Desktop Reference
for
Crash Reduction Factors

Report No. FHWA-SA-08-011
U.S. Department of Transportation
Federal Highway Administration

September 2008

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Federal Highway Administration

Technical Report Documentation Page

1. Report No.: FHWA-SA-08-011	2. Government Accession No.:	3. Recipient's Catalog No.:	
4. Title and Subtitle *Desktop Reference for Crash Reduction Factors*		5. Report Date: September 2008 6. Performing Organization Code: iTRANS Consulting Ltd.	
7. Authors: Bahar, Geni; Masliah, Maurice; Wolff, Rhys; Park, Peter		8. Performing Organization Report No.: 7067	
9. Performing Organization Name and Address: iTRANS Consulting Ltd. 1220 L Street NW, #100-467 Washington, DC 2005-4018 (research) Vanasse Hangen Brustlin, Inc 8300 Boone Blvd., Ste. 700 Vienna, VA 22182-2626 (editorial)		10. Work Unit No.: 11. Contract or Grant No.: DTFH61-05-D-00024	
12. Sponsoring Agency Name and Address: U.S. Department of Transportation Federal Highway Administration (FHWA) Office of Safety 1200 New Jersey Avenue, SE Washington, DC 20590		13. Type of Report and Period Covered: Information Guide Book January 2007 – September 2008 14. Sponsoring Agency Code: FHWA/HSA	
15. Supplementary Notes: FHWA Office of Safety Contract Task Order Manager Dr. Clayton Chen and Karen Yunk.			
16. Abstract. This Desktop Reference documents the estimates of the crash reduction that might be expected if a specific countermeasure or group of countermeasures is implemented with respect to intersections, roadway departure and other non-intersection crashes, and pedestrian crashes. The estimates of crash reduction are known as Crash Reduction Factors (CRFs), and represent the information available to date. Where available, the Desktop Reference includes multiple CRFs for the same countermeasure to allow the reader to review the range of potential effectiveness. The CRFs are a useful as a guide, but it remains necessary to apply engineering judgment and to consider site-specific environmental, traffic volume, traffic mix, geometric, and operational conditions which will affect the safety impact of a countermeasure. This report is a revision of Report FHWA-SA-07-015.			
17. Key Words: crash reduction factor, CRF, intersection crashes, pedestrian crashes, roadway departure crashes	18. Distribution Statement: No restrictions. This document is available to the public through the National Technical Information Service, Springfield, VA 22161		
19. Security Classification (of this report): Unclassified	20. Security Classifications (of this page): Unclassified	21. No. of Pages: 112	22. Price

Form DOT F 1700.7 (8-72) Reproduction of completed pages authorized

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This report is a revision of Report FHWA-SA-07-015. This report includes hyperlinks to the source references, which may be found in the References section in the electronic version of this report.

Introduction

This Desktop Reference provides estimates of the crash reduction that might be expected if a specific countermeasure or group of countermeasures is implemented with respect to intersection crashes, roadway departure and other non-intersection crashes, and pedestrian crashes. The crash reduction estimates are known as Crash Reduction Factors (CRFs). The CRFs presented are the CRF information available to date. In some cases, the CRF is expressed as a Crash Reduction Function.

Where available, the Desktop Reference includes multiple CRFs for the same countermeasure to allow the reader to review the range of potential effectiveness. This Desktop Reference includes CRFs for which the reliability of the estimate is low, or very low. This approach is part of the philosophy of bringing together all the information available to date. (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.) The CRFs in this Desktop Reference may be periodically updated as new information becomes available.

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.) *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 will affect the safety impact of a countermeasure.* The user must ensure that a countermeasure applies to the particular conditions being considered. The reader is also encouraged to obtain and review the original source documents for more detailed information, and to search databases such as the National Transportation Library (ntlsearch.bts.gov) for information that becomes available after the publication of this Reference.

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?*

In the Tables presented in the Desktop Reference, CRFs are provided in the column "Crash Reduction Factor/Function." The standard error of the CRF is given where available in the column "Std Error." The standard error is the standard deviation of the error in the estimate of the CRF. The true value of the CRF is unknown. The standard error provides a measure of the precision of estimate of the true value of the CRF. A relatively small standard error indicates that a CRF is relatively precisely known. A relatively large standard error indicates that a CRF is not precisely known. The standard error may be used to estimate a confidence interval of the true value of the CRF. (An example of a confidence interval calculation is given below.)

As an example, the CRF for the countermeasure *install cameras to detect red-light running* for right-angle fatal/injury crashes is **16**. The following points should be noted:

- The CRF of 16 means that a 16% reduction in fatal/injury crashes is expected after the installation of red-light running cameras.
- This CRF is bolded which means that a) a rigorous study methodology was used to estimate the CRF, and b) the standard error is relatively small. A CRF which is not bolded indicates that a less rigorous methodology (e.g. a simple before-after study) was used to estimate the CRF, and/or the standard error is large compared with the CRF.
- The standard error for this CRF is 6. Using the standard error, it is possible to calculate the 95% confidence interval for the potential crash reduction that might be achieved by implementing the countermeasure. The 95% confidence interval is ±2 standard errors from the CRF. Therefore, the 95% confidence interval for the installation of red-light running cameras is between 4% and 28% (16 - 2×6 = 4%, and 16 + 2×6 = 28%).
- The reference number is 45 (Persaud et al., as listed in the References at the end of this Desktop Reference).

Crash Reduction Functions

In some cases, a CRF is given in the form of a function. As an example of a function, consider the countermeasure "Vary truck presence" at 4-leg signalized intersections on rural highways. This function is shown in Table 3. The study was conducted by Bonneson et al.

The function for "Vary truck presence" is:

$$CRF = 100\times[1-e^{(0.026\times(Pt-9))}]$$

Where Pt = percent trucks during the peak hour (average for all intersection movements)

The value of 9 in the function reflects the base condition: 9% trucks at 4-leg signalized intersections during the peak hour on rural highways (average for all intersection movements). If, for example, a practitioner wants to know the safety effect of decreasing the truck presence to 7%, then the resulting CRF value from the function would be 5 ($=100\times(1-e^{(0.026\times (7-9))})$). The CRF value of 5 suggests that crash frequency is reduced by about 5% for a 2 percentage point decrease in truck presence (from 9% to 7%).

Using the Tables

Twelve Tables of CRFs are provided in this Reference. The Tables are grouped under intersection, roadway departure, and pedestrian crashes, and summarize the information available. The Tables include as much information as is available for each CRF.

The Tables for intersection CRFs contain the following information (where available) for each countermeasure: crash type, crash severity, area type, configuration, control, major road daily traffic volume (vehicles/day), minor road daily traffic volume (vehicles/day), reference, number of intersections observed, crash reduction factor/function, standard error, range, and study type.

The Tables for roadway departure CRFs contain the following information (where available) for each countermeasure: crash type, crash severity, area type, road type, maximum daily traffic volume (vehicles/day), minimum daily traffic volume (vehicles/day), reference, crash reduction factor/function, standard error, range, and study type.

The Tables for pedestrian CRFs contain the following information (where available) for each countermeasure: crash type, crash severity, area type, reference, crash reduction factor/function, standard error, range, and study type.

The following points should be noted:

- The crash severities are: all, fatal/injury (fatal and injury crashes combined), fatal, injury, or property damage only (PDO).
- Where available, the Tables provide existing traffic control information (i.e. the conditions existing before implementation of a countermeasure). The control information for the pre-countermeasure study site may be “no signal,” “signal,” “stop,” or “stop/yield.” “No signal” is used when a publication specifies that the intersection was not signalized before the countermeasure was introduced, but does not provide details. (In these cases, the intersection could have yield or stop signs, or no controls at all.) Where the original study is not clear, or omits to give the information, the cell is left blank.

- Road type information (for roadway departure countermeasures) uses the following road types (where available): all, multilane, multilane divided, arterial, highway, or freeway. Where the original study was not clear, or omitted to give the information, the cell is left blank or the study's wording is used.
- In the observed column, a higher number of intersections/sites usually corresponds with a more reliable estimate of the safety effectiveness.
- For some countermeasures, a range of safety effectiveness is provided in the Range Low and Range High columns.
- The study type refers to the methodology used in the CRF study.
- A blank cell means that no information is reported in the source document.
- The following abbreviations appear in the Tables:
    - App = Approaches
    - Avg = Average
    - Config = Configuration
    - EB = Empirical Bayes
    - Emerg = Emergency
    - Max = Maximum
    - Min = Minimum
    - Obs = Number of observed intersections
    - PDO = Property Damage Only
    - Ped = Pedestrian
    - Ref = Reference
    - ROR = Run-Off-Road
    - Std Error = Standard Error

- For additional information, please visit the FHWA Office of Safety website safety.fhwa.dot.gov.

Tables for Intersection Crash Reduction Factors

Table 1: Signalization Countermeasures

Countermeasure(s)	Crash Type	Crash Severity	Area Type	Config	Control	Major Daily Traffic Volume (veh/day)	Minor Daily Traffic Volume (veh/day)	Ref	Obs	Effectiveness: Crash Reduction Factor / Function	Effectiveness: Std Error	Effectiveness: Range Low	Effectiveness: Range High	Study Type
SIGNAL OPERATIONS COUNTERMEASURES														
Add all-red clearance interval	All	All			Signal			15		15				Cross-section
	Right-angle	All			Signal			15		30				Cross-section
Add all-red clearance interval (from 0 to 1 second)	Right-angle	All	Urban		Signal			47	6	0	44	-32	67	
Add exclusive pedestrian phasing	Ped	All			Signal			28		34		7	60	
Convert exclusive leading protected to exclusive lagging protected	All	All			Signal			25		-15	19			Simple Before-After
	Left-turn	All			Signal			25		-49	54			Simple Before-After
Convert permissive or permissive/protected to protected only left-turn phasing	All	All			Signal			62		1	7			Empirical Before-After/ Expert Panel
	Left-turn	All			Signal			62		**99**	1			Empirical Before-After/ Expert Panel
Convert permissive to permissive/protected left-turn phasing	All	All			Signal			62		0				Expert Panel
	Left-turn	All			Signal			62		16	2			Expert Panel
Convert protected left-turn phase to protected/permissive	All	All			Signal			25		-20	17			Comparison Group Before-After
	All	Fatal/Injury			Signal			25		-10	25			Comparison Group Before-After
	Left-turn	All			Signal			25		-65	71			Comparison Group Before-After
	Rear-end	All			Signal			25		4	22			Comparison Group Before-After

Countermeasure(s)	Crash Type	Crash Severity	Area Type	Config	Control	Major Daily Traffic Volume (veh/day)	Minor Daily Traffic Volume (veh/day)	Ref	Obs	Effectiveness: Crash Reduction Factor / Function	Effectiveness: Std Error	Effectiveness: Range Low	Effectiveness: Range High	Study Type
Convert protected/permissive left-turn phase to permissive/protected	All	All			Signal			29		13	19			Simple Before-After
	Left-turn	All			Signal			29		33	22			Simple Before-After
Improve signal timing [to intervals specified by the ITE *Determining Vehicle Change Intervals: A Proposed Recommended Practice* (1985)]	All	All		4-Leg	Signal			49		**8**	9			Experimental Design (Case-Control Study)
	All	All		4-Leg	Signal			39	20	18				
	All	Fatal/Injury		4-Leg	Signal			49		12	9			Experimental Design (Case-Control Study)
	Head-on	Fatal/Injury			Signal			15		75				Simple Before-After
	Left-turn	All			Signal			15		75				
	Left-turn	Fatal/Injury			Signal			15		55				Simple Before-After
	Left-turn	PDO			Signal			15		63				Simple Before-After
	Multi-vehicle	All	All		Signal			21	40	5				Comparison Group Before-After
	Multi-vehicle	Fatal/Injury	All		Signal			21	40	9				Comparison Group Before-After
	ROR	Fatal/Injury			Signal			15		62				Simple Before-After
	ROR	PDO			Signal			15		28				Simple Before-After
	Older-driver	All		4-Leg	Signal			39	20	42				
	Rear-end	All		4-Leg	Signal			49		-12	16			Experimental Design (Case-Control Study)

Countermeasure(s)	Crash Type	Crash Severity	Area Type	Config	Control	Major Daily Traffic Volume (veh/day)	Minor Daily Traffic Volume (veh/day)	Ref	Obs	Effectiveness: Crash Reduction Factor / Function	Effectiveness: Std Error	Effectiveness: Range Low	Effectiveness: Range High	Study Type
Improve signal timing [to intervals specified by the ITE *Determining Vehicle Change Intervals: A Proposed Recommended Practice* (1985)] (cont'd)	Rear-end	Fatal/Injury		4-Leg	Signal			49		-8	17			Experimental Design (Case-Control Study)
	Rear-end	PDO			Signal			15		17				Simple Before-After
	Right-angle	All		4-Leg	Signal			49		4	18			Experimental Design (Case-Control Study)
	Right-angle	Fatal/Injury			Signal			15		30				Simple Before-After
	Right-angle	Fatal/Injury		4-Leg	Signal			49		-6	22			Experimental Design (Case-Control Study)
	Right-angle	PDO			Signal			15		46				Simple Before-After
	Ped	Fatal/Injury			Signal			49		37				Comparison Group Before-After
Increase yellow change interval	All	All			Signal			15		15				Cross-section
	Right-angle	All			Signal			15		30				Cross-section
Install emergency vehicle pre-emption systems	Emerg vehicle	All						51		70				
Install pedestrian signal	All	All			Signal			15		20				
	All	All						15		25				
	All	All						15		15				
	Ped	All			Signal			15		53				
	Ped	All			Signal			5		0				
	Ped	All						15		55				
	Ped	All						15		50				

Countermeasure(s)	Crash Type	Crash Severity	Area Type	Config	Control	Major Daily Traffic Volume (veh/day)	Minor Daily Traffic Volume (veh/day)	Ref	Obs	Effectiveness				Study Type
										Crash Reduction Factor / Function	Std Error	Range		
												Low	High	
Modify signal phasing (implement a leading pedestrian interval)	Ped	All			Signal			28		5				
Provide actuated signals	Left-turn	All			Signal			15		80				Cross-section
	Right-angle	All			Signal			15		10				Cross-section
Provide Advanced Dilemma Zone Detection for rural high speed approaches	All	Fatal/Injury	Rural	4-Leg (1 app)	Signal			61	5	39				Simple Before-After
Provide protected left-turn phase	All	All			Signal	<5,000/lane(Total)		15		30				Simple Before-After
	All	All			Signal	>5,000/lane(Total)		15		36				Simple Before-After
	All	All			Signal			15		15				Simple Before-After
	All	All			Signal			15		25				Cross-section
	All	All			Signal			15		30				Simple Before-After
	All	All			Signal			15		27				
	Left-turn	All			Signal	<5,000/lane(Total)		15		41				Simple Before-After
	Left-turn	All			Signal	>5,000/lane(Total)		15		46				Simple Before-After
	Left-turn	All			Signal			15		35				Simple Before-After
	Left-turn	All			Signal			15		70				Cross-section
	Left-turn	All			Signal			15		48				
	Left-turn	Fatal/Injury	Urban		Signal			31	30	**16**	2			EB Before-After

Countermeasure(s)	Crash Type	Crash Severity	Area Type	Config	Control	Major / Minor Daily Traffic Volume (veh/day)		Ref	Obs	Effectiveness: Crash Reduction Factor / Function	Effectiveness: Std Error	Effectiveness: Range Low	Effectiveness: Range High	Study Type
Provide protected left-turn phase (cont'd)	Right-angle	Fatal/Injury	Urban		Signal			31	30	**19**	2			EB Before-After
	Overturn	All			Signal	<5,000/lane(Total)		15		27				Simple Before-After
	Overturn	All			Signal	>5,000/lane(Total)		15		35				Simple Before-After
	Overturn	All			Signal			15		31				
	Ped	All			Signal			28		5				
	Rear-end	All			Signal	<5,000/lane(Total)		15		27				Simple Before-After
	Rear-end	All			Signal	>5,000/lane(Total)		15		35				Simple Before-After
	Rear-end	All			Signal			15		31				
	Right-angle	All			Signal	<5,000/lane(Total)		15		54				Simple Before-After
	Right-angle	All			Signal	>5,000/lane(Total)		15		56				Simple Before-After
	Right-angle	All			Signal			15		80				Simple Before-After
	Right-angle	All			Signal			15		63				
Provide protected/permissive left-turn phase (leading flashing green) (Request MUTCD Experimentation)	Left-turn	Fatal/Injury	Urban		Signal			31	15	**16**	4			EB Before-After
	Right-angle	Fatal/Injury	Urban		Signal			31	15	**12**	4			EB Before-After
Provide protected left-turn phase (leading green arrow)	Left-turn	Fatal/Injury	Urban		Signal			31	20	**17**	2			EB Before-After
	Right-angle	Fatal/Injury	Urban		Signal			31	20	**25**	2			EB Before-After
Provide signal coordination	All	All	All		Signal			1		15				
	All	All			Signal			28		16				
	All	All	Arizona		Signal			3		7				
	Right-angle	All			Signal			28		32		25	38	

