SAFETY PREDICTION METHODS WEBINAR

IMPLEMENTATION OF SAFETY PREDICTION METHODS DEVELOPED FOR TEXAS HIGHWAYS (5-7083)

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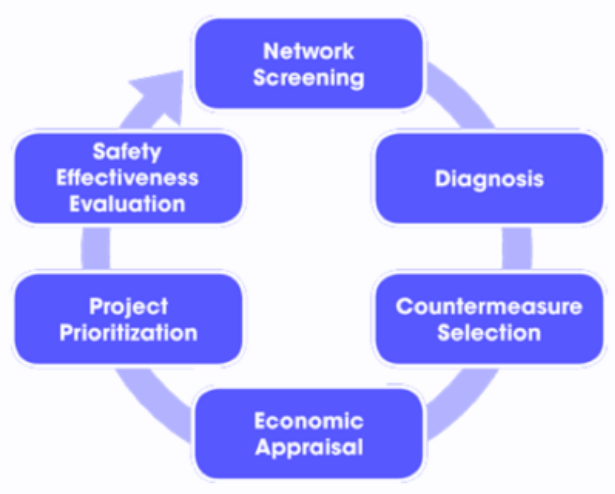
WELCOME



- Introductions
- Introductory session
  - Objectives
  - Scope
  - Main points
  - Background
  - Agenda

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INTRODUCTIONS

Course Instructors

- Srinivas Geedipally
- Mike Pratt
- Robert Wunderlich



Participants

- Now it's your turn. . .

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OBJECTIVES

To inform participants about. .

- Availability of safety predictive methods for all facility types in Texas
- Availability of simple-to-easy tools to apply these methods

To demonstrate how to use these tools

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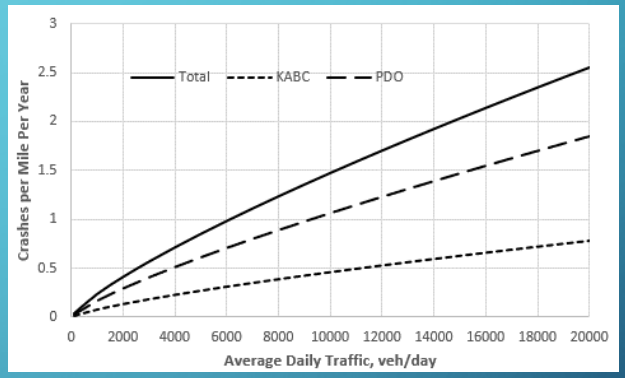
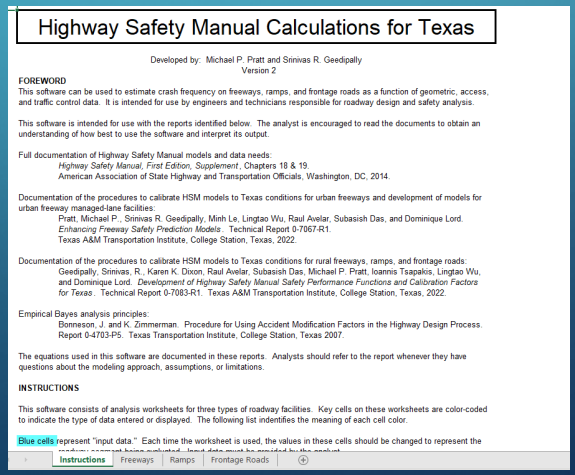
OBJECTIVES

- Course Elements
  - How to estimate crash frequency using safety prediction methods



  - Use of spreadsheet tools and their data needs



Highway Safety Manual Calculations for Texas

Developed by: Michael P. Pratt and Srinivas R. Geedipally
Version 2

FOREWORD

This software can be used to estimate crash frequency on freeways, ramps, and frontage roads as a function of geometric, access, and traffic control data. It is intended for use by engineers and technicians responsible for roadway design and safety analysis.

This software is intended for use with the reports identified below. The analyst is encouraged to read the documents to obtain an understanding of how best to use the software and interpret its output.

Full documentation of Highway Safety Manual models and data needs:
Highway Safety Manual, First Edition, Supplement, Chapters 18 & 19.
American Association of State Highway and Transportation Officials, Washington, DC, 2014.

Documentation of the procedures to calibrate HSM models to Texas conditions for urban freeways and development of models for urban freeway managed-lane facilities:
Pratt, Michael P., Srinivas R. Geedipally, Minh Le, Lingtao Wu, Raul Avelar, Subasish Das, and Dominique Lord. *Enhancing Freeway Safety Prediction Models*. Technical Report 0-7067-R1. Texas A&M Transportation Institute, College Station, Texas, 2022.

Documentation of the procedures to calibrate HSM models to Texas conditions for rural freeways, ramps, and frontage roads:
Geedipally, Srinivas, R., Karen K. Dixon, Raul Avelar, Subasish Das, Michael P. Pratt, Ioannis Tsapakis, Lingtao Wu, and Dominique Lord. *Development of Highway Safety Manual Safety Performance Functions and Calibration Factors for Texas*. Technical Report 0-7083-R1. Texas A&M Transportation Institute, College Station, Texas, 2022.

Empirical Bayes analysis principles:
Bonneson, J. and K. Zimmerman. Procedure for Using Accident Modification Factors in the Highway Design Process. Report 0-4703-P5. Texas Transportation Institute, College Station, Texas 2007.

The equations used in this software are documented in these reports. Analysts should refer to the report whenever they have questions about the modeling approach, assumptions, or limitations.

INSTRUCTIONS

This software consists of analysis worksheets for three types of roadway facilities. Key cells on these worksheets are color-coded to indicate the type of data entered or displayed. The following list indentifies the meaning of each cell color.

Blue cells represent "input data." Each time the worksheet is used, the values in these cells should be changed to represent the

Instructions | Freeways | Ramps | Frontage Roads

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SCOPE

Intended Audience

Engineers and practitioners who want to incorporate safety performance into the network screening, design, and project development processes

Roadway Types

Rural Roads

- Two-lane undivided (2U)
- Four-lane undivided (4U),
- Four-lane divided (4D)
- Rural Intersections
- Freeways, frontage roads, and ramps

Urban Streets and Highways

- Two-lane undivided (2U)
- Two-lane with TWLTL (3T),
- 4U,
- 4D,
- Four-lane with TWLTL (5T)
- Urban Intersections
- Freeway, frontage roads, and ramps

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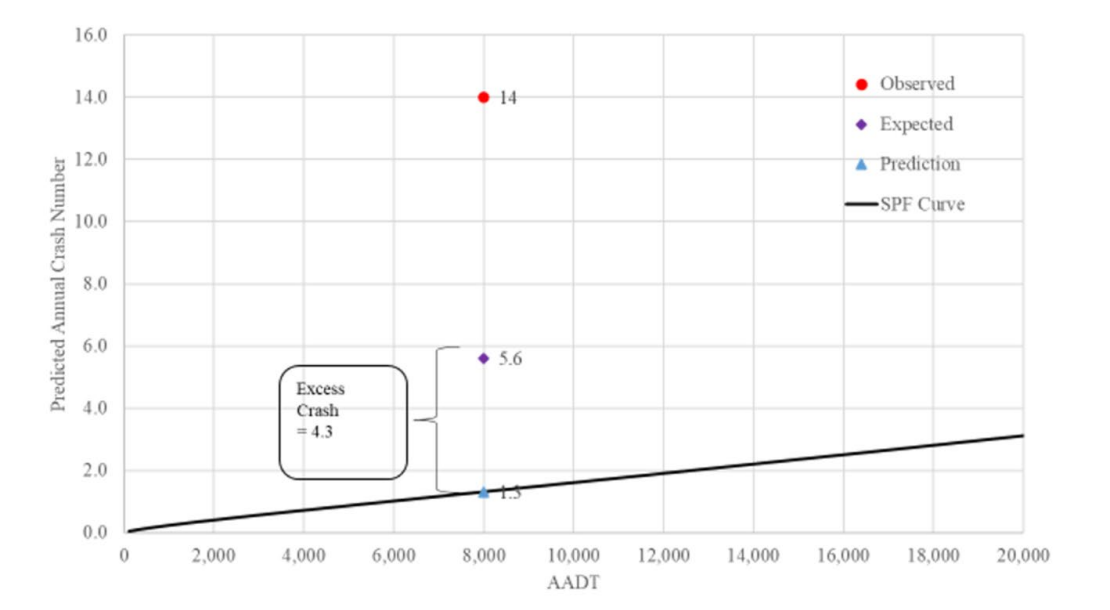
USE CRASH PREDICTION METHODS



- To:
  - Make Project-level decisions
  - Compare various alternatives
  - Screen the network for problem areas
  - Aid in the project development process

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BACKGROUND

Project 0-7067

- "Enhancing Freeway Safety Prediction Models"
  - Project Director: Khalid Jamil
  - Project Manager: Shelley Pridgen

