



VIRGINIA STATE PREFERRED CMF LIST

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Introduction

A crash modification factor (CMF) is a useful tool for estimating changes in safety performance that can be expected when implementing a countermeasure. Developed using various forms of statistical analyses, they provide average changes in crash frequency, and sometimes severity, which are commonly observed when a treatment is installed.

Almost all CMFs can be found in the **Crash Modification Factors Clearinghouse**, a web-based repository of more than 6,000 CMFs covering hundreds of treatments. Often, a search for a countermeasure on the website will return many CMFs for a single treatment. As a result, this document was developed.

The Virginia State Preferred CMF List is a condensed directory with common CMFs relative to Virginia. The State preferred list contains CMFs with high quality ratings and includes the applicable crash type, area type, severity, service life, functional class, and site description. These CMFs will be used to support Virginia’s HSIP program as well as other, broader applications.

WHAT IS A CMF?

Mathematically, a CMF is a multiplicative factor used to compute the expected number of crashes after implementing a given countermeasure at a specific site. For example, a countermeasure expected to reduce the number of injury crashes by 23 percent will have a CMF of 0.77 ($1 - [23/100] = 0.77$). On the other hand, if the treatment is expected to increase the number of property damage crashes by 23 percent, the CMF will be $= 1 - (-23/100) = 1.23$.

To estimate future expected crash frequency with the treatment, the CMFs are applied to expected crash frequency assuming no changes. For example, a stop-controlled intersection is expected to experience five crashes per year. A treatment is installed with a CMF of 0.77, so the expected crash frequency with the installation would be $5 * 0.77 = 3.85$, a reduction of 1.15 crashes per year.

HOW TO USE THIS DOCUMENT

This document consists of three tables spread over multiple pages which describe and provide supporting documentation for the CMFs. Descriptions of each table are provided later in this section. CMFs should be selected based on applicability, where the characteristics associated with the CMF closely match the characteristics of the scenario at hand. For example, CMFs often vary by crash type and crash severity. CMFs may also be specific to urban or rural areas and should be applied to situations that match.

As an example, consider the CMF “Convert At-Grade Intersection to Interchange” shown in Figure A-1. The location of interest is 4-leg at-grade intersection, and a new interchange was suggested by a safety assessment team to help mitigate crashes at this intersection. Use the CMF by crash severity to determine the expected number of crashes for the applicable severity.

Figure A-1 Convert Intersection to Interchange CMF Information

COUNTERMEASURE	CRASH TYPE	AREA TYPE	K	A	BC	O	ALL SEVERITIES	SERVICE LIFE	FUNCTIONAL CLASS	SITE DESCRIPTION	PRIOR CONDITION	REFERENCE
Add Crosswalk	VP	-	1	1	1	1	1	2	-	Pedestrian Crossing	No Marked Crosswalk	FHWA Safety Report

Table 1: Virginia State Preferred CMF List

Table 1 provides CMFs by crash type and severity for the identified countermeasures. The countermeasures are separated into four categories: bike/ped, interchanges, intersections, and segments. For each countermeasure, the following information is provided:

- ▶ Countermeasure name;
- ▶ Applicable crash type, using codes defined within the key;
- ▶ Applicable area type, using codes defined within the key;
- ▶ CMFs for five severity categories;
 - ▶ Fatal Crash (K);
 - ▶ Suspected Serious Injury Crash (A);
 - ▶ Suspected Minor Injury and Possible Injury Crashes (BC)
 - ▶ Property Damage Only (PDO) Crash (O); and
 - ▶ All Severities.
- ▶ The anticipated service life for the treatment;
- ▶ The applicable functional class;
- ▶ A general site description;
- ▶ The designated prior condition for the countermeasure; and
- ▶ References for the CMF(s).

When applying these CMFs, analysts should be careful to apply the CMF only to the designated crash types and severities. However, these crash types should not limit consideration of the countermeasure’s usage. Just because a CMF is not available for the specific conditions does not mean the countermeasure is not useful in that context, it just might not have been researched yet.

Countermeasures with ** listed for a CMF indicate this CMF is defined using an equation, which can be found in Table 2.

Table 2: CMFunction Equations

Some CMFs may require the use of an equation, which can be called Crash Modification Functions (CMFunctions), and the equations are provided in Table 2. For some of the more complex CMFunctions, an online calculator has been provided to assist users in determining the expected number of crashes. This calculator can be found on VDOT’s HSIP **website**.

The equations are functions of existing and proposed conditions, with the units varying based on the CMF; the units can be verified in the Units column. In all cases, the existing condition is represented as the variable X and the proposed condition is represented as the variable Y. For equations that are not on the website, simply enter the existing and proposed conditions into the appropriate equation using the designated units. The resulting value from the equation is the CMF.

The countermeasures in Table 2 are divided into three categories: interchanges, intersections, and segments. Data provided for the countermeasures in Table 2 include:

- ▶ Countermeasure name.
- ▶ CMFunctions for five severity categories:
 - ▶ Fatal Crash (K);
 - ▶ Suspected Serious Injury Crash (A);
 - ▶ Suspected Minor Injury and Possible Injury Crashes (BC);
 - ▶ Property Damage Only (PDO) Crash (O); and
 - ▶ All Severities.
- ▶ Units for the existing and proposed conditions.

The resulting CMFs from the equation should be cross-referenced with Table 1 to ensure the CMF is being applied to the appropriate crash types.

Table 3: References

Specific references for the selected CMFs are provided in Table 3. The countermeasures in Table 3 are divided into four categories: bike/ped, interchanges, intersections, and segments. For each countermeasure, four pieces of data are provided:

- ▶ Countermeasure name;
- ▶ The shorthand reference from Table 1;
- ▶ The hyperlink for the first reference; and
- ▶ The hyperlink for the second reference, when applicable.

If there are questions about the study design, applicability, and/or prior conditions of a CMF, the analyst can refer to the linked documents, which can offer some clarification from the authors of the CMF study.

CAN'T FIND YOUR COUNTERMEASURE?

The list below contains an exhaustive list of countermeasures used in Virginia. If the user is proposing a countermeasure that cannot be located on this list, they are to identify relevant research supporting an estimated CMF value and submit this documentation to VDOT HSIP staff for review and approval.

PREFERRED CMF LIST KEY

Key <i>Crash Type</i>		Key <i>Area Type</i>	
VP	Vehicle-Pedestrian	SC	Secondary Crashes
VT	Vehicle-Train	VB	Vehicle-Bicycle
SV	Single Vehicle	HO	Head-On
CM	Cross-Median	CFO	Crashes with Fixed Objects
F	Frontal		
O	Opposing Direction Sideswipe		
		U+S	Urban and Suburban
		Sub	Suburban

▲ Refer to the HSIP or SmartScale website.
 ▲ Refer to specific treatment
 ** Refer to Equations Sheet on page 14

Table 1 Virginia State Preferred CMF List

	COUNTERMEASURE	CRASH TYPE	AREA TYPE	K	A	BC	O	ALL SEVERITIES	SERVICE LIFE	FUNCTIONAL CLASS	SITE DESCRIPTION	PRIOR CONDITION	REFERENCE
BIKE/PED	Add Crosswalk	VP	-	1	1	1	1	1	2	-	Pedestrian Crossing	No Marked Crosswalk	FHWA Safety Report
	Add Crosswalk Lighting	VP	-	0.56	0.41	0.41	0.56	0.56	15	-	Pedestrian Crosswalk	No Lighting Present	CMF ID: 441, 2379
	Add Curb Extensions/ Corner Bulb Outs	VP	-	1	1	1	1	1	20	-	Pedestrian Crossing at an Intersection Approach	No Bulb Outs or Curb Extensions Present	NYC Study
	Add Median Pedestrian Island	VP	-	0.75	0.75	0.75	0.75	0.75	20	-	Multilane Pedestrian Crossing	One-Stage At-Grade Pedestrian Crossing	PED CMF Toolbox
	Add or Upgrade Sidewalk	VP	-	0.12	0.12	0.12	0.12	0.12	20	-	Roadway Segment with Pedestrian Traffic Along Roadside	No Sidewalk or Deficient Sidewalk Present	PED CMF Toolbox
	Add Pedestrian Bridge	VP	-	0.1	0.1	0.1	0.14	0.14	30	-	High-Volume Pedestrian Crossing	At-Grade Pedestrian Crossing	PED CMF Toolbox
	Add Pedestrian Hybrid Beacon (PHB)	VP	U+S	0.453	0.453	0.453	0.453	0.453	20	Minor Arterial	Mid-Block Pedestrian Crossing	No Pedestrian Hybrid Beacon Present	CMF ID: 9020
	Add PHB, Advanced Yield/ Stop Markings	VP	U+S	0.432	0.432	0.432	0.432	0.432	20	Minor Arterial	Mid-Block Pedestrian Crossing	No Pedestrian Hybrid Beacon Present	CMF ID: 9021
	Add Pedestrian Signal Heads	ALL	U+S	0.85	0.85	0.85	0.96	0.92	20	-	Signalized Intersection with Pedestrian Crossings	No Pedestrian Signals Present	CMF ID: 8480, 8481
	Add Rectangular Rapid Flashing Beacon (RRFB)	VP	U+S	0.526	0.526	0.526	0.526	0.526	6	Minor Arterial	Mid-Block Pedestrian Crossing	No RRFB present	CMF ID: 9024
	Add Shared Use Path	VB	Urban	1	0.41	0.41	1	0.75	20	-	Roadway segment with Pedestrian and Bicycle Traffic	No Shared-Use Path Present	CMF ID: 4102, 9250
	Change Pedestrian Phase to Barnes Dance	VP	Urban	0.49	0.49	0.49	0.49	0.49	20	-	Signalized Intersection with Pedestrian Crossings	No Pedestrian Phasing or Standard Pedestrian Phasing	CMF ID: 4117
	Convert from Walk/ Don't Walk to Pedestrian Countdown	VP	-	0.3	0.3	0.3	0.3	0.3	20	-	Signalized Intersection with Walk/Don't Walk Pedestrian Signals	Walk/Don't Walk Pedestrian Signal	CMF ID: 5272
	Convert Mid-Block Crossing to HAWK	VP	U+S	0.453	0.453	0.453	0.453	0.453	20	Minor Arterial	Mid-Block Pedestrian Crossing	Mid-Block Crossing with No PHB or HAWK Present	CMF ID: 9020
	Convert Standard Crosswalk Pavement Marking to High-Visibility Crosswalk	VP	-	0.63	0.63	0.63	0.63	0.63	2	-	Pedestrian Crossing with Standard Crosswalk Pavement Markings	Standard Crosswalk Pavement Markings	CMF ID: 2697
Implement Leading Pedestrian Interval	VP	Urban	0.413	0.413	0.413	0.413	0.413	20	Principal Arterial - Other	Signalized Intersection with Pedestrian Crossings	Signalized intersection with Pedestrian Signal Heads and No Leading Interval	CMF ID: 1993	

Table 1 Virginia State Preferred CMF List (cont)

