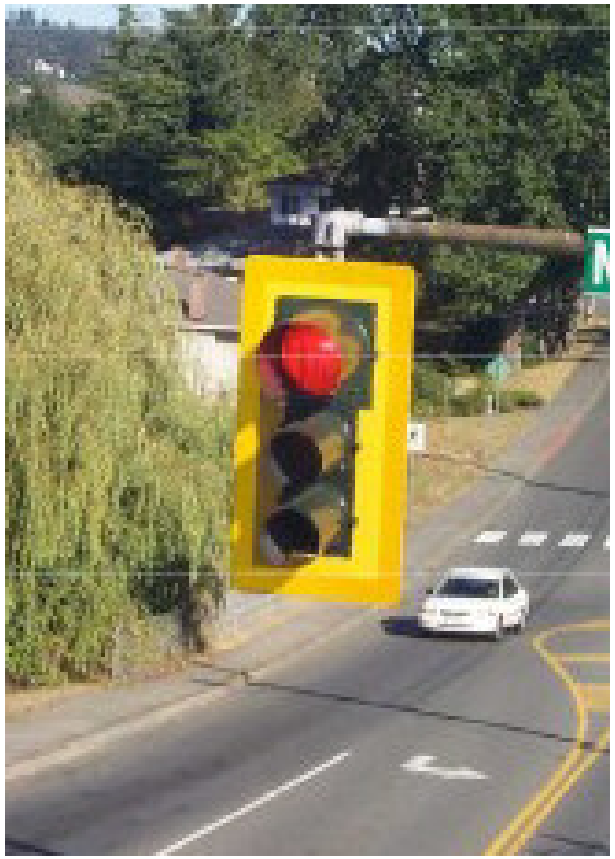
Systematic Approach to Intersection Safety – Signal Visibility:

- ❑ **Signal Head per lane**
- ❑ **Backplates**

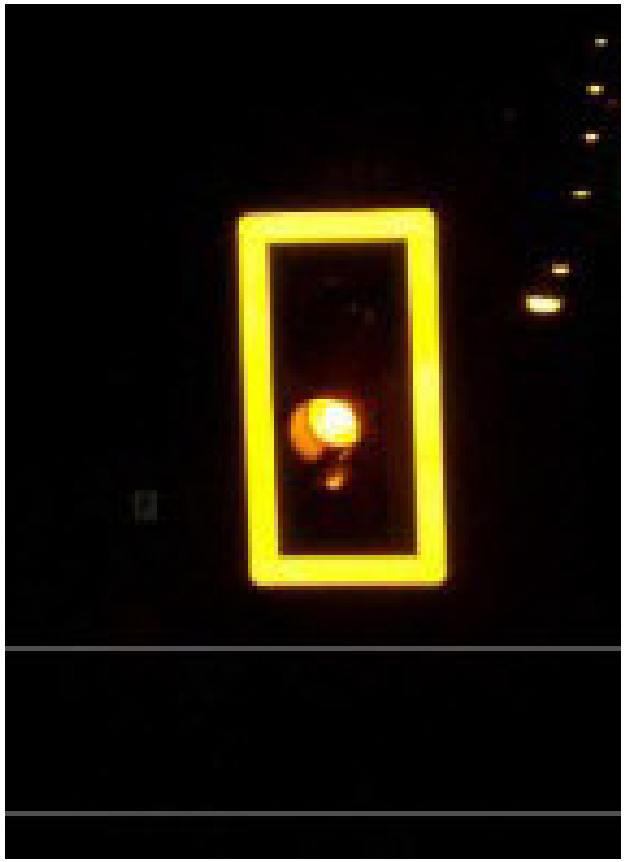
IL 64-Glendale Heights, IL

Signalized Intersection Countermeasures:

5. Add Back Plates



Retro- reflectorized backplate



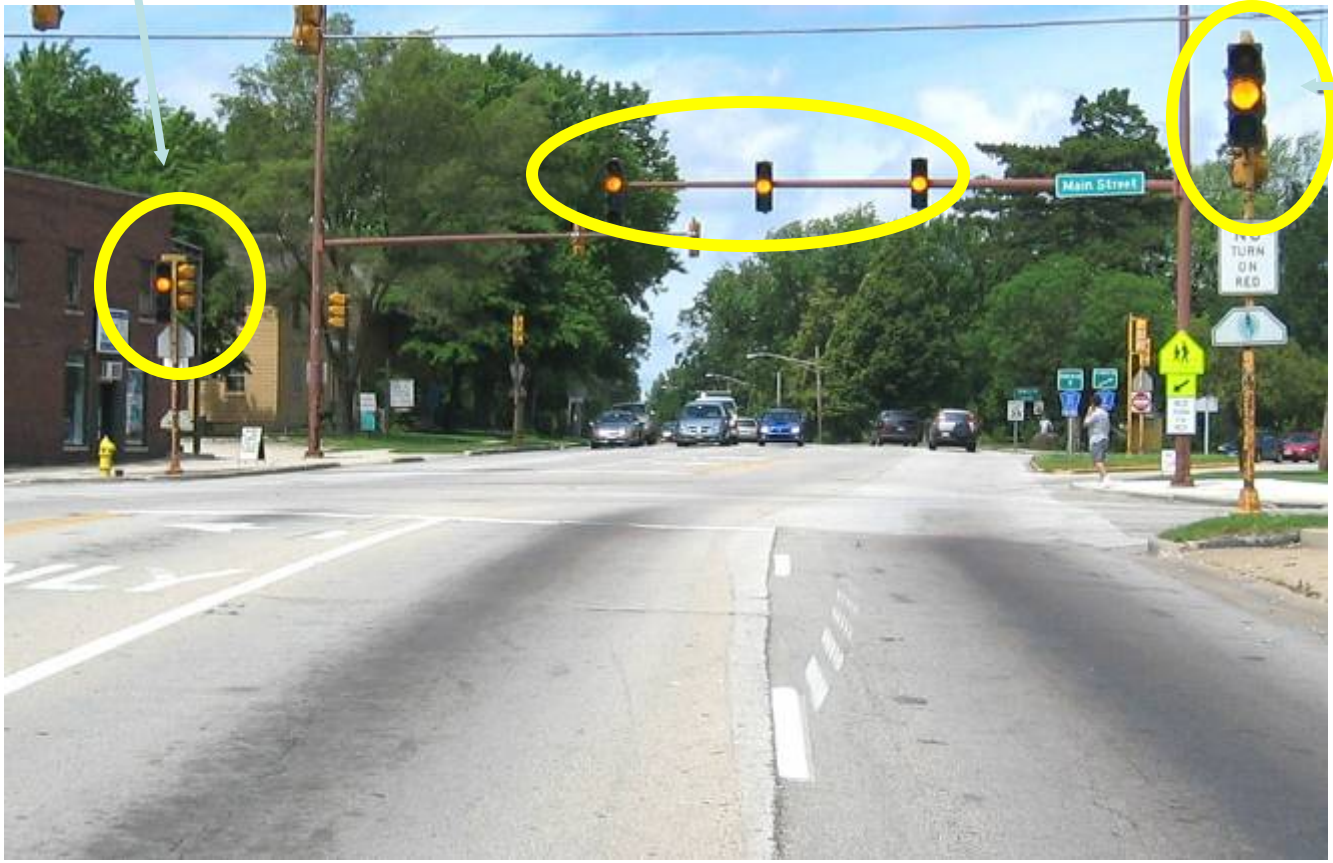
Signalized Intersection Countermeasures:

5. Add Retro-Reflectorized Back Plates

CRF = 15%

Signalized Intersection Countermeasures:

Improve Visibility (Supplemental Signal Heads)



Supplemental Signal Head

48%

Reduction in Right Angle Crashes

Winston-Salem, NC

Signalized Intersection Countermeasures:

Add Supplemental Signal Head(s)

Signalized Intersection Countermeasures:

Add Supplemental Signal Head(s)

Signalized Intersection Countermeasures:

Add Supplemental Signal Head(s)

- Crest Vertical Curve + Right Hand Curve
- Sight Distance is Limited By Noise Walls

Intersection Safety Example:

- **Ohio – 90th Worst Intersection for State – 184 crashes in 3 years**

Intersection Safety Example:

Identify Underlying Crash Cause:

- **AIRS Crash Data identified 85% of Crashes were Red Light Running**

Apply two guiding principles for design and operation of an intersection:

- **Clarify**
- **Simplify**

Intersection Safety Example:

- Removed 7 signs including 2 overhead guide signs from overpass
- Signal Heads Positioned over Lanes into Driver's Line of Sight
- Lowered signal heads on Mast Arms
- Added Supplemental Left Hand Signal
- Added Back Plates to Signal Heads
- Removed two street light poles

Intersection Safety Example:

- 4 month Period Before – 15 Crashes
- 12 month Period After - 7 Crashes

Improving Safety of Signalized Intersections:

Questions?

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Intersection Geometrics Countermeasures

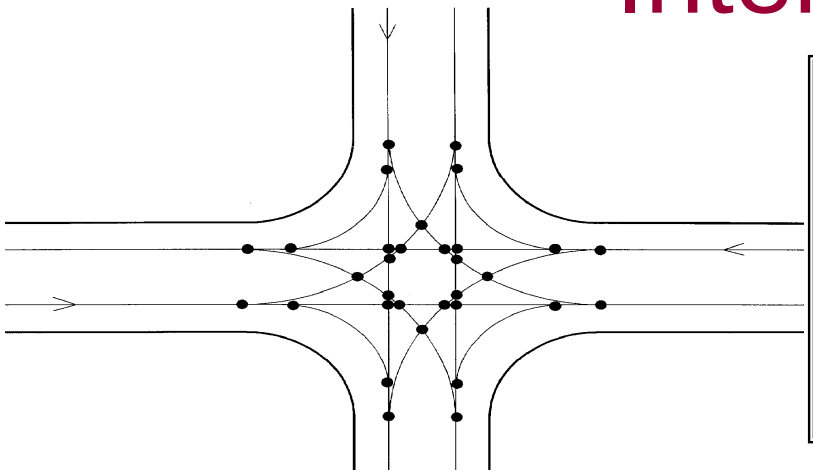
Geometric Features Related to Safety at Intersections