Product:

- Research report
- Spreadsheet tool for urban freeways
  - General-purpose lanes
  - Managed lanes

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BACKGROUND

Project 0-7083

- "Calibrating the Highway Safety Manual Predictive Methods for Texas Highways"
  - Project Director: Khalid Jamil
  - Project Manager: Jade` Adediwura

Product:

- Research report
- *Spreadsheet Tools* (0-7083-P1)
  - Rural Two-Lane Highways
  - Rural Multi-Lane Highways
  - Urban Arterials
  - Freeway Facilities

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AGENDA

- Lesson 1: Safety Models
- Lesson 2: Spreadsheet Tools
  - Input data
  - Estimate crashes

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QUESTIONS

- Questions are encouraged
- Please ask them as they occur to you

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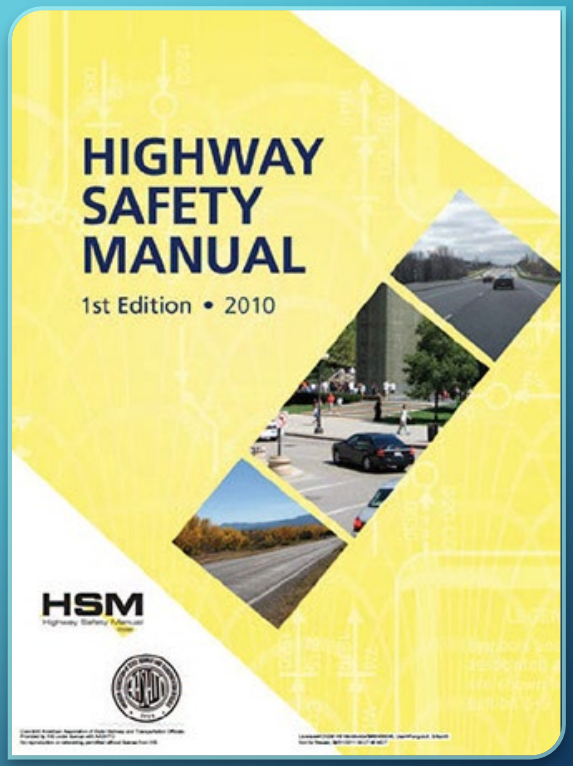
HIGHWAY SAFETY MANUAL BASED

- Familiarity of Group with HSM



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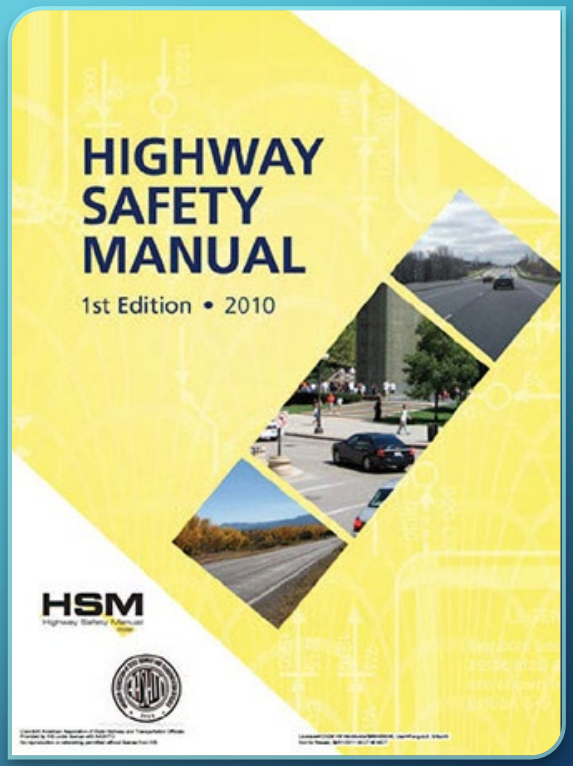
1. SAFETY MODELS

- Safety Performance Functions (SPFs)
- Crash Modification Factors
- Calibration to Texas
- Developing new SPFs
- Regional factors



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SAFETY PERFORMANCE FUNCTION

- Establishes statistical relationship between exposure and risk
- Exposure – Traffic Volume and length (VMT)
- Risk – likelihood of a crash

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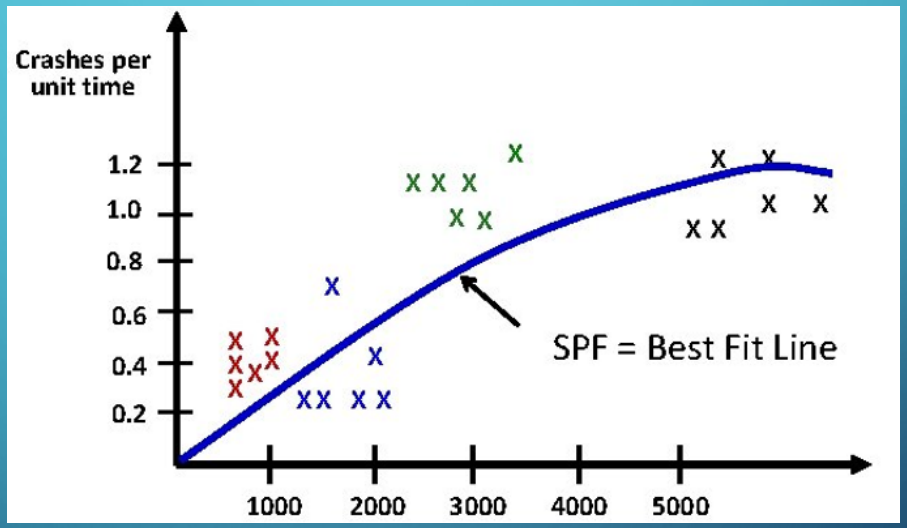
SAFETY PERFORMANCE FUNCTION

- A regression equation to determine the predicted crash frequency at a location



$$N_{predicted} = AADT \times L \times 365 \times 10^{-6} \times e^{(-0.312)}$$

Exposure

Risk

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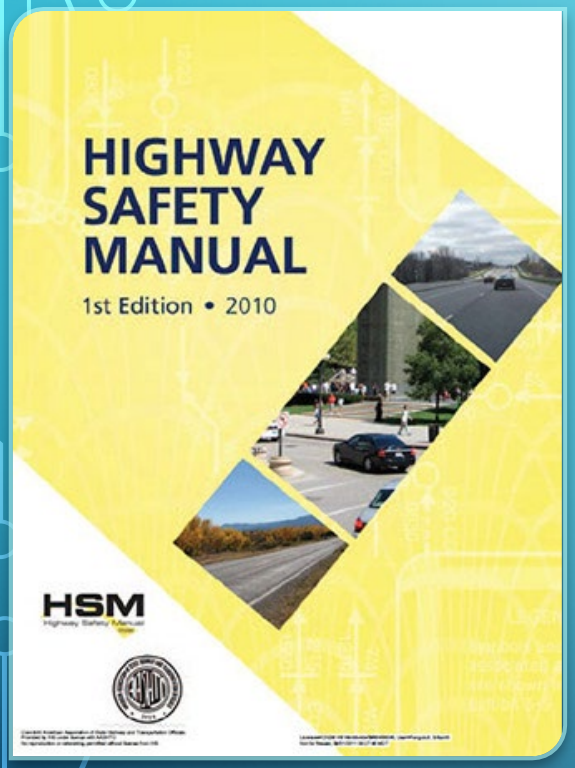
SAFETY PERFORMANCE FUNCTIONS FOR TEXAS CONDITIONS



- Calibration to Texas
- Developing new SPFs
- Regional factors

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CRASH MODIFICATION FACTOR

- "an index of how much crash experience is expected to change following a modification in design or traffic control" (HSM, 2010)

$$CMF = \frac{Expected\ crash\ frequency\ if\ change\ is\ made}{Expected\ crash\ frequency\ if\ change\ is\ not\ made}$$

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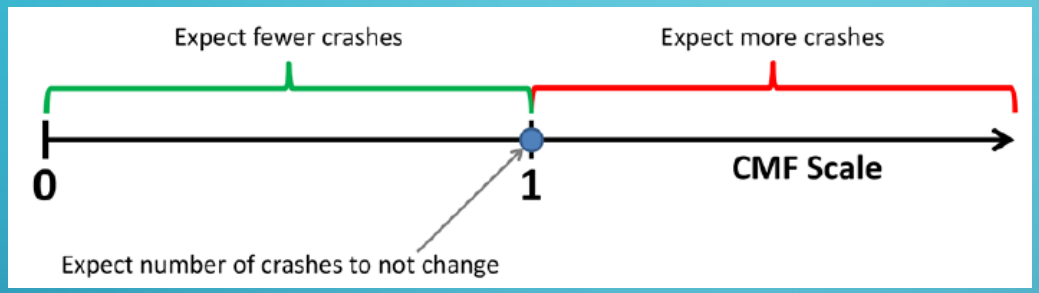
CRASH MODIFICATION FACTOR