	COUNTERMEASURE	CRASH TYPE	AREA TYPE	K	A	BC	O	ALL SEVERITIES	SERVICE LIFE	FUNCTIONAL CLASS	SITE DESCRIPTION	PRIOR CONDITION	REFERENCE
BIKE/PED	Install PHB or HAWK with Advanced Stop or Yield Markings and Signs	VP	U+S	0.432	0.432	0.432	0.432	0.432	20	Minor Arterial	Mid-Block Pedestrian Crossing	No PHB or HAWK at Mid-Block Crossing	CMF ID: 9021
	Install Raised Pedestrian Crossing	ALL	-	0.64	0.64	0.64	0.7	0.7	20	-	Pedestrian Crossing	At-Grade Pedestrian Crossing	PED CMF Toolbox
	Prohibit Left Turns	VP	-	0.9	0.9	0.9	0.9	0.9	6	-	Intersection with Left Turns into Pedestrian Crossings	Left Turns Allowed	Ped CMF Toolbox
	Remove Parking Near Intersection	VP	-	0.7	0.7	0.7	0.7	0.7	Δ	-	Intersection with Parking on Approaches	Parking Present Near Intersection Approaches	PED CMF Toolbox
	Upgrade Crosswalk to High-Visibility	VP	-	0.52	0.52	0.52	0.52	0.6	2	-	Pedestrian Crosswalk	Standard Crosswalk Markings	CMF ID: 298, 4123
	Widen Sidewalk at Intersection	ALL	-	1	1.12	1.12	1	1.04	20	-	Intersection with Sidewalks	Existing Sidewalk Width	CMF ID: 413
INTERCHANGE	Add Auxiliary Lane Between Entrance and Exit Ramps	ALL	-	0.77	0.77	0.77	0.79	0.79	20	Principal Arterial- Other Freeways and Expressways	Freeway Interchange Weaving Area	No Auxiliary Lane Present	CMF ID: 7440, 7441
	Add Collector-Distributor Road	ALL	-	0.9	0.9	0.9	0.9	0.9	20	-	Freeway Interchange Area	No Collector-Distributor Road Present	ISATe, HSM Chapters 18 and 19
	Add Entrance Ramp to One Side of Freeway	ALL	-	▲	▲	▲	▲	▲	20	-	Directional Freeway Segment	Freeway Segment with No Entrance Ramp	ISATe, HSM Chapters 18 and 19
	Add Exit Ramp to One Side of Freeway	ALL	-	▲	▲	▲	▲	▲	20	-	Directional Freeway Segment	Freeway Segment with No Exit Ramp	ISATe, HSM Chapters 18 and 19
	Convert Diamond Interchange to Diverging Diamond Interchange	ALL	Sub	0.59	0.59	0.59	0.67	0.67	20	Principal Arterial - Interstate	Diamond Interchange	Traditional Diamond Interchange	CMF ID: 8258, 8278
	Convert Diamond Interchange to SPUI	ALL	-	0.62	0.62	0.62	0.62	0.62	20	-	Diamond Interchange	Traditional Diamond Interchange	VDOT Planning Level CMFs, ISATe
	Extend Deceleration Lane Length by 100 Feet	ALL	-	0.93	0.93	0.93	0.93	0.93	20	-	Freeway Segment with Deceleration Lane	Existing Deceleration Lane Length	CMD ID: 475
	Interchange Lighting	Night Time	-	0.5	0.5	0.5	0.5	0.5	15	Principal Arterial - Interstate	Freeway Interchange	No Highway Lighting Present	CMF ID: 1283

Table 1 Virginia State Preferred CMF List (cont)

	COUNTERMEASURE	CRASH TYPE	AREA TYPE	K	A	BC	O	ALL SEVERITIES	SERVICE LIFE	FUNCTIONAL CLASS	SITE DESCRIPTION	PRIOR CONDITION	REFERENCE
INTERCHANGE	Lengthen Acceleration Lane from X Miles to Y Miles	ALL	-	**	**	**	**	**	20	Principal Arterial - Interstate	Freeway Segment with Acceleration Lane	Existing Acceleration Lane of Length X Miles	CMF ID: 5215, 5216
	Replace Loop Ramp with Short Direct Ramp	ALL	-	0.7	0.7	0.7	0.7	0.7	20	-	Interchange Ramp	Existing Loop Ramp	CMF ID: 480
	Widen Ramp Lane Width from X to Y in Feet	ALL	-	**	**	**	1	**	20	Freeway Ramp	Freeway Ramp	Existing Ramp Lane Width of X Feet	HSM Eqn 19-34
	Widen Ramp Left Shoulder	ALL	-	**	**	**	**	**	20	Freeway Ramp	Freeway Ramp	Existing Left-Shoulder Width of X Feet	HSM Eqn 19-36
	Widen Ramp Right Shoulder	ALL	-	**	**	**	**	**	20	Freeway Ramp	Freeway Ramp	Existing Right-Shoulder Width of X Feet	HSM Eqn 19-35
INTERSECTION	Install Intersection Lighting	Night Time	ALL	0.881	0.881	0.881	0.881	0.881	15	-	Intersection	No Lighting Present	CMF ID: 4462
	Increase Stopping Sight Distance on Crest Vertical Curve-Intersection Approach	ALL	Rural	0.62	0.62	0.62	0.70	0.7	20	-	Intersection Approach with Crest Vertical Curve	Crest Vertical Curve with Inadequate Sight Distance	CMF ID: 6870, 6871
	Add Flashing Lights to Railroad (RR) Crossings with Signs	VT	-	0.23	0.23	0.23	0.23	0.23	10	-	RR Grade Crossing	RR Grade Crossing with Static Warning Signs	CMF ID: 487
	Add Gates to RR Crossings with Signs	VT	-	0.06	0.06	0.06	0.06	0.06	10	Minor Arterial	RR Grade Crossing	RR Grade Crossing with Static Warning Signs	CMF ID: 489
	Adaptive Signal Control	ALL	U+S	0.92	0.92	0.92	0.83	0.83	20	-	Signalized Intersection	Non-Adaptive Traffic Signal	CMF ID: 6856, 6857
	Add 3-Inch Yellow Retroreflective Sheeting to Signal Backplates	ALL	Urban	0.85	0.85	0.85	0.85	0.85	6	-	Signalized Intersection	No Backplates Present	CMF ID: 1410
	Advanced Activated/Dynamic Flasher	ALL	-	0.82	0.82	0.82	0.814	0.814	6	-	Signalized Intersection	Signalized Intersection with No Advance Warning System	CMF ID: 4198, 4201
	Advanced Cross Street Name Sign	ALL	-	0.99	0.99	0.99	0.984	0.984	6	-	Signalized Intersection	Signalized Intersection with No Advanced Street Sign	CMF ID: 2449, 2450
	Advanced Dilemma Zone Detection	ALL	Rural	0.918	0.887	0.887	0.918	0.918	20	-	High Speed Signalized Intersection	No Dilemma Zone Warning System	CMF ID: 4855, 4857
Change from Permissive Left-Turn to Flashing Yellow Arrow	Left Turn	Urban	0.635	0.635	0.635	0.635	0.635	20	-	Signalized Intersection	Permissive Left-Turn Phasing	CMF ID: 4175	

Table 1 Virginia State Preferred CMF List (cont)

	COUNTERMEASURE	CRASH TYPE	AREA TYPE	K	A	BC	O	ALL SEVERITIES	SERVICE LIFE	FUNCTIONAL CLASS	SITE DESCRIPTION	PRIOR CONDITION	REFERENCE
INTERSECTION	Change from Permitted Left-Turn to Permitted/Protected	Left Turn	Urban	0.862	0.862	0.862	0.862	0.862	20	-	Signalized Intersection	Permissive Left-Turn Phasing	CMF ID: 4270
	Change from Permitted Left-Turn to Protected on Major Approach	Angle	Urban	0.01	0.01	0.01	0.01	0.01	20	-	Signalized Intersection	Permissive Left-Turn Phasing on a Major Approach	CMF ID: 335
	Change from Permitted/Protected Left-Turn to Protected on Major Approach	Angle	Urban	0.01	0.01	0.01	0.01	0.01	20	-	Signalized Intersection	Protected/Permissive or Vice-Versa Left-Turn Phasing on a Major Approach	CMF ID: 339
	Change from Permitted/Protected Left-Turn to Protected on Minor Approach	Angle	Urban	0.04	0.04	0.04	0.04	0.04	20	-	Signalized Intersection	Protected/Permissive or Vice-Versa Left-Turn Phasing on a Minor Approach	CMF ID: 337
	Change from Pretimed Signal to Actuated Signal	ALL	-	0.8	0.8	0.8	0.8	0.9	20	-	Signalized Intersection	Pretimed Signal Control	NCDOT CRF List 1.6
	Change from Protected Left-Turn to Flashing Yellow Arrow	Left Turn	Urban	2.242	2.242	2.242	2.242	2.242	20	-	Signalized Intersection	Protected Left-Turn Phasing	CMF ID: 4173
	Change from Protected/Permissive Left-Turn to Flashing Yellow Arrow	Left Turn	Urban	0.806	0.806	0.806	0.806	0.806	20	-	Signalized Intersection	Protected/Permissive Left-Turn Phasing	CMF ID: 4177
	Change Number of Approaches with Left-Turn Lanes from X Approaches to Y Approaches	ALL	ALL	**	**	**	**	**	20	-	Signalized Intersection	Left-Turn Lanes on X Number of Approaches	HSM
	Change Number of Approaches with Prohibited Right Turn on Red from X Approaches to Y Approaches	ALL	-	**	**	**	**	**	20	-	Signalized Intersection	Right Turn on Red Permitted on X Number of Approaches	CMF ID: 5194
	Change Number of Approaches with Right-Turn Lanes from X Approaches to Y Approaches	ALL	-	**	**	**	**	**	20	-	Signalized Intersection	Right-Turn Lanes on X Number of Approaches	HSM Table 10-14, 12-26
Change Number of Cycles per Hour from X Cycles per Hour to Y Cycles per Hour	Rear End	U+S	**	**	**	**	**	20	20	Arterial	Signalized Intersection	X Cycles per Hour	CMF ID: 3072

Table 1 Virginia State Preferred CMF List (cont)