Countermeasure(s)	Crash Type	Crash Severity	Area Type	Config	Control	Major Daily Traffic Volume (veh/day)	Minor Daily Traffic Volume (veh/day)	Ref	Obs	Effectiveness: Crash Reduction Factor / Function	Effectiveness: Std Error	Effectiveness: Range Low	Effectiveness: Range High	Study Type
Provide split phases	All	All			Signal			28		25				
Remove flash mode (late night/early morning)	All	All			Signal			28		29				
	Right-angle	All			Signal			47	17	75	19	29	100	Simple Before-After
	Right-angle	All			Signal			28		80				
Replace existing WALK / DON'T WALK signals with pedestrian countdown signal heads	Ped	All	Urban (San Francisco)		Signal			32		25				
SIGNAL HARDWARE COUNTERMEASURES														
Add 3-inch yellow retroreflective sheeting to signal backplates	All	All	Urban		Signal			54		15	51			EB Before-After
Add additional signal and upgrade to 12-inch lenses	Older-driver	All		4-Leg	Signal			39	33	31				
	Younger-driver	All		4-Leg	Signal			39	33	17				
Add signal (additional primary head)	All	All			Signal			28		10				
	All	All	Urban	4-Leg	Signal			14	63	28		20	30	EB Before-After
	All	Fatal/Injury	Urban	4-Leg	Signal			14	63	17		10	25	EB Before-After
	All	PDO	Urban	4-Leg	Signal			14	63	31		30	35	EB Before-After
	Rear-end	All	Urban	4-Leg	Signal			14	63	28		0	45	EB Before-After
	Right-angle	All			Signal			28		42				
	Right-angle	All	Urban	4-Leg	Signal			14	63	35		15	45	EB Before-After

Countermeasure(s)	Crash Type	Crash Severity	Area Type	Config	Control	Major Daily Traffic Volume (veh/day)	Minor Daily Traffic Volume (veh/day)	Ref	Obs	Effectiveness: Crash Reduction Factor / Function	Effectiveness: Std Error	Effectiveness: Range Low	Effectiveness: Range High	Study Type
Convert signal from pedestal-mounted to mast arm	All	All			Signal			51		49				
	All	All			Signal			35	6	25				Simple Before-After
	All	All			Signal			35	33	32				Simple Before-After
	All	All			Signal			28		36		28	43	
	All	Fatal/Injury			Signal			51		44				
	All	PDO			Signal			51		51				
	Left-turn	All			Signal			51		12				
	Rear-end	All			Signal			51		41				
	Right-angle	All			Signal			51		74				
	Right-angle	All			Signal			35	6	63				Simple Before-After
Improve visibility of signal heads (increase signal lens size, install new backboards, add reflective tape to existing backboards, and/or install additional signal heads)	All	All	Urban		Signal			52	224	7				EB Before-After
	All	Fatal/Injury	Urban		Signal			52	224	3				EB Before-After
	All	PDO	Urban		Signal			52	224	9				EB Before-After
	Day	All	Urban		Signal			52	224	6				EB Before-After
	Night	All	Urban		Signal			52	224	6				EB Before-After
Improve visibility of signal heads (install two red displays in each head)	All	All			Signal			28		9				
	Right-angle	All			Signal			28		36				
Install larger signal lenses (12 inch)	All	All	All		Signal			1		10				
	All	All			Signal			28		11				
	All	All			Signal			15		10				
	All	All			Signal			15		10				Cross-section
	All	All			Signal			28		11		10	12	
	All	All	Urban		Signal			54		24				Cross-section

Countermeasure(s)	Crash Type	Crash Severity	Area Type	Config	Control	Major Daily Traffic Volume (veh/day)	Minor Daily Traffic Volume (veh/day)	Ref	Obs	Effectiveness: Crash Reduction Factor / Function	Effectiveness: Std Error	Effectiveness: Range Low	Effectiveness: Range High	Study Type
Install larger signal lenses (12 inch) (cont'd)	All	Fatal/Injury	Urban		Signal			54		16				Cross-section
	Right-angle	All			Signal			47	44	46		-89	100	Simple Before-After
	Right-angle	All			Signal			28		48				
Install signal backplates only	All	All			Signal			28		13		2	24	
	Right-angle	All			Signal			28		50		7	93	
Install signal backplates (or visors)	Right-angle	All			Signal			15		20				
	Right-angle	All			Signal			15		20				Cross-section
Install signals	All	All			No signal	<5,000/lane(Total)		15		38				Simple Before-After
	All	All			No signal	>5,000/lane(Total)		15		20				Simple Before-After
	All	All			No signal			28		33		20	45	
	Left-turn	All			No signal			43	447	38				Simple Before-After
	Right-turn	All			No signal			43	447	50				Simple Before-After
	All	All	Rural		No signal			43	447	15				Simple Before-After
	All	Fatal			No signal			43	447	38				Simple Before-After
	Rear-end	All			No signal			43	447	-48				Simple Before-After
	Right-angle	All			No signal			43	447	29				Simple Before-After
	All	All	Urban		No signal			43	447	17				Simple Before-After
	All	All			No signal			15		22				
	All	All			No signal			15		15				Simple Before-After
	All	All			No signal			15		13				Simple Before-After
	All	All			No signal			15		20				Simple Before-After

Countermeasure(s)	Crash Type	Crash Severity	Area Type	Config	Control	Major Daily Traffic Volume (veh/day)	Minor Daily Traffic Volume (veh/day)	Ref	Obs	Effectiveness: Crash Reduction Factor / Function	Effectiveness: Std Error	Effectiveness: Range Low	Effectiveness: Range High	Study Type
Install signals (cont'd)	All	All			No signal			15		25				Cross-section
	All	All			No signal			15		20				Simple Before-After
	All	Fatal/Injury	Urban	3-Leg	Stop	11,750-42,000	900-4,000	34		14	32			EB Before-After
	All	Fatal/Injury	Urban	4-Leg	Stop	12,650-22,400	2,400-3,625	34		23	22			EB Before-After
	Overturn	All			No signal	<5,000/lane(Total)		15		22				Simple Before-After
	Overturn	All			No signal	>5,000/lane(Total)		15		20				Simple Before-After
	Rear-end	All			No signal	<5,000/lane(Total)		15		22				Simple Before-After
	Rear-end	All			No signal	>5,000/lane(Total)		15		20				Simple Before-After
	Rear-end	Fatal/Injury	Urban	3-Leg	Stop	11,750-42,000	900-4,000	34		-50	51			EB Before-After
	Rear-end	Fatal/Injury	Urban	4-Leg	Stop	12,650-22,400	2,400-3,625	34		-38	39			EB Before-After
	Right-angle	All			No signal	<5,000/lane(Total)		15		74				Simple Before-After
	Right-angle	All			No signal	>5,000/lane(Total)		15		43				Simple Before-After
	Right-angle	All			No signal			15		58				
	Right-angle	All			No signal			15		60				Simple Before-After
	Right-angle	All			No signal			15		42				Simple Before-After
	Right-angle	All			No signal			15		65				Cross-section
	Right-angle	All			No signal			15		65				Simple Before-After
	Right-angle	All			No signal			28		68				
	Right-angle	All			No signal			47	8	74	66	56	100	Simple Before-After
	Right-angle	Fatal/Injury	Urban	3-Leg	Stop	11,750-42,000	900-4,000	34		34	45			EB Before-After

Countermeasure(s)	Crash Type	Crash Severity	Area Type	Config	Control	Major Daily Traffic Volume (veh/day)	Minor Daily Traffic Volume (veh/day)	Ref	Obs	Effectiveness				Study Type
										Crash Reduction Factor / Function	Std Error	Range Low	Range High	
Install signals (cont'd)	Right-angle	Fatal/Injury	Urban	4-Leg	Stop	12,650-22,400	2,400-3,625	34		**67**	20			EB Before-After
	All	PDO			No signal			43	447	-15				Simple Before-After
Install signals (temporary)	Head-on	PDO			No signal			15		83				Simple Before-After
	Left-turn	PDO			No signal			15		11				Simple Before-After
	Right-angle	Fatal/Injury			No signal			15		39				Simple Before-After
	Right-angle	PDO			No signal			15		73				Simple Before-After
	Sideswipe	Fatal/Injury			No signal			15		50				Simple Before-After
Install signals (to have one over each approach lane)	Right-angle	All	All					35		46				Simple Before-After
Remove unwarranted signals	All	All			Signal			15		75				
	All	All			Signal			15		100				Simple Before-After
	All	All			Signal			15		50				Cross-section
	All	All			Signal			15		75				Simple Before-After
	All	All			Signal			28		52		50	53	
	All	All	Urban		Signal			21	199	24				EB Before-After
	All	Fatal/Injury	Urban		Signal			21	199	53				EB Before-After
	All	PDO	Urban		Signal			21	199	24				EB Before-After
	Day	All	Urban		Signal			21	199	22				EB Before-After
	Fixed-object	All	Urban		Signal			21	199	31				EB Before-After
	Night	All	Urban		Signal			21	199	30				EB Before-After
	Rear-end	All			Signal			15		95		90	100	

Countermeasure(s)	Crash Type	Crash Severity	Area Type	Config	Control	Major Daily Traffic Volume (veh/day)	Minor Daily Traffic Volume (veh/day)	Ref	Obs	Effectiveness: Crash Reduction Factor / Function	Effectiveness: Std Error	Effectiveness: Range Low	Effectiveness: Range High	Study Type
Remove unwarranted signals (cont'd)	Rear-end	All			Signal			15		100				Simple Before-After
	Rear-end	All			Signal			15		90				Cross-section
	Rear-end	All	Urban		Signal			21	199	29				EB Before-After
	Right-angle	All	Urban		Signal			21	199	24				EB Before-After
Replace signal lenses with optical lenses	All	All			Signal			28		17		15	18	
	All	All			Signal			15		15				
	All	All			Signal			15		15				Cross-section
	Head-on	All			Signal			15		20				Cross-section
	Left-turn	All			Signal			15		10				Cross-section
	Rear-end	All			Signal			15		10				Cross-section
	Right-angle	All			Signal			15		10				Cross-section
COMBINATION SIGNAL AND OTHER COUNTERMEASURES														
Install left-turn lane and add turn phase	All	All			Signal			28		58		46	69	
Install signals and add channelization	Head-on	PDO			No signal			15		27				Simple Before-After
	Left-turn	PDO			No signal			15		24				Simple Before-After
	ROR	Fatal/Injury			No signal			15		35				Simple Before-After
	Right-angle	Fatal/Injury			No signal			15		67				Simple Before-After
	Right-angle	PDO			No signal			15		63				Simple Before-After
	Sideswipe	Fatal/Injury			No signal			15		54				Simple Before-After

Countermeasure(s)	Crash Type	Crash Severity	Area Type	Config	Control	Major Daily Traffic Volume (veh/day)	Minor Daily Traffic Volume (veh/day)	Ref	Obs	Effectiveness: Crash Reduction Factor / Function	Effectiveness: Std Error	Effectiveness: Range Low	Effectiveness: Range High	Study Type
LEFT-TURN COUNTERMEASURES														
Add indirect left-turn treatments to minimize conflicts	All	All			Stop	>34,000		59		18	8			Cross-section
	All	All			Stop	>34,000 4 lanes		59		-24	35			Cross-section
	All	All			Stop	>34,000 6 lanes		59		26	8			Cross-section
	All	All			Stop	>34,000 8 lanes		59		24	63			Cross-section
	All	Fatal/Injury			Stop	>34,000		59		27	12			Cross-section
	All	PDO			Stop	>34,000		59		6	11			Cross-section
Create directional median openings to allow left-turns and u-turns	All	All			Signal			51		51				
Install left-turn lane	All	All	All					1		25				
	All	All	Rural	3-Leg	Signal	4,200-26,000	1,300-11,400	22	199	15				Expert Panel
	All	All	Rural	3-Leg	Stop	1,100-32,400	25-11,800	22		**44**	6			EB Before-After
	All	All	Rural	4-Leg (1 app)	Signal	4,200-26,000	1,300-11,400	22	199	18				Expert Panel
	All	All	Rural	4-Leg (1 app)	Stop	1,100-32,400	25-11,800	22		**28**	3			EB Before-After
	All	All	Rural	4-Leg (2 app)	Stop	1,100-32,400	25-11,800	22		**48**	3			EB Before-After
	All	All			No signal			15		34				
	All	All			No signal			15		35				Simple Before-After
	All	All			No signal			15		35				Cross-section
	All	All			No signal			15		25				Simple Before-After
	All	All			No signal			15		40				Simple Before-After

Countermeasure(s)	Crash Type	Crash Severity	Area Type	Config	Control	Major Daily Traffic Volume (veh/day)	Minor Daily Traffic Volume (veh/day)	Ref	Obs	Effectiveness				Study Type
										Crash Reduction Factor / Function	Std Error	Range Low	Range High	
Install left-turn lane (cont'd)	All	All			No signal			28		33		25	41	
	All	All	Urban	3-Leg	Signal	4,600-55,100	100-26,000	22	199	7				Expert Panel
	All	All	Urban	3-Leg	Stop	1,520-40,600	80-8,000	22		**33**	12			EB Before-After
	All	All	Urban	4-Leg (1 app)	Signal	4,600-55,100	100-26,000	22		**10**	10			EB Before-After
	All	All	Urban	4-Leg (1 app)	Stop	1,520-40,600	80-8,000	22		**27**	3			EB Before-After
	All	All	Urban	4-Leg (2 app)	Signal	4,600-55,100	100-26,000	22		19	13			EB Before-After
	All	All	Urban	4-Leg (2 app)	Stop	1,520-40,600	80-8,000	22		**47**	4			EB Before-After
	All	Fatal/Injury	Rural	3-Leg	Stop	1,100-32,400	25-11,800	22		**55**	8			EB Before-After
	All	Fatal/Injury	Rural	4-Leg (1 app)	Stop	1,100-32,400	25-11,800	22		**35**	3			EB Before-After
	All	Fatal/Injury	Rural	4-Leg (2 app)	Stop	1,100-32,400	25-11,800	22		**58**	4			EB Before-After
	All	Fatal/Injury	Urban	4-Leg (1 app)	Signal	4,600-55,100	100-26,000	22		**9**	1			EB Before-After
	All	Fatal/Injury	Urban	4-Leg (1 app)	Stop	1,520-40,600	80-8,000	22		**29**	4			EB Before-After
	All	Fatal/Injury	Urban	4-Leg (2 app)	Signal	4,600-55,100	100-26,000	22		**17**	2			EB Before-After
	All	Fatal/Injury	Urban	4-Leg (2 app)	Stop	1,520-40,600	80-8,000	22		50	6			Comparison Group
	All	Fatal/Injury	All	All	All			58		30				
	Left-turn	All	Rural	3-Leg	Stop	1,100-32,400	25-11,800	21	35	62				Comparison Group Before-After
	Left-turn	All	Rural	4-Leg (1 app)	Stop	1,100-32,400	25-11,800	21	23	37				EB Before-After
	Left-turn	All	Rural	4-Leg (2 app)	Stop	1,100-32,400	25-11,800	21	23	60				EB Before-After
	Left-turn	All			No signal			15		55				
	Left-turn	All			No signal			15		55				Simple Before-After

Countermeasure(s)	Crash Type	Crash Severity	Area Type	Config	Control	Major Daily Traffic Volume (veh/day)	Minor Daily Traffic Volume (veh/day)	Ref	Obs	Effectiveness: Crash Reduction Factor / Function	Effectiveness: Std Error	Effectiveness: Range Low	Effectiveness: Range High	Study Type
Install left-turn lane (cont'd)	Left-turn	All			No signal			28		68		50	86	
	Left-turn	All			Signal	>5,000/lane(Total)		15		24				Simple Before-After
	Left-turn	All	Urban	4-Leg (1 app)	Signal	4,600-55,100	100-26,000	21	35	13				Yorked Comparison Before-After
	Left-turn	All	Urban	4-Leg (1 app)	Stop	1,520-40,600	80-8,000	21	7	26				EB Before-After
	Left-turn	All	Urban	4-Leg (2 app)	Signal	4,600-55,100	100-26,000	21	35	24				Yorked Comparison Before-After
	Left-turn	All	Urban	4-Leg (2 app)	Stop	1,520-40,600	80-8,000	21	7	45				EB Before-After
	Night	All			Signal	>5,000/lane(Total)		15		28				Simple Before-After
	Overturn	All			Signal	>5,000/lane(Total)		15		28				Simple Before-After
Install left-turn lane (double)	Head-on	Fatal/Injury						15		75				Simple Before-After
	Left-turn	Fatal/Injury						15		47				Simple Before-After
	Left-turn	PDO						15		71				Simple Before-After
	ROR	Fatal/Injury						15		8				Simple Before-After
	ROR	PDO						15		13				Simple Before-After
	Rear-end	Fatal/Injury						15		29				Simple Before-After
	Rear-end	PDO						15		32				Simple Before-After
	Right-angle	Fatal/Injury						15		20				Simple Before-After
	Right-angle	PDO						15		8				Simple Before-After
	Sideswipe	Fatal/Injury						15		50				Simple Before-After

Countermeasure(s)	Crash Type	Crash Severity	Area Type	Config	Control	Major Daily Traffic Volume (veh/day)	Minor Daily Traffic Volume (veh/day)	Ref	Obs	Effectiveness: Crash Reduction Factor / Function	Effectiveness: Std Error	Effectiveness: Range Low	Effectiveness: Range High	Study Type
Install left-turn lane (painted separation)	All	All				<5,000/lane(Total)		15		50				Simple Before-After
	All	Fatal/Injury	Rural	3-Leg		5,000-15,000		13		22	14			Meta-analysis
	All	Fatal/Injury	Rural	4-Leg		5,000-15,000		13		-28	27			Meta-analysis
	All	PDO	Rural	3-Leg		5,000-15,000		13		20	19			Meta-analysis
	All	PDO	Rural	4-Leg		5,000-15,000		13		26	12			Meta-analysis
	Left-turn	All				<5,000/lane(Total)		15		57				Simple Before-After
	Left-turn	All				>5,000/lane(Total)		15		35				Simple Before-After
	Overturn	All				<5,000/lane(Total)		15		54				Simple Before-After
	Overturn	All				>5,000/lane(Total)		15		39				Simple Before-After
	Rear-end	All				<5,000/lane(Total)		15		54				Simple Before-After
	Rear-end	All				>5,000/lane(Total)		15		39				Simple Before-After
	Right-angle	All				<5,000/lane(Total)		15		62				Simple Before-After
	Right-angle	All				>5,000/lane(Total)		15		49				Simple Before-After
Install left-turn lane (physical channelization)	All	All	All		No signal			1		35				
	All	All	All		Signal			1		25				
	All	All	Rural	3-Leg	No signal			28		44				
	All	All	Rural	4-Leg (1 app)	No signal			28		28				
	All	All		4-Leg (2 app)	No signal			28		42				
	All	All				<5,000/lane(Total)		15		51				Simple Before-After
	All	All				>5,000/lane(Total)		15		19				Simple Before-After
	All	All	Urban	3-Leg	No signal			28		33				