A CMF of:

0.75 (Crashes go down)

1.10 (Crashes go up)

$$Expected\ reduction\ in\ crashes = 100(1 - CMF)$$

A CMF of:

0.75 = 25% reduction
1.10 = 10% increase

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CRASH MODIFICATION FACTOR

- Estimated based on statistical analysis of crash data using:
  - Before-after study
  - Cross-sectional study

- Recommended source: http://www.cmfclearinghouse.org/

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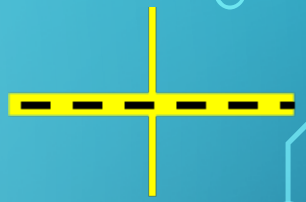
HSM SPFS



Rural Two-Lane Highways (Chapter 10)

- Segments (2U)
- Intersections
  - Three-leg stop-controlled (3ST)
  - Four-leg stop-controlled (4ST)
  - Four-leg signal-controlled (4SG)

HSM SPFS

Rural Multi-Lane Highways (Chapter 11)

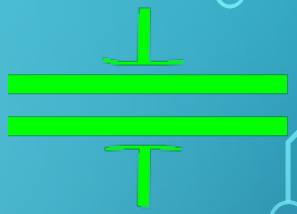
- Segments
  - Divided (4D)
  - Undivided (4U)
- Intersections
  - Three-leg stop-controlled (3ST)
  - Four-leg stop-controlled (4ST)
  - Four-leg signal-controlled (4SG)

HSM SPFS

Urban Arterials (Chapter 12)

- Segments
  - Two-lane (2U)
  - Two-lane with TWLTL (3T)
  - Four-lane divided (4U)
  - Four-lane undivided (4D)
  - Four-lane with TWLTL (5T)
- Intersections
  - Three-leg stop-controlled (3ST)
  - Four-leg stop-controlled (4ST)
  - Three-leg signal-controlled (3SG)
  - Four-leg signal-controlled (4SG)

HSM SPFS



Freeways
(Chapter 18)

- Mainline segments
- Speed-change lanes
- Severity distribution functions

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HSM SPFS

Ramps
(Chapter 19)

- Ramp segments
- Ramp terminals
- Severity distribution functions

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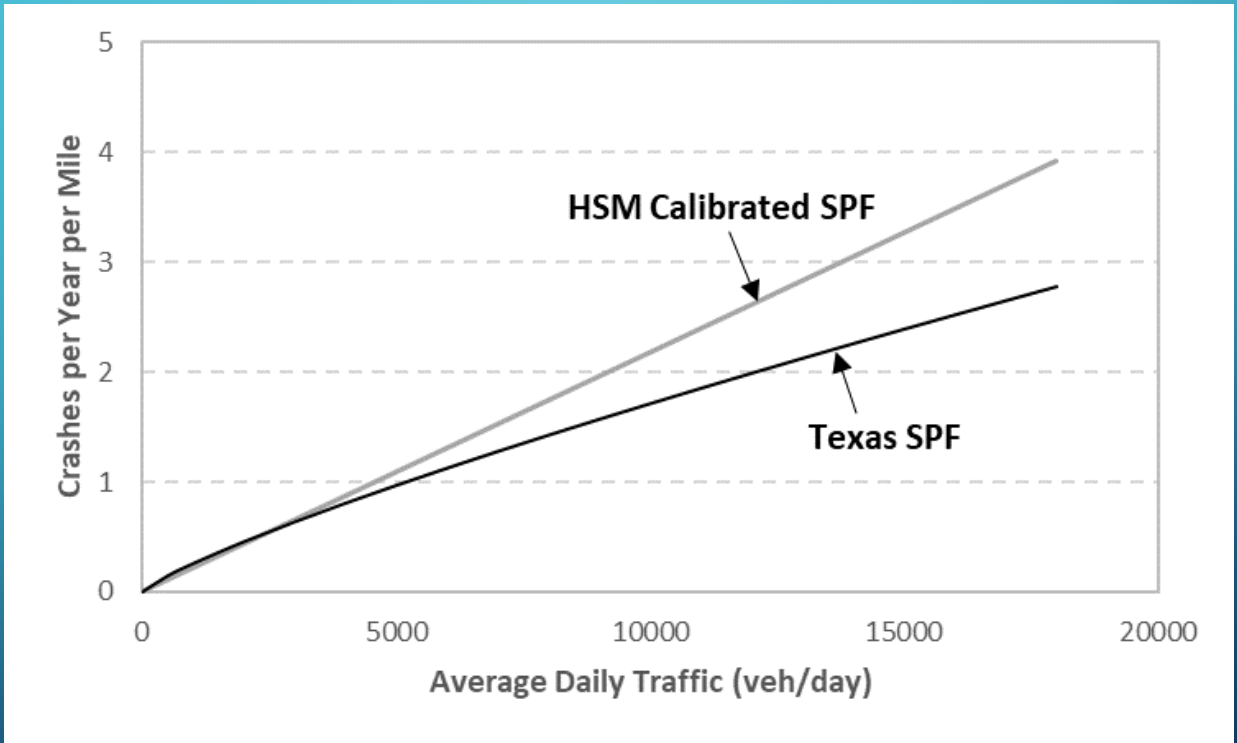
CALIBRATION TO TEXAS

Segment Type	Collision Type	Crash Count		Local Calibration Factor C
		Observed	Predicted	
R2U	All	232	284.63	0.82
R4D	All	1,046	1,154.70	0.91
R4U	All	685	989.55	0.69
U2U	MV	302	321.69	0.94
	SV	221	200.58	1.10
U3T	MV	255	416.71	0.61
	SV	118	79.93	1.48
U4D	MV	1,142	682.11	1.67
	SV	479	243.39	1.97
U4U	MV	1,157	865.06	1.34
	SV	289	192.84	1.5
U5T	MV	1,008	2,028.51	0.50
	SV	327	440.71	0.74

$$\hat{c} = \frac{Observed}{Predicted}$$

CALIBRATION TO TEXAS

- Rural two-lane segments



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CALIBRATION TO TEXAS

- Freeway segments

Urban

Rural

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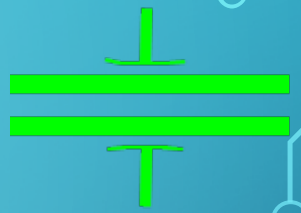
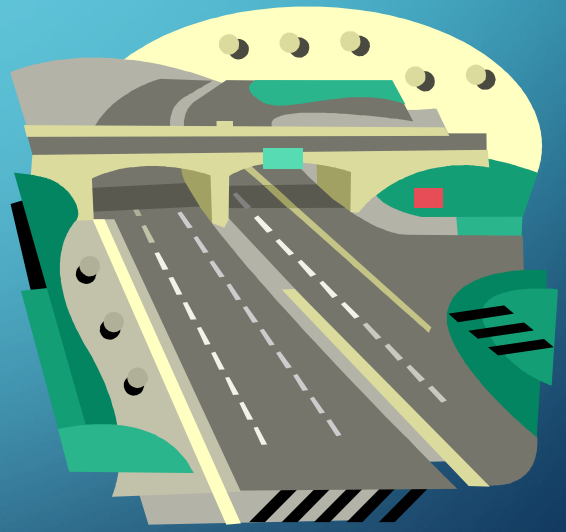
NEW SPFS



- HSM does not include SPFs for several segment types commonly used in Texas freeway corridors
  - Urban segments with more than 10 lanes
  - Frontage roads
  - Managed lanes
    - Reversible or non-reversible
    - Separated by barrier, pylons, or pavement stripes