	COUNTERMEASURE	CRASH TYPE	AREA TYPE	K	A	BC	O	ALL SEVERITIES	SERVICE LIFE	FUNCTIONAL CLASS	SITE DESCRIPTION	PRIOR CONDITION	REFERENCE
INTERSECTION	Channelize Right Turn	ALL	-	0.65	0.65	0.65	1	0.88	20	-	Signalized Intersection	No Right-Turn Channelization	FHWA CMF Desktop Reference Guide
	Closed Loop Signal System	ALL	-	0.85	0.85	0.85	0.85	0.85	20	-	Signalized Intersection	Signal System that is Not Closed Loop	NCDOT CRF List 1.7
	Convert from Pedestal-Mounted Traffic Signal to Mast Arm-Mounted Traffic Signal	ALL	Urban	0.56	0.56	0.56	0.49	0.51	20	-	Signalized Intersection	Pedestal-Mounted Signal	CMF ID: 1424, 1425
	Convert from Span Wire-Mounted Traffic Signal to Mast Arm-Mounted Traffic Signal	ALL	ALL	0.98	0.98	0.98	0.97	0.97	20	-	Signalized Intersection	Span Wire-Mounted Signal	UVA Khattak and Fontaine Study
	Convert to LED Signal Heads - 3-Leg Intersection	ALL	-	1.41	1.41	1.41	0.929	0.929	20	-	3-Leg Signalized Intersection	Incandescent Signal Bulbs	UVA CMF
	Convert to LED Signal Heads - 4-Leg Intersection	ALL	-	0.986	0.986	0.986	0.932	0.932	20	-	4-Leg Signalized Intersection	Incandescent Signal Bulbs	UVA CMF
	Extend Left-Turn Lane	ALL	-	0.85	0.85	0.85	1	0.95	20	-	Signalized Intersection	Existing Turn-Lane Length	FHWA Desktop Reference
	Extend Right-Turn Lane	ALL	-	0.85	0.85	0.85	1	0.95	20	-	Signalized Intersection	Existing Turn-Lane Length	FHWA Desktop Reference
	Increase All-Red Clearance Interval	ALL	Urban	0.863	0.863	0.863	0.798	0.798	20	-	Signalized Intersection	Short All-Red Clearance Interval	CMF ID: 4211, 4212
	Increase Left-Turn Lane Offset	ALL	-	0.644	0.644	0.644	0.662	0.662	20	-	Signalized Intersection	Zero or Negative Left-Turn Lane Offset	CMF ID: 6095, 6096
	Increase Yellow Change Interval by 1 Second	ALL	Urban	1.07	1.07	1.07	1.14	1.14	20	-	Signalized Intersection	Existing Yellow Interval	CMF ID:4207, 4208
	Install Red-Light Camera	ALL	U+S	0.676	0.676	0.676	1.014	0.916	20	-	Signalized Intersection	No Red-Light Camera Present	CMF ID: 6876, 6877
	Offset Right-Turn Lane	N/A	-	1	1	1	1	1	20	-	Signalized Intersection	No Offset for Right-Turn Lane	N/A
	Permit Right Turn on Red	ALL	-	1.07	1.07	1.07	1.07	1.07	20	-	Signalized Intersection	Right Turn on Red Prohibited	CMF ID: 4580
Replace 8-inch Signal Heads with 12-inch Signal Heads	ALL	U+S	0.97	0.97	0.97	0.97	0.97	20	-	Signalized Intersection	8-inch Signal Heads	CMF ID: 2334	

Table 1 Virginia State Preferred CMF List (cont)

	COUNTERMEASURE	CRASH TYPE	AREA TYPE	K	A	BC	O	ALL SEVERITIES	SERVICE LIFE	FUNCTIONAL CLASS	SITE DESCRIPTION	PRIOR CONDITION	REFERENCE	
INTERSECTION	Retroreflective Backplates and LED Signal Heads	Night Time	-	0.65	0.65	0.65	0.74	0.74	20	-	Signalized Intersections	No Retroreflective Backplates and Non-LED Signal Heads	UVA CMF	
	Add Left-Turn Lane to Major Approach of 3-Leg Stop-Controlled Intersection	ALL	-	0.56	0.56	0.56	0.56	0.56	20	-	3-Leg Stop-Controlled Intersection	Left-Turn Lanes on X Number of Approaches	HSM Table 11-22	
	Change Number of Uncontrolled Approaches with Left-Turn Lanes from X Approaches to Y Approaches at 4-Leg Intersection	ALL	-	**	**	**	**	**	20	-	4-Leg Stop-Controlled Intersection	Left-Turn Lanes on X Number of Approaches	HSM Table 10-13	
	Change Number of Uncontrolled Approaches with Right-Turn Lanes from X to Y at Intersection of Rural, Multilane Highway	ALL	Rural	**	**	**	**	**	20	-	Stop-Controlled Intersection - Rural Multilane Highway	Right-Turn Lanes on X Number of Approaches	HSM Table 11-23	
	Change Number of Uncontrolled Approaches with Right-Turn Lanes from X to Y at Intersection of Rural, Two-Lane Roads	ALL	Rural	**	**	**	**	**	20	-	Stop-Controlled Intersection - Rural Two-Lane Road	Right-Turn Lanes on X Number of Approaches	HSM Table 10-14	
	Change Number of Uncontrolled Approaches with Right-Turn Lanes from X to Y at Urban or Suburban Arterial Intersection	ALL	U+S	**	**	**	**	**	20	-	Stop-Controlled Intersection - Urban and Suburban Arterial	Right-Turn Lanes on X Number of Approaches	HSM Table 12-26	
	High-Friction Surface Treatment on Approach	ALL	-	0.799	0.799	0.799	0.799	0.799	10	-	Stop-Controlled Intersection Approach	Standard Pavement on Intersection Approach	CMF ID: 2259	
	Increase Intersection Sight Distance from X Feet of Available Sight Distance to Y Feet	Angle & Left Turn	-	**	**	**	**	**	**	10	-	Stop-Controlled Intersection Approach	Intersection Sight Distance of X Feet	NCHRP 17-59, Report 875
	Intersection Collision Warning System	ALL	-	0.742	0.742	0.742	0.704	0.704	6	-	Stop-Controlled Intersection	No Collision Warning System Present	CMF ID: 8474, 8475	
	Reduce Intersection Skew from X to Y - 3-Leg Intersection	ALL	Rural	**	**	**	**	**	**	20	-	3-Leg Stop-Controlled Intersection	Intersection Skew Angle of X Degrees	HSM Equation: 10-22
Reduce Intersection Skew from X to Y - 4-Leg Intersection	ALL	Rural	**	**	**	**	**	**	20	-	4-Leg Stop-Controlled Intersection	Intersection Skew Angle of X Degrees	HSM Equation: 10-23	

Table 1 Virginia State Preferred CMF List (cont)

	COUNTERMEASURE	CRASH TYPE	AREA TYPE	K	A	BC	O	ALL SEVERITIES	SERVICE LIFE	FUNCTIONAL CLASS	SITE DESCRIPTION	PRIOR CONDITION	REFERENCE
INTERSECTION	Systemic Signage and Pavement Marking Improvements	ALL	-	0.899	0.899	0.899	0.917	0.917	6	-	Stop-Controlled Intersection	Stop-Controlled Intersection with No Supplemental Signage	FHWA Proven Safety Countermeasures, CMF ID: 8867, 8866
	Transverse Rumble Strips	ALL	Rural	0.987	0.987	0.987	1.191	1.118	10	Minor Arterial	Stop-Controlled Intersection Approach	No Transverse Rumble Strips Present	CMF ID: 2707, 2708, 2706
	Add Quadrant Roadway to Intersection	N/A	-	-	-	-	-	-	20	-	Conventional Intersection	Conventional Intersection	N/A
	Convert 3-Leg Signalized Intersection to Continuous Green T-Intersection	ALL	-	0.846	0.846	0.846	0.958	0.958	20	-	3-Leg Signalized Intersection	Standard 3-Leg Signalized Intersection	CMF ID: 8655, 8656
	Convert At-Grade Intersection to Interchange	ALL	-	0.58	0.43	0.43	0.64	0.58	20	-	4-Leg Intersection	At-Grade Intersection	CMF ID: 459, 460, 461
	Convert 4-Leg Intersection to Two Offset T-Intersections	ALL	Urban	0.75	0.75	0.75	1	1	20	-	4-Leg Stop-Controlled Intersection	4-Leg Stop-Controlled Intersection	HSM CMF: Table 14-2
	Convert Minor Stop-Control to All-Way Stop Control	ALL	ALL	0.23	0.23	0.23	0.319	0.319	20	-	Minor Stop-Controlled Intersection	Stop-Control on Minor Approaches	CMF ID: 3127, 3128
	Convert Signalized Intersection to Roundabout	ALL	-	0.52	0.22	0.22	0.52	0.52	20	-	Signalized Intersection	Signalized Intersection	CMF ID: 225, 226
	Convert Stop-Controlled Intersection to Roundabout	ALL	ALL	0.56	0.18	0.18	0.56	0.56	20	-	Stop-Controlled Intersection	Minor Stop-Controlled Intersection	CMF ID: 227, 228
	Convert Stop-Controlled Intersection to Signalized Intersection	ALL	ALL	0.642	0.642	0.642	0.639	0.639	20	-	Stop-Controlled Intersection	Minor Stop-Controlled Intersection	CMF ID: 7983, 7986
	Convert to Displaced Left-Turn Intersection	ALL	-	0.81	0.81	0.81	0.76	1.11	20	-	High-Speed Intersection	Traditional Intersection	FHWA TechBrief; CMF ID: 10889
	Convert to J-Turn Intersection	ALL	Rural	0.652	0.463	0.463	0.652	0.63	20	Principal Arterial-Other	High-Speed Intersection	At-Grade Minor Stop-Controlled Intersection	CMF ID: 5555, 5556
	Convert to Median U-Turn Intersection	ALL	-	0.70	0.70	0.70	0.91	0.63	20	Arterial	High-Speed Intersection	Conventional Signalized Intersection	FHWA TechBrief; CMF ID: 10851
	Convert to Signalized Intersection to Signalized RCUT	ALL	-	0.78	0.78	0.78	0.85	0.85	20	-	High-Speed Signalized Intersection	Conventional Signalized Intersection	FHWA Report
Convert to Signalized Intersection to Unsignalized RCUT	N/A	-	-	-	-	-	-	20	-	High-Speed Signalized Intersection	Signalized Intersection	N/A	

Table 1 Virginia State Preferred CMF List (cont)

	COUNTERMEASURE	CRASH TYPE	AREA TYPE	K	A	BC	O	ALL SEVERITIES	SERVICE LIFE	FUNCTIONAL CLASS	SITE DESCRIPTION	PRIOR CONDITION	REFERENCE
INTERSECTION	Convert to Unsignalized Intersection to Unsignalized RCUT	ALL	Rural	0.37	0.37	0.37	0.54	0.54	20	Principal Arterial-Other	High-Speed Stop-Controlled Intersection	Conventional Unsignalized Intersection	CMF ID: 4883, 4884
	Convert Two Offset T-Intersection, Offset by X Miles, to T-Intersections with Major Road AADT	ALL	Rural	**	**	**	**	**	20	-	Offset T-Intersections	T-Intersections Offset by X Miles	HSM Eqn 10-17
	Convert Unsignalized Intersection to Unsignalized Superstreet Intersection	ALL	Rural	0.37	0.37	0.37	0.54	0.54	20	Principal Arterial-Other	High-Speed Stop-Controlled Intersection	Stop-Control on Minor Approaches	CMF ID: 4883, 4884
	Install Interim Roundabout	ALL	ALL	0.23	0.23	0.23	0.319	0.319	5	-	Stop-Controlled Intersection	Stop-Control on Minor Approaches	CMF ID: 3127, 3128
	Remove Unwarranted Signal	ALL	U	0.76	0.76	0.76	0.76	0.76	20	Minor Arterial, Collectors	Signalized Intersection of One-Way Streets	Unwarranted Traffic Signal	CMF ID: 332
	Install Temporary Traffic Circle	N/A	-	-	-	-	-	-	2	-	Unsignalized Intersection	No Control, Yield Control, or Stop Controlled	N/A
SEGMENTS (FREEWAY)	Active Traffic Management with Hard Shoulder Running	ALL	-	0.69	0.69	0.69	0.75	0.75	20	Principal Arterial - Interstate	Freeway Segment	No Active Traffic Management or Hard Shoulder Running	UVA CMF
	Active Traffic Management without Hard Shoulder Running	ALL	-	1.18	1.18	1.18	1.16	1.16	20	Principal Arterial - Interstate	Freeway Segment	No Active Traffic Management	UVA CMF
	Add Cable Median Barrier	CM,F, O, HO	Rural	0.09	0.09	0.09	0.09	0.09	15	Principal Arterial - Interstate	Freeway Segment with Traversable Median	No Median Barrier Present	CMF ID: 1966
	Add Rumble Strips to Inside Shoulder	SV	-	0.811	0.811	0.811	1	1	10	Principal Arterial - Intersectate	Freeway Segment	No Rumble Strips Present on Inside Shoulder	HSM Eqn 18-36
	Add Median Concrete Barrier	CM,F, O,HO	Rural	0	0	0	0	0	15	Principal Arterial - Other Freeways and Expressways	Freeway Segment	No Median Barrier Present	CMF ID: 2256
	Add Median Guardrail	CM	-	0.22	0.22	0.22	0.22	0.22	15	Principal Arterial - Other Freeways and Expressways	Freeway Segment	No Median Barrier Present	CMF ID: 51