Countermeasure(s)	Crash Type	Crash Severity	Area Type	Config	Control	Major Daily Traffic Volume (veh/day)	Minor Daily Traffic Volume (veh/day)	Ref	Obs	Effectiveness: Crash Reduction Factor / Function	Effectiveness: Std Error	Effectiveness: Range Low	Effectiveness: Range High	Study Type
Install left-turn lane (physical channelization) (cont'd)	All	All	Urban	4-Leg (1 app)	No signal			28		27				
	All	Fatal/Injury	Rural	3-Leg		5,000-15,000		13		27	13			Meta-analysis
	All	Fatal/Injury	Rural	4-Leg		5,000-15,000		13		4	12			Meta-analysis
	All	PDO	Rural	3-Leg		5,000-15,000		13		-20	23			Meta-analysis
	All	PDO	Rural	4-Leg		5,000-15,000		13		16	22			Meta-analysis
	Left-turn	All				<5,000/lane(Total)		15		24				Simple Before-After
	Left-turn	All				>5,000/lane(Total)		15		24				Simple Before-After
	Left-turn	Fatal/Injury						15		50				Simple Before-After
	ROR	PDO						15		50				Simple Before-After
	Overturn	All				<5,000/lane(Total)		15		50				Simple Before-After
	Overturn	All				>5,000/lane(Total)		15		28				Simple Before-After
	Rear-end	All				<5,000/lane(Total)		15		50				Simple Before-After
	Rear-end	All				>5,000/lane(Total)		15		28				Simple Before-After
	Rear-end	Fatal/Injury						15		11				Simple Before-After
	Rear-end	PDO						15		56				Simple Before-After
	Right-angle	All				<5,000/lane(Total)		15		68				Simple Before-After
	Right-angle	All				>5,000/lane(Total)		15		55				Simple Before-After
	Right-angle	Fatal/Injury						15		58				Simple Before-After
	Right-angle	PDO						15		54				Simple Before-After

Countermeasure(s)	Crash Type	Crash Severity	Area Type	Config	Control	Major Daily Traffic Volume (veh/day)	Minor Daily Traffic Volume (veh/day)	Ref	Obs	Effectiveness: Crash Reduction Factor / Function	Effectiveness: Std Error	Effectiveness: Range Low	Effectiveness: Range High	Study Type
Install left-turn lane (signal has left-turn phase)	All	All			Signal			28		31		25	36	
	All	All			Signal			51		35				
	Left-turn	All			Signal			28		44		43	45	
	Older-driver head-on	All		4-Leg	Signal			39	13	73				
	Younger-driver head-on	All		4-Leg	Signal			39	13	66				
Install left-turn lane (signal has no turn phase)	All	All			Signal			28		23		21	25	
	Left-turn	All			Signal			28		50		46	54	
Install left-turn lane (with channelization and existing left-turn phase)	All	All			Signal			15		35				
	All	All			Signal			15		35				Simple Before-After
	All	All			Signal			15		35				Cross-section
Install left-turn lane (with channelization and no left-turn phase)	All	All						15		15				
	All	All						15		15				Simple Before-After
	All	All						15		15				Cross-section
Install left-turn lane (within existing curbs)	All	All			Signal			28		26				
	Left-turn	All			Signal			28		66				
Install left-turn refuge within flush median	All	All				<5,000/lane(Total)		15		24				Simple Before-After
	All	All				>5,000/lane(Total)		15		44				Simple Before-After
	Head-on	All				>5,000/lane(Total)		15		52				Simple Before-After
	Left-turn	All				>5,000/lane(Total)		15		77				Simple Before-After
	Overturn	All				<5,000/lane(Total)		15		44				Simple Before-After

Countermeasure(s)	Crash Type	Crash Severity	Area Type	Config	Control	Major Daily Traffic Volume (veh/day)	Minor Daily Traffic Volume (veh/day)	Ref	Obs	Effectiveness: Crash Reduction Factor / Function	Effectiveness: Std Error	Effectiveness: Range Low	Effectiveness: Range High	Study Type
Install left-turn refuge within flush median (cont'd)	Overturn	All				>5,000/lane(Total)		15		40				Simple Before-After
	Rear-end	All				<5,000/lane(Total)		15		44				Simple Before-After
	Rear-end	All				>5,000/lane(Total)		15		40				Simple Before-After
	Sideswipe	All				>5,000/lane(Total)		15		52				Simple Before-After
Remove left-turn lane	All	All	Rural	3-Leg	Signal			6		-18				
	All	All	Rural	4-Leg (1 app)	Signal			6		-22				
	All	All	Rural	4-Leg (2 app)	Signal			6		-49				
	All	All	Urban	3-Leg	Signal			6		-8				
	All	All	Urban	3-Leg	Stop			6		-49				
	All	All	Urban	4-Leg (1 app)	Signal			6		-11				
	All	All	Urban	4-Leg (1 app)	Stop			6		-37				
	All	All	Urban	4-Leg (2 app)	Signal			6		-23				
	All	All	Urban	4-Leg (2 app)	Stop			6		-88				
	All	Fatal/Injury	Rural	3-Leg	Signal			6		-16				
	All	Fatal/Injury	Rural	4-Leg (1 app)	Signal			6		-21				
	All	Fatal/Injury	Rural	4-Leg (2 app)	Signal			6		-45				
	All	Fatal/Injury	Urban	3-Leg	Signal			6		-6				
	All	Fatal/Injury	Urban	3-Leg	Stop			6		-53				
	All	Fatal/Injury	Urban	4-Leg (1 app)	Signal			6		-10				
	All	Fatal/Injury	Urban	4-Leg (1 app)	Stop			6		-41				
	All	Fatal/Injury	Urban	4-Leg (2 app)	Signal			6		-21				
	All	Fatal/Injury	Urban	4-Leg (2 app)	Stop			6		-98				

Countermeasure(s)	Crash Type	Crash Severity	Area Type	Config	Control	Major Daily Traffic Volume (veh/day)	Minor Daily Traffic Volume (veh/day)	Ref	Obs	Effectiveness: Crash Reduction Factor / Function	Effectiveness: Std Error	Effectiveness: Range Low	Effectiveness: Range High	Study Type
RIGHT-TURN COUNTERMEASURES														
Increase length of right-turn lane	All	Fatal/Injury	All	All	All			58		15				
Install right-turn lane	All	All	All	4-Leg (1 app)	Signal	4,200-55,100	100-26,000	22		**4**	2			EB Before-After
	All	All	All	4-Leg (1 app)	Stop	1,100-40,600	25-11,800	22		**14**	5			EB Before-After
	All	All	All	4-Leg (2 app)	Signal	4,200-55,100	100-26,000	22		**8**	3			EB Before-After
	All	All	All	4-Leg (2 app)	Stop	1,100-40,600	25-11,800	22		**26**	7			EB Before-After
	All	All	All	All	All			58		35				
	All	All	All					1		25				
	All	All	Rural	4-Leg (1 app)	No signal			28		14				
	All	All	Rural	4-Leg (1 app)	No signal			28		21		14	27	
	All	All		All	No signal			28		27		24	30	
	All	All						15		25				
	All	All						15		25				Cross-section
	All	All						15		25				Simple Before-After
	All	All						15		25				Simple Before-After
	All	Fatal/Injury	All	4-Leg (1 app)	Signal	4,200-55,100	100-26,000	22		**9**	3			EB Before-After
	All	Fatal/Injury	All	4-Leg (1 app)	Stop	1,100-40,600	25-11,800	22		**23**	7			EB Before-After
	All	Fatal/Injury	All	All	No signal			58		35				
	All	Fatal/Injury	All	All	Signal			58		35				
	All	Fatal/Injury	All	All				51		40				
	All	Fatal/Injury	Rural	All	All			58		35				
	All	Fatal/Injury	Urban	All	All			58		30				
	Rear-end	All						15		65				Simple Before-After

Countermeasure(s)	Crash Type	Crash Severity	Area Type	Config	Control	Major Daily Traffic Volume (veh/day)	Minor Daily Traffic Volume (veh/day)	Ref	Obs	Effectiveness				Study Type
										Crash Reduction Factor / Function	Std Error	Range		
												Low	High	
Install right-turn lane (cont'd)	Right-angle	All						15		50				Simple Before-After
	Right-turn	All						15		53				
	Right-turn	All						15		56				Simple Before-After
	Right-turn	All						15		50				Cross-section
	Sideswipe	All						15		20				Simple Before-After
Install right-turn lane (painted separation)	All	Fatal/Injury	All	All	All			58		30				
Install right-turn lane (physical channelization)	All	Fatal/Injury	All	All	All			58		35				

Table 2: Geometric Countermeasures

Countermeasure(s)	Crash Type	Crash Severity	Area Type	Config	Control	Major Daily Traffic Volume (veh/day)	Minor Daily Traffic Volume (veh/day)	Ref	Obs	Effectiveness: Crash Reduction Factor / Function	Effectiveness: Std Error	Effectiveness: Range Low	Effectiveness: Range High	Study Type
OTHER GEOMETRIC COUNTERMEASURES														
Convert four-leg to two T-intersections	All	All		4-Leg	No signal			28		57				
	All	Fatal/Injury	Urban	4-Leg		<70%*	>30%*	13		**33**	6			Meta-analysis
	All	Fatal/Injury	Urban	4-Leg		>85%*	<15%*	13		**-35**	15			Meta-analysis
	All	Fatal/Injury	Urban	4-Leg		70-85%*	15-30%*	13		**25**	5			Meta-analysis
	All	PDO	Urban	4-Leg		<70%*	>30%*	13		**10**	5			Meta-analysis
	All	PDO	Urban	4-Leg		>85%*	<15%*	13		**-15**	6			Meta-analysis
	All	PDO	Urban	4-Leg		70-85%*	15-30%*	13		0	5			Meta-analysis
	All	All		4-Leg				51		57				Meta-analysis
Convert intersection to roundabout	All	All	All		All			50	55	**35**	3			EB Before-After
	All	All	All		Signal			50	9	**48**	5			EB Before-After
	All	All	All		Signal			21	23	40				EB Before-After
	All	All	All		Stop (2-way)			50	36	**44**	4			EB Before-After
	All	All	All		Stop (4-way)			50	10	-3	15			EB Before-After
	All	All	Rural	1-lane	Stop (2-way)			50	9	**72**	4			EB Before-After
	All	All	Rural		Stop	7,185-17,220		44		**58**	7			EB Before-After
	All	All		3-Leg				15		50				Simple Before-After
	All	All		4-Leg				15		75				Simple Before-After

* Percentage of Total Daily Traffic Volume

Countermeasure(s)	Crash Type	Crash Severity	Area Type	Config	Control	Major Daily Traffic Volume (veh/day)	Minor Daily Traffic Volume (veh/day)	Ref	Obs	Effectiveness: Crash Reduction Factor / Function	Effectiveness: Std Error	Effectiveness: Range Low	Effectiveness: Range High	Study Type
Convert intersection to roundabout (cont'd)	All	Fatal/Injury						55	181	65				Simple Before-After
	All	PDO						55	181	42				Simple Before-After
	Ped	All						55	181	89				Simple Before-After
	All	All	Urban		Stop	13,272-30,418		44		5	10			EB Before-After
	All	All	Urban		Signal	5,322-31,525		44		**35**	9			EB Before-After
	All	All	Urban		Signal			50	5	1	12			EB Before-After
	All	All	Urban		Signal			21	4	35				EB Before-After
	All	All	Urban		Stop (2-way)			50	27	**31**	6			EB Before-After
	All	All	Urban	1-lane	Stop (2-way)			50	16	**56**	6			EB Before-After
	All	All	Urban	2-lane	Signal			50	4	**67**	4			EB Before-After
	All	All	Urban	2-lane	Stop (2-way)			50	11	**18**	8			EB Before-After
	All	All	Urban		Stop	4,600-17,825		44		**72**	6			EB Before-After
	All	Fatal/Injury	All		All			50	55	**76**	3			EB Before-After
	All	Fatal/Injury	All		Signal			50	9	**78**	6			EB Before-After
	All	Fatal/Injury	All		Stop (2-way)			50	36	**82**	3			EB Before-After
	All	Fatal/Injury	All		Stop (4-way)			50	10	-28	41			EB Before-After
	All	Fatal/Injury	All		All			21	23	80				EB Before-After
	All	Fatal/Injury	Rural	1-lane	Stop (2-way)			50	9	**87**	3			EB Before-After
	All	Fatal/Injury	Rural		Stop	7,185-17,220		44		**82**	9			EB Before-After

Countermeasure(s)	Crash Type	Crash Severity	Area Type	Config	Control	Major Daily Traffic Volume (veh/day)	Minor Daily Traffic Volume (veh/day)	Ref	Obs	Effectiveness: Crash Reduction Factor / Function	Effectiveness: Std Error	Effectiveness: Range Low	Effectiveness: Range High	Study Type
Convert intersection to roundabout (cont'd)	All	Fatal/Injury			No signal			11	62	44		34	52	EB and Meta-analysis
	All	Fatal/Injury			Signal			11	34	32		19	43	EB and Meta-analysis
	All	Fatal/Injury						11	96	39		31	45	EB and Meta-analysis
	All	Fatal/Injury	Urban		Signal			50	5	**60**	12			EB Before-After
	All	Fatal/Injury	Urban		Stop (2-way)			50	27	**74**	6			EB Before-After
	All	Fatal/Injury	Urban	1-lane	Stop (2-way)			50	16	**78**	7			EB Before-After
	All	Fatal/Injury	Urban	2-lane	Stop (2-way)			50	11	**72**	9			EB Before-After
	All	Fatal/Injury	Urban		Signal	5,322-31,525		44		**74**	14			EB Before-After
	All	Fatal/Injury	Urban		Stop	4,600-17,825		44		**88**	8			EB Before-After
	Ped	Fatal/Injury			No signal			11		27				
	Ped	Fatal/Injury			Signal			11		-28				
Improve intersection alignment (reduce skew)	All	All	Rural	3-Leg	Stop			6		100(1-EXP(0.0048*|intersection angle - 90º|)); angle in degrees				
	All	All	Rural	4-Leg	Stop			6		100(1-EXP(0.0054*|intersection angle - 90º|)); angle in degrees				
Improve sight distance in 1 quadrant	All	All	Rural	4-Leg	Stop/Yield (2-way)			23		5				Expert Panel
Improve sight distance in 2 quadrants	All	All	Rural	4-Leg	Stop/Yield (2-way)			23		9				
Improve sight distance in 3 quadrants	All	All	Rural	4-Leg	Stop/Yield (2-way)			23		13				
Improve sight distance in 4 quadrants	All	All	Rural	4-Leg	Signal			23		0				
	All	All	Rural	4-Leg	Stop/Yield (2-way)			23		17				

Countermeasure(s)	Crash Type	Crash Severity	Area Type	Config	Control	Major Daily Traffic Volume (veh/day)	Minor Daily Traffic Volume (veh/day)	Ref	Obs	Effectiveness: Crash Reduction Factor / Function	Effectiveness: Std Error	Effectiveness: Range Low	Effectiveness: Range High	Study Type
Improve sight distance to intersection	All	Fatal						51		56				
	All	Injury						51		37				
Increase median width by 3 ft	Multiple-vehicle	All	Rural	4-Leg	Stop			24		**4**	1			Cross-section
	Multiple-vehicle	All	Urban	3-Leg	Stop			24		**-3**	1			Cross-section
	Multiple-vehicle	All	Urban	4-Leg	Signal			24		**-3**	1			Cross-section
	Multiple-vehicle	All	Urban	4-Leg	Stop			24		**-6**	1			Cross-section
	Multiple-vehicle	Fatal/Injury	Rural	4-Leg	Stop			24		**4**	1			Cross-section
	Multiple-vehicle	Fatal/Injury	Urban	4-Leg	Signal			24		**-3**	1			Cross-section
	Multiple-vehicle	Fatal/Injury	Urban	4-Leg	Stop			24		**-5**	1			Cross-section
Increase pedestrian storage area at corner	All	Fatal/Injury						5		-12	126			Meta-analysis
Install median	All	All	Rural		Stop			6		27				
Install median islands (painted) on major road approaches	All	Fatal/Injury	All	All	All			58		15				
Install median islands (physical) on major road approaches	All	Fatal/Injury	All	All	All			58		25				
Install raised median	All	All			No signal			28		25				
	All	All						28		25				
	Ped	All			No signal			28		69				
Install raised median (marked crosswalk)	Ped	All						60		46				