- Configuration - Number of Legs
- Access near Intersections
- Left and Right Turn Lanes
- Shoulder Widening
- Intersection Sight Distance
- Horizontal and Vertical Alignment
- Angle of Intersection (Skew)
- Splitter Islands (Channelization)
- Intersection Designs - Roundabouts

Number of Intersection Legs

- Intersections with more than 4 approaches have crash rates 2 to 8 times greater than 4 approach intersections

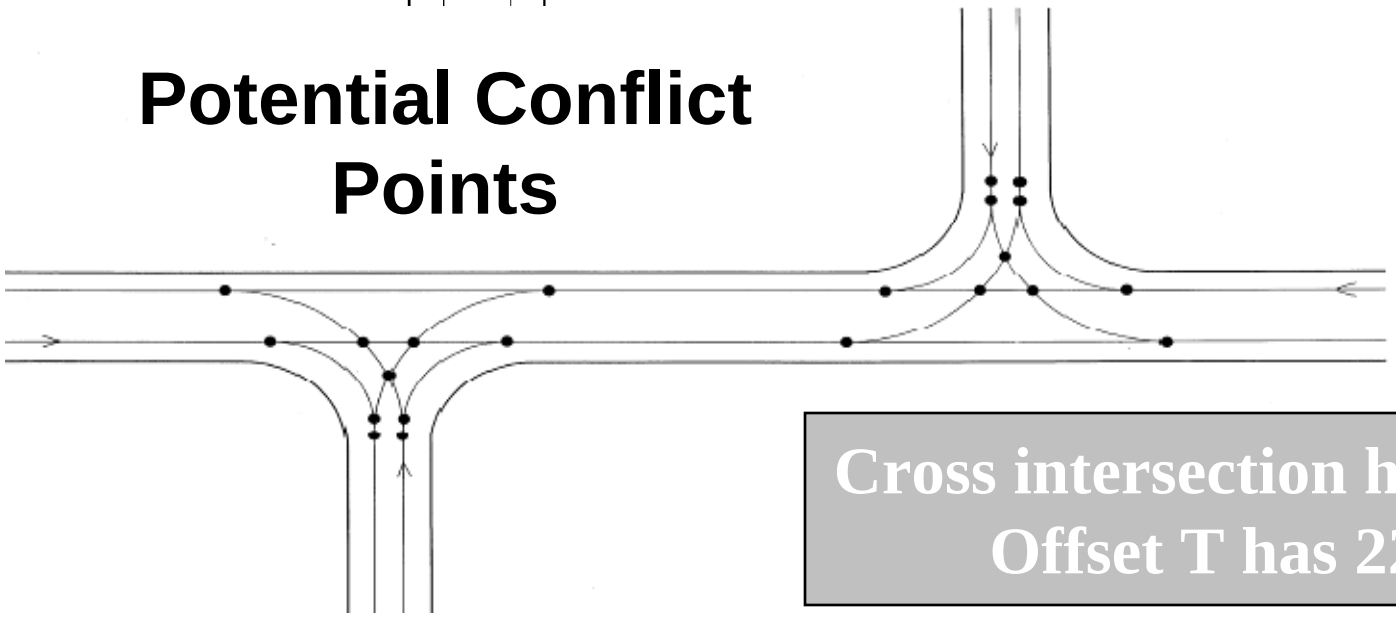
Comparison of 4-leg/3-leg Intersections



Unsignalized Intersections

NCHRP 500, Strategy 17.1 B4
Convert 4-legged intersection to two Offset "T"s

Potential Conflict Points



Cross intersection has 32 points, Offset T has 22 points

Reduce Number of Intersection Legs