Table 1 Virginia State Preferred CMF List (cont)

	COUNTERMEASURE	CRASH TYPE	AREA TYPE	K	A	BC	O	ALL SEVERITIES	SERVICE LIFE	FUNCTIONAL CLASS	SITE DESCRIPTION	PRIOR CONDITION	REFERENCE
SEGMENTS (FREEWAY)	Add Rumble Strips to Outside Shoulder	SV	-	0.811	0.811	0.811	1	1	10	Principal Arterial - Intersectate	Freeway Segment	No Rumble Strips Present on Outside Shoulder	HSM Eqn 18-36
	Add Raised Pavement Markers	ALL	Rural	0.87	0.87	0.87	0.87	0.87	2	Principal Arterial - Other Freeways and Expressways	Freeway Segment	No Raised Pavement Markers Present	CMF ID: 5498
	Add Roadside Guardrail	ALL	-	0.84	0.84	0.99	1.06	1.06	15	Principal Arterial - Other Freeways and Expressways	Freeway Segment	No Roadside Barrier Present	CMF ID: 8391, 8392, 8393
	Implement Incident Management to Reduce Incident Duration Time	SC	-	0.85	0.85	0.85	0.85	0.85	6	Principal Arterial - Interstate	Freeway Segment	No Incident Management Program	VA Planning Level CMFs
	Implement Variable Speed Limits	ALL	Urban	0.71	0.71	0.71	0.75	0.71	6	Principal Arterial - Interstate	Freeway Segment	Static Posted Speed Limit	CMF ID: 8730, 8731
	Rural: Widen from 4 Lanes to 6 Lanes	ALL	Rural	0.7	0.7	0.7	0.7	0.7	20	-	Rural Freeway Segment	4-Lane Cross-Section	VDOT SPFs, Crash Rate Ratios
	Upgrade Horizontal Curve Signage	ALL	Rural	0.75	0.75	0.75	0.82	0.82	6	-	Freeway Horizontal Curve Segment	No Horizontal Curve Signs or Dirty Signs with No Retroreflectivity	CMF ID: 2431, 2433
	Upgrade Pavement Markings to Wet-Reflective Pavement Markings	ALL	-	0.881	0.881	0.881	1.032	1.032	2	Principal Arterial - Other Freeways and Expressways	Freeway Segment	Standard Pavement Markings	CMF ID: 8093, 8134
	Upgrade Roadside Guardrail	ALL	-	0.95	0.95	0.95	0.95	0.95	10	-	Freeway Segment with Roadside Guardrail	Damaged or Below Standard Guardrail	Desktop Reference Guide
	Urban: Widen from 4 Lanes to 6 Lanes	ALL	Urban	0.9	0.9	0.9	0.9	0.9	20	-	Urban Freeway Segment	4-Lane Cross-Section	VDOT SPFs, Crash Rate Ratios
	Urban: Widen from 4 Lanes to 8+ Lanes	ALL	Urban	0.75	0.75	0.75	0.75	0.75	20	-	Urban Freeway Segment	4-Lane Cross-Section	VDOT SPFs, Crash Rate Ratios
Urban: Widen from 6 Lanes to 8+ Lanes	ALL	Urban	0.8	0.8	0.8	0.8	0.8	20	-	Urban Freeway Segment	6-Lane Cross-Section	VDOT SPFs, Crash Rate Ratios	

Table 1 Virginia State Preferred CMF List (cont)

	COUNTERMEASURE	CRASH TYPE	AREA TYPE	K	A	BC	O	ALL SEVERITIES	SERVICE LIFE	FUNCTIONAL CLASS	SITE DESCRIPTION	PRIOR CONDITION	REFERENCE
SEGMENTS (FREEWAY)	Widen Clear Zone from X Feet to Y Feet	SV	-	**	**	**	1	**	20	-	Freeway Segment	Clear Zone Width of X Feet	HSM Eqn 18-38
	Widen Median from X Feet to Y Feet	ALL	-	**	**	**	**	**	20	-	Freeway Segment	Median Width of X Feet	HSM Equation 18-27
	Widen Paved Inside Shoulder from X Feet to Y Feet	ALL	-	**	**	**	**	**	20	-	Freeway Segment	Inside Shoulder Width of X Feet	HSM Eqn 18-26
	Widen Paved Outside Shoulder on Horizontal Curve from X Feet to Y Feet	SV	-	**	**	**	**	**	20	-	Freeway Horizontal Curve Segment	Outside Shoulder Width of X Feet	HSM Eqn 18-35 and Table 18-21
	Widen Paved Outside Shoulder on Horizontal Tangent from X Feet to Y Feet	SV	-	**	**	**	1	**	20	-	Freeway Horizontal Tangent Segment	Outside Shoulder Width of X Feet	HSM Eqn 18-35 and Table 18-21
SEGMENTS (NON-FREEWAY)	Add Automated Speed Enforcement Cameras	ALL	-	0.83	0.83	0.83	0.84	0.84	6	-	Non-Freeway Segment	No Automated Speed Enforcement Present	CMF ID: 2688, 4583
	Add Auxiliary Passing Lane	ALL	Rural	0.67	0.67	0.67	0.58	0.58	20	-	Rural Two-Lane Undivided Highway	No Passing Lanes Present	CMF ID: 9111, 9112
	Add Centerline Rumble Strips (Including Sinusoidal/ Mumble)	HO, O	Rural	0.55	0.55	0.55	0.63	0.63	10	-	Non-Freeway Segment	No Centerline Rumble Strips Present	CMF ID: 3355, 3360
	Add Chevron Signs at Horizontal Curves	Night Time	Rural	0.75	0.75	0.75	0.75	0.75	6	-	Small Radius Horizontal Curve on Rural Two-Lane Undivided Highway	No Chevrons Present	CMF ID: 2439
	Add Chevron Signs, Curve Warning Signs, and Sequential Flashing Beacons	Night Time	-	0.592	0.592	0.592	0.592	0.592	6	-	Horizontal Curve on Multilane Highway	No Curve Delineation Treatment Present	CMF ID: 1852
	Add Raised Pavement Markers	ALL	Rural	0.81	0.81	0.81	0.81	0.81	2	Principal Arterial - Other Freeways and Expressways	Non-Freeway Segment	No Raised Pavement Markers Present	CMF ID: 5496
Add Safety Edge	Run Off Road	Rural	0.79	0.79	0.79	0.79	0.79	15	Principal Arterial - Other	Two-Lane Undivided Rural Highway	No Safety Edge Present	FHWA Proven Safety Countermeasures	

Table 1 Virginia State Preferred CMF List (cont)

	COUNTERMEASURE	CRASH TYPE	AREA TYPE	K	A	BC	O	ALL SEVERITIES	SERVICE LIFE	FUNCTIONAL CLASS	SITE DESCRIPTION	PRIOR CONDITION	REFERENCE
SEGMENTS (NON-FREEWAY)	Add Segment Lighting	Night Time	Urban	0.68	0.68	0.68	0.76	0.74	15	Minor Arterial	Non-Freeway Segment	No Lighting Present	CMF ID: 7781, 7782, 7783
	Add Shoulder Rumble Strips (Including Sinusoidal/ Mumble)	Run Off Road-right	Rural	0.83	0.83	0.83	0.84	0.84	10	-	Non-Freeway Segment	No Shoulder Rumble Strips Present	CMF ID: 3442, 3447
	Add Two-Way Left-Turn Lane (2U to 3T)	ALL	-	0.739	0.739	0.739	0.797	0.797	20	-	Two-Lane Undivided Highway	No TWLTL Present	CMF ID: 2341, 2346
	Add Two-Way Left-Turn Lane (4U to 5T)	ALL	Urban	0.45	0.45	0.45	0.45	0.45	20	-	Four-Lane Undivided Highway	No TWLTL Present	CMF ID: 4084
	Breakaway Supports for Utility Poles in Clear Zones	ALL	Rural	0.94	0.94	0.94	1.00	1	10	-	Non-Freeway Segment	Non-Breakaway Supports	HSM Eqn 10-20
	Change 4" Wide Edgelines to 6" Wide Edgelines	ALL	Rural	0.635	0.635	0.635	0.877	0.825	2	-	Rural Two-Lane Highway	4" Edgelines	CMF ID: 4737, 4738, 4736
	Change Driveway Density (Driveways/Mile) from X to Y	ALL	Rural	**	**	**	**	**	20	Principal Arterial - Other	Rural Non-Freeway Segment	Driveway Density of X Driveways per Mile	CMF ID: 1973, 2248
	Change Roadside Hazard Rating from X to Y by Flattening Roadside Slope	ALL	Rural	**	**	**	**	**	20	-	Two-Lane Undivided Highway	Roadside Hazard Rating of X	HSM Eqn 10-20
	Change Superelevation Variance from X to Y (if Variance Between 0.01 and 0.02)	ALL	Rural	**	**	**	**	**	20	-	Horizontal Curve on Two-Lane Undivided Highway	Superelevation Deficiency of X Feet per Foot in Decimal	HSM Eqn 10-15
	Change Superelevation Variance from X to Y (if Variance Greater than 0.02)	ALL	Rural	**	**	**	**	**	20	-	Horizontal Curve on Two-Lane Undivided Highway	Superelevation Deficiency of X Feet per Foot in Decimal	HSM Eqn 10-16
	Dynamic Speed Feedback Signs	ALL	Rural	0.95	0.95	0.95	0.95	0.95	6	-	Two-Lane Undivided Highway	No Dynamic Speed Feedback Sign Present	CMF ID: 6885
	Flatten Horizontal Curve	ALL	Rural	▲	▲	▲	▲	0.315	20	-	Horizontal Curve on Two-Lane Undivided Highway	Please use the Existing Horizontal Curve Geometry Tab to Calculate the CMFs	CMF ID: 9271, 9272, 9525
	Implement High-Friction Surface Treatment on Horizontal Curve	ALL	-	0.759	0.759	0.759	0.759	0.759	10	-	Horizontal Curve on Non-Freeway Segment	Horizontal Curve with Standard Pavement	CMF ID: 7900
Increase Stopping Sight Distance on Crest Vertical Curve	ALL	Rural	0.76	0.76	0.76	0.82	0.7	20	-	Crest Vertical Curve on Two-Lane Highway	Crest Vertical Curve with Inadequate Sight Distance	CMF ID: 6868, 6869, 6870	