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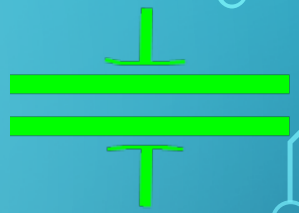
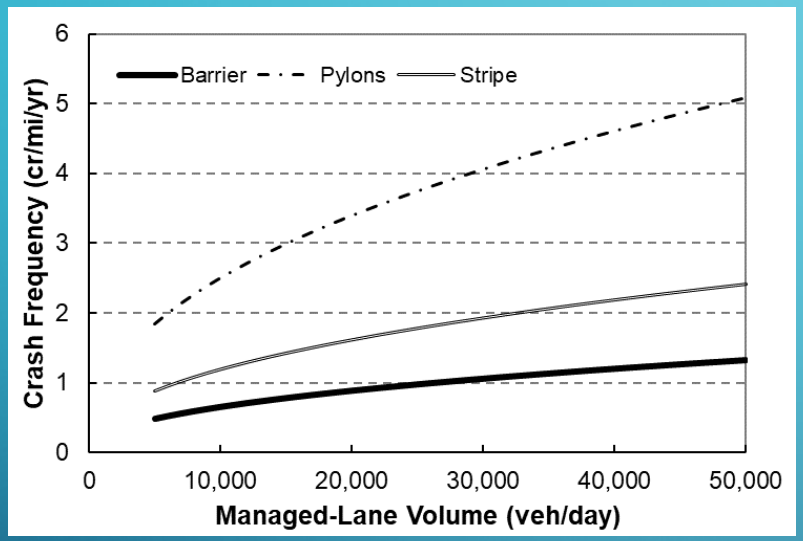
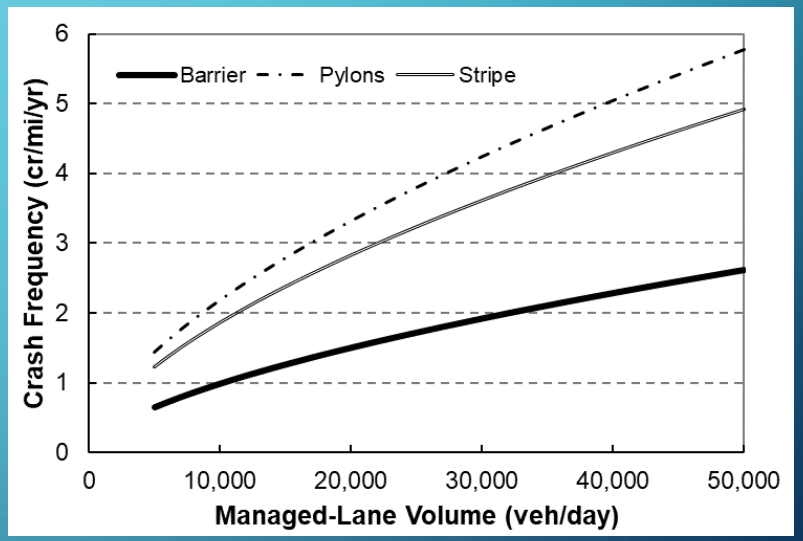
NON-REVERSIBLE MANAGED LANES NEW SPF





Single-vehicle Crashes



Multi-vehicle Crashes

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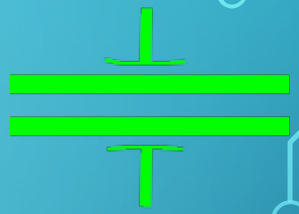
NON-REVERSIBLE MANAGED LANES



Crash Modification Factors:

- ✓ Shoulder width
- ✓ Access point density

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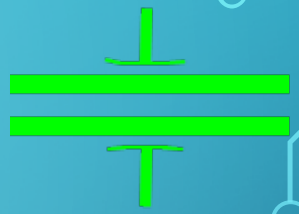
NON-REVERSIBLE MANAGED LANES



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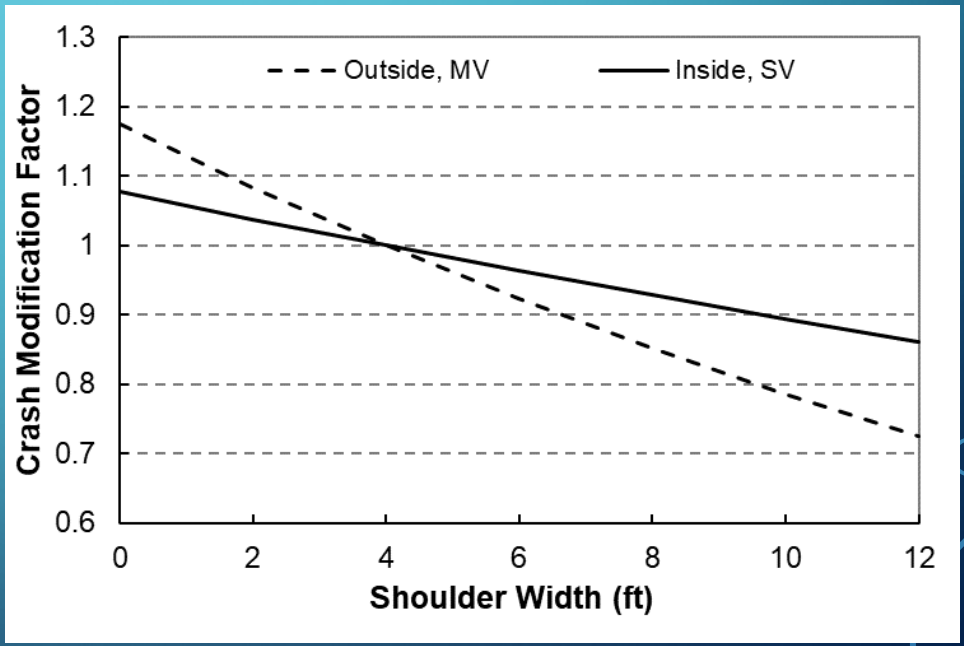

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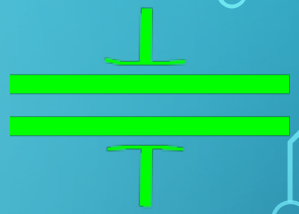
NON-REVERSIBLE MANAGED LANES



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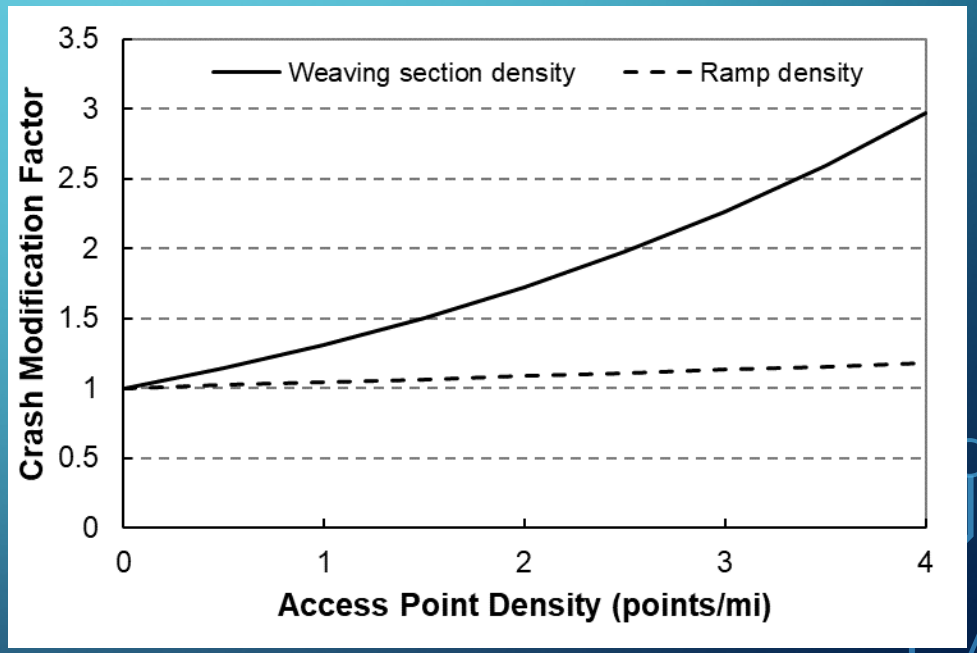

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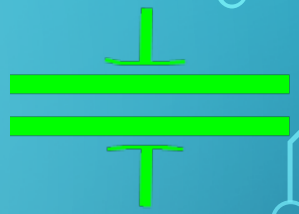
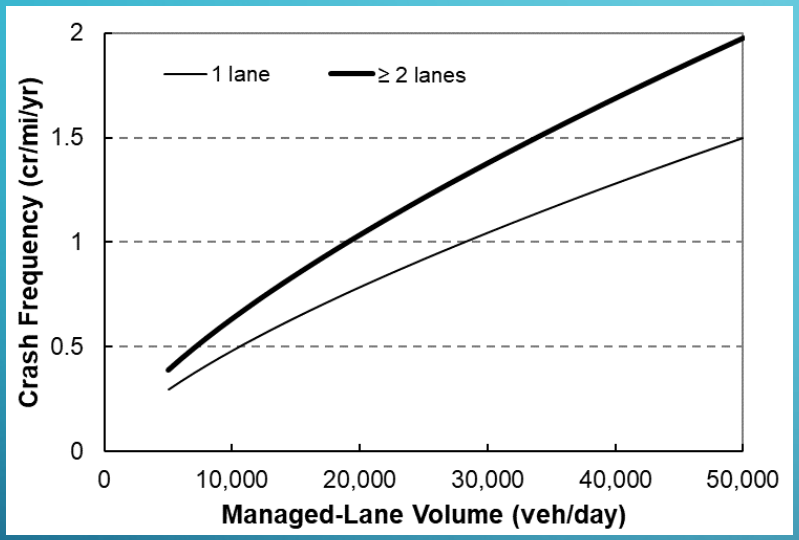
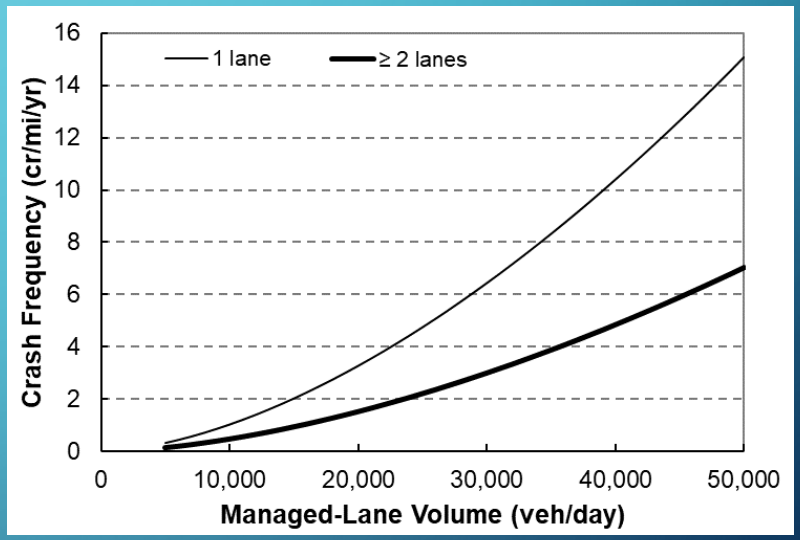
REVERSIBLE MANAGED LANES NEW SPFS