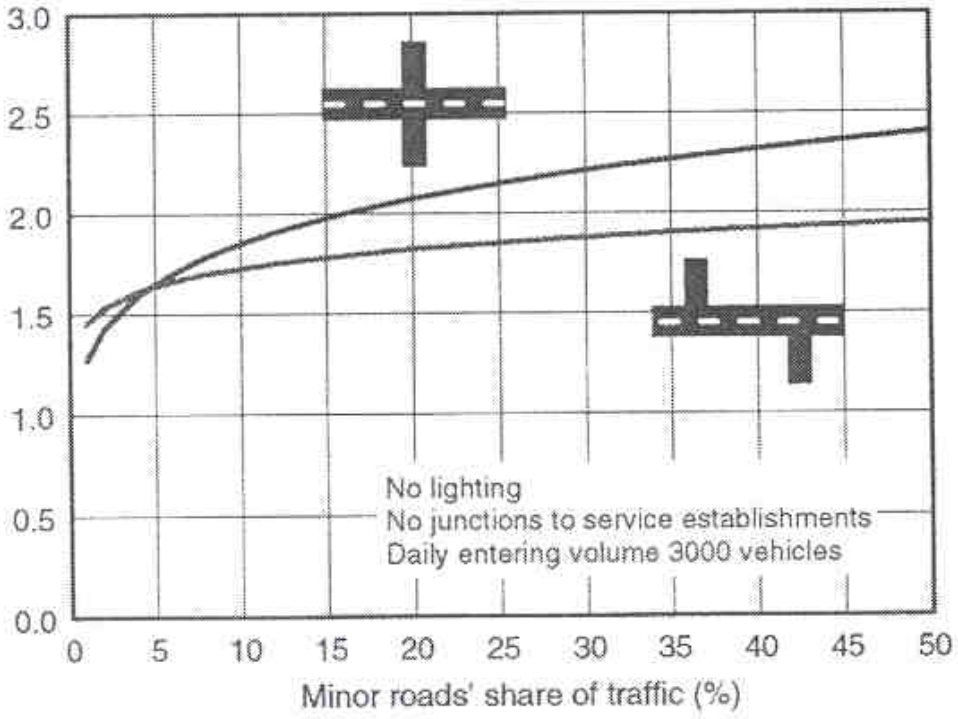


Figure 20.1

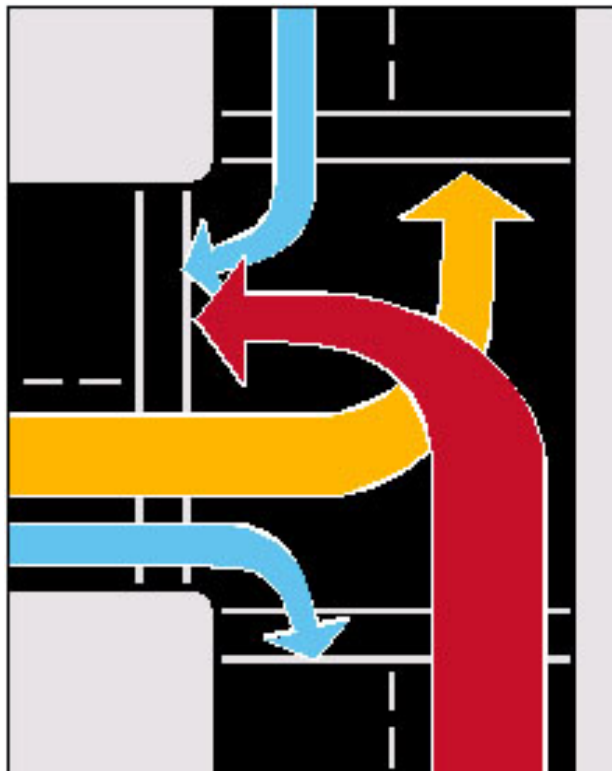
Expected number of injury collisions in 5 years

- Collision rates at offset pair of ”T” intersections 37%- 43% of the crash rate of one 4-approach intersection
- Safety Benefits of “Offset T” intersections increases as minor road traffic increases

Consider for unsignalized intersections with very low through volumes on minor streets

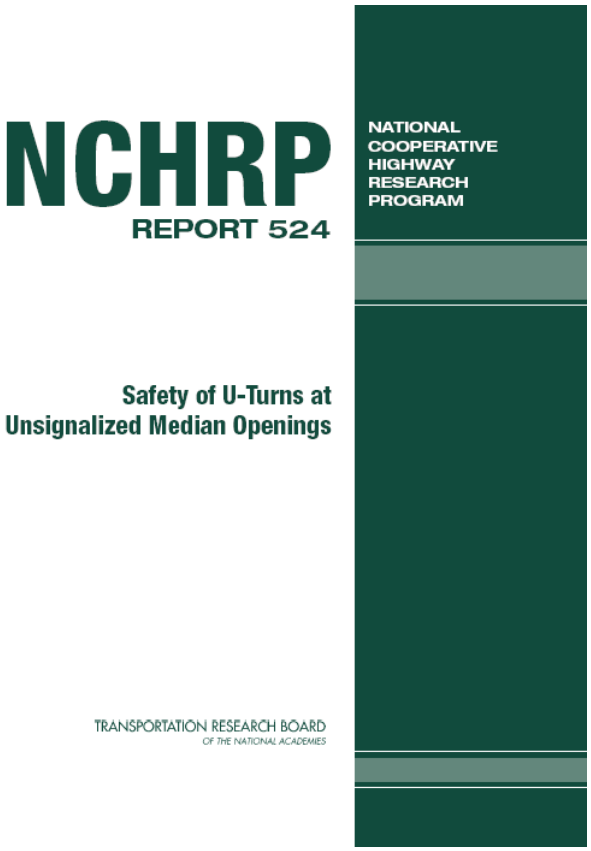
Driveway Related Crashes

- **75% of driveway related crashes involve a left turning vehicle – either into the driveway or out of the driveway**



NCHRP 500, Objective 17.1A – Improve Management of Access Near Unsignalized Intersections