Table 1 Virginia State Preferred CMF List (cont)

	COUNTERMEASURE	CRASH TYPE	AREA TYPE	K	A	BC	O	ALL SEVERITIES	SERVICE LIFE	FUNCTIONAL CLASS	SITE DESCRIPTION	PRIOR CONDITION	REFERENCE
SEGMENTS (NON-FREEWAY)	Pave Unpaved Shoulder	ALL	Rural	0.97	0.97	0.97	0.97	0.97	20	-	Two-Lane Undivided Rural Highway	Unpaved Shoulder	HSM Eqn 10-12, Table 10-9 and 10-10
	Pavement Resurfacing - Rural	ALL	Rural	1.03	1.03	1.03	1.03	1.03	10	-	Two-Lane Undivided Highway	Old Pavement	CMF ID: 5626
	Pavement Resurfacing - Urban	ALL	Urban	0.894	0.894	0.894	0.929	0.929	10	Principal Arterial - Other	Non-Freeway Segment	Old Pavement	CMF ID: 9289, 9290
	Prohibit On-Street Parking	ALL	Urban	0.78	0.78	0.78	0.72	0.74	20	Principal Arterial - Other	Urban Arterial with Street Parking	On-Street Parking Allowed	CMF ID: 4574, 4575
	Remove or Relocate Fixed Object Outside of Clear Zone	CFO	-	0.62	0.62	0.62	0.62	0.62	20	-	Non-Freeway Segment	Fixed Object within Clear Zone	CMF ID: 1024, 1044
	Road Diet (4U to 3T)	ALL	Urban	0.71	0.71	0.71	0.71	0.71	20	Minor Arterial	4-Lane Undivided Highway	4-Lane Cross-Section	CMF ID: 199
	Upgrade Chevrons with Fluorescent Sheeting	Night time	Rural	0.65	0.65	0.65	0.65	0.65	6	-	Horizontal Curve on Rural Two-Lane Undivided Highway	No Signs Present, Signs with No Fluorescent Sheeting, or Dirty Signs Present	CMF ID: 2434
	Upgrade Pavement Markings by Increasing Retroreflectivity	Night time	-	0.81	0.81	0.81	0.81	0.81	2	-	Non-Freeway Segment	Edgeline, Centerline, and Skip Line Pavement Markings with Low Retroreflectivity	CMF ID: 2116, 2117, 2120
	Upgrade Pavement Markings to Wet-Reflective Pavement Markings	ALL	-	0.881	0.881	0.881	1.032	1.032	2	Principal Arterial - Other Freeways and Expressways	Non-Freeway Segment	Traditional Pavement Markings	CMF ID: 8093, 8134
	Widen Clear Zone	ALL	Rural	0.78	0.78	0.78	0.78	0.78	20	-	Rural Two-Lane Highway	Rural Two-Lane Highway with Narrow Clear Zone	CMF ID: 35
Widen Lane	ALL	Rural	0.87	0.87	0.87	0.87	0.87	20	-	Two-Lane Undivided Highway	Narrow Lane Width	HSM Table 10-8, Eqn 10-11	
Widen Average Shoulder Width	HO, CFO, O, S	Rural	▲	▲	▲	▲	▲	▲	20	-	Two-Lane Undivided Highway	Existing Shoulder Width	HSM Table 10-9

Table 2 CMFunction Equations

	COUNTERMEASURE	K	A	BC	O	ALL SEVERITIES	UNITS
INTERCHANGE	Lengthen Acceleration Lane from X Miles to Y Miles	$e^{-4.55*[Y-X]}$	$e^{-4.55*[Y-X]}$	$e^{-4.55*[Y-X]}$	$e^{-2.59*[Y-X]}$	$e^{-2.59*[Y-X]}$	Miles
	Widen Ramp Lane Width from X to Y in Feet	$e^{0.0458*[X-Y]}$	$e^{0.0458*[X-Y]}$	$e^{0.0458*[X-Y]}$	1	$0.294146 * e^{0.0458*[X-Y]} + 0.705854 *$	Feet
	Widen Ramp Left Shoulder X Feet to Y Feet	$e^{0.0539*[X-Y]}$	$e^{0.0539*[X-Y]}$	$e^{0.0539*[X-Y]}$	$e^{0.0259*[X-Y]}$	$0.294146 * e^{0.0539*[X-Y]} + 0.705854 * e^{0.0259*[X-Y]}$	Feet
	Widen Ramp Right Shoulder X Feet to Y Feet	$e^{0.0539*[X-Y]}$	$e^{0.0539*[X-Y]}$	$e^{0.0539*[X-Y]}$	$e^{0.0259*[X-Y]}$	$0.294146 * e^{0.0539*[X-Y]} + 0.705854 * e^{0.0259*[X-Y]}$	Feet
INTERSECTION	Change Number of Approaches with Left-Turn Lanes from X Approaches to Y Approaches	0.90^{Y-X}	0.90^{Y-X}	0.90^{Y-X}	0.90^{Y-X}	0.90^{Y-X}	Approaches
	Change Number of Approaches with Prohibited Right Turn on Red from X Approaches to Y Approaches	0.98^{Y-X}	0.98^{Y-X}	0.98^{Y-X}	0.98^{Y-X}	0.98^{Y-X}	Approaches
	Change Number of Approaches with Right-Turn Lanes from X Approaches to Y Approaches	0.96^{Y-X}	0.96^{Y-X}	0.96^{Y-X}	0.96^{Y-X}	0.96^{Y-X}	Approaches
	Change Number of Cycles per Hour from X Cycles per Hour to Y Cycles per Hour	$e^{-0.0444*[Y-X]}$	$e^{-0.0444*[Y-X]}$	$e^{-0.0444*[Y-X]}$	$e^{-0.0444*[Y-X]}$	$e^{-0.0444*[Y-X]}$	Cycles per Hour
	Change Number of Uncontrolled Approaches with Left-Turn Lanes from X Approaches to Y Approaches at 4-Leg Intersection	0.72^{Y-X}	0.72^{Y-X}	0.72^{Y-X}	0.72^{Y-X}	0.72^{Y-X}	Approaches
	Change Number of Uncontrolled Approaches with Right-Turn Lanes from X to Y at Intersection of Rural, Multilane Highway	0.77^{Y-X}	0.77^{Y-X}	0.77^{Y-X}	0.86^{Y-X}	$0.379 * 0.77^{Y-X} + 0.621 * 0.86^{Y-X}$	Approaches
	Change Number of Uncontrolled Approaches with Right-Turn Lanes from X to Y at Intersection of Rural, Two-Lane Roads	0.86^{Y-X}	0.86^{Y-X}	0.86^{Y-X}	0.86^{Y-X}	0.86^{Y-X}	Approaches
	Change Number of Uncontrolled Approaches with Right-Turn Lanes from X to Y at Urban or Suburban Arterial Intersection	0.86^{Y-X}	0.86^{Y-X}	0.86^{Y-X}	0.86^{Y-X}	0.86^{Y-X}	Approaches
	Increase Intersection Sight Distance from X Feet of Available Sight Distance to Y Feet	$e^{195.791*[1/Y-1/X]}$	$e^{195.791*[1/Y-1/X]}$	$e^{195.791*[1/Y-1/X]}$	$e^{203.368*[1/Y-1/X]}$	$0.379 * e^{195.791*[1/Y-1/X]} + 0.621 * e^{203.368*[1/Y-1/X]}$	Feet

Table 2 CMFunction Equations (cont)

	COUNTERMEASURE	K	A	BC	O	ALL SEVERITIES	UNITS
INTERSECTION	Reduce Intersection Skew from X to Y - 3 Leg Intersection	$e^{0.004*[Y-X]}$	$e^{0.004*[Y-X]}$	$e^{0.004*[Y-X]}$	$e^{0.004*[Y-X]}$	$e^{0.004*[Y-X]}$	Degrees of Skew
	Reduce Intersection Skew from X to Y - 4 Leg Intersection	$e^{0.0054*[Y-X]}$	$e^{0.0054*[Y-X]}$	$e^{0.0054*[Y-X]}$	$e^{0.0054*[Y-X]}$	$e^{0.0054*[Y-X]}$	Degrees of Skew
	Convert Two Offset T-Intersection, Offset by X Miles, to 4-Leg Signalized Intersection with Major Road AADT	$\frac{0.05-0.005*\ln(AADT)}{x} + 0.322$ $\frac{2*(0.05-0.005 * \ln(AADT))}{x} + 0.322$	X-Miles AADT-Vehicles per Day				
SEGMENTS (FREEWAY)	Widen Clear Zone from X Feet to Y Feet	$e^{0.00451*[X-Y]}$	$e^{0.00451*[X-Y]}$	$e^{0.00451*[X-Y]}$	1	$0.274*e^{0.00451*[X-Y]}+0.726*$	Feet
	Widen Median from X Feet to Y Feet	$e^{0.131*[1/Y-1/X]}$	$e^{0.131*[1/Y-1/X]}$	$e^{0.131*[1/Y-1/X]}$	$e^{0.169*[1/Y-1/X]}$	$0.274*e^{0.131*[1/Y-1/X]}+0.726*$ $e^{0.169*[1/Y-1/X]}$	Feet
	Widen Paved Inside Shoulder from X Feet to Y Feet	$e^{0.0172*[X-Y]}$	$e^{0.0172*[X-Y]}$	$e^{0.0172*[X-Y]}$	$e^{0.0153*[X-Y]}$	$0.274*e^{0.0172*[X-Y]}+0.726*$ $e^{0.0153*[X-Y]}$	Feet
	Widen Paved Outside Shoulder on Horizontal Curve from X Feet to Y Feet	$e^{0.0897*[X-Y]}$	$e^{0.0897*[X-Y]}$	$e^{0.0897*[X-Y]}$	$e^{0.0840*[X-Y]}$	$0.274*e^{0.0897*[X-Y]}+0.726*$ $e^{0.0840*[X-Y]}$	Feet
	Widen Paved Outside Shoulder on Horizontal Tangent from X Feet to Y Feet	$e^{0.0647*[X-Y]}$	$e^{0.0647*[X-Y]}$	$e^{0.0647*[X-Y]}$	1	$0.274*e^{0.0647*[X-Y]}+0.726$	Feet
	Change Driveway Density (Driveways/Mile) from X to Y	$e^{0.0152*[Y-X]}$	$e^{0.0152*[Y-X]}$	$e^{0.0152*[Y-X]}$	$e^{0.0232*[Y-X]}$	$e^{0.0232*[Y-X]}$	Driveways per Mile
	Change Roadside Hazard Rating from X to Y by Flattening Roadside Slope	$e^{0.0668*[Y-X]}$	$e^{0.0668*[Y-X]}$	$e^{0.0668*[Y-X]}$	$e^{0.0668*[Y-X]}$	$e^{0.0668*[Y-X]}$	Roadside Hazard Rating ■
	Change Superelevation Variance from X to Y (if Variance Between 0.01 and 0.02)	$\frac{1+6*[Y-0.01]}{1+6*[X-0.01]}$	$\frac{1+6*[Y-0.01]}{1+6*[X-0.01]}$	$\frac{1+6*[Y-0.01]}{1+6*[X-0.01]}$	$\frac{1+6*[Y-0.01]}{1+6*[X-0.01]}$	$\frac{1+6*[Y-0.01]}{1+6*[X-0.01]}$	Feet per Foot
Change Superelevation Variance from X to Y (if Variance Greater than 0.02)	$\frac{1.06+3*[Y-0.02]}{1.06+3*[X-0.02]}$	$\frac{1.06+3*[Y-0.02]}{1.06+3*[X-0.02]}$	$\frac{1.06+3*[Y-0.02]}{1.06+3*[X-0.02]}$	$\frac{1.06+3*[Y-0.02]}{1.06+3*[X-0.02]}$	$\frac{1.06+3*[Y-0.02]}{1.06+3*[X-0.02]}$	Feet per Foot	

■ Please go to <https://www.fhwa.dot.gov/publications/research/safety/99207/appd.cfm> for a description of RHR ratings.