Single-vehicle Crashes



Multi-vehicle Crashes

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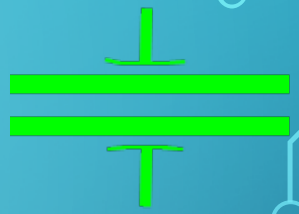
REVERSIBLE MANAGED LANES



Crash Modification Factors:

- ✓ Shoulder width
- ✓ Access ramp density

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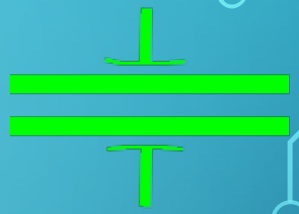
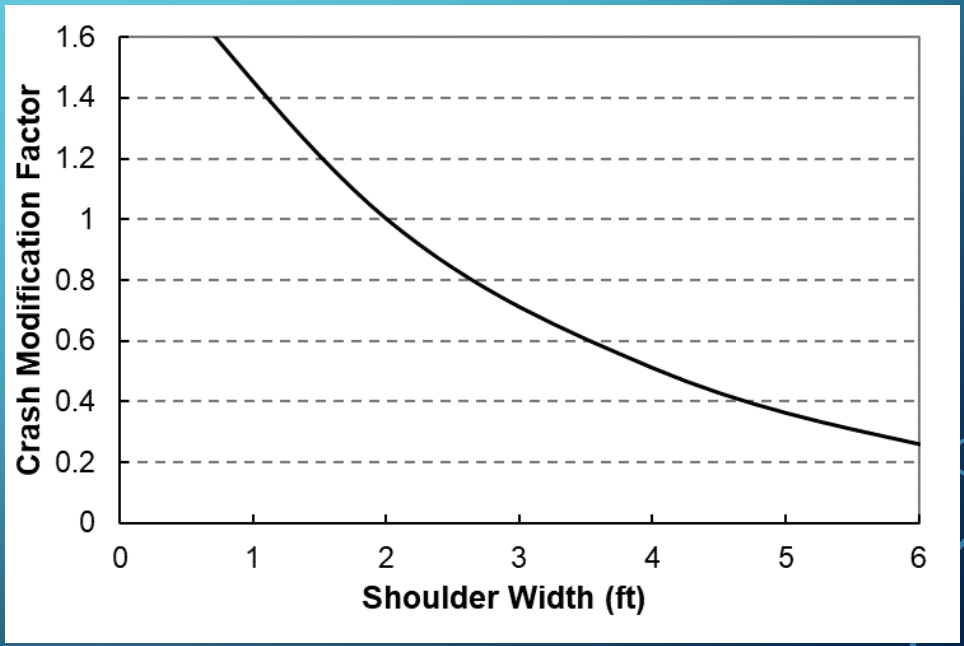
REVERSIBLE MANAGED LANES



Crash Modification Factor:

✓ Shoulder width



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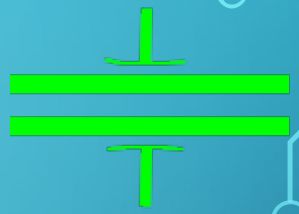
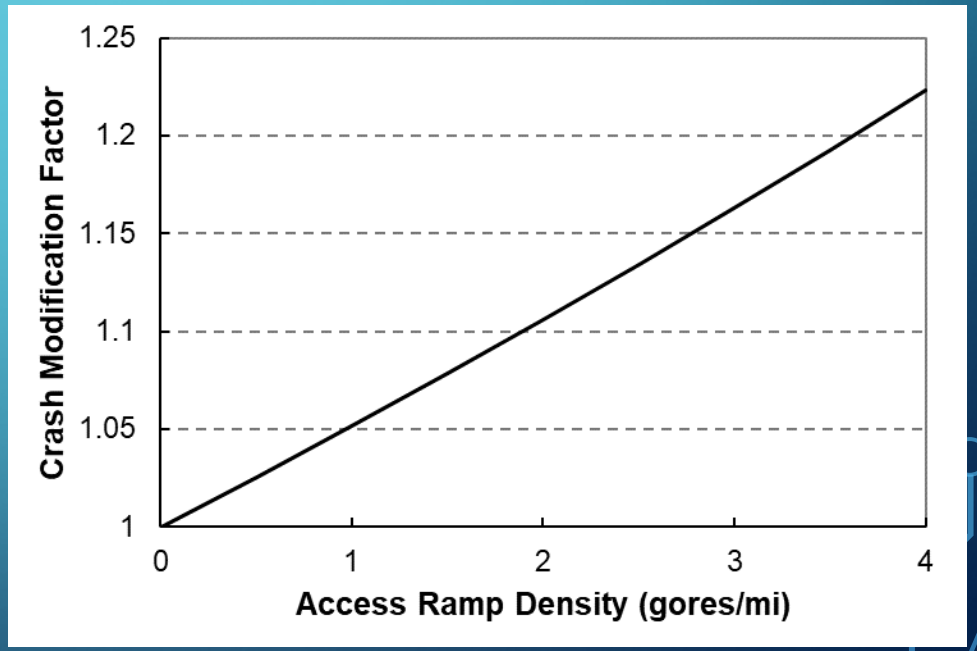
REVERSIBLE MANAGED LANES



Crash Modification Factor:

✓ Access ramp density



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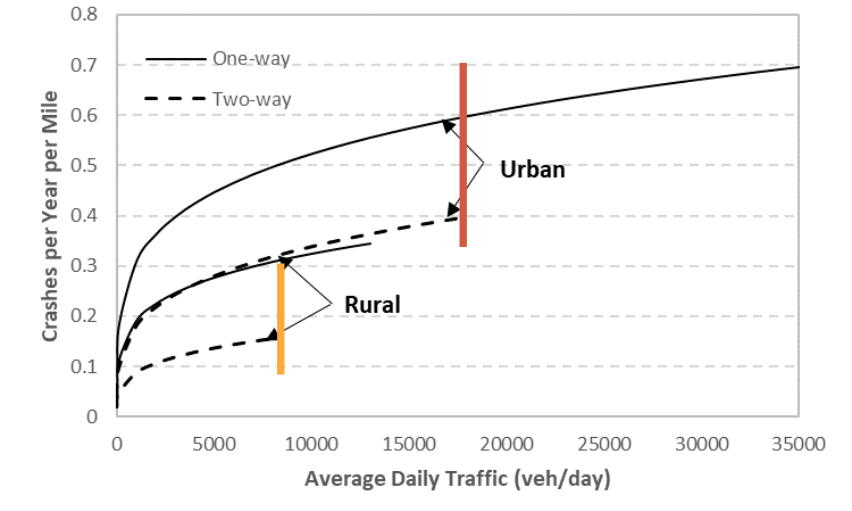
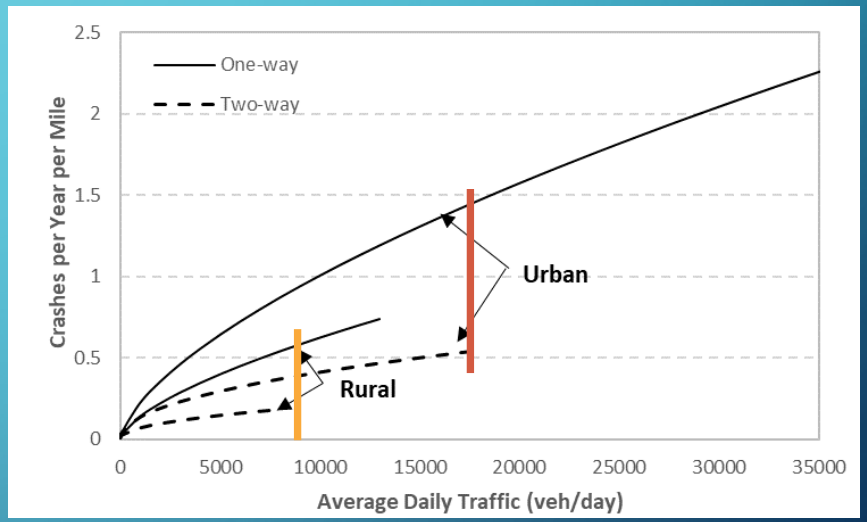
NEW SPFS