Access Management – Unsignalized Median Openings

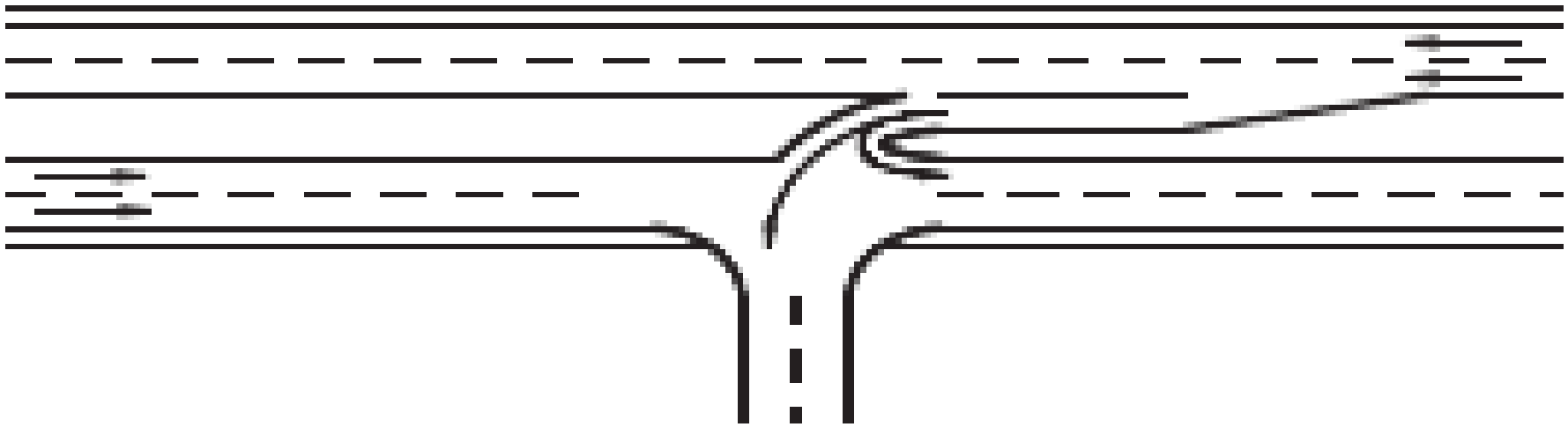


"… there is no indication that U-turns at unsignalized median openings constitute a major safety concern."

"Access management strategies that increase U-turn volumes at unsignalized median openings can be used safely and effectively."

Directional Median Opening for Left Turns from Major Road at 3-Leg Int

Type 4a—Directional Median Opening for Left Turns From Major Road at Three-Leg Intersection



*Average median opening accident rates for directional three-leg median openings are about 48 percent lower than for conventional three-leg median openings

Directional Median Opening for 4-leg Intersection

Type 6—Directional Median Opening for 4-leg Intersection With Left-Turn Lanes

Directional Median Opening for 4-leg Intersection

Type 6a—Directional Midblock Median Opening for Left Turns from Major Road at Four-Leg Intersection

Route 395, Carson City, NV


File Edit View Add Tools Help
Type 6a—Directional Midblock Median Opening for Left Turns from Major Road at Four-Leg Intersection
Google
Pointer 39°11'19.81" N 119°46'15.76" W elev 4724 ft
Streaming
25%
Eye alt 7149 ft

Left Turn Lanes in the Rural Highway Environment

- Left turn lanes remove stopped traffic from through lanes
  - mitigate rear-end conflict
  - enable selection of safe gap

❑ **"Capacity" is generally not the issue**

***NCHRP 500, Strategy 17.1 B1 – Provide Left-Turn Lanes**

Crash Reduction – Presence of Left Turn Lanes

Table 1. Expected Percentage Reduction in Total Accidents from Installation of Left-Turn Lanes on the Major-Road Approaches to Rural Intersections

Intersection type	Intersection traffic control	Number of major-road approaches on which left-turn lanes are installed	
		One approach	Both approaches
Three-leg intersection	STOP sign[a]	44[b]	
	Traffic signal	15[c]	
Four-leg intersection	STOP sign[a]	28[b]	48[b]
	Traffic signal	18[c]	33[c]

[a] STOP signs on minor-road approach(es)
[b] based on EB evaluation in Reference 1
[c] based on Reference 4