Table 3 References

	COUNTERMEASURE	REFERENCE	REFERENCE/CITATION HYPERLINK #1	REFERENCE/CITATION HYPERLINK #2
BIKE/PED	Add Crosswalk	FHWA Safety Report	https://safety.fhwa.dot.gov/provencountermeasures/ped_medians/	
	Add Crosswalk Lighting	CMF ID: 441, 2379	http://www.cmfclearinghouse.org/detail.cfm?facid=441	http://www.cmfclearinghouse.org/detail.cfm?facid=2379
	Add Curb Extensions/Corner Bulb Outs	NYC Study	http://onlinepubs.trb.org/Onlinepubs/circulars/ec019/Ec019_i3.pdf	
	Add Median Pedestrian Island	PED CMF Toolbox	https://safety.fhwa.dot.gov/ped_bike/tools_solve/fhwasa18041/fhwasa18041.pdf	
	Add or Upgrade Sidewalk	PED CMF Toolbox	https://safety.fhwa.dot.gov/ped_bike/tools_solve/fhwasa18041/fhwasa18041.pdf	
	Add Pedestrian Bridge	PED CMF Toolbox	https://safety.fhwa.dot.gov/ped_bike/tools_solve/fhwasa18041/fhwasa18041.pdf	
	Add PHB	CMF ID: 9020	http://www.cmfclearinghouse.org/detail.cfm?facid=9020	
	Add PHB, Advanced Yield/Stop Markings	CMF ID: 9021	http://www.cmfclearinghouse.org/detail.cfm?facid=9021	
	Add Pedestrian Signal Heads	CMF ID: 8480, 8481	http://www.cmfclearinghouse.org/detail.cfm?facid=8480	http://www.cmfclearinghouse.org/detail.cfm?facid=8481
	Add RRFB	CMF ID: 9024	http://www.cmfclearinghouse.org/detail.cfm?facid=9024	
	Add Shared Use Path	CMF ID: 4102	http://www.cmfclearinghouse.org/detail.cfm?facid=4102	http://www.cmfclearinghouse.org/detail.cfm?facid=9250
	Change Pedestrian Phase to Barnes Dance	CMF ID: 4117	http://www.cmfclearinghouse.org/detail.cfm?facid=4117	
	Convert from Walk/Don't Walk to Pedestrian Countdown	CMF ID: 5272	http://www.cmfclearinghouse.org/detail.cfm?facid=5272	
	Convert Mid-Block Crossing to HAWK	CMF ID: 9020	http://www.cmfclearinghouse.org/detail.cfm?facid=9020	
	Convert Standard Crosswalk Pavement Marking to High-Visibility Crosswalk	CMF ID: 2697	http://www.cmfclearinghouse.org/detail.cfm?facid=2697	
	Implement Leading Pedestrian Interval	CMF ID: 1993	http://www.cmfclearinghouse.org/detail.cfm?facid=1993	
Install PHB or HAWK with Advanced Stop or Yield Markings and Signs	CMF ID: 9021	http://www.cmfclearinghouse.org/detail.cfm?facid=9021		

Table 3 References (cont)

	COUNTERMEASURE	REFERENCE	REFERENCE/CITATION HYPERLINK #1	REFERENCE/CITATION HYPERLINK #2
BIKE/PED	Install Raised Pedestrian Crossing	PED CMF Toolbox	https://safety.fhwa.dot.gov/ped_bike/tools_solve/fhwas18041/fhwas18041.pdf	
	Prohibit Left Turns	Ped CMF Toolbox	https://safety.fhwa.dot.gov/ped_bike/tools_solve/fhwas18041/fhwas18041.pdf	
	Remove Parking Near Intersection	PED CMF Toolbox	https://safety.fhwa.dot.gov/ped_bike/tools_solve/fhwas18041/fhwas18041.pdf	
	Upgrade Crosswalk to High-Visibility	CMF ID: 4658	http://www.cmfclearinghouse.org/detail.cfm?facid=298	
	Widen Sidewalk at Intersection	CMF ID: 413	http://www.cmfclearinghouse.org/detail.cfm?facid=413	
INTERCHANGE	Add Auxiliary Lane Between Entrance and Exit Ramps	CMF ID: 7440, 7441	http://www.cmfclearinghouse.org/detail.cfm?facid=7440	http://www.cmfclearinghouse.org/detail.cfm?facid=4123
	Add Collector-Distributor Road	ISATe, HSM Chapters 18 and 19	http://onlinepubs.trb.org/onlinepubs/nchrp/docs/nchrp17-45_fr.pdf	
	Add Entrance Ramp to One Side of Freeway	ISATe, HSM Chapters 18 and 19	http://onlinepubs.trb.org/onlinepubs/nchrp/docs/nchrp17-45_fr.pdf	http://www.cmfclearinghouse.org/detail.cfm?facid=7441
	Add Exit Ramp to One Side of Freeway	ISATe, HSM Chapters 18 and 19	http://onlinepubs.trb.org/onlinepubs/nchrp/docs/nchrp17-45_fr.pdf	
	Convert Diamond Interchange to Diverging Diamond Interchange	CMF ID: 8258, 8278	http://www.cmfclearinghouse.org/detail.cfm?facid=8258	
	Convert Diamond Interchange to SPUI	VDOT Planning Level CMFs	http://onlinepubs.trb.org/onlinepubs/nchrp/docs/nchrp17-45_fr.pdf	
	Extend Deceleration Lane Length by 100 Feet	CMD ID: 475	http://www.cmfclearinghouse.org/detail.cfm?facid=475	http://www.cmfclearinghouse.org/detail.cfm?facid=8278
	Interchange Lighting	CMF ID: 1283	http://www.cmfclearinghouse.org/detail.cfm?facid=1283	
	Lengthen Acceleration Lane from X Miles to Y Miles	CMF ID: 5215, 5216	http://www.cmfclearinghouse.org/detail.cfm?facid=5215	
	Replace Loop Ramp with Short Direct Ramp	CMF ID: 480	http://www.cmfclearinghouse.org/detail.cfm?facid=480	
	Widen Ramp Lane Width from X to Y in Feet	HSM Eqn 19-34	http://onlinepubs.trb.org/onlinepubs/nchrp/docs/nchrp17-45_fr.pdf	http://www.cmfclearinghouse.org/detail.cfm?facid=5216
	Widen Ramp Left Shoulder	HSM Eqn 19-36	http://onlinepubs.trb.org/onlinepubs/nchrp/docs/nchrp17-45_fr.pdf	
Widen Ramp Right Shoulder	HSM Eqn 19-35	http://onlinepubs.trb.org/onlinepubs/nchrp/docs/nchrp17-45_fr.pdf		

Table 3 References (cont)

	COUNTERMEASURE	REFERENCE	REFERENCE/CITATION HYPERLINK #1	REFERENCE/CITATION HYPERLINK #2
INTERSECTION	Install Intersection Lighting	CMF ID: 4462	http://www.cmfclearinghouse.org/detail.cfm?facid=4462	
	Increase Stopping Sight Distance on Crest Vertical Curve-Intersection Approach	CMF ID: 6870, 6871	http://www.cmfclearinghouse.org/detail.cfm?facid=6870	
	Add Flashing Lights to RR Crossings with Signs	CMF ID: 487	http://www.cmfclearinghouse.org/detail.cfm?facid=487	
	Add Gates to RR Crossings with Signs	CMF ID: 489	http://www.cmfclearinghouse.org/detail.cfm?facid=489	http://www.cmfclearinghouse.org/detail.cfm?facid=6871
	Adaptive Signal Control	CMF ID: 6856, 6857	http://www.cmfclearinghouse.org/detail.cfm?facid=6856	
	Add 3-Inch Yellow Retroreflective Sheeting to Signal Backplates	CMF ID: 1410	http://www.cmfclearinghouse.org/detail.cfm?facid=1410	
	Advanced Activated/Dynamic Flasher	CMF ID: 4198, 4201	http://www.cmfclearinghouse.org/detail.cfm?facid=4198	http://www.cmfclearinghouse.org/detail.cfm?facid=6857
	Advanced Cross Street Name Sign	CMF ID: 2449, 2450	http://www.cmfclearinghouse.org/detail.cfm?facid=2449	
	Advanced Dilemma Zone Detection	CMF ID: 4855, 4857	http://www.cmfclearinghouse.org/detail.cfm?facid=4855	http://www.cmfclearinghouse.org/detail.cfm?facid=4201
	Change from Permissive Left-Turn to Flashing Yellow Arrow	CMF ID: 4175	http://www.cmfclearinghouse.org/detail.cfm?facid=4175	http://www.cmfclearinghouse.org/detail.cfm?facid=2450
	Change from Permitted Left-Turn to Permitted/Protected	CMF ID: 4270	http://www.cmfclearinghouse.org/detail.cfm?facid=4270	http://www.cmfclearinghouse.org/detail.cfm?facid=4857
	Change from Permitted Left-Turn to Protected on Major Approach	CMF ID: 335	http://www.cmfclearinghouse.org/detail.cfm?facid=335	
	Change from Permitted/Protected Left-Turn to Protected on Major Approach	CMF ID: 339	http://www.cmfclearinghouse.org/detail.cfm?facid=339	
	Change from Permitted/Protected Left-Turn to Protected on Minor Approach	CMF ID: 337	http://www.cmfclearinghouse.org/detail.cfm?facid=337	
	Change from Pretimed Signal to Actuated Signal	NCDOT CRF List 1.6	https://connect.ncdot.gov/resources/safety/TrafficSafetyResources/NCDOT%20CRF%20Update.pdf	
	Change from Protected Left-Turn to Flashing Yellow Arrow	CMF ID: 4173	http://www.cmfclearinghouse.org/detail.cfm?facid=4173	
	Change from Protected/Permissive Left-Turn to Flashing Yellow Arrow	CMF ID: 4177	http://www.cmfclearinghouse.org/detail.cfm?facid=4177	
Change Number of Approaches with Left-Turn Lanes from X Approaches to Y Approaches	HSM	https://www.fhwa.dot.gov/publications/research/safety/99207/99207.pdf		