- Frontage roads



Single-vehicle Crashes



Multi-vehicle Crashes

Two –Way < One-Way

Only in range on graph
Consider severity
CMFs

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NEW SPFS

- Frontage roads

Severity	One-way		Two-way	
	Rural	Urban	Rural	Urban
K	0.9%	0.4%	4.4%	0.6%
A	4.6%	1.3%	6.1%	0.6%
B	8.7%	10.4%	11.4%	10.3%
C	13.3%	18.2%	16.7%	12.8%
O	72.4%	69.6%	61.4%	76.3%

14.2%

21.9%

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NEW SPFS

- Frontage roads

Crash Modification Factors:

- ✓ Shoulder width
- ✓ Access point density
- ✓ Ramp presence
- ✓ Posted speed limit
- ✓ Horizontal curve density

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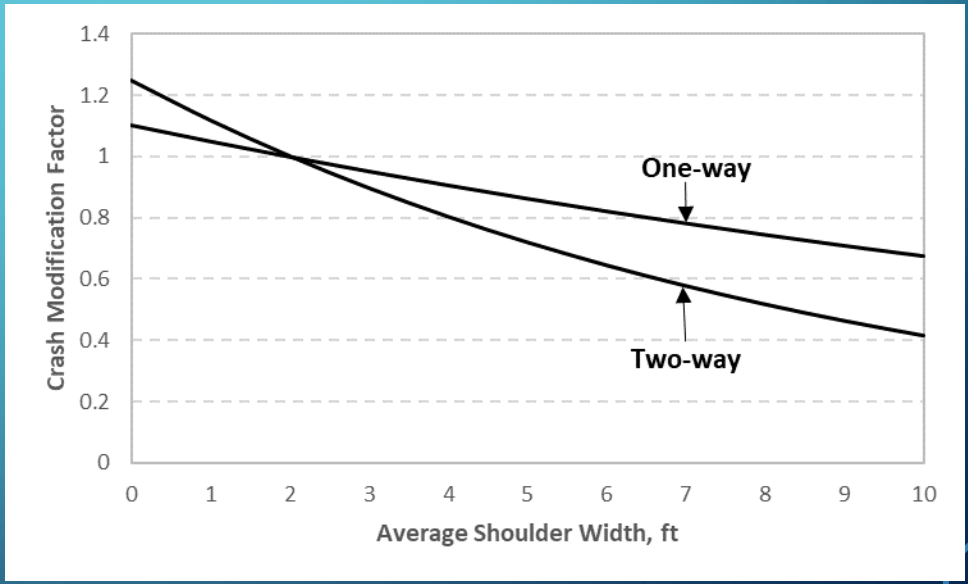
NEW SPFS

- Frontage roads

Crash Modification Factors:

✓Shoulder width



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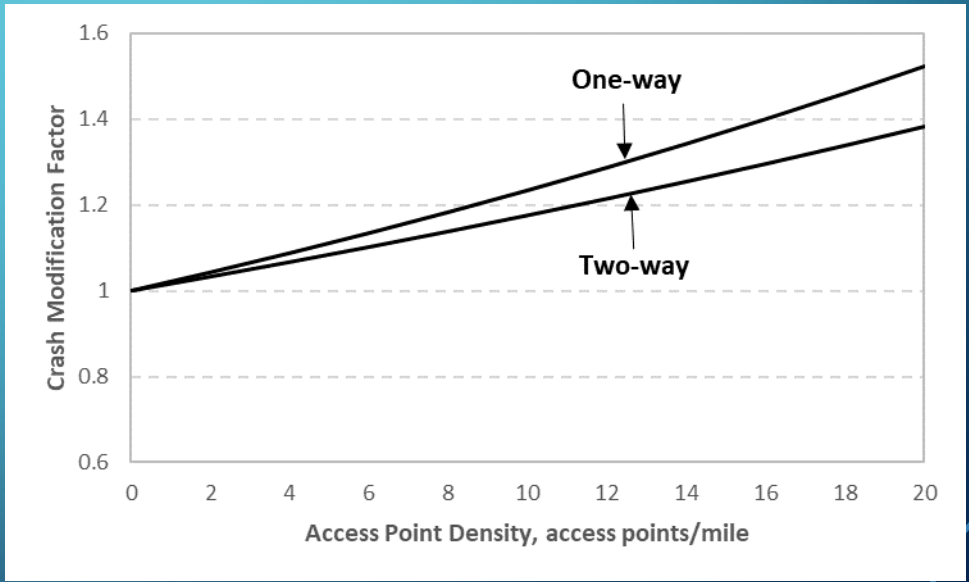
NEW SPFS

- Frontage roads

Crash Modification Factors:

✓Access point density



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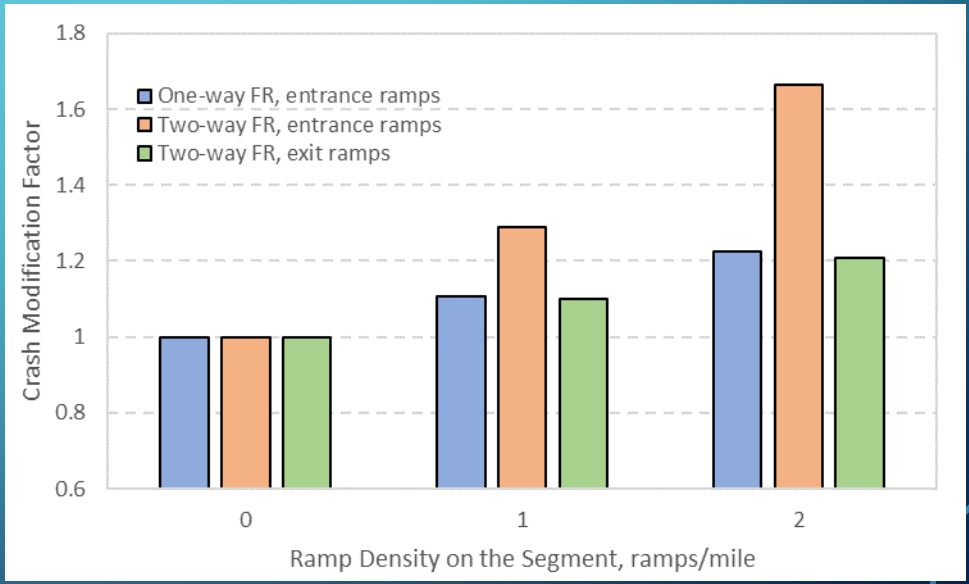
NEW SPFS

- Frontage roads

Crash Modification Factors:

✓Ramp presence



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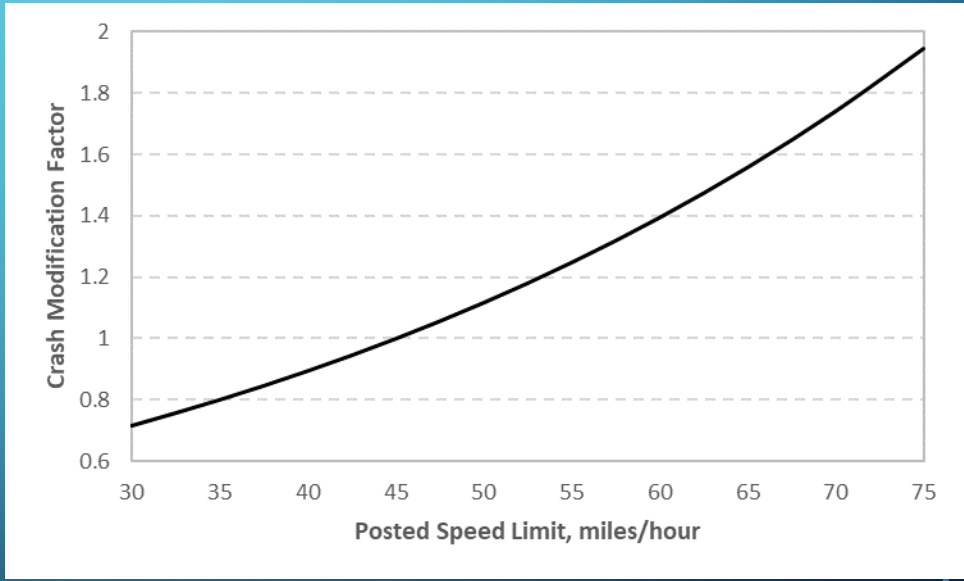
NEW SPFS