Countermeasure(s)	Crash Type	Crash Severity	Area Type	Config	Control	Major Daily Traffic Volume (veh/day)	Minor Daily Traffic Volume (veh/day)	Ref	Obs	Effectiveness: Crash Reduction Factor / Function	Effectiveness: Std Error	Effectiveness: Range Low	Effectiveness: Range High	Study Type
Install raised median (unmarked crosswalk)	Ped	All						60		39				
Install refuge islands	Ped	All						28		56				
Install splitter islands on minor road approaches	All	Fatal/Injury	All	3-Leg	All			58		45				
	All	Fatal/Injury	All	4-Leg	All			58		40				
	All	Fatal/Injury	All	All	All			58		40				
	All	Fatal/Injury	Rural	All	All			58		35				
	All	Fatal/Injury	Urban	All	All			58		40				
Install turn and bypass lanes	All	All	Rural		Stop			48		5	10			Simple Before-After
	Head-on	PDO		3-Leg				15		13				Simple Before-After
	Left-turn	Injury		3-Leg				15		36				Simple Before-After
	Left-turn	PDO		3-Leg				15		28				Simple Before-After
	ROR	PDO		3-Leg				15		40				Simple Before-After
	Rear-end	Injury		3-Leg				15		18				Simple Before-After
	Rear-end	PDO		3-Leg				15		21				Simple Before-After
	Right-angle	Injury		3-Leg				15		24				Simple Before-After
	Right-angle	PDO		3-Leg				15		53				Simple Before-After
	Sideswipe	PDO		3-Leg				15		30				Simple Before-After
Vary median width	All	All	Rural		Stop			6		100(1-EXP(-0.012(Wm-16))); Wm=median width (ft)				
	All	All	Urban	3-Leg	Stop			6		100(1-EXP(0.0082(Wm-16))) for Wm>16 1.0 for Wm<=16; Wm=median width (ft)				

Countermeasure(s)	Crash Type	Crash Severity	Area Type	Config	Control	Major Daily Traffic Volume (veh/day)	Minor Daily Traffic Volume (veh/day)	Ref	Obs	Effectiveness: Crash Reduction Factor / Function	Effectiveness: Std Error	Effectiveness: Range Low	Effectiveness: Range High	Study Type
Vary median width (cont'd)	All	All	Urban	4-Leg	Stop			6		100(1-EXP(0.0173(Wm-16))) for Wm>16 1.0 for Wm<=16; Wm=median width (ft)				
	All	Fatal/Injury	Urban	3-Leg	Stop			6		100(1-EXP(0.0076(Wm-16))) for Wm>16 1.0 for Wm<=16; Wm=median width (ft)				
	All	Fatal/Injury	Urban	4-Leg	Stop			6		100(1-EXP(0.016(Wm-16))) for Wm>16 1.0 for Wm<=16; Wm=median width (ft)				
Vary shoulder width	All	All	Rural	3-Leg and 4-Leg	Stop			6		100(1-EXP(-0.03(Ws-8)); Ws=outside shoulder width (ft)				
	All	All	Urban		Stop			6		100(1-EXP(-0.02(Ws-1.5)); Ws=outside shoulder width (ft)				

Table 3: Signs / Markings / Operational Countermeasures

Countermeasure(s)	Crash Type	Crash Severity	Area Type	Config	Control	Major Daily Traffic Volume (veh/day)	Minor Daily Traffic Volume (veh/day)	Ref	Obs	Effectiveness: Crash Reduction Factor / Function	Effectiveness: Std Error	Effectiveness: Range Low	Effectiveness: Range High	Study Type
SIGNS														
Install double stop signs	All	All			No signal			28		11				
	Right-angle	All			No signal			47	10	55	52	-38	100	Simple Before-After
	Right-angle	All			No signal			28		36				
Install flashing beacons as advance warning	All	All		3-Leg				15		70				Simple Before-After
	All	All		4-Leg				15		39				Simple Before-After
	All	All			Signal			28		27		25	28	
	All	All						15		25				
	All	All						15		25				Cross-section
	All	All						15		27				Simple Before-After
	All	All						15		25				Simple Before-After
	Left-turn	Fatal/Injury						15		67				Simple Before-After
	Left-turn	PDO						15		79				Simple Before-After
	Rear-end	All		4-Leg	Signal			39		36				
	Right-angle	All		4-Leg	Signal			39		62				
	Right-angle	Fatal/Injury						15		73				Simple Before-After
	Right-angle	Fatal/Injury						15		73				Simple Before-After
	Right-angle	PDO						15		62				Simple Before-After
Install larger stop signs	All	All			Stop	>5,000/lane(Total)		15		19				Simple Before-After
Install pedestrian signing	All	All						15		4				
	Ped	All						15		15				

Countermeasure(s)	Crash Type	Crash Severity	Area Type	Config	Control	Major Daily Traffic Volume (veh/day)	Minor Daily Traffic Volume (veh/day)	Ref	Obs	Effectiveness: Crash Reduction Factor / Function	Effectiveness: Std Error	Effectiveness: Range Low	Effectiveness: Range High	Study Type
Install advance warning signs (positive guidance)	All	All	All					1		35				
	All	All			Signal			28		22		3	40	
	All	All	Urban					15		30				Cross-section
	All	All	Rural					15		40				
	Right-angle	All			Signal			47	11	35		20	100	Simple Before-After
	Right-angle	All			Signal			28		35				
Provide overhead lane-use signs	Rear-end	All						51		10				
	Sidewipe	All						51		20				
PAVEMENT MARKINGS/MODIFICATIONS														
Add centerline and move STOP bar to extended curb lines	All	All			No signal			28		29				
	Right-angle	All			No signal			28		24				
Add centerline and move STOP bar to extended curb lines, double stop signs	All	All			No signal			28		9				
	Right-angle	All			No signal			28		0				
Add centerline and STOP bar, replace 24-inch with 30-inch stop signs	Right-angle	All			No signal			47		67	11	27	100	Simple Before-After
	Right-angle	All			No signal			28		67				
Improve pavement friction (groove)	All	All						28		25				
	Wet	All						28		59		42	75	
Improve/install pedestrian crossing	All	All						15		25				
	Ped	All						15		25				
Install pedestrian crossing	Ped	All						15		25				
	Ped	All						15		25				
	Ped	Fatal/Injury	Rural					38		60				EB Before-After
Install pedestrian crossing (raised)	All	All						5		30	67			Meta-analysis
	All	Fatal/Injury						5		36	54			Meta-analysis
	Ped	All						28		8				

Countermeasure(s)	Crash Type	Crash Severity	Area Type	Config	Control	Major Daily Traffic Volume (veh/day)	Minor Daily Traffic Volume (veh/day)	Ref	Obs	Effectiveness: Crash Reduction Factor / Function	Effectiveness: Std Error	Effectiveness: Range Low	Effectiveness: Range High	Study Type
Install raised intersection	All	Fatal/Injury		4-Leg				13		-5				Meta-analysis
	All	PDO		4-Leg				13		-13				Meta-analysis
Install raised pavement markers	All	All						28		10		6	13	
	Wet	All						28		25		20	30	
	Wet/Night	All						28		33		20	46	
Install STOP bars (pedestrian crosswalk)	All	All			Signal			28		18		10	25	
Install STOP bars (STOP bar on minor road approaches, with short segments of centerline)	All	All						28		19		10	27	
	Right-angle	All						28		47				
Install transverse pavement markings	All	All						15		18				Simple Before-After
	Speed-related	Fatal/Injury			Stop			18		57	8			Simple Before-After
	Speed-related	Serious injury			Stop			18		74	13			Simple Before-After
	Speed-related	Slight injury			Stop			18		52	11			Simple Before-After
	Speed-related and day	All			Stop			18		66	8			Simple Before-After
	Speed-related and dry	All			Stop			18		45	15			Simple Before-After
	Speed-related	All			Stop			18		48	14			Simple Before-After
	Speed-related and wet	All			Stop			18		68	11			Simple Before-After

Countermeasure(s)	Crash Type	Crash Severity	Area Type	Config	Control	Major Daily Traffic Volume (veh/day)	Minor Daily Traffic Volume (veh/day)	Ref	Obs	Effectiveness: Crash Reduction Factor / Function	Effectiveness: Std Error	Effectiveness: Range Low	Effectiveness: Range High	Study Type
Install transverse rumble strips on approaches	All	All	Rural		No signal			28		35				
	All	All			Stop			15		28				Simple Before-After
	All	All						28		23		2	44	
	Rear-end	All						15		90				Simple Before-After
Mark pavement with supplementary warning messages	All	All			No signal			28		6				
	Right-angle	All			No signal			28		30				
	Right-angle	All	Urban		Stop			47	5	30	66	-20	100	Simple Before-After
Provide bicycle box (advance stop bar to leave dedicated space for cyclists)	Bicycle	All			Signal			51		35				
Provide bike lanes	Bicycle	All						51		36				
Resurface pavement	All	All						28		33		7	59	
	Wet	All						28		47		42	75	
REGULATORY														
Convert STOP control to Yield control	All	All	All		Stop			21	141	-137				Comparison Group Before-After
	All	All	Urban	4-Leg	Stop			33		-127	70			Comparison Group Before-After
Convert to all-way STOP control (from 2-way control)	All	All	All		Stop			21	360	47				Before-After with Likelihood Functions
	All	All			No signal			28		64		53	74	
	All	All			Stop			15		53				
	All	Fatal/Injury	Urban		Stop			30		71	6			Simple Before-After
	Left-turn	All	Urban		Stop			30		20	52			Simple Before-After

Countermeasure(s)	Crash Type	Crash Severity	Area Type	Config	Control	Major Daily Traffic Volume (veh/day)	Minor Daily Traffic Volume (veh/day)	Ref	Obs	Effectiveness: Crash Reduction Factor / Function	Effectiveness: Std Error	Effectiveness: Range Low	Effectiveness: Range High	Study Type
Convert to all-way STOP control (from 2-way control) (cont'd)	Left-turn	All			Stop			15		20				Cross-section
	Ped	All						15		39				
	Ped	All	Urban		Stop			30		**39**	8			Before-After
	Rear-end	All	Urban		Stop			30		13	13			Simple Before-After
	Rear-end	All			Stop			15		13				Cross-section
	Right-angle	All	Urban		Stop			30		72	3			Simple Before-After
	Right-angle	All			No signal			28		84				
	Right-angle	All			Stop			15		72				Cross-section
	Right-angle	All	Urban		Stop			47	10	80	41	49	100	Simple Before-After
Convert two-way to one-way roadway	All	All						15		26				
	All	All						15		26				Cross-section

Countermeasure(s)	Crash Type	Crash Severity	Area Type	Config	Control	Major Daily Traffic Volume (veh/day)	Minor Daily Traffic Volume (veh/day)	Ref	Obs	Effectiveness: Crash Reduction Factor / Function	Effectiveness: Std Error	Effectiveness: Range Low	Effectiveness: Range High	Study Type
Convert Yield control to STOP control	All	All			No signal			28		29				
	Right-angle	All			No signal			28		9				
Install no left-turn and no u-turn signs	All	All	Urban			19,435-42,000(Total)		7		62	6			Simple Before-After
	Left-turn (or u-turn)	All	Urban			19,435-42,000(Total)		7		59	5			Simple Before-After
Permit right-turn-on-red	All	All			Signal			5		-7	1			Simple Before-After
	All	All			Signal			10		-5	1			Simple Before-After
	Ped	All	New Orleans		Signal			5		-81	88			Before-After
	Ped	All	New York		Signal			5		-43	24			Before-After
	Ped	All	Ohio		Signal			5		-57	31			Before-After
	Ped	All	Wisconsin		Signal			5		-108	51			Before-After
	Right-turn	Fatal/Injury			Signal			13		-60	5			Meta-analysis
	Right-turn	PDO			Signal			13		-10	1			Meta-analysis
Prohibit left-turns	All	All						15		45				
	All	All						15		45				Cross-section
	Left-turn	All						15		90				Cross-section
	Ped	All						15		10				
	Rear-end	All						15		30				Cross-section
Prohibit right-turn-on-red	All	All			Signal			28		23		20	25	
	ROR	All			Signal			15		30				Cross-section
	Rear-end	All			Signal			15		20				Cross-section

Countermeasure(s)	Crash Type	Crash Severity	Area Type	Config	Control	Major Daily Traffic Volume (veh/day)	Minor Daily Traffic Volume (veh/day)	Ref	Obs	Effectiveness: Crash Reduction Factor / Function	Effectiveness: Std Error	Effectiveness: Range Low	Effectiveness: Range High	Study Type
Prohibit right-turn-on-red (cont'd)	All	All	Urban/ Suburban		Signal			62		100(1-(0.984)^n); n=number of signalized intersection appraoches where RTOR is prohibited				Expert Panel
	Right-angle	All			Signal			15		30				Cross-section
	Sideswipe	All			Signal			15		20				Cross-section
Prohibit turns	All turns	All	All					1		45		40	90	
Restrict parking near intersections (to off-street)	All	All						28		49		8	90	
	Ped	All						15		30				
Vary speed	All	All	Rural					6		100(1-EXP(0.019(V-55))); V=major-road speed limit (or design speed) (mph)				
	All	All	Urban					6		100(1-EXP(0.005(V-40))); V=major-road speed limit (or design speed) (mph)				
LIGHTING														
Improve lighting at intersection	Ped	Fatal						5		78	87			
	Ped	Injury						5		**42**	18			
Install lighting	All	All			Signal			51		30				
	All	Fatal/Injury			Signal			51		17				
	Night	All			Signal			51		50				
	All	All			No Signal			28		47				
	All	All						62		4				Meta Analysis/ Expert Panel
	All	Injury						62		6				Meta Analysis/ Expert Panel
	Night	All						62		21				Meta Analysis/ Expert Panel
	Night	Injury						62		29				Meta Analysis/ Expert Panel

Countermeasure(s)	Crash Type	Crash Severity	Area Type	Config	Control	Major Daily Traffic Volume (veh/day)	Minor Daily Traffic Volume (veh/day)	Ref	Obs	Effectiveness: Crash Reduction Factor / Function	Effectiveness: Std Error	Effectiveness: Range Low	Effectiveness: Range High	Study Type
OPERATIONAL														
Convert STOP control (2-way) to signal control	All	All			Stop			15		28				Cross-section
	All	Injury			Stop			15		43				Cross-section
	Right-angle	All			Stop			15		74				Cross-section
Convert STOP control (2-way) to signal control and install left-turn lane	All	All			Stop			15		36				Cross-section
	All	Injury			Stop			15		53				Cross-section
	Rear-end	All			Stop			15		8				Cross-section
	Right-angle	All			Stop			15		74				Cross-section
Increase enforcement related to motorist yielding in marked crosswalks combined with a public education campaign	Ped	All						63		23				
Increase enforcement to reduce speed	Ped	All						28		70				
Install angled median crosswalk	All	All						28		12				
Install beacon (flashing) at intersection	All	All	All					1		30		7	50	
	All	All	All					1		30				
	All	All			Signal			28		34		30	38	
	All	All						15		30				
	All	All						15		30				Cross-section
	All	All						15		4				Simple Before-After
	All	All						15		30				Simple Before-After

Countermeasure(s)	Crash Type	Crash Severity	Area Type	Config	Control	Major Daily Traffic Volume (veh/day)	Minor Daily Traffic Volume (veh/day)	Ref	Obs	Effectiveness: Crash Reduction Factor / Function	Effectiveness: Std Error	Effectiveness: Range Low	Effectiveness: Range High	Study Type
Install cameras to detect red-light running	All	All			Signal	17,000-78,000		37	46	**-12**	5			EB Before-After
	All	All	Urban (Scottsdale)		Signal			56		11				EB Before-After
	All	Fatal/Injury	All	All	Signal			58		5				
	All	Fatal/Injury			Signal	17,000-78,000		37	46	-14	9			EB Before-After
	Left-turn	All	Urban (Scottsdale)		Signal			56	14	**45**	6			EB Before-After
	Rear-end	All			Signal	52,625-109,067	12,562-33,679	45		**-15**	3			EB Before-After
	Rear-end	All			Signal	17,000-78,000		37	13	**-57**	1			EB Before-After
	Rear-end	All	Urban (Scottsdale)		Signal			56		**-41**	11			EB Before-After
	Rear-end	Fatal/Injury			Signal	52,625-109,067	12,562-33,679	45		**-24**	12			EB Before-After
	Right-angle	All			Signal	52,625-109,067	12,562-33,679	45		**25**	3			EB Before-After
	Right-angle	All	Urban (Scottsdale)		Signal			56	14	20				EB Before-After
	Right-angle	Fatal/Injury			Signal	52,625-109,067	12,562-33,679	45		**16**	6			EB Before-After
Install far-side bus stops	Ped	All						28		1				
Install flashing red/yellow signal (MUTCD: intersection control beacon)	All	All			No signal	<5,000/lane(Total)		15		25				Simple Before-After
	All	All			No signal	>5,000/lane(Total)		15		26				Simple Before-After
	All	All			No signal			15		26				
	All	Fatal/Injury			No signal			15		50				Simple Before-After
	Head-on	All			No signal			15		50				Simple Before-After
	Right-angle	All			No signal	<5,000/lane(Total)		15		35				Simple Before-After
	Right-angle	All			No signal	>5,000/lane(Total)		15		36				Simple Before-After
	Right-angle	All			No signal			15		36				

Countermeasure(s)	Crash Type	Crash Severity	Area Type	Config	Control	Major Daily Traffic Volume (veh/day)	Minor Daily Traffic Volume (veh/day)	Ref	Obs	Effectiveness: Crash Reduction Factor / Function	Effectiveness: Std Error	Effectiveness: Range Low	Effectiveness: Range High	Study Type
Install pedestrian crossing (signed and marked with curb ramps and extensions)	All	All			No signal			28		37		25	48	
Install pedestrian overpass/underpass	Ped	All			No signal			28		13				
Install stop signs at alternate intersections in residential areas	All	All	Urban		Stop			53		50		45	55	
	All	Fatal/Injury	Urban		Stop			53		67		61	72	
Vary frequency of driveways within 250 ft of intersection	All	All	Rural		Signal			6		100(1-EXP(0.046(Nd-3))); Nd=number of driveways on the major road within 250ft of the intersection				
	All	All	Rural		Stop			6		100(1-EXP(0.056(Nd-3))); Nd=number of driveways on the major road within 250ft of the intersection				
Vary lane width	All	All	Urban		Signal			6		100(1-EXP(-0.053(Wl-12))); Wl=lane width (ft)				
	All	All	Urban		Stop			6		100(1-EXP(-0.057(Wl-12))); Wl=lane width (ft)				
Vary sight distance	All	All	Rural		Signal			6		0				
Vary through lanes	All	All	Rural		Signal			6		100(1-EXP(0.007(Nln-2))); Nln=number of through lanes on the road				
	All	All	Rural		Stop			6		100(1-EXP(-0.093(Nln-2))); Nln=number of through lanes on the road				
Vary truck presence	All	All	Rural	4-Leg	Signal			6		100(1-EXP(0.026(Pt-9))); Pt=percent truck during the peak hour (average for all intersection movements)				
	All	Fatal/Injury	Rural	3-Leg	Stop			6		100(1-EXP(-0.0253(Pt-9))); Pt=percent truck during the peak hour (average for all intersection movements)				