Table 3 References (cont)

	COUNTERMEASURE	REFERENCE	REFERENCE/CITATION HYPERLINK #1	REFERENCE/CITATION HYPERLINK #2
INTERSECTION	Change Number of Approaches with Prohibited Right Turn on Red from X Approaches to Y Approaches	CMF ID: 5194	http://www.cmfclearinghouse.org/detail.cfm?facid=5194	
	Change Number of Approaches with Right-Turn Lanes from X Approaches to Y Approaches	HSM Table 10-14, 12-26	https://www.fhwa.dot.gov/publications/research/safety/99207/99207.pdf	
	Change Number of Cycles per Hour from X Cycles per Hour to Y Cycles per Hour	CMF ID: 3072	http://www.cmfclearinghouse.org/detail.cfm?facid=3072	
	Channelize Right Turn	FHWA CMF Desktop Reference Guide	http://www.cmfclearinghouse.org/collateral/FHWA_Desktop_Reference_Guide.pdf	
	Closed Loop Signal System	NCDOT CRF List 1.7	https://connect.ncdot.gov/resources/safety/TrafficSafetyResources/NCDOT%20CRF%20Update.pdf	
	Convert from Pedestal-Mounted Traffic Signal to Mast Arm-Mounted Traffic Signal	CMF ID: 1424, 1425	http://www.cmfclearinghouse.org/detail.cfm?facid=1424	
	Convert from Span Wire-Mounted Traffic Signal to Mast Arm-Mounted Traffic Signal	UVA Khattak and Fontaine Study	https://journals.sagepub.com/doi/abs/10.1177/0361198118768525	
	Convert to LED Signal Heads - 3-Leg Intersection	UVA CMF	Gonzales, D. "LED Signal Head and Traffic Signal Backplate Countermeasure Effectiveness in Virginia." Semester Project, CEE 6450. University of Virginia. 2017	http://www.cmfclearinghouse.org/detail.cfm?facid=1425
	Convert to LED Signal Heads - 4-Leg Intersection	UVA CMF	Gonzales, D. "LED Signal Head and Traffic Signal Backplate Countermeasure Effectiveness in Virginia." Semester Project, CEE 6450. University of Virginia. 2017	
	Extend Left-Turn Lane	FHWA Desktop Reference	http://www.cmfclearinghouse.org/collateral/FHWA_Desktop_Reference_Guide.pdf	
	Extend Right-Turn Lane	FHWA Desktop Reference	http://www.cmfclearinghouse.org/collateral/FHWA_Desktop_Reference_Guide.pdf	
	Increase All-Red Clearance Interval	CMF ID: 4211, 4212	http://www.cmfclearinghouse.org/detail.cfm?facid=4211	
	Increase Left-Turn Lane Offset	CMF ID: 6095, 6096	http://www.cmfclearinghouse.org/detail.cfm?facid=6095	
	Increase Yellow Change Interval by 1 Second	CMF ID: 4207, 4208	http://www.cmfclearinghouse.org/detail.cfm?facid=4207	http://www.cmfclearinghouse.org/detail.cfm?facid=4212
	Install Red-Light Camera	CMF ID: 6876, 6877	http://www.cmfclearinghouse.org/detail.cfm?facid=6876	http://www.cmfclearinghouse.org/detail.cfm?facid=6096
	Offset Right-Turn Lane	N/A	N/A	http://www.cmfclearinghouse.org/detail.cfm?facid=4208
Permit Right Turn on Red	CMF ID: 4580	http://www.cmfclearinghouse.org/detail.cfm?facid=4580	http://www.cmfclearinghouse.org/detail.cfm?facid=6877	

Table 3 References (cont)

	COUNTERMEASURE	REFERENCE	REFERENCE/CITATION HYPERLINK #1	REFERENCE/CITATION HYPERLINK #2
INTERSECTION	Replace 8-inch Signal Heads with 12-inch Signal Heads	CMF ID: 2334	http://www.cmfclearinghouse.org/detail.cfm?facid=2334	
	Retroreflective Backplates and LED Signal Heads	UVA CMFs	Gonzales, D. "LED Signal Head and Traffic Signal Backplate Countermeasure Effectiveness in Virginia." Semester Project, CEE 6450. Unviersity of Virginia. 2017	
	Add Left-Turn Lane to Major Approach of 3-Leg Stop-Controlled Intersection	HSM Table 11-22	http://www.trb.org/Publications/Blurbs/159935.aspx	
	Change Number of Uncontrolled Approaches with Left-Turn Lanes from X Approaches to Y Approaches at 4-Leg Intersection	HSM Table 10-13	https://www.fhwa.dot.gov/publications/research/safety/99207/99207.pdf	
	Change Number of Uncontrolled Approaches with Right-Turn Lanes from X to Y at Intersection of Rural, Multilane Highway	HSM Table 11-23	http://www.trb.org/Publications/Blurbs/159935.aspx	
	Change Number of Uncontrolled Approaches with Right-Turn Lanes from X to Y at Intersection of Rural, Two-Lane Roads	HSM Table 10-14	https://www.fhwa.dot.gov/publications/research/safety/99207/99207.pdf	
	Change Number of Uncontrolled Approaches with Right-Turn Lanes from X to Y at Urban or Suburban Arterial Intersection	HSM Table 12-26	https://www.nap.edu/catalog/23084/methodology-to-predict-the-safety-performance-of-urban-and-suburban-arterials	
	High-Friction Surface Treatment on Approach	CMF ID: 2259	http://www.cmfclearinghouse.org/detail.cfm?facid=2259	
	Increase Intersection Sight Distance from X Feet of Available Sight Distance to Y Feet	NCHRP 17-59, Report 875	http://www.trb.org/Publications/Blurbs/177421.aspx	
	Intersection Collision Warning System	CMF ID: 8474, 8475	http://www.cmfclearinghouse.org/detail.cfm?facid=8474	
	Reduce Intersection Skew from X to Y - 3 Leg Intersection	HSM Equation: 10-22	https://www.fhwa.dot.gov/publications/research/safety/99207/99207.pdf	
	Reduce Intersection Skew from X to Y - 4 Leg Intersection	HSM Equation: 10-23	https://www.fhwa.dot.gov/publications/research/safety/99207/99207.pdf	http://www.cmfclearinghouse.org/detail.cfm?facid=8475
	Systemic Signage and Pavement Marking Improvements	FHWA Proven Safety Counter-measures	https://safety.fhwa.dot.gov/provencountermeasures/syst_stop_control/	
	Transverse Rumble Strips	CMF ID: 2707, 2708	http://www.cmfclearinghouse.org/detail.cfm?facid=2707	
Add Quadrant Roadway to Intersection	N/A	N/A	http://www.cmfclearinghouse.org/detail.cfm?facid=8866	
Convert 3-Leg Signalized Intersection to Continuous Green T-Intersection	CMF ID: 8655, 8656	http://www.cmfclearinghouse.org/detail.cfm?facid=8655	http://www.cmfclearinghouse.org/detail.cfm?facid=2708	

Table 3 References (cont)

	COUNTERMEASURE	REFERENCE	REFERENCE/CITATION HYPERLINK #1	REFERENCE/CITATION HYPERLINK #2
INTERSECTION	Convert At-Grade Intersection to Interchange	CMF ID: 459, 460, 461	http://www.cmfclearinghouse.org/detail.cfm?facid=459	
	Convert 4-Leg Intersection to Two Offset T-Intersections	HSM CMF: Table 14-2	https://www.fhwa.dot.gov/publications/research/safety/99207/99207.pdf	http://www.cmfclearinghouse.org/detail.cfm?facid=8656
	Convert Minor Stop-Controlled to All-Way Stop Controlled	CMF ID: 3127, 3128	http://www.cmfclearinghouse.org/detail.cfm?facid=3127	http://www.cmfclearinghouse.org/detail.cfm?facid=460
	Convert Signalized Intersection to Roundabout	CMF ID: 225, 226	http://www.cmfclearinghouse.org/detail.cfm?facid=225	
	Convert Stop-Controlled Intersection to Roundabout	CMF ID: 227, 228	http://www.cmfclearinghouse.org/detail.cfm?facid=227	http://www.cmfclearinghouse.org/detail.cfm?facid=3128
	Convert Stop-Controlled Intersection to Signalized Intersection	CMF ID: 7983, 7986	http://www.cmfclearinghouse.org/detail.cfm?facid=7983	http://www.cmfclearinghouse.org/detail.cfm?facid=226
	Convert to Displaced Left-Turn Intersection	FHWA TechBrief	https://safety.fhwa.dot.gov/provencountermeasures/reduced_left/	http://www.cmfclearinghouse.org/detail.cfm?facid=228
	Convert to J-Turn Intersection	CMF ID: 5555, 5556	http://www.cmfclearinghouse.org/detail.cfm?facid=5555	http://www.cmfclearinghouse.org/detail.cfm?facid=7986
	Convert to Median U-Turn Intersection	FHWA TechBrief	https://safety.fhwa.dot.gov/provencountermeasures/reduced_left/	http://www.cmfclearinghouse.org/detail.cfm?facid=10889
	Convert to Signalized Intersection to Signalized RCUT	FHWA Report	https://www.fhwa.dot.gov/publications/research/safety/17082/17082.pdf	http://www.cmfclearinghouse.org/detail.cfm?facid=5556
	Convert to Signalized Intersection to Unsignalized RCUT	N/A	N/A	http://www.cmfclearinghouse.org/detail.cfm?facid=10851
	Convert to Unsignalized Intersection to Unsignalized RCUT	CMF ID: 4883, 4884	http://www.cmfclearinghouse.org/detail.cfm?facid=4883	
	Convert Two Offset T-Intersection, Offset by X Miles, to T-Intersection with Major Road AADT	HSM Eqn 10-17	https://www.fhwa.dot.gov/publications/research/safety/99207/99207.pdf	
	Convert Unsignalized Intersection to Unsignalized Superstreet Intersection	CMF ID: 4883, 4884	http://www.cmfclearinghouse.org/detail.cfm?facid=4883	http://www.cmfclearinghouse.org/detail.cfm?facid=4884
	Interim Roundabout	CMF ID: 3127, 3128	http://www.cmfclearinghouse.org/detail.cfm?facid=3127	
	Remove Unwarranted Signal	CMF ID: 332	http://www.cmfclearinghouse.org/detail.cfm?facid=332	http://www.cmfclearinghouse.org/detail.cfm?facid=4884
Temporary Traffic Circle	N/A	N/A	http://www.cmfclearinghouse.org/detail.cfm?facid=3128	

Table 3 References (cont)