***NCHRP 500, Strategy 17.1 B1 – Provide Left-Turn Lanes**

Crash Reduction – Presence of Left Turn Lanes

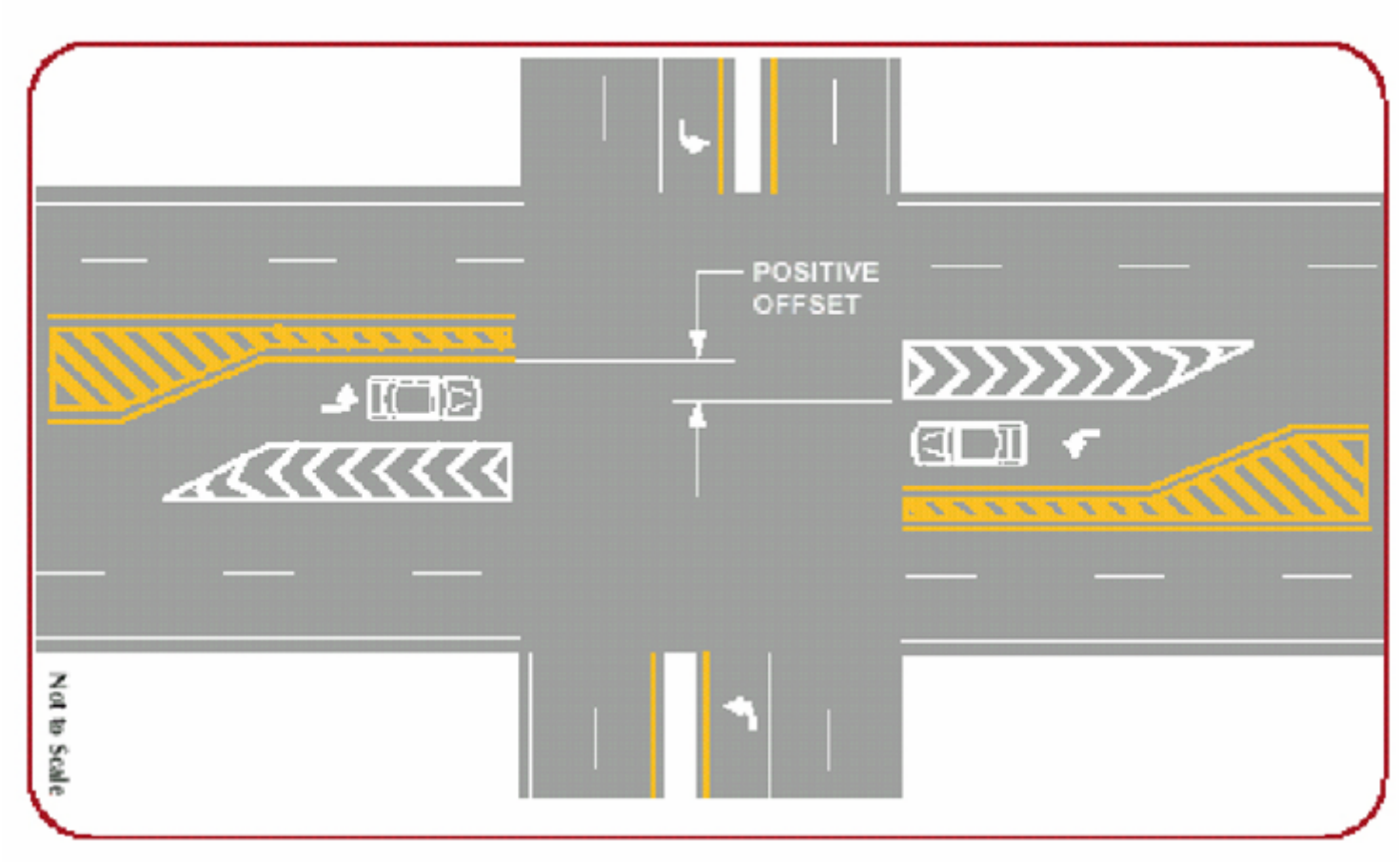
Table 2. Expected Percentage Reduction in Total Accidents from Installation of Left-Turn Lanes on the Major-Road Approaches to Urban Intersections

Intersection type	Intersection traffic control	Number of major-road approaches on which left-turn lanes are installed	
		One approach	Both approaches
Three-leg intersection	STOP sign[a]	33[b]	
	Traffic signal	7[d]	
Four-leg intersection	STOP sign[a]	27[c]	47[b]
	Traffic signal	10[b]	19[b]

[a] STOP signs on minor-road approach(es)
[b] based on EB evaluation in Reference 1
[c] based on CG evaluation in Reference 1
[d] estimated from EB results in Reference 1 and from results in Reference 4

***NCHRP 500, Strategy 17.1 B1 – Provide Left-Turn Lanes**

Offset Left-Turn Lane Geometry



***NCHRP 500, Strategy 17.2 B1 – Provide Positive Offset for Left-Turn Lanes**

Positive Offset for Left Turn Lanes

Positive Offset for Left Turn Lanes

SC 329, Florence, South Carolina

Positive Offset for Left Turn Lanes

SC 71, Florence, South Carolina

Crash Reduction – Presence of Right Turn Lanes

Table 3. Expected Percentage Accident Reduction in Total Accidents from Installation of Right-Turn Lanes on the Major-Road Approaches to Rural and Urban Intersections

Intersection traffic control	Number of major-road approaches on which right-turn lanes are installed	
	One approach	Both approaches
STOP sign[a]	14[b]	26[b]
Traffic signal	4[c]	8[c]

[a] STOP signs on minor-road approach(es)
[b] based on EB evaluation for rural intersections in Reference 1
[c] based on EB evaluation for urban intersections in Reference 1