Countermeasure(s)	Crash Type	Crash Severity	Area Type	Config	Control	Major Daily Traffic Volume (veh/day)	Minor Daily Traffic Volume (veh/day)	Ref	Obs	Effectiveness: Crash Reduction Factor / Function	Effectiveness: Std Error	Effectiveness: Range Low	Effectiveness: Range High	Study Type
Vary truck presence (cont'd)	All	Fatal/Injury	Rural	4-Leg	Stop			6		100(1-EXP(-0.0520(Pt-9))); Pt=percent truck during the peak hour (average for all intersection movements)				
	All	Fatal/Injury	Rural	4-Leg	Signal			6		100(1-EXP(0.0323(Pt-9))); Pt=percent truck during the peak hour (average for all intersection movements)				

Tables for Roadway Departure Crash Reduction Factors

U.S. Department of Transportation
Federal Highway Administration

Table 4: Barrier Countermeasures

Countermeasure(s)	Crash Type	Crash Severity	Area Type	Road Type	Daily Traffic Volume (veh/day)	Ref	Effectiveness				Study Type
							Crash Reduction Factor / Function	Std Error	Range		
									Low	High	
BARRIER COUNTERMEASURES											
Improve guardrail	All	All			<5,000/lane	15	18				
	All	All			>5,000/lane	15	9				
	All	All	All	All		1	5				
	All	All				15	5				
	All	All				15	6				
	All	All				15	7				
	All	All				15	7				
	All	All				15	11				
	All	All				15	15				
	All	All				15	15				
	All	All				15	20				
	All	Fatal	All	All		1	50				
	All	Injury				15	35				
	All	Injury	All	All		1	35				
	Fixed object	All			<5,000/lane	15	23				
	Fixed object	All			>5,000/lane	15	18				
	Fixed object	All				15	21				
	ROR	All				15	26				
	ROR	All			>5,000/lane	15	32				
	ROR	All				15	28				
	Overturn	All			<5,000/lane	15	41				
	Overturn	All			>5,000/lane	15	27				
	Overturn	All				15	34				
	Rear-end	All			<5,000/lane	15	41				
	Rear-end	All			>5,000/lane	15	27				
	Rear-end	All				15	34				
Install animal fencing	Animal	All				15	80				
	Animal	All	All	All		1	90				
	Animal	All				15	70				
	Animal	All				15	90				
	Animal	Injury				15	91				

Countermeasure(s)	Crash Type	Crash Severity	Area Type	Road Type	Daily Traffic Volume (veh/day)	Ref	Effectiveness				Study Type
							Crash Reduction Factor / Function	Std Error	Range		
									Low	High	
Install animal fencing (cont'd)	Animal	PDO				15	61				
	Animal head-on	All				15	85				
Install barrier (concrete) inside and outside curve	All	Fatal/ Injury				15	39				
Install guardrail (as shield for rocks and posts)	All	All				15	14				
	All	Injury				15	31				
	Fixed object	All				15	100				
Install guardrail (as shield for trees)	All	Fatal				15	65				
	All	Injury				15	51				
Install guardrail (at culvert)	All	All				15	27				
	All	All				15	24				
	All	All				15	30				
Install guardrail (at ditch)	All	Injury				15	26				
Install guardrail (at embankment)	All	Injury				15	42				
	ROR	All		All		5	7	31			Meta Analysis
	ROR	Fatal		All		5	44	10			Meta Analysis
	ROR	Injury		All		5	47	5			Meta Analysis
Install guardrail (inside curves)	All	Fatal/ Injury				15	28				
Install guardrail (outside curves)	All	Fatal/ Injury				15	63				
Install impact attenuators	All	All				15	29				
	All	All	All	All		1	5				
	All	All				15	5				
	All	All				15	20				
	All	All				15	20				
	All	All				15	35				
	All	All				15	41				

Countermeasure(s)	Crash Type	Crash Severity	Area Type	Road Type	Daily Traffic Volume (veh/day)	Ref	Effectiveness				Study Type
							Crash Reduction Factor / Function	Std Error	Range		
									Low	High	
Install impact attenuators (cont'd)	All	All				15	50				
	All	Fatal	All	All		1	75				
	All	Fatal				15	75				
	All	Fatal				15	83				
	All	Fatal				15	90				
	All	Injury	All	All		1	50				
	All	Injury				15	50				
	Fixed object	Fatal	All	All		5	69	28			Meta Analysis
	Fixed object	Injury	All	All		5	69	10			Meta Analysis
	Fixed object	PDO				5	46	30			Meta Analysis
	ROR	All				15	45				
Replace guardrail with a softer material (concrete→steel→wire)	ROR	Fatal		All		5	41	31			Meta Analysis
	ROR	Injury		All		5	**32**	10			Meta Analysis

Table 5: Bridge Countermeasures

Countermeasure(s)	Crash Type	Crash Severity	Area Type	Road Type	Daily Traffic Volume (veh/day)	Ref	Effectiveness				Study Type
							Crash Reduction Factor / Function	Std Error	Range		
									Low	High	
BRIDGE COUNTERMEASURES											
Install bridge lighting	All	All				15	59				
Install delineators (on bridges)	All	All				15	43				
	All	All				15	39				
	All	All				15	40				
	All	All				15	50				
Install guardrail (at bridge)	All	All			<5,000/lane	15	22				
	All	All			>5,000/lane	15	20				
	All	All				15	11				
	All	All				15	24				
	All	All				15	24				
	All	All				15	44				
	All	Fatal				15	90				
	All	Injury				15	45				
	Overturn	All			<5,000/lane	15	41				
	Overturn	All			>5,000/lane	15	32				
	Rear-end	All			<5,000/lane	15	37				
	Rear-end	All			>5,000/lane	15	32				
	Wet	All				15	50				
Repair bridge deck	All	All				15	14				
	All	All				15	13				
	All	All				15	15				
Replace bridge (general)	All	All	All	All		1	45				
Replace bridge (2-lane)	All	All				15	45				
Upgrade bridge parapet	All	All				15	5				
Upgrade bridge railing	All	All				15	20				
	All	All	All	All		1	5				
	All	Fatal				15	76				
	All	Fatal				15	60				
	All	Fatal				15	92				

Countermeasure(s)	Crash Type	Crash Severity	Area Type	Road Type	Daily Traffic Volume (veh/day)	Ref	Effectiveness				Study Type
							Crash Reduction Factor / Function	Std Error	Range		
									Low	High	
Upgrade bridge railing (cont'd)	All	Injury				15	61				
	All	Injury	All	All		1	30				
	All	Injury				15	30				
	All	Injury				15	92				
	All	PDO				15	50				
Vary bridge width	All	All	Rural	Rural Highway		6	100(1-(EXP(-0.135Ibr(Wb-12)-1.0)Ps+1.0)); Ibr=presence of bridges (1 if one or more bridges present, 0 if not), Wb=bridge width – approach traveled-way width (ft), Ps=proportion of crash type subset (for values of Ps, refer to source).				
Vary horizontal bridge radius	All	All	Urban	Urban Street		6	100(1-(2.30(EXP(-2298/R)+343.8/R)(1-Poff-road)+0.781(EXP(320.9/R)Poff-road))); Poff-road=proportion of crashes that occur off the roadway.				
Widen bridge	All	All				15	45				
	All	All	All	All		1	45				
	All	All				15	36				
	All	All				15	40				
	All	All				15	45				
	All	All				15	47				
	All	All				15	48				
	All	All				15	55				
	All	Fatal/ Injury				15	92				
	All	PDO				15	95				
	Fixed object	All				15	45				
	Fixed object	All				15	40				
	Fixed object	All				15	50				
	Head-on	All				15	45				

Countermeasure(s)	Crash Type	Crash Severity	Area Type	Road Type	Daily Traffic Volume (veh/day)	Ref	Effectiveness				Study Type
							Crash Reduction Factor / Function	Std Error	Range		
									Low	High	
Widen bridge (cont'd)	Head-on	All				15	40				
	Head-on	All				15	50				
	ROR	All				15	44				
	Sideswipe	All				15	49				
	Sideswipe	All				15	40				
	Sideswipe	All				15	50				
	Sideswipe	All				15	57				
Widen bridge (18 to 24 ft)	All	All				15	68				
Widen bridge (18 to 30 ft)	All	All				15	93				
Widen bridge (20 to 24 ft)	All	All				15	56				
Widen bridge (20 to 30 ft)	All	All				15	90				
Widen bridge (22 to 24 ft)	All	All				15	36				
Widen bridge (22 to 30 ft)	All	All				15	86				

Table 6: Geometric Countermeasures

Countermeasure(s)	Crash Type	Crash Severity	Area Type	Road Type	Daily Traffic Volume (veh/day)	Ref	Effectiveness				Study Type
							Crash Reduction Factor / Function	Std Error	Range		
									Low	High	
GEOMETRIC COUNTERMEASURES											
Change shoulder type and/or width	All	All	Rural			21	100(1-((AMFWRA x AMFTRA-1.0)PRA+1.0)), AMFWRA=accident modification factor for related accidents based on shoulder width (for values of AMfWRA, refer to source), AMFTRA=accident modification factor for related accidents based on shoulder type (for values of AMFTRA, refer to source), PRA=proportion of total crashes constituted by related crashes.				Expert Panel
Flatten crest vertical curve	All	All	All	All		27	20	19			EB Before-After
	All	Fatal/ Injury	All	All		27	**51**	19			EB Before-After
	All	Fatal/ Injury	Rural	2-lane		38	50				
Flatten horizontal curve	All	All				15	39				
	All	All	All	All		1	40				
	All	All				15	35				
	All	All	Rural			21	100(1-((1.55Lc+80.2/R-0.012Is)/1.55Lc)); Lc=length of horizontal curve (mi) without spirial curve length, R=curve radius (ft), Is=presence of a spiral transition curve (1 if a spiral transition is present, 0 otherwise).				Expert Panel
	All	Fatal				15	87				
	All	Injury				15	87				
	All	PDO				15	87				
	Fixed object	All			<5,000/lane	15	68				

Countermeasure(s)	Crash Type	Crash Severity	Area Type	Road Type	Daily Traffic Volume (veh/day)	Ref	Effectiveness				Study Type
							Crash Reduction Factor / Function	Std Error	Range		
									Low	High	
Flatten horizontal curve (cont'd)	Fixed object	All			>5,000/lane	15	87				
	Head-on	All			<5,000/lane	15	67				
	Head-on	All			>5,000/lane	15	64				
	ROR	All			<5,000/lane	15	90				
	ROR	All			>5,000/lane	15	79				
	Overturn	All			<5,000/lane	15	73				
	Overturn	All			>5,000/lane	15	24				
	Rear-end	All			<5,000/lane	15	73				
	Rear-end	All			>5,000/lane	15	24				
	Rear-end	All				15	49				
Flatten horizontal curves (10 to 5 degrees)	All	All				15	45				
Flatten horizontal curves (15 to 5 degrees)	All	All				15	63				
Flatten horizontal curves (20 to 10 degrees)	All	All				15	48				
Flatten side slopes	All	All			<5,000/lane	15	43				
	All	All			>5,000/lane	15	45				
	All	All	All	All		1	30				
	All	All				15	25				
	All	All				15	30				
	All	All				15	32				
	All	All				15	35				
	Fixed object	All				15	62				
	ROR	All				15	10				
Flatten side slopes (11 to 8 degrees)	All	All				15	8				
	Ped	All				15	14				
	Right-turn	All				15	14				

Countermeasure(s)	Crash Type	Crash Severity	Area Type	Road Type	Daily Traffic Volume (veh/day)	Ref	Effectiveness				Study Type
							Crash Reduction Factor / Function	Std Error	Range		
									Low	High	
Flatten side slopes (14 to 9 degrees)	All	All				15	7				
	All	Injury	Rural	2-lane		5	**22**	4			Meta Analysis
	All	PDO	Rural	2-lane		5	**24**	2			Meta Analysis
	Ped	All				15	12				
	Right-turn	All				15	12				
Flatten side slopes (18 to 9 degrees)	All	All	Rural	2-lane		15	11				
	ROR	All	Rural	2-lane		5	24	21			Cross-section
	Ped	All	Rural	2-lane		15	19				
	Right-turn	All				15	19				
Flatten side slopes (18 to 11 degrees)	All	All				15	8				
	Ped	All				15	14				
	Right-turn	All				15	14				
Flatten side slopes (18 to 14 degrees)	All	All				15	5				
	All	Injury	Rural	2-lane		5	**42**	4			Meta Analysis
	All	PDO	Rural	2-lane		5	**29**	4			Meta Analysis
	ROR	All	Rural	2-lane		5	18	16			Cross-section
	Ped	All				15	8				
	Right-turn	All				15	8				
Flatten side slopes (27 to 9 degrees)	All	All				15	12				
	Ped	All				15	21				
	Right-turn	All				15	21				
Flatten side slopes (27 to 11 degrees)	All	All				15	9				
	Ped	All				15	15				
	Right-turn	All				15	15				
Flatten side slopes (27 to 14 degrees)	All	All				15	6				
	Ped	All				15	10				
	Right-turn	All				15	10				

Countermeasure(s)	Crash Type	Crash Severity	Area Type	Road Type	Daily Traffic Volume (veh/day)	Ref	Effectiveness				Study Type
							Crash Reduction Factor / Function	Std Error	Range		
									Low	High	
Flatten side slopes and remove guardrail	All	All	All	All		27	42	58			EB Before-After
Improve curve superelevation	All	All	Rural	All		21	0				Expert Panel
	All	All	Rural			21	100(1-(1.00+6(SD-0.01))); SD=superelevation deficiency between 0.01 and 0.02				Expert Panel
	All	All	Rural			21	100(1-(1.06+3(SD-0.02))); SD=superelevation deficiency greater than 0.02				Expert Panel
Improve gore area	All	All				15	25				
	All	All	All	All		1	25				
Improve horizontal and vertical alignments	All	All				15	58				
	All	All	All	All		1	50				
	All	All				15	50				
	All	All				15	50				
	All	All				15	73				
Improve longitudinal grade	All	All				15	49				
	All	All	All	All		1	40				
	All	All				15	40				
	All	All				15	57				
	All	Fatal/ Injury				15	87				
	All	PDO				15	83				
Improve superelevation	All	All				15	40				
	All	All				1	40				
	ROR	All				15	50				
Improve superelevation (for drainage)	All	All				15	45				
	All	All				15	40				
	All	All				15	49				
Increase number of lanes	All	All			<5,000/lane	15	20				
	All	All			>5,000/lane	15	31				
	All	All				15	10				
	All	All				15	20				
	All	All				15	22				

Countermeasure(s)	Crash Type	Crash Severity	Area Type	Road Type	Daily Traffic Volume (veh/day)	Ref	Effectiveness				Study Type
							Crash Reduction Factor / Function	Std Error	Range		
									Low	High	
Increase number of lanes (cont'd)	All	All				15	25				
	All	All				15	25				
	All	All				15	25				
	All	Fatal				15	39				
	All	Injury				15	23				
	All	PDO				15	27				
	Head-on	All			<5,000/lane	15	38				
	Head-on	All			>5,000/lane	15	44				
	Head-on	All				15	53				
	Head-on	All				15	53				
	Head-on	PDO				15	50				
	Left-turn	All				15	71				
	Left-turn	PDO				15	67				
	ROR	All				15	44				
	ROR	All				15	26				
	ROR	All				15	44				
	ROR	All				15	44				
	ROR	PDO				15	50				
	Overturn	All			<5,000/lane	15	42				
	Overturn	All			>5,000/lane	15	52				
	Rear-end	All			<5,000/lane	15	42				
	Rear-end	All			>5,000/lane	15	52				
	Rear-end	All				15	32				
	Rear-end	All				15	32				
	Rear-end	All				15	40				
	Rear-end	All				15	53				
	Rear-end	PDO				15	53				
	Right-angle	All			<5,000/lane	15	35				
	Right-angle	All			>5,000/lane	15	45				
	Right-angle	All				15	15				
	Right-angle	PDO				15	46				
	Sideswipe	All			<5,000/lane	15	38				

Countermeasure(s)	Crash Type	Crash Severity	Area Type	Road Type	Daily Traffic Volume (veh/day)	Ref	Effectiveness				Study Type
							Crash Reduction Factor / Function	Std Error	Range		
									Low	High	
Increase number of lanes (cont'd)	Sideswipe	All			>5,000/lane	15	44				
	Sideswipe	All				15	30				
	Sideswipe	All				15	30				
	Sideswipe	All				15	35				
	Sideswipe	PDO				15	64				
Increase vertical grade by 1%	All	All	Rural	2-lane		23	-1.6P; P=percent grade (absolute value)				
Install acceleration/ deceleration lanes	All	All				15	26				
	All	All	All	All		1	10				
	All	All				15	10				
	All	All				15	10				
	All	All				15	10				
	All	All				15	25				
	All	All				15	75				
	Rear-end	All				15	75				
	Sideswipe	All				15	75				
Install channelized lane	All	All				15	67				
	All	PDO				15	62				
	Rear-end	All				15	93				
Install climbing lane (where large difference between car and truck speed)	All	Fatal/ Injury	Rural	2-lane		38	33				
Install passing/climbing lane	All	All	All	All		1	20				
	All	Fatal/ Injury	Rural	2-lane		38	33				
Install shoulder	All	All				15	9				
Install shoulder bus lanes	Head-on	Fatal/ Injury				15	50				
	Head-on	PDO				15	86				
	Left-turn	Fatal/ Injury				15	42				
	Left-turn	PDO				15	57				