	COUNTERMEASURE	REFERENCE	REFERENCE/CITATION HYPERLINK #1	REFERENCE/CITATION HYPERLINK #2
SEGMENTS (FREEWAY)	Active Traffic Management with Hard Shoulder Running	UVA Study	<i>Boateng, R.A. "Evaluation of the Safety Effects of Active Traffic Management System on I-66 in Northern Virginia". Semester Project, CEE 6450. Unviersity of Virginia. 2017</i>	
	Active Traffic Management without Hard Shoulder Running	UVA Study	<i>Boateng, R.A. "Evaluation of the Safety Effects of Active Traffic Management System on I-66 in Northern Virginia". Semester Project, CEE 6450. Unviersity of Virginia. 2017</i>	
	Add Cable Median Barrier	CMF ID: 1966	http://www.cmfclearinghouse.org/detail.cfm?facid=1966	
	Add Rumble Strips to Inside Shoulder	HSM Eqn 18-36	http://onlinepubs.trb.org/onlinepubs/nchrp/docs/nchrp17-45_fr.pdf	
	Add Median Concrete Barrier	CMF ID: 2256	http://www.cmfclearinghouse.org/detail.cfm?facid=2256	
	Add Median Guardrail	CMF ID: 51	http://www.cmfclearinghouse.org/detail.cfm?facid=51	
	Add Rumble Strips to Outside Shoulder	HSM Eqn 18-36	http://onlinepubs.trb.org/onlinepubs/nchrp/docs/nchrp17-45_fr.pdf	
	Add Raised Pavement Markers	CMF ID: 5498	http://www.cmfclearinghouse.org/detail.cfm?facid=5498	
	Add Roadside Guardrail	CMF ID: 8391, 8392, 8393	http://www.cmfclearinghouse.org/detail.cfm?facid=8391	
	Implement Incident Management to Reduce Average Duration Time	VA Planning Level CMFs	http://vasmartscale.org/documents/ss_planning_level_cmfs_092116.pdf	
	Implement Variable Speed Limits	CMF ID: 8730, 8731	http://www.cmfclearinghouse.org/detail.cfm?facid=8730	http://www.cmfclearinghouse.org/detail.cfm?facid=8392
	Rural: Widen from 4 Lanes to 6 Lanes	VDOT SPFs, Crash Rate Ratios	http://vasmartscale.org/documents/ss_planning_level_cmfs_092116.pdf	
	Upgrade Horizontal Curve Signage	CMF ID: 2431, 2433	http://www.cmfclearinghouse.org/detail.cfm?facid=2431	http://www.cmfclearinghouse.org/detail.cfm?facid=8731
	Upgrade Pavement Markings to Wet-Reflective Pavement Markings	CMF ID: 8093, 8134	http://www.cmfclearinghouse.org/detail.cfm?facid=8093	
	Upgrade Roadside Guardrail	Desktop Reference Guide	http://www.cmfclearinghouse.org/collateral/FHWA_Desktop_Reference_Guide.pdf	http://www.cmfclearinghouse.org/detail.cfm?facid=2433

Table 3 References (cont)

	COUNTERMEASURE	REFERENCE	REFERENCE/CITATION HYPERLINK #1	REFERENCE/CITATION HYPERLINK #2
SEGMENTS (FREEWAY)	Urban: Widen from 4 Lanes to 6 Lanes	VDOT SPFs, Crash Rate Ratios	http://vasmartscale.org/documents/ss_planning_level_cmf_092116.pdf	http://www.cmfclearinghouse.org/detail.cfm?facid=8134
	Urban: Widen from 4 Lanes to 8+ Lanes	VDOT SPFs, Crash Rate Ratios	http://vasmartscale.org/documents/ss_planning_level_cmf_092116.pdf	
	Urban: Widen from 6 Lanes to 8+ Lanes	VDOT SPFs, Crash Rate Ratios	http://vasmartscale.org/documents/ss_planning_level_cmf_092116.pdf	
	Widen Clear Zone from X Feet to Y Feet	HSM Eqn 18-38	http://onlinepubs.trb.org/onlinepubs/nchrp/docs/nchrp17-45_fr.pdf	
	Widen Median from X Feet to Y Feet	HSM Equation 18-27	http://onlinepubs.trb.org/onlinepubs/nchrp/docs/nchrp17-45_fr.pdf	
	Widen Paved Inside Shoulder from X Feet to Y Feet	HSM Eqn 18-26	http://onlinepubs.trb.org/onlinepubs/nchrp/docs/nchrp17-45_fr.pdf	
	Widen Paved Outside Shoulder on Horizontal Curve from X Feet to Y Feet	HSM Eqn 18-35 and Table 18-21	http://onlinepubs.trb.org/onlinepubs/nchrp/docs/nchrp17-45_fr.pdf	
	Widen Paved Outside Shoulder on Horizontal Tangent from X Feet to Y Feet	HSM Eqn 18-35 and Table 18-21	http://onlinepubs.trb.org/onlinepubs/nchrp/docs/nchrp17-45_fr.pdf	
SEGMENTS (NON-FREEWAY)	Add Automated Speed Enforcement Cameras	CMF ID: 2688, 4583	http://www.cmfclearinghouse.org/detail.cfm?facid=2688	
	Add Auxiliary Passing Lane	CMF ID: 9111, 9112	http://www.cmfclearinghouse.org/detail.cfm?facid=9111	
	Add Centerline Rumble Strips (Including Sinusoidal/Mumble)	CMF ID: 3355, 3360	http://www.cmfclearinghouse.org/detail.cfm?facid=3355	http://www.cmfclearinghouse.org/detail.cfm?facid=4583
	Add Chevron Signs at Horizontal Curves	CMF ID: 2439	http://www.cmfclearinghouse.org/detail.cfm?facid=2439	http://www.cmfclearinghouse.org/detail.cfm?facid=9112
	Add Chevron Signs, Curve Warning Signs, and Sequential Flashing Beacons	CMF ID: 1852	http://www.cmfclearinghouse.org/detail.cfm?facid=1852	http://www.cmfclearinghouse.org/detail.cfm?facid=3360
	Add Raised Pavement Markers	CMF ID: 5496	http://www.cmfclearinghouse.org/detail.cfm?facid=5496	
	Add Safety Edge	FHWA Proven Safety Countermeasures	https://safety.fhwa.dot.gov/provencountermeasures/safety_edge/	
	Add Segment Lighting	CMF ID: 7781, 7782	http://www.cmfclearinghouse.org/detail.cfm?facid=7781	
Add Shoulder Rumble Strips (Including Sinusoidal/Mumble)	CMF ID: 3442, 3447	http://www.cmfclearinghouse.org/detail.cfm?facid=3442		

Table 3 References (cont)

	COUNTERMEASURE	REFERENCE	REFERENCE/CITATION HYPERLINK #1	REFERENCE/CITATION HYPERLINK #2
SEGMENTS (NON-FREEWAY)	Add Two-Way Left-Turn Lane (2U to 3T)	CMF ID: 2341, 2346	http://www.cmfclearinghouse.org/detail.cfm?facid=2341	http://www.cmfclearinghouse.org/detail.cfm?facid=7782
	Add Two-Way Left-Turn Lane (4U to 5T)	CMF ID: 4084	http://www.cmfclearinghouse.org/detail.cfm?facid=4084	http://www.cmfclearinghouse.org/detail.cfm?facid=3447
	Breakaway Supports for Utility Poles in Clear Zones	HSM Eqn 10-20	https://www.fhwa.dot.gov/publications/research/safety/99207/99207.pdf	http://www.cmfclearinghouse.org/detail.cfm?facid=2346
	Change 4" Wide Edgelines to 6" Wide Edgelines	CMF ID: 4737, 4738	http://www.cmfclearinghouse.org/detail.cfm?facid=4737	
	Change Driveway Density (Driveways/Mile) from X to Y	CMF ID: 1973, 2248	http://www.cmfclearinghouse.org/detail.cfm?facid=1973	
	Change Roadside Hazard Rating from X to Y by Flattening Roadside Slope	HSM Eqn 10-20	https://www.fhwa.dot.gov/publications/research/safety/99207/99207.pdf	http://www.cmfclearinghouse.org/detail.cfm?facid=4738
	Change Superelevation Variance from X to Y (if Variance Between 0.01 and 0.02)	HSM Eqn 10-15	https://www.fhwa.dot.gov/publications/research/safety/99207/99207.pdf	http://www.cmfclearinghouse.org/detail.cfm?facid=2248
	Change Superelevation Variance from X to Y (if Variance Greater than 0.02)	HSM Eqn 10-16	https://www.fhwa.dot.gov/publications/research/safety/99207/99207.pdf	
	Dynamic Speed Feedback Signs	CMF ID: 6885	http://www.cmfclearinghouse.org/detail.cfm?facid=6885	
	Flatten Horizontal Curve	CMF ID: 9271, 9272	http://www.cmfclearinghouse.org/detail.cfm?facid=9271	
	Implement High-Friction Surface Treatment on Horizontal Curve	CMF ID: 7900	http://www.cmfclearinghouse.org/detail.cfm?facid=7900	
	Increase Stopping Sight Distance on Crest Vertical Curve	CMF ID: 6868, 6869	http://www.cmfclearinghouse.org/detail.cfm?facid=6868	http://www.cmfclearinghouse.org/detail.cfm?facid=9272
	Pave Unpaved Shoulder	HSM Eqn 10-12, Table 10-9 and 10-10	https://www.fhwa.dot.gov/publications/research/safety/99207/99207.pdf	
	Pavement Resurfacing - Rural	CMF ID: 5626	http://www.cmfclearinghouse.org/detail.cfm?facid=5626	http://www.cmfclearinghouse.org/detail.cfm?facid=6869
	Pavement Resurfacing - Urban	CMF ID: 9289, 9290	http://www.cmfclearinghouse.org/detail.cfm?facid=9289	
Prohibit On-Street Parking	CMF ID: 4574, 4575	http://www.cmfclearinghouse.org/detail.cfm?facid=4574		

Table 3 References (cont)

	COUNTERMEASURE	REFERENCE	REFERENCE/CITATION HYPERLINK #1	REFERENCE/CITATION HYPERLINK #2
SEGMENTS (NON-FREEWAY)	Remove or Relocate Fixed Object Outside of Clear Zone	CMF ID: 1024, 1044	http://www.cmfclearinghouse.org/detail.cfm?facid=1024	http://www.cmfclearinghouse.org/detail.cfm?facid=9290
	Road Diet (4U to 3T)	CMF ID: 199	http://www.cmfclearinghouse.org/detail.cfm?facid=199	http://www.cmfclearinghouse.org/detail.cfm?facid=4575
	Upgrade Chevrons with Fluorescent Sheeting	CMF ID: 2434	http://www.cmfclearinghouse.org/detail.cfm?facid=2434	http://www.cmfclearinghouse.org/detail.cfm?facid=1044
	Upgrade Pavement Markings by Increasing Retroreflectivity	CMF ID: 2116, 2117, 2120	http://www.cmfclearinghouse.org/detail.cfm?facid=2116	
	Upgrade Pavement Markings to Wet-Reflective Pavement Markings	CMF ID: 8093, 8134	http://www.cmfclearinghouse.org/detail.cfm?facid=8093	
	Widen Clear Zone	CMF ID: 35	http://www.cmfclearinghouse.org/detail.cfm?facid=35	http://www.cmfclearinghouse.org/detail.cfm?facid=2117
	Widen Lane	HSM Table 10-8, Eqn 10-11	https://www.fhwa.dot.gov/publications/research/safety/99207/99207.pdf	http://www.cmfclearinghouse.org/detail.cfm?facid=8134
	Widen Average Shoulder Width	HSM Table 10-9	https://www.fhwa.dot.gov/publications/research/safety/99207/99207.pdf	