*** NCHRP 500, Strategy 17.1 B6 – Provide Right Turn Lanes**

Signalized Intersection Geometry

US-1 (Two Notch) & Sparkleberry SC

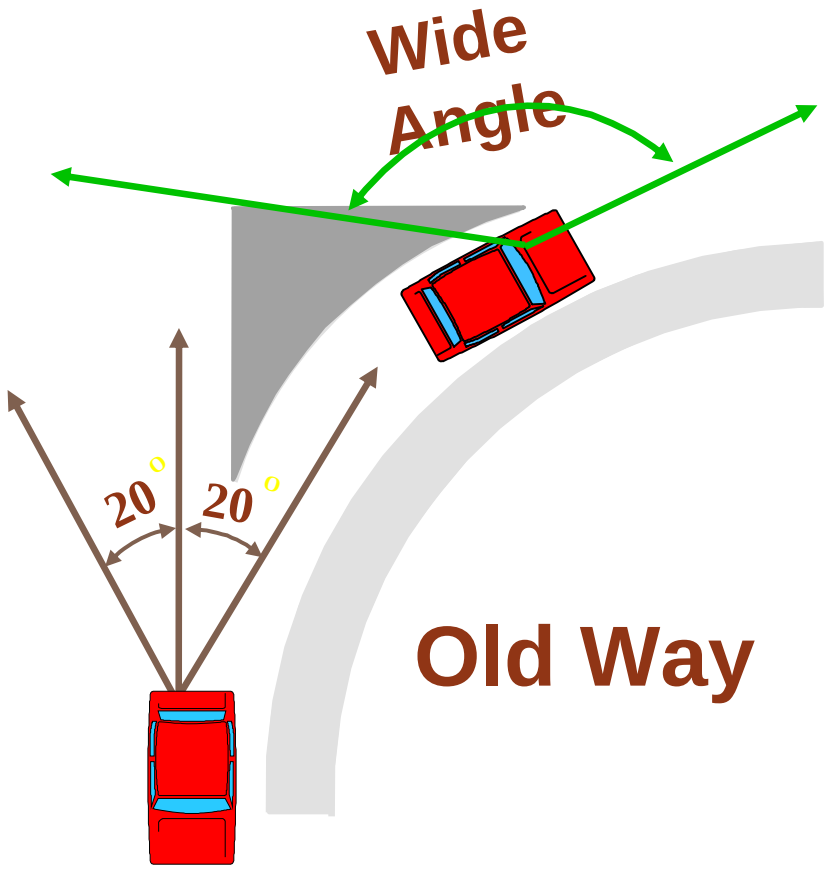
Large Radius Right Turn Lane Crash

Driver can’t see gap
- Driver is relying on rear-view mirror

Driver can’t see gap -> CRASH

Right-Turn Slip Lane:

Design for pedestrians

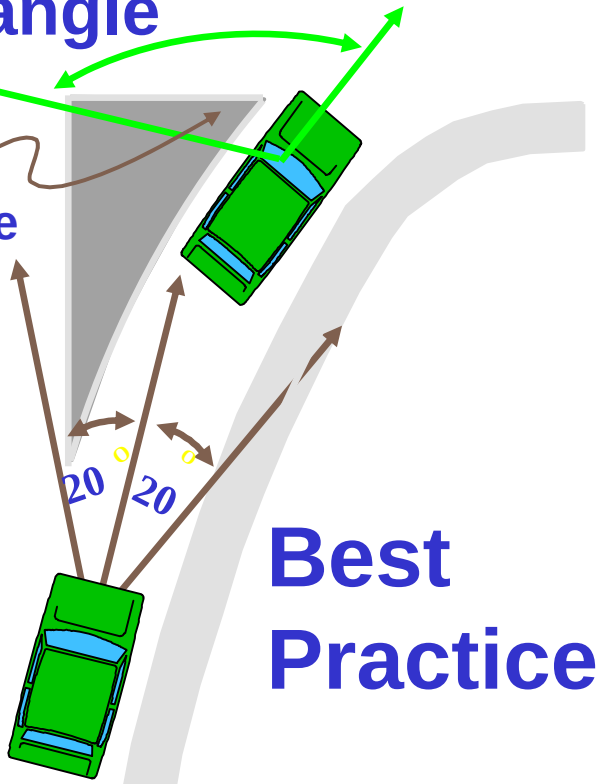


Old Way

High speed, head turner low visibility of pedestrians

Tighter angle

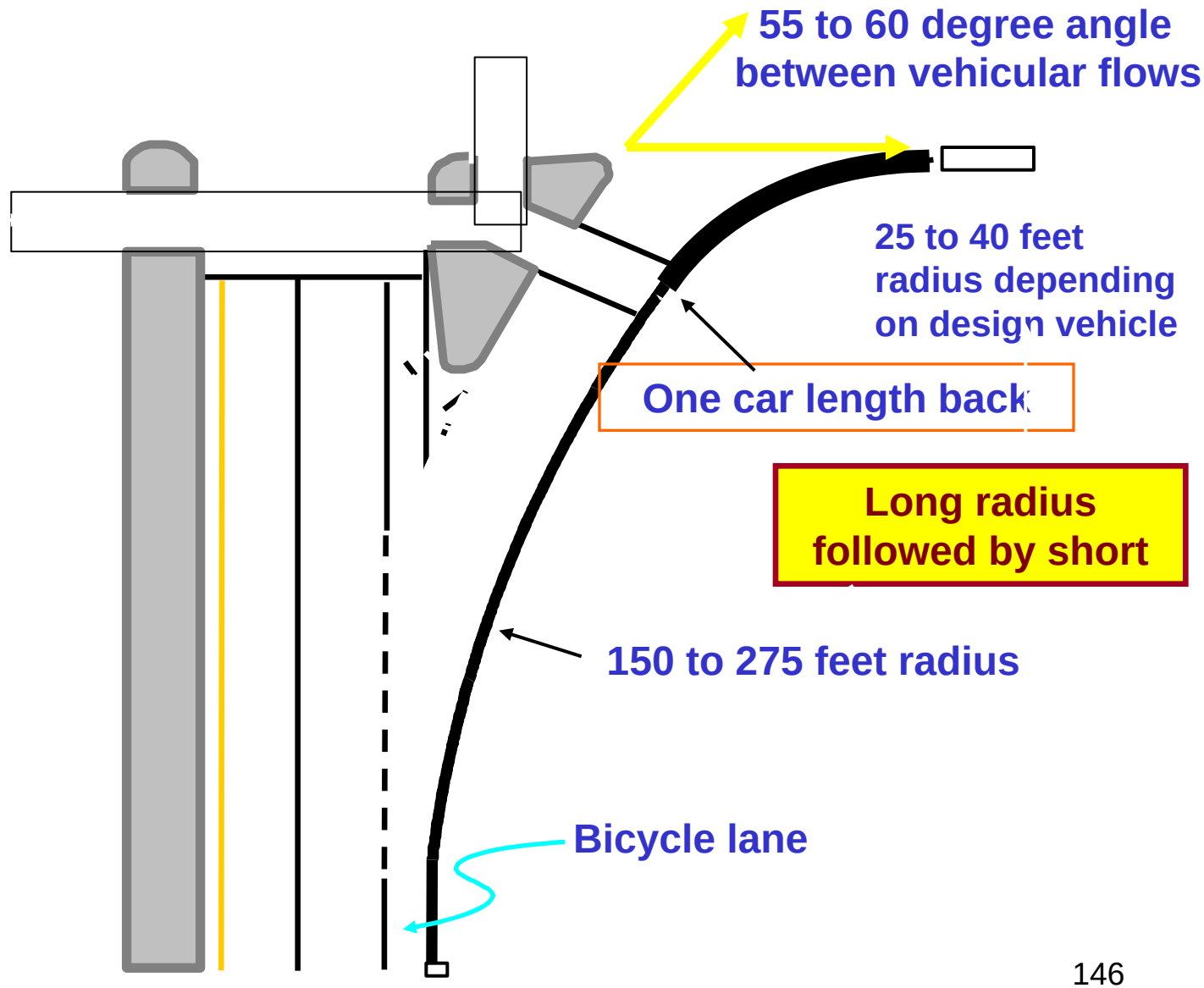
55 to 60 degree angle between vehicle flows.