Countermeasure(s)	Crash Type	Crash Severity	Area Type	Road Type	Daily Traffic Volume (veh/day)	Ref	Effectiveness				Study Type
							Crash Reduction Factor / Function	Std Error	Range		
									Low	High	
Install shoulder bus lanes (cont'd)	ROR	PDO				15	27				
	Right-angle	Fatal/ Injury				15	34				
	Right-angle	PDO				15	31				
	Sideswipe	Fatal/ Injury				15	27				
	Sideswipe	PDO				15	8				
Install truck escape ramp	All	All				15	18				
	ROR	All				15	75				
	Rear-end	All				15	33				
Lengthen culverts	All	All				15	44				
	All	All				15	40				
	All	All				15	48				
	All	All				15	30				
Narrow cross section (4 to 3 lanes with two way left-turn lane)	All	All	Urban	4-lane highway	8,000-17,400	17	**37**	1			EB Before-After
	All	All		4-lane		42	26		23	28	
	All	Fatal/ Injury	Urban	4-lane highway	8,000-17,400	17	**0**	2			EB Before-After
	All	PDO	Urban	4-lane highway	8,000-17,400	17	**46**	1			EB Before-After
	Left-turn	All	Urban	4-lane highway	8,000-17,400	17	**24**	2			EB Before-After
	Rear-end	All	Urban	4-lane highway	8,000-17,400	17	**31**	2			EB Before-After
	Right-angle	All	Urban	4-lane highway	8,000-17,400	17	**37**	1			EB Before-After
	All	All	Urban		3,718-26,376	62	**29**	2			EB Before-After
Reduce horizontal curve angle	All	All				15	38				
	All	All				15	40				
Reduce shoulder width (6 ft to 0 ft)	All	All	Rural	2-lane		20	-12	3			Cohort

Countermeasure(s)	Crash Type	Crash Severity	Area Type	Road Type	Daily Traffic Volume (veh/day)	Ref	Effectiveness				Study Type
							Crash Reduction Factor / Function	Std Error	Range		
									Low	High	
Reduce shoulder width (6 ft to 1 ft)	All	All	Rural	2-lane		20	-17	6			Cohort
Reduce shoulder width (6 ft to 2 ft)	All	All	Rural	2-lane		20	-11	2			Cohort
Reduce shoulder width (6 ft to 4 ft)	All	All	Rural	2-lane		20	-6	2			Cohort
Reduce shoulder width (6 ft to 5 ft)	All	All	Rural	2-lane		20	-2	2			
Reduce vertical grade by 1%	All	All	Rural	2-lane		23	1.6P; P=percent grade (absolute value)				Expert Panel
Resurface pavement and improve superelevation	All	All				15	28				
	Wet pavement	All				15	51				
Stabilize shoulder	All	All				15	25				
Stabilize shoulder and dropoff	All	All	All	All		1	25				
Vary grade	All	All		Freeway		6	100(1-((EXP(bPg)-1.0)Ps+1.0)); b=regression coefficient (for values of b, refer to source), Pg=percent grade(absolute value), Ps=proportion of crash type subset (for values of Ps, refer to source).				
	All	All	Rural	Rural Highway		6	100(1-(EXP(bPg-1.0)1.0+1.0)); b=regression coefficient (for values of b, refer to source)., Pg=percent grade (absolute value).				
Vary horizontal curvature	All	All	Rural	Rural Highway		6	100(1-((1.55Lc+80.2/R-0.012Is)/1.55Lc)); Lc=length of horizontal curve (mi), R=curve radius (ft), Is=presence of a spiral transition curve (1 if a spiral transition is present, 0 otherwise).				

Countermeasure(s)	Crash Type	Crash Severity	Area Type	Road Type	Daily Traffic Volume (veh/day)	Ref	Effectiveness				Study Type
							Crash Reduction Factor / Function	Std Error	Range		
									Low	High	
Vary inside shoulder width	All	All		Freeway		6	100(1-((EXP(-0.021(Wis-Wsb))-1.0)(Pi/0.15)+1.0)); Wis=inside shoulder width (ft), Wsb=base inside shoulder width (ft) (=4.0 for four lanes, 10.0 for six or more lanes), Pi=proportion of crash type subset (for values of Pi, refer to source).				
	All	All	Rural	Rural Highway		6	100(1-((EXP(-0.021(Wis-4))-1.0)(Pi/0.16)+1.0)); Wis=inside shoulder width (ft), Pi=proportion of crash type subset (for values of Pi, refer to source).				
Vary lane width	All	All		Freeway		6	100(1-((EXP(-0.047(Wl-12))-1.0)(Pi/0.37)+1.0)); Wl=lane width (ft), Pi=proportion of crash type subset (for values of Pi, refer to source).				
	All	All	Rural	Rural Highway		6	100(1-((EXP(-0.047(Wl-12))-1.0)(Pi/0.36)+1.0)); Wl=lane width (ft), Pi=proportion of crash type subset (for values of Pi, refer to source).				
	All	All	Urban	Urban Street		6	100(1-((EXP(-0.040(Wl-12))-1.0)(Pi/0.24)+1.0)); Wl=lane width (ft), Pi=proportion of crash type subset (for values of Pi, refer to source)				
Vary outside shoulder width	All	All		Freeway		6	100(1-((EXP(-0.021(Ws-10))-1.0)(Pi/0.15)+1.0)); Ws=outside shoulder width (ft), Pi=proportion of crash type subset (for values of Pi, refer to source).				

Countermeasure(s)	Crash Type	Crash Severity	Area Type	Road Type	Daily Traffic Volume (veh/day)	Ref	Effectiveness				Study Type
							Crash Reduction Factor / Function	Std Error	Range		
									Low	High	
Vary outside shoulder width (cont'd)	All	All	Rural	Rural Highway		6	100(1-((EXP(-0.021(Ws-8))-1.0)(Pi/0.16)+1.0)); Ws=outside shoulder width (ft), Pi=proportion of crash type subset (for values of Pi, refer to source).				
Vary shoulder width	All	All	Urban	Urban Street		6	100(1-((EXP(-0.014(Ws-1.5))-1.0)(Pi/0.088)+1.0)); Ws=shoulder width (ft), Pi=proportion of crash type subset (for values of Pi, refer to source).				
Vary side slopes	All	All	Rural	Rural Highway		6	100(1-((EXP(0.692(1/Ss-0.25))-1.0)Ps+1.0)), Ss= horizontal run for a 1ft change in elevation (average for length of segment, ft), Ps=proportion of crash type subset (for values of Ps, refer to source).				
Vary spiral transition curvature	All	All	Rural	Rural Highway		6	100(1-((1.55Lc+80.2/R-0.012)/(1.55Lc+80.2/R))); Lc=length of horizontal curve (mi), R=curve radius (ft).				
Vary superelevation	All	All	Rural	Rural Highway		6	0 through -15 according to the superelevation deficiency (refer to source).				
Vary uncurbed cross-sections	All	All	Urban	Urban Street		6	100(1-((EXP(-0.074)(1-Poff-road))+EXP(-0.225)Poff-road)); Poff-road=proportion of off-road crashes.				
Widen lane (add 1 ft to both sides)	Head-on	All				15	12				
	ROR	All				15	12				
	Sideswipe	All				15	12				
Widen lane (add 2 ft to both sides)	Head-on	All				15	23				
	ROR	All				15	23				
Widen lane (add 2 ft to both sides) (cont'd)	Sideswipe	All				15	23				

Countermeasure(s)	Crash Type	Crash Severity	Area Type	Road Type	Daily Traffic Volume (veh/day)	Ref	Effectiveness				Study Type
							Crash Reduction Factor / Function	Std Error	Range		
									Low	High	
Widen lane (add 3 ft to both sides)	Head-on	All				15	32				
	ROR	All				15	32				
	Sideswipe	All				15	32				
Widen lane (add 4 ft to both sides)	Head-on	All				15	40				
	ROR	All				15	40				
	Sideswipe	All				15	40				
Widen lane (initially less than 9 ft)	All	Fatal/ Injury	Rural	2-lane	400-2,000	38	28		5	50	
Widen lane (initially between 9 ft and 10.75 ft)	All	Fatal/ Injury	Rural	2-lane	400-2,000	38	16		2	30	
Widen lanes	All	All	All			15	56				
	All	All	Rural			21	100(1-((AMFRA-1.0)PRA+1.0)); AMFRA=accident modification factor for related accidents (for values of AMFRA, refer to source), PRA=proportion of total crashes constituted by related crashes.				Expert Panel
	All	All				15	50				
	Fixed object	All				15	5				
	Head-on	All				15	70				
	Head-on	All				15	5				
	Head-on	All				15	70				
	ROR	All				15	49				
Widen lanes (cont'd)	Overturn	All				15	5				
	Sideswipe	All				15	52				
	Sideswipe	All				15	5				
	Sideswipe	All				15	52				
Widen shoulder (from 6 to 7 ft)	All	All	Rural	2-lane		20	-1	4			

Countermeasure(s)	Crash Type	Crash Severity	Area Type	Road Type	Daily Traffic Volume (veh/day)	Ref	Effectiveness				Study Type
							Crash Reduction Factor / Function	Std Error	Range		
									Low	High	
Widen shoulder (from 6 to 8 ft)	All	All	Rural	2-lane		20	4	2			
Widen shoulder (from 6 to 9 ft)	All	All	Rural	2-lane		20	21	6			
Widen shoulder (from 6 to >9 ft)	All	All	Rural	2-lane		20	18	3			
Widen shoulder	All	All	All	All		1	20				
Widen shoulder (initially less than 1 ft)	All	Fatal/ Injury	Rural	2-lane	400-2,000	38	25		9	40	
Widen shoulder (initially between 1 ft and 3.3 ft)	All	Fatal/ Injury	Rural	2-lane	400-2,000	38	13		6	20	
Widen shoulder (initially less than or equal to 4 ft)	All	All	All	All		1	20				
Widen shoulder (initially more than 4 ft)	All	All	All	All		1	35				
Widen shoulder (paved)	All	All				15	29				
	All	All				15	57				
	All	All				15	20				
	All	All				15	8				
	All	All				15	32				
	All	All				15	50				
	Fixed object	All				15	15				
	Head-on	All				15	45				
	Head-on	All				15	75				
Widen shoulder (paved) (cont'd)	Head-on	All				15	15				
	ROR	All				15	60				
	Ped	All				15	71				
	Sideswipe	All				15	28				
	Sideswipe	All				15	41				
	Sideswipe	All				15	15				

Countermeasure(s)	Crash Type	Crash Severity	Area Type	Road Type	Daily Traffic Volume (veh/day)	Ref	Effectiveness				Study Type
							Crash Reduction Factor / Function	Std Error	Range		
									Low	High	
Widen shoulder (paved) (from 0 to 2 ft)	Fixed object	All				15	16				
	ROR	All				15	16				
Widen shoulder (paved) (from 0 to 4 ft)	Fixed object	All				15	29				
	ROR	All				15	29				
Widen shoulder (paved) (from 0 to 6 ft)	Fixed object	All				15	40				
	ROR	All				15	40				
Widen shoulder (paved) (from 0 to 8 ft)	Fixed object	All				15	49				
	ROR	All				15	49				
Widen shoulder (unpaved)	All	All	Rural	2-lane		15	15				
	All	All				15	22				
Widen shoulder (unpaved) (from 0 to 2 ft)	Fixed object	All				15	13				
	ROR	All				15	13				
Widen shoulder (unpaved) (from 0 to 4 ft)	Fixed object	All				15	25				
	ROR	All				15	25				
Widen shoulder (unpaved) (from 0 to 6 ft)	Fixed object	All				15	34				
	ROR	All				15	34				
Widen shoulder (unpaved) (from 0 to 8 ft)	Fixed object	All				15	43				
	ROR	All				15	43				

Table 7: Median Countermeasures

Countermeasure(s)	Crash Type	Crash Severity	Area Type	Road Type	Daily Traffic Volume (veh/day)	Ref	Effectiveness				Study Type
							Crash Reduction Factor / Function	Std Error	Range		
									Low	High	
MEDIAN COUNTERMEASURES											
Install median	All	All	All	All		1	15				
	All	Fatal/ Injury	Rural	2-lane		5	-94	56			Meta Analysis
	All	Fatal/ Injury	Urban	2-lane		5	39	10			Meta Analysis
	All	Injury	Rural	Multilane		5	12	3			Meta Analysis
	All	Injury	Urban	Multilane		5	22	2			Meta Analysis
	All	PDO	Rural	Multilane		5	18	3			Meta Analysis
	All	PDO	Rural	2-lane		5	-128	55			Meta Analysis
	All	PDO	Urban	Multilane		5	-9	2			Meta Analysis
Install median (flush)	All	All			<5,000/lane	15	44				
	All	All			>5,000/lane	15	52				
	All	All	All	All		1	25				
	All	All				15	15				
	All	All				15	15				
	All	Fatal				15	90				
	Left-turn	All			<5,000/lane	15	72				
	Left-turn	All			>5,000/lane	15	78				
Install median barrier	All	All	All	All		27	**86**	3			EB Before-After
	All	All		Multilane divided		5	-24	3			Meta Analysis
	All	All				15	19				
	All	All	All	All		1	5				
	All	All				15	5				
	All	All				15	15				
	All	All				15	19				
	All	All				15	20				
	All	All				15	25				
	All	All				15	25				

Countermeasure(s)	Crash Type	Crash Severity	Area Type	Road Type	Daily Traffic Volume (veh/day)	Ref	Effectiveness				Study Type
							Crash Reduction Factor / Function	Std Error	Range		
									Low	High	
Install median barrier (cont'd)	All	All				15	36				
	All	Fatal		Multilane divided		5	43	10			Meta Analysis
	All	Fatal	All	All		1	65				
	All	Fatal				15	65				
	All	Fatal/ Injury	All	All		27	**88**	5			EB Before-After
	All	Injury		Multilane divided		5	30	6			Meta Analysis
	All	Injury	All	All		1	40				
	All	Injury				15	40				
	ROR	All				15	35				
	Right-angle	All			<5,000/lane	15	58				
	Right-angle	All			>5,000/lane	15	54				
Install median barrier (cable)	All	All		Highway (three-lane)		5	-34	74			Meta Analysis
	All	Fatal		Highway (three-lane)		5	100	254			Meta Analysis
	All	Injury		Highway (three-lane)		5	26	84			Meta Analysis
	All	Injury		Multilane divided		5	29	11			Meta Analysis
	Head-on	Fatal	Rural	Highway		9	92				Simple Before-After
Install median barrier (concrete)	All	Fatal				15	90				
	All	Injury		Multilane divided		5	-15	36			Meta Analysis
	All	Injury				15	10				
Install median barrier (steel)	All	Injury		Multilane divided		5	35	8			Meta Analysis

Countermeasure(s)	Crash Type	Crash Severity	Area Type	Road Type	Daily Traffic Volume (veh/day)	Ref	Effectiveness				Study Type
							Crash Reduction Factor / Function	Std Error	Range		
									Low	High	
Install or upgrade median barrier near gore area	All	All			<5,000/lane	15	17				
	All	All			>5,000/lane	15	17				
	All	All				15	17				
	ROR	All			<5,000/lane	15	56				
	ROR	All			>5,000/lane	15	56				
	ROR	All				15	56				
	Rear-end	All			<5,000/lane	15	39				
	Rear-end	All			>5,000/lane	15	39				
	Rear-end	All				15	39				
Install raised median	All	All				15	20				
	All	All				15	25				
	Head-on	All				15	75				
	Ped	All				15	25				
Vary median width	All	All	Urban	Urban Street		6	100(1-((b0(EXP(b1Wm^b2)-1.0)+1.0)/(b0(EXP(b1x16b^b2)-1.0)+1.0))); b0, b1, and b2=regression coefficients (for values of b0, b1, and b2, refer to source), Wm=median width (ft).				
	All	All	Rural	Rural Highway		6	100(1-((b0(EXP(b1Wm^b2)-1.0)+1.0)/(b0(EXP(b1Wmb^b2)-1.0)+1.0))); b0, b1, and b2=regression coefficients (for values of b0, b1, and b2, refer to source), Wm=median width (ft), Wmb=base median width (ft) (16 for surfaced median, 76 for depressed median).				
	All	All		Freeway		6	100(1-((b0(EXP(b1Wm^b2)-1.0)+1.0)/(b0(EXP(b1Wmb^b2)-1.0)+1.0))); b0, b1, and b2=regression coefficients (for values of b0, b1, and b2, refer to source), Wm=median width (ft), Wmb=base median width (ft) (24 for surfaced median, 76 for depressed median).				