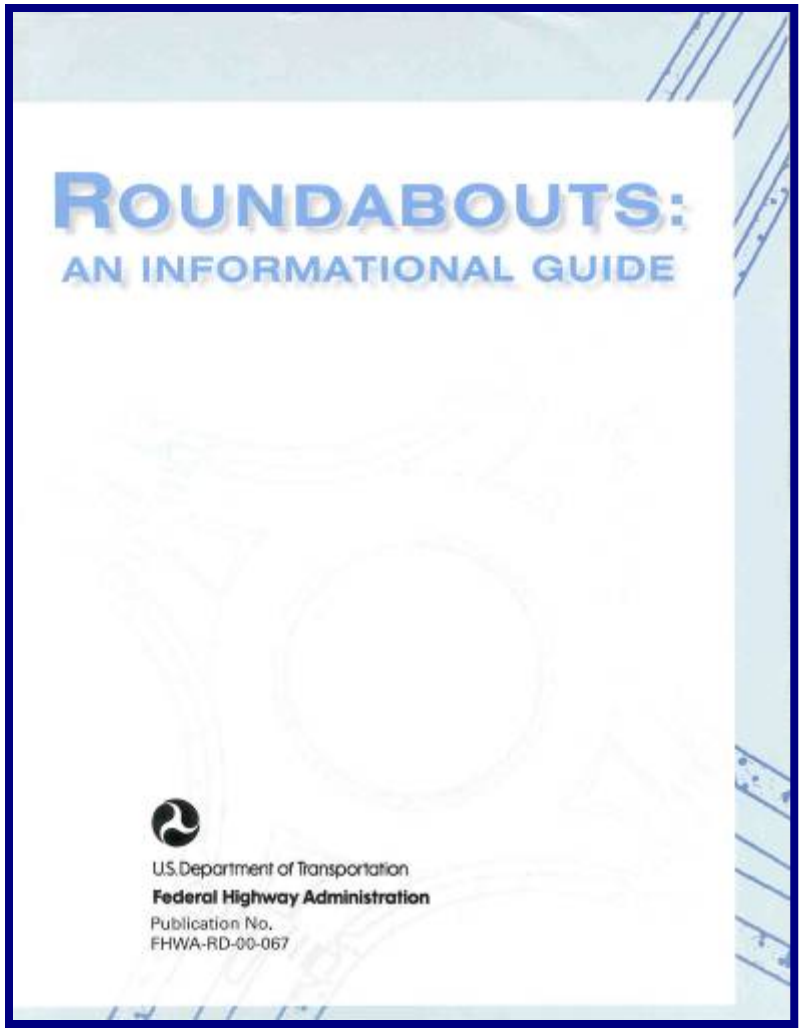
Best Practice

Slower vehicle speeds, good visibility of pedestrians

Right-Turn Slip Lane - Details



Roundabouts are alternatives to conventional intersections



- Number of conflicts is reduced
- Severe conflicts (angle) are eliminated
- Speed differentials are reduced or eliminated

***NCHRP 500, Strategy 17.1 F3 – Provide Roundabouts at appropriate locations**

Roundabouts are Proven Safety-effective

Photos source: City of Portland, OR Web site

*NCHRP 500, Strategy 17.1
F3 – Provide Roundabouts

Intersections Geometrics Countermeasures:

Questions?

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