Table 8: Roadside Countermeasures

Countermeasure(s)	Crash Type	Crash Severity	Area Type	Road Type	Daily Traffic Volume (veh/day)	Ref	Effectiveness				Study Type
							Crash Reduction Factor / Function	Std Error	Range		
									Low	High	
ROADSIDE COUNTERMEASURES											
Install frontage road	All	All				15	40				
	All	All	All	All		1	40				
Install snow fencing	Snow	All				15	53				
	Snow	All				15	71				
	Snow	All				15	35				
Remove poles by burying utility lines	All	All				15	40				
Remove obstacles on curves to improve sight distance	All	Fatal/ Injury	Rural	2-lane		38	5				
Remove or relocate fixed objects outside of clear zone	All	All	All	All		27	**38**	10			EB Before-After
	All	All			<5,000/lane	15	18				
	All	All			>5,000/lane	15	17				
	All	All	All	All		1	30				
	All	All	All	All		1	25				
	All	All				15	29				
	All	All				15	35				
	All	All				15	61				
	All	All				15	20				
	All	All				15	25				
	All	All				15	30				
	All	All				15	30				
	All	All				15	55				
	All	All				15	25				
	All	Fatal	All	All		1	50				
	All	Fatal	All	All		1	40				
	All	Fatal				15	40				
	All	Fatal				15	50				
	All	Fatal				15	40				
	All	Fatal				15	50				
	All	Fatal/ Injury	All	All		27	**38**	13			EB Before-After
	All	Injury	All	All		1	30				

Countermeasure(s)	Crash Type	Crash Severity	Area Type	Road Type	Daily Traffic Volume (veh/day)	Ref	Effectiveness				Study Type
							Crash Reduction Factor / Function	Std Error	Range		
									Low	High	
Remove or relocate fixed objects outside of clear zone (cont'd)	All	Injury	All	All		1	25				
	All	Injury				15	25				
	All	Injury				15	30				
	All	Injury				15	25				
	All	Injury				15	30				
	Fixed object	All				15	65				
	Fixed object	All	Urban			15	20				
	Fixed object	All			<400	15	40				
	Fixed object	All				15	88				
	Fixed object	All				15	90				
	Fixed object	All				15	100				
	Fixed object	All				15	75				
	ROR	All				15	71				
	Overturn	All			<5,000/lane	15	42				
	Overturn	All			>5,000/lane	15	44				
Vary horizontal clearance	All	All	Rural	Rural Highway		6	100(1-((EXP(-0.0137(Whc-30))-1.0)Ps+1.0)); Whc=horizontal clearance (average for length of segment, ft), Ps=proportion of crash type subset (for values of Ps, refer to source).				
Vary utility pole density	All	All		Freeway		6	100(1-((fp-1.0)Ps+1.0)); fp=((0.0000984ADT+0.0354Dp)Wo^-0.6-0.04)/(0.0000128ADT+0.075); Dp=utility pole density (two-way total) (pole/mi), Wo =average pole offset from nearest edge of traveled way (ft), Ps=proportion of crash type subset (for values of Ps, refer to source).				

Countermeasure(s)	Crash Type	Crash Severity	Area Type	Road Type	Daily Traffic Volume (veh/day)	Ref	Effectiveness				Study Type
							Crash Reduction Factor / Function	Std Error	Range		
									Low	High	
Vary utility pole density (cont'd)	All	All	Rural	Rural Highway		6	100(1-((fp-1.0)Ps+1.0)); fp=((0.0000984ADT+0.0354Dp)Wo^-0.6-0.04)/(0.0000128ADT+0.075); Dp=utility pole density (two-way total) (pole/mi), Wo =average pole offset from nearest edge of traveled way (ft), Ps=proportion of crash type subset (for values of Ps, refer to source)				
	All	All	Urban	Urban Street		6	100(1-(0.022(fp-1.0)+1.0)), fp=((0.0000984ADT+0.0354Dp)Wo^-0.6-0.04)/(0.0000649ADT+1.128); Dp=utility pole density (two-way total) (poles/mi), Wo=average pole offset from nearest edge of traveled way (ft)				
Widen clear zone (add 5 ft)	Fixed object	All				15	13				
Widen clear zone (add 8 ft)	Fixed object	All				15	21				
Widen clear zone (add 10 ft)	Fixed object	All				15	25				
Widen clear zone (add 15 ft)	Fixed object	All				15	35				
Widen clear zone (add 20 ft)	Fixed object	All				15	44				

Table 9: Signs / Markings / Operational Countermeasures

Countermeasure(s)	Crash Type	Crash Severity	Area Type	Road Type	Daily Traffic Volume (veh/day)	Ref	Effectiveness				Study Type
							Crash Reduction Factor / Function	Std Error	Range		
									Low	High	
SIGNS											
Implement sign corrections to MUTCD standards	All	Injury	Urban	Local		5	15	10			Meta Analysis
	All	PDO	Urban	Local		5	**7**	6			Meta Analysis
Install chevron signs on horizontal curves	All	Fatal/ Injury	Rural	2-lane		38	20				
	All	All				15	35				
	All	All	Urban	Arterial (urban)		5	64	49			Simple Before-After
	All	All				15	20				
	All	All				15	35				
	All	All				15	50				
Install curve advance warning signs	All	Fatal/ Injury	Rural	2-lane		38	10				
	All	Injury				5	30	71			Meta Analysis
	All	PDO				5	8	76			Meta Analysis
	All	All				15	30				
	All	Fatal				15	55				
	All	All				15	30				
	All	All				15	23				
	All	Injury				15	20				
	Head-on	All				15	29				
	ROR	All				15	30				
	ROR	All	All	All		1	30				
Install curve advance warning signs (advisory speed)	All	Injury				5	13	9			Meta Analysis
	All	PDO				5	29	23			Meta Analysis
	All	All				15	29				
	All	All				15	20				

Countermeasure(s)	Crash Type	Crash Severity	Area Type	Road Type	Daily Traffic Volume (veh/day)	Ref	Effectiveness				Study Type
							Crash Reduction Factor / Function	Std Error	Range		
									Low	High	
Install curve advance warning signs (flashing beacon)	All	All				15	30				
Install delineators (general)	All	All				15	11				
	Head-on	All				15	67				
	Night	All				15	25				
	ROR	All				15	34				
	Sideswipe	All				15	67				
Install dynamic/variable accident warning signs	All	Injury		Freeways		5	44	17			Meta Analysis
	Rear-end	Injury		Freeways		5	16	10			Meta Analysis
Install dynamic/variable queue warning signs	Rear-end	PDO		Freeways		5	-16	15			Meta Analysis
Install dynamic/variable speed warning signs	All	All				5	46	17			Meta Analysis
	All	Injury				5	41	62			Meta Analysis
Install guide signs (general)	All	All	All			15	15				
Install guideposts or barrier reflectors	All	Fatal/ Injury	Rural	2-lane		38	8				
Install illuminated signs	All	All				15	15				
Install lane assignment signs	Rear-end	All				15	10				
	Sideswipe	All				15	20				
Install nonvehicular (animal) reflectors	All	All				15	10				
	Night	All				15	25				
Install pavement condition warning signs	All	All				15	5				
	Wet pavement	All				15	20				
	Wet pavement	All				15	20				
	Wet weather	All	All	All		1	20				

Countermeasure(s)	Crash Type	Crash Severity	Area Type	Road Type	Daily Traffic Volume (veh/day)	Ref	Effectiveness				Study Type
							Crash Reduction Factor / Function	Std Error	Range		
									Low	High	
Install post-mounted delineators (curves)	All	All				15	25				
	All	All				15	20				
	All	All				15	25				
	All	All				15	30				
	Night	All	All	All		1	30				
Install post-mounted delineators (tangents and curves combined)	All	Injury	Rural	2-lane		5	-4	10			Meta Analysis
	All	PDO	Rural	2-lane		5	-5	7			Meta Analysis
	All	All				15	25				
PAVEMENT											
Improve pavement friction	All	All				15	13				
	Ped	All				15	10				
Improve pavement friction (groove shoulder)	All	All				15	22				
	All	All	All	All		1	25				
	All	All				15	18				
	All	All				15	25				
	All	All				15	25				
	All	Fatal/ Injury				15	18				
	All	PDO				15	17				
	ROR	All				15	27				
	ROR	All				15	27				
Improve pavement friction (grooving)	All	All				15	21				
	All	All			<5,000/lane	15	37				
	All	All			>5,000/lane	15	21				
	All	All	All	All		1	25				
	All	All				15	10				
	All	All				15	14				
	All	All				15	25				
	Fixed object	All			<5,000/lane	15	36				
	Fixed object	All			>5,000/lane	15	19				
	ROR	All			<5,000/lane	15	41				

Countermeasure(s)	Crash Type	Crash Severity	Area Type	Road Type	Daily Traffic Volume (veh/day)	Ref	Effectiveness				Study Type
							Crash Reduction Factor / Function	Std Error	Range		
									Low	High	
Improve pavement friction (grooving) (cont'd)	ROR	All			>5,000/lane	15	40				
	Overturn	All			<5,000/lane	15	54				
	Overturn	All			>5,000/lane	15	35				
	Rear-end	All			<5,000/lane	15	54				
	Rear-end	All			>5,000/lane	15	35				
	Wet pavement	All				15	60				
	Wet pavement	All			<5,000/lane	15	64				
	Wet pavement	All			>5,000/lane	15	54				
	Wet pavement	All	All	All		1	60				
Improve pavement friction (increase skid resistance)	Wet pavement	All	All	All		1	45				
	Wet pavement	Fatal/ Injury	Rural	2-lane		38	30				
Improve pavement friction (overlay)	All	All			<5,000/lane	15	13				
	All	All			>5,000/lane	15	20				
	Fixed object	All			<5,000/lane	15	43				
	Fixed object	All			>5,000/lane	15	34				
	Head-on	All			<5,000/lane	15	43				
	Head-on	All			>5,000/lane	15	61				
	Head-on	Fatal/ Injury				15	19				
	Head-on	PDO				15	30				
	Left-turn	Fatal/ Injury				15	41				
	Left-turn	PDO				15	34				
	ROR	Fatal/ Injury				15	28				
	ROR	PDO				15	29				
	Rear-end	Fatal/ Injury				15	12				

Countermeasure(s)	Crash Type	Crash Severity	Area Type	Road Type	Daily Traffic Volume (veh/day)	Ref	Effectiveness				Study Type
							Crash Reduction Factor / Function	Std Error	Range		
									Low	High	
Improve pavement friction (overlay) (cont'd)	Rear-end	PDO				15	21				
	Right-angle	All				15	23				
	Right-angle	Fatal/ Injury				15	11				
	Right-angle	PDO				15	31				
	Sideswipe	All			<5,000/lane	15	43				
	Sideswipe	All			>5,000/lane	15	61				
	Sideswipe	Fatal/ Injury				15	12				
	Sideswipe	PDO				15	27				
	Wet pavement	All			<5,000/lane	15	23				
	Wet pavement	All			>5,000/lane	15	50				
Improve pavement friction (curve overlay)	All	All				15	17				
	All	All				15	10				
	All	All				15	24				
	Head-on	All				15	86				
	Wet pavement	All				15	51				
Improve pavement friction (resurface with deicing additives)	Head-on	All				15	31				
Improve pavement friction (resurface with open-graded mix)	All	All				15	75				
	Fixed object	All				15	93				
	Head-on	All				15	90				
	Sideswipe	All				15	90				
	Wet pavement	All				15	91				

Countermeasure(s)	Crash Type	Crash Severity	Area Type	Road Type	Daily Traffic Volume (veh/day)	Ref	Effectiveness				Study Type
							Crash Reduction Factor / Function	Std Error	Range		
									Low	High	
Improve pavement friction (skid treatment with overlay)	Ped	Fatal/ Injury				15	3				
Install centerline rumble strips	All	All	Rural	2-lane	5,000-22,000	5	**14**	5			EB Before-After
	All	Injury	Rural	2-lane	5,000-22,000	5	**15**	8			EB Before-After
	Head-on	All	Rural	2-lane highway		26	55				Simple Before-After
	Head-on	Fatal	Rural	2-lane highway		26	68				Simple Before-After
	Head-on	Injury (minor)	Rural	2-lane highway		26	26				Simple Before-After
	Head-on	Injury (major)	Rural	2-lane highway		26	33				Simple Before-After
	Head-on/ Sideswipe	All	Rural	2-lane	5,000-22,000	5	21	12			EB Before-After
	Head-on/ Sideswipe	Injury	Rural	2-lane	5,000-22,000	5	25	15			EB Before-After
Install or upgrade curbing	Fixed object	All				15	50				
Install shoulder rumble strips	All	All	Rural	Multilane divided		8	16				Simple Before-After
	All	Injury	Rural	Multilane divided		8	17				Simple Before-After
	ROR	All	Rural	2-lane	>4,000	41	13	8			
	ROR	All	Rural	Multilane divided		8	10				Simple Before-After
	ROR	All	Rural	Highway		16	27	22	22	33	
	ROR	All	All	Freeway		19	18	7			Comparison Group Before-After
	ROR	All	Rural	Freeway		19	21	10			Comparison Group Before-After

Countermeasure(s)	Crash Type	Crash Severity	Area Type	Road Type	Daily Traffic Volume (veh/day)	Ref	Effectiveness				Study Type
							Crash Reduction Factor / Function	Std Error	Range		
									Low	High	
Install shoulder rumble strips (cont'd)	ROR	All	Rural	All		57	34				
	ROR	All	Rural	Arterial		57	16				
	ROR	All	Rural	Between ramps		57	34				
	ROR	All	Rural	Highway		57	38				
	ROR	All	Rural	Three-lane		57	36				
	ROR	All	Rural	2-lane		57	32				
	ROR	Fatal/ Injury	Rural	2-lane	>4,000	41	18	12			
	ROR	Injury	Rural	Multilane divided		8	22				Simple Before-After
	ROR	Injury	All	Freeway		19	13	12			Comparison Group Before-After
	ROR	Injury	Rural	Freeway		19	7	16			Comparison Group Before-After
Install shoulder rumble strips on illuminated highways	ROR	All	Rural	All		57	41				
Install shoulder rumble strips on unilluminated highways	ROR	All	Rural	All		57	31				
Pave shoulder	All	All				15	15				
	Head-on	All				15	86				
	Night	All				15	62				
Vary centerline rumble strip width	All	All	Rural	Rural Highway		6	12	6			
Vary shoulder rumble strips	All	All	Rural	Rural Highway		6	100(1-(-0.07Pi+1.0)); Pi=proportion of crash type subset (for values of Pi, refer to source).				
	All	All		Freeway		6	100(1-(-0.12Pi+1.0)); Pi=proportion of influential crashes that occur on roadway type i				

Countermeasure(s)	Crash Type	Crash Severity	Area Type	Road Type	Daily Traffic Volume (veh/day)	Ref	Effectiveness				Study Type
							Crash Reduction Factor / Function	Std Error	Range		
									Low	High	
MARKINGS											
Delineate multiple lanes (painted lane lines)	All	All	Urban	Multilane		13	18	22			Meta Analysis
Install centerline markings	All	All				15	33				
	All	All	All	All		1	36				
	All	All				15	35				
	All	All				15	30				
	All	Injury	All	2-lane		13	1	6			Meta Analysis
	All	PDO	All	2-lane		13	-1	5			Meta Analysis
Install chevron converging pattern markings on pavement	All	All	Urban			18	38	6			Simple Before-After
	All	Injury		Freeways		5	56	26			Meta Analysis
Install edgelines and centerlines	All	All	Rural	Undivided	1,000-4,000	2	-3	21			EB Before-After
	All	Injury	All	All		13	**24**	11			Meta Analysis
Install edgelines, centerlines and delineators	All	Injury	All	All		13	**45**	11			Meta Analysis
Install edgeline markings	All	All			<5,000/lane	15	44				
	All	All			>5,000/lane	15	38				
	All	All	All	All		1	20				
	All	All				15	24				
	All	All				15	30				
	All	All				15	4				
	All	All				15	15				
	All	All				15	15				
	All	All				15	25				
	All	Injury				15	15				
	All	PDO				15	8				
	Fixed object	All			<5,000/lane	15	66				

Countermeasure(s)	Crash Type	Crash Severity	Area Type	Road Type	Daily Traffic Volume (veh/day)	Ref	Effectiveness				Study Type
							Crash Reduction Factor / Function	Std Error	Range		
									Low	High	
Install edgeline markings (cont'd)	Fixed object	All			>5,000/lane	15	59				
	ROR	All				15	30				
	ROR	All	All	All		1	25				
	Overturn	All			<5,000/lane	15	45				
	Overturn	All			>5,000/lane	15	50				
	Rear-end	All			<5,000/lane	15	45				
	Rear-end	All			>5,000/lane	15	50				
Install edgeline markings (from 4 to 6 in)	All	Injury	Rural	2-lane		13	3	4			Meta Analysis
	All	PDO	Rural	2-lane		13	3	11			Meta Analysis
Install edgeline markings (8 in)	All	Injury	Rural	2-lane		13	-5	8			Meta Analysis
	All	PDO	Rural	2-lane		13	1	15			Meta Analysis
Install raised pavement markers (snowplowable) where DOC = Degree of Curvature	Night	All	Rural	4-lane freeway	≤20000	4	-13	14			EB Before-After
	Night	All	Rural	4-lane freeway	<60000	4	33	21			EB Before-After
	Night	All	Rural	4-lane freeway	20,001-60,000	4	6	21			EB Before-After
	Night	All	Rural	2-lane, DOC>3.5	≤5,000	4	**-43**	9			EB Before-After
	Night	All	Rural	2-lane, DOC>3.5	5,001-15,000	4	**-26**	10			EB Before-After
	Night	All	Rural	2-lane, DOC>3.5	15,001-20,000	4	-3	11			EB Before-After
	Night	All	Rural	2-lane, DOC<3.5	≤5,000	4	**-16**	3			EB Before-After
	Night	All	Rural	2-lane, DOC<3.5	5,001-15,000	4	**1**	5			EB Before-After
	Night	All	Rural	2-lane, DOC<3.5	15,001-20,000	4	**24**	7			EB Before-After

Countermeasure(s)	Crash Type	Crash Severity	Area Type	Road Type	Daily Traffic Volume (veh/day)	Ref	Effectiveness				Study Type
							Crash Reduction Factor / Function	Std Error	Range		
									Low	High	
REGULATORY											
Install no-passing line	All	All				15	53				
	Head-on	All				15	40				
	Sideswipe	All				15	40				
Lower posted speed	All	All	All	All		40	-7				Paired comparison
	Fatal/injury	All	All	All		40	-5				Paired comparison
Lower posted speed by 5 mph	All	All	All	All		40	-44				Paired comparison
Lower posted speed by 10 mph	All	All	All	All		40	7				Paired comparison
Lower posted speed by 15-20 mph	All	All	All	All		40	5				Paired comparison
Prohibit on-street parking	All	All	Urban	Arterial (64ft)	30,000	5	42	8			Simple Before-After
	All	All				15	22				
	All	All				15	8				
	All	All				15	35				
	All	Injury	Urban	Arterial		5	20	5			Meta Analysis
	All	Injury	Urban	Arterial (64ft)	30,000	5	35	14			Simple Before-After
	All	PDO	Urban	Arterial		5	27	2			Meta Analysis
	All	PDO	Urban	Arterial (64ft)	30,000	5	48	1			Simple Before-After
	Fixed object	All				15	40				
Raise posted speed	All	All	All	All		40	11				Paired comparison
	Fatal/injury	All	All	All		40	7				Paired comparison
Raise posted speed by 5 mph	All	All	All	All		40	8				Simple Before-After

Countermeasure(s)	Crash Type	Crash Severity	Area Type	Road Type	Daily Traffic Volume (veh/day)	Ref	Effectiveness				Study Type
							Crash Reduction Factor / Function	Std Error	Range		
									Low	High	
Raise posted speed by 10-15 mph	All	All	All	All		40	15				Simple Before-After
Reduce mean speed by 5% through speed limit change and enforcement	All	Fatal	All	All		5	17	5			Meta analysis
	All	Injury	All	All		5	7	3			Meta analysis
	All	PDO	All	All		5	5	4			Meta analysis
Reduce mean speed by 10% through speed limit change and enforcement	All	Fatal	All	All		5	32	9			Meta analysis
	All	Injury	All	All		5	15	5			Meta analysis
	All	PDO	All	All		5	10	8			Meta analysis
Reduce mean speed by 15% through speed limit change and enforcement	All	Fatal	All	All		5	44	14			Meta analysis
	All	Injury	All	All		5	22	8			Meta analysis
	All	PDO	All	All		5	15	12			Meta analysis
Vary curb parking extent	All	All	Urban	Urban Street		6	100(1-(1+Ppk(Bpk-1))), Bpk=(1.10+0.365Iu2+0.609Pb/o)((fap/pp-1.0)Pap+1.0); Ppk=proportion of street segment length with parallel or angle parking (=0.5 Lpk/L), Lpk=curb miles allocated to parking (mi), Iu2=indicator variable for cross section(1 for two-lane street; 0 otherwise), Pb/o=for that part of the street with parking, the proportion that has business or office as an adjacent land use, fap/pp=ratio of crashes on streets with angle parking to those on streets with parallel parking, Pap= for that part of the street with parking, the proportion with angle parking				

Countermeasure(s)	Crash Type	Crash Severity	Area Type	Road Type	Daily Traffic Volume (veh/day)	Ref	Effectiveness				Study Type
							Crash Reduction Factor / Function	Std Error	Range		
									Low	High	
Vary speed limit	All	All		Freeway		6	100(1-EXP(-0.012(V-55))); V=speed limit (mph)				
	All	All	Urban	Urban Street		6	100(1-((EXP(0.252IV<=30+0.318IV>=45)Poff-road+1.15((V^2.066)(Exp(-0.0689V)))(1-Poff-road)))); Poff-road=proportion of crashes that occur off the roadway, for values of IV<=30 and IV>=45, refer to source; 100(1-(EXP(b(V-40)))); b= vary per roadway type, V=Speed limit (mph).				
LIGHTING											
Improve lighting	All	All	All	All		1	25				
	All	All				15	23				
	All	All				15	20				
	All	All				15	25				
	All	Fatal	All	Freeway		5	73	71			Meta Analysis
	All	Fatal	All	Highway		5	69	36			Meta Analysis
	All	Fatal	Rural	Highway		5	73	72			Meta Analysis
	All	Fatal	Urban	Highway		5	63	52			Meta Analysis
	All	Injury	All	Freeway		5	27	12			Meta Analysis
	All	Injury	All	Highway		5	28	6			Meta Analysis
	All	Injury	Rural	Highway		5	20	12			Meta Analysis
	All	Injury	Urban	Highway		5	31	7			Meta Analysis
	All	PDO	All	Freeway		5	32	26			Meta Analysis
	All	PDO	All	Highway		5	18	7			Meta Analysis
	All	PDO	Rural	Highway		5	30	43			Meta Analysis

Countermeasure(s)	Crash Type	Crash Severity	Area Type	Road Type	Daily Traffic Volume (veh/day)	Ref	Effectiveness				Study Type
							Crash Reduction Factor / Function	Std Error	Range		
									Low	High	
Improve lighting (cont'd)	All	PDO	Urban	Highway		5	16	8			Meta Analysis
	Night	All				15	37				
	Night	All				15	20				
	Night	All				15	45				
	Night	All				15	45				
Install lighting	All	All				62	6				Meta Analysis/ Expert Panel
	All	Injury				62	8				Meta Analysis/ Expert Panel
	Night	All				62	20				Meta Analysis/ Expert Panel
	Night	Injury				62	29				Meta Analysis/ Expert Panel
Install lighting at interchanges	All	All	All	All		27	**50**	17			EB Before-After
	All	Fatal/ Injury	All	All		27	26	38			EB Before-After
OPERATIONAL											
Add two-way left-turn lane	All	All		All		27	8	16			EB Before-After
	All	All		All		1	34		25	45	
	All	All				15	30				Simple Before-After
	All	All				15	25				Simple Before-After
	All	All				15	35				Cross-section
	All	All				15	34				Simple Before-After
	All	All				15	25				Simple Before-After

Countermeasure(s)	Crash Type	Crash Severity	Area Type	Road Type	Daily Traffic Volume (veh/day)	Ref	Effectiveness				Study Type
							Crash Reduction Factor / Function	Std Error	Range		
									Low	High	
Add two-way left-lane (cont'd)	All	Fatal/ Injury		All		27	20	25			EB Before-After
	All	Injury				15	20				Cross-section
	All	PDO				15	35				Cross-section
	Head-on	All				15	36				
	Head-on	Fatal/ Injury				15	67				Simple Before-After
	Head-on	PDO				15	64				Simple Before-After
	Left-turn	All				15	33				
	Left-turn	All				15	33				Simple Before-After
	Left-turn	Fatal/ Injury				15	17				Simple Before-After
	Left-turn	PDO				15	38				Simple Before-After
	ROR	All				15	37				
	ROR	Fatal/ Injury				15	90				Simple Before-After
	ROR	PDO				15	16				Simple Before-After
	Ped	All				15	19				
	Rear-end	All				15	36				
	Rear-end	All				15	36				Simple Before-After
	Rear-end	All				15	36				Cross-section
	Rear-end	Fatal/ Injury				15	32				Simple Before-After
	Rear-end	PDO				15	38				Simple Before-After
	Right-angle	All				15	20				Simple Before-After
	Right-angle	Fatal/ Injury				15	31				Simple Before-After

Countermeasure(s)	Crash Type	Crash Severity	Area Type	Road Type	Daily Traffic Volume (veh/day)	Ref	Effectiveness				Study Type
							Crash Reduction Factor / Function	Std Error	Range		
									Low	High	
Add two-way left-lane (cont'd)	Right-angle	PDO				15	23				Simple Before-After
	Sideswipe	Fatal/ Injury				15	32				Simple Before-After
	Sideswipe	PDO				15	37				Simple Before-After
Convert from two-way to one-way traffic	All	All				15	43				
	All	All	All	All		1	33				
Implement crossover at work zone	All	All		4-lane divided	6,800-38,000	12	0				Simple Before-After
Implement maintenance and bituminous overlay	Head-on	All				15	31				
	Left-turn	Fatal/ Injury				15	37				
	Left-turn	PDO				15	13				
	ROR	Fatal/ Injury				15	19				
	ROR	PDO				15	30				
	Ped	Fatal/ Injury				15	33				
	Ped	PDO				15	42				
	Rear-end	Fatal/ Injury				15	21				
	Right-angle	Fatal/ Injury				15	16				
	Right-angle	PDO				15	23				
	Sideswipe	PDO				15	29				
Implement single lane closure at work zone	All	All		4-lane divided	20,000-41,500	12	-56				Simple Before-After
Improve drainage patterns	All	All				15	32				
	All	All	All	All		1	20				
	All	All				15	20				
	Wet pavement	All				15	40				

Countermeasure(s)	Crash Type	Crash Severity	Area Type	Road Type	Daily Traffic Volume (veh/day)	Ref	Effectiveness				Study Type
							Crash Reduction Factor / Function	Std Error	Range		
									Low	High	
Install sidewalk (to avoid walking along roadway)	Ped	All				15	74				
	Ped	All				15	75				
	Ped	All				15	89				
	Ped	All				15	65				
	Ped	All				15	65				
	Ped	All				36	88				
Reconfigure lanes within existing pavement width (two to three in one direction)	All	All		2-lane		15	32				
	All	Injury		2-lane		15	59				
	Left-turn	All		2-lane		15	46				
	Rear-end	All		2-lane		15	46				
	Sideswipe	All		2-lane		15	46				
Reconfigure lanes within existing pavement width (four to five in one direction)	All	All	Urban	Freeway	77,000-126,000	5	**-11**	5			EB Before-After
	All	Fatal/ Injury	Urban	Freeway	77,000-126,000	5	-11	8			EB Before-After
	All	Fatal/ Injury/ PDO	Urban	Freeway	77,000-126,000	5	**-10**	7			EB Before-After
Reconfigure lanes within existing pavement width (five to six in one direction)	All	All	Urban	Freeway	77,000-126,000	5	**-3**	8			EB Before-After
	All	Fatal/ Injury	Urban	Freeway	77,000-126,000	5	-7	13			EB Before-After
	All	Fatal/ Injury/ PDO	Urban	Freeway	77,000-126,000	5	-4	11			EB Before-After
Reduce driveway density (general)	All	All	Urban	Urban Street		6	100(1-(EXP(0.008(Dd,b/o-50)))); Dd,b/o = density of driveways serving business of office land uses (driveways/mi)				
Remove unwarranted signals (one-way streets)	Ped	All				46	17				Comparison Group Before-After
Vary passing lanes	All	All	Rural	Rural Highway		6	0.25 for one direction with three lane; 0.35 for two direction with four lane				

Countermeasure(s)	Crash Type	Crash Severity	Area Type	Road Type	Daily Traffic Volume (veh/day)	Ref	Effectiveness				Study Type
							Crash Reduction Factor / Function	Std Error	Range		
									Low	High	
Vary truck presence	All	All	Urban	Urban Street		6	100(1-((ftk-1.0)(1-Poff-road)+1.0)), ftk=(2EXP(-0.059Pt)+0.017Pt)/1.506; Poff-road=proportion of crashes that occur off the roadway, Pt=percent of truck presence; 100(1-(1.0+Truck/Basei)), for values of Truck and Basei, refer to source.				

Tables for Pedestrian Crash Reduction Factors

U.S. Department of Transportation
Federal Highway Administration

Table 10: Signalization Countermeasures

Countermeasures	Crash Type	Crash Severity	Area Type	Ref	Obs	Effectiveness				
						Crash Reduction Factor / Function	Std Error	Range		Study Type
								Low	High	
SIGNALIZATION COUNTERMEASURES										
Add exclusive pedestrian phasing	Pedestrian	All		28		34		7	60	
Convert permissive or permissive/protected to protected only left-turn phasing	All	All		62		1	7			Empirical Before-After/ Expert Panel
	Left-turn	All		62		99	1			Empirical Before-After/ Expert Panel
Convert permissive to permissive/protected left-turn phasing	All	All		62		0				Expert Panel
	Left-turn	All		62		16	2			Expert Panel
Improve signal timing [to intervals specified by the ITE *Determing Vehicle Change Intervals: A Proposed Recommended Practice (1985)]*	All	Fatal/Injury		49		12	9			Experimental Design (Case-Control Study)
	Pedestrian	Fatal/Injury		49		37				Experimental Design (Case-Control Study)
Replace existing WALK / DON'T WALK signals with pedestrian countdown signal heads	Pedestrian	Fatal/Injury	Urban (San Francisco)	32		25				
Install pedestrian signal	All	All		15		20				
	Pedestrian	All		15		53				
	Pedestrian	All		5		0				
	All	All		15		25				
	All	All		15		15				
	Pedestrian	All		15		55				
	Pedestrian	All		15		50				
Modify signal phasing (implement a leading pedestrian interval)	Pedestrian	All		28		5				
Remove unwarranted signals (one-way street)	Pedestrian	All		46		17				Comparison Group Before-After

Table 11: Geometric Countermeasures

Countermeasures	Crash Type	Crash Severity	Area Type	Ref	Obs	Effectiveness				
						Crash Reduction Factor / Function	Std Error	Range		Study Type
								Low	High	
GEOMETRIC COUNTERMEASURES										
Convert unsignalized intersection to roundabout	Pedestrian	Fatal/Injury	Urban	11		**27**	12	44	3	
Convert intersection to roundabout	Pedestrian	All		55		89				
Install pedestrian overpass/underpass	Pedestrian	All		15		86				
	Pedestrian	All		1	14	90		60	95	
	Pedestrian	Fatal/Injury		15		90				
	Pedestrian	PDO		15		90				
	Pedestrian	All		15		100				
	Pedestrian	All		15		67				
	Pedestrian	All		15		5				
	Pedestrian	All		15		90				
Install pedestrian overpass/underpass (unsignalized intersection)	Pedestrian	All		28		13				
Install raised median	Pedestrian	All		15		25				
Install raised median (marked crosswalk) at unsignalized intersection	Pedestrian	All		60		46				
Install raised median (unmarked crosswalk) at unsignalized intersection	Pedestrian	All		60		39				
Install raised median (unsignalized intersection)	Pedestrian	All		28		69				
Install raised pedestrian crossing	All	All		5		30	67			Meta-analysis
	All	Fatal/Injury		5		36	54			Meta-analysis
	Pedestrian	All		28		8				
Install refuge islands	Pedestrian	All		28		56				
Install sidewalk (to avoid walking along roadway)	Pedestrian	All		15		74				
	Pedestrian	All		36		88		43	99	Case-Control Study

Countermeasures	Crash Type	Crash Severity	Area Type	Ref	Obs	Effectiveness				
						Crash Reduction Factor / Function	Std Error	Range		Study Type
								Low	High	
Install sidewalk (to avoid walking along roadway) (cont'd)	Pedestrian	All		15		75				
	Pedestrian	All		15		89				
	Pedestrian	All		15		65				
	Pedestrian	All		15		65				
Narrow cross section (4 to 3 lanes with two way left-turn lane)	All	All	Urban	62		29	2			EB Before-After
Provide paved shoulder (of at least 4 feet) (to avoid walking along roadway)	Pedestrian	All		15		71				

Table 12: Signs / Markings / Operational Countermeasures

Countermeasures	Crash Type	Crash Severity	Area Type	Ref	Obs	Effectiveness				
						Crash Reduction Factor / Function	Std Error	Range		Study Type
								Low	High	
SIGNS / MARKINGS / OPERATIONAL COUNTERMEASURES										
Add intersection lighting	All	All		62		4				Meta Analysis/ Expert Panel
	All	Injury		62		6				Meta Analysis/ Expert Panel
	Night	All		62		21				Meta Analysis/ Expert Panel
	Night	Injury		62		29				Meta Analysis/ Expert Panel
Add segment lighting	All	All		62		6				Meta Analysis/ Expert Panel
	All	Injury		62		8				Meta Analysis/ Expert Panel
	Night	All		62		20				Meta Analysis/ Expert Panel
	Night	Injury		62		29				Meta Analysis/ Expert Panel
Convert two-way to all-way STOP control	Pedestrian	All		15		39				
	Pedestrian	All		21	69	19				Before-After with Likelihood Functions
	Pedestrian	All	Urban	30		39				Simple Before-After
Improve lighting at intersections	Pedestrian	Fatal		13		78	87			Meta-analysis
	Pedestrian	Injury		13		**42**	18			Meta-analysis
Improve pavement friction	Pedestrian	All		15		10				
Improve pavement friction (skid treatment with overlay)	Pedestrian	Fatal/Injury		15		3				

Countermeasures	Crash Type	Crash Severity	Area Type	Ref	Obs	Effectiveness				
						Crash Reduction Factor / Function	Std Error	Range		Study Type
								Low	High	
Increase enforcement related to motorist yielding in marked crosswalks combined with a public education campaign	Pedestrian	All		63		23				
Increase enforcement to reduce speed	Pedestrian	All		28		70				
Install far-side bus stops (signalized intersection)	Pedestrian	All		28		1				
Install object markers	Pedestrian	All		15		29				
Install school zone warning signs	All	All		15		18				
	All	All		15		15				
	All	All		15		20				
	All	All		15		15				
	All	All		15		20				
Permit right-turn-on-red	Pedestrian	All	New Orleans	5		-81	88			Simple Before-After
	Pedestrian	All	New York	5		-43	24			Simple Before-After
	Pedestrian	All	Ohio	5		-57	31			Simple Before-After
	Pedestrian	All	Wisconsin	5		-108	51			Simple Before-After
	All	All	Urban/ Suburban	62		100(1-(0.984)^n); n=number of signalized intersection appraoches where RTOR is prohibited				Expert Panel
Prohibit left-turns	Pedestrian	All		15		10				
Remove marked unprotected crosswalks from arterial intersections	Pedestrian	All	Urban	5		73				
Restrict parking near intersections (to off-street)	Pedestrian	All		15		30				

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Report No. FHWA-SA-08-011

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