- Frontage roads

Crash Modification Factors:

✓Posted speed limit



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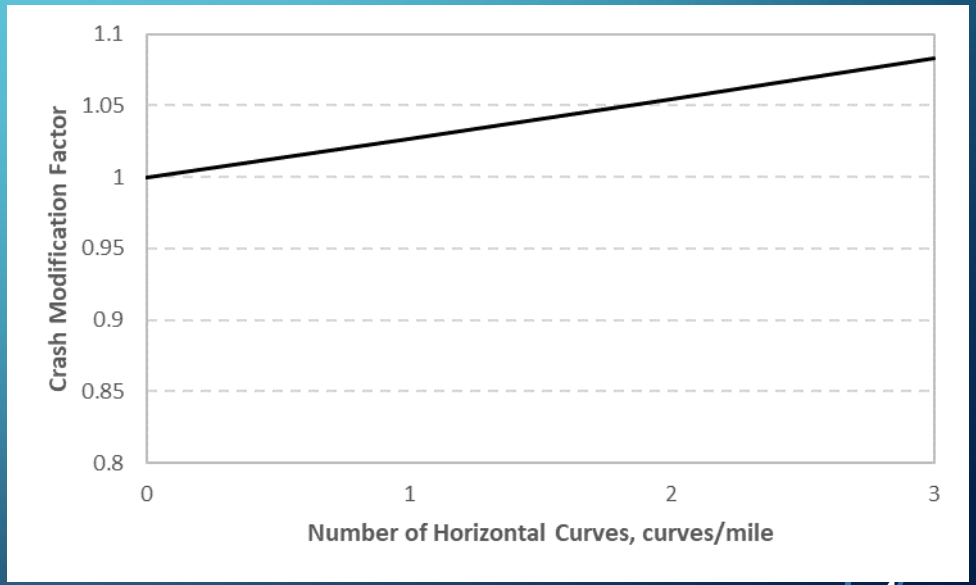
NEW SPFS

- Frontage roads

Crash Modification Factors:



✓ Horizontal curve density

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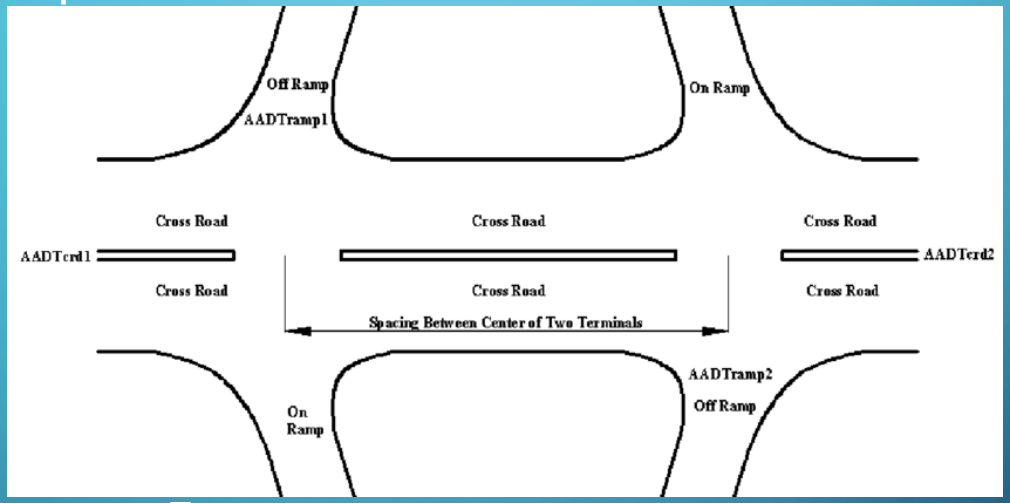
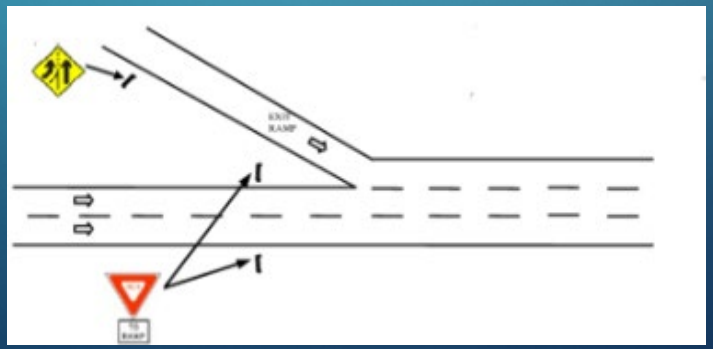
NEW SPFS

- Ramps considered in HSM are different from ramps in Texas
  - Typical ramps in the HSM

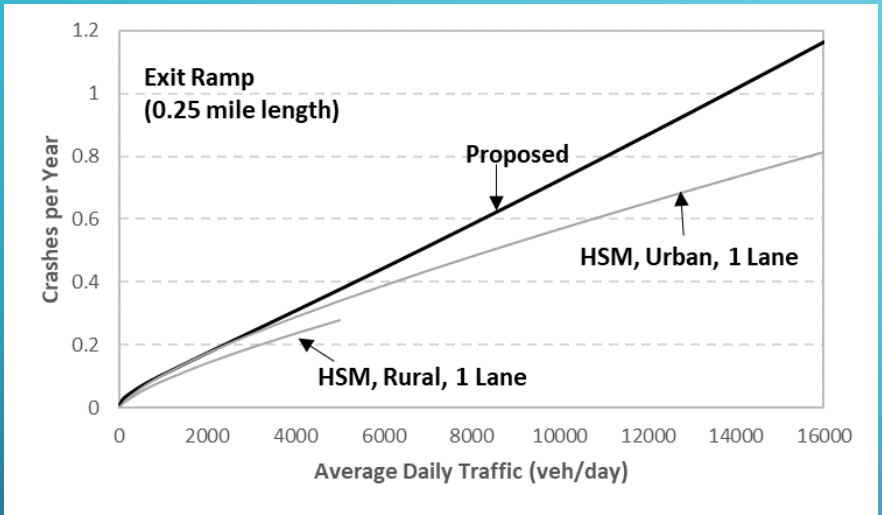


  - Typical ramps in Texas

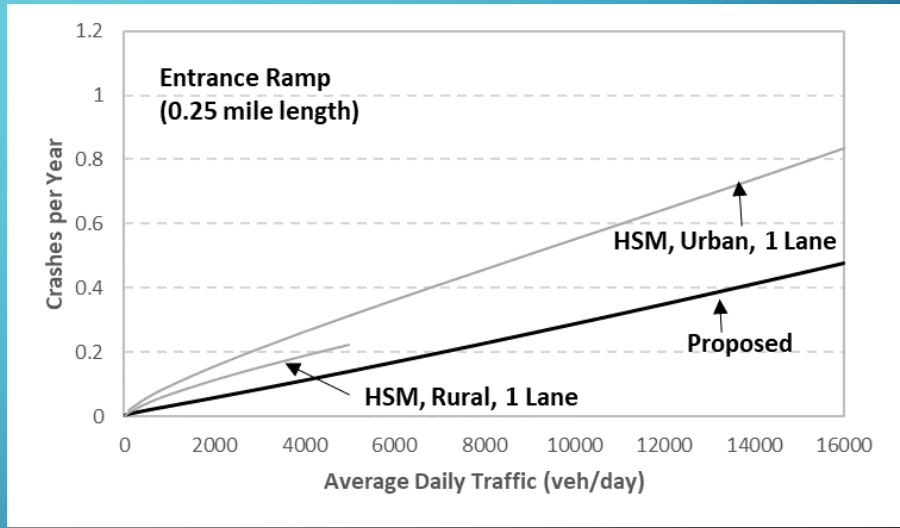


NEW SPFS

- Ramps



Exit Ramp



Entrance Ramp

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RAMPS
SEVERITY DISTRIBUTIONS

Severity	Ramp Type	
	Exit	Entrance
K	0.4%	2.9%
A	3.3%	2.9%
B	10.7%	20.0%
C	15.6%	18.6%
O	70.1%	55.7%

14.4%

25.8%

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RAMPS

Crash Modification Factors:

- ✓Shoulder width
- ✓Horizontal curve density
- ✓Barrier presence

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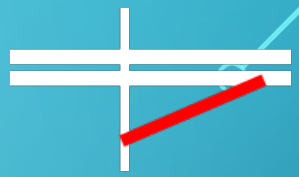
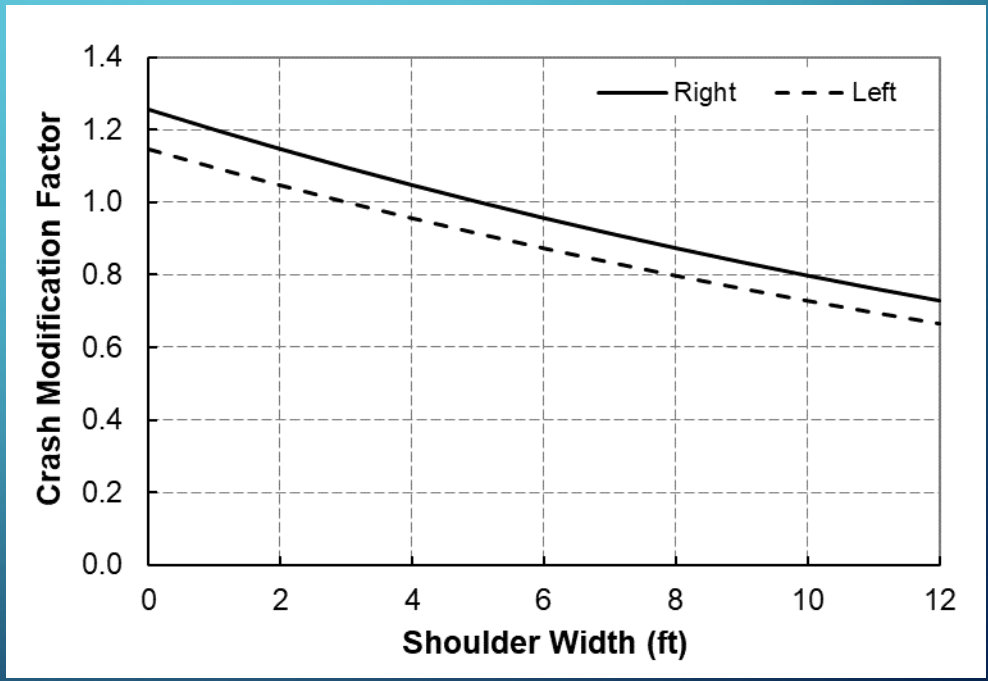
RAMPS



Crash Modification Factor:

✓Shoulder width



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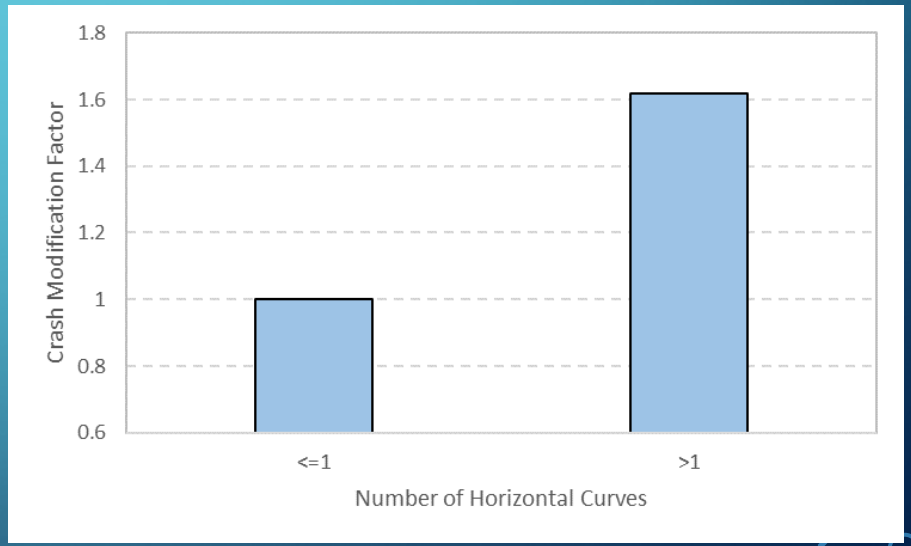
NEW SPFS

- Ramps

Crash Modification Factor:

✓Horizontal curve density



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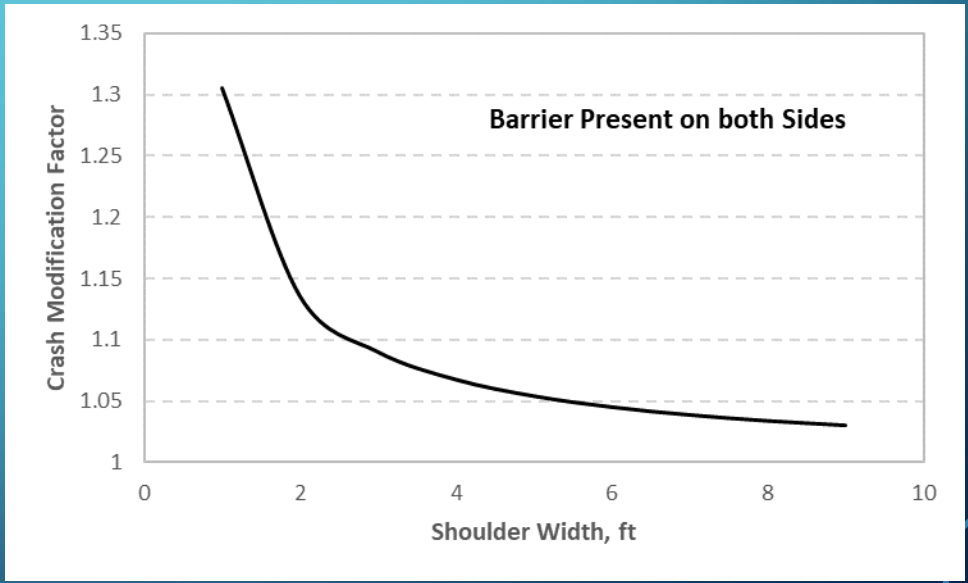
NEW SPFS

- Ramps

Crash Modification Factor:

✓Barrier presence



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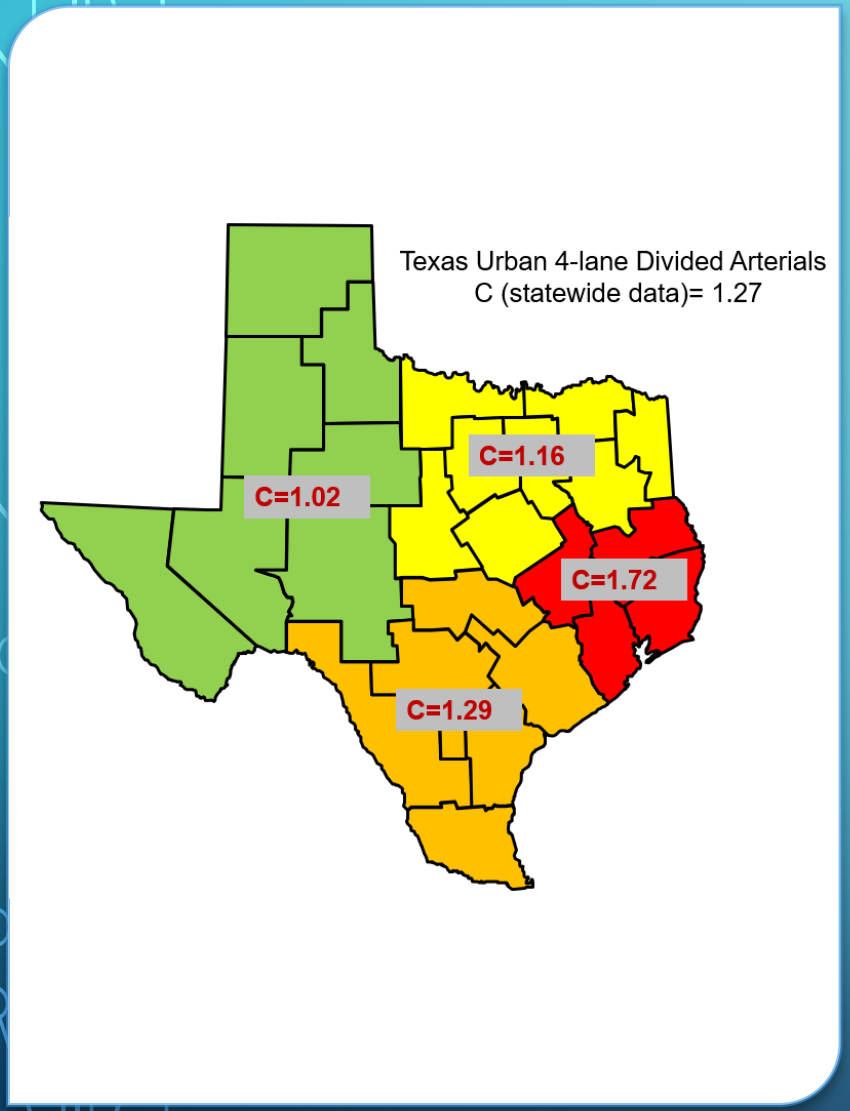

REGIONAL FACTORS

$$f_{region} = \frac{C_{region}}{C_{state}}$$

QUESTIONS?

2. SPREADSHEET TOOLS

- Rural Two-Lane Highways
- Rural Multi-Lane Highways
- Urban Arterials
- Freeways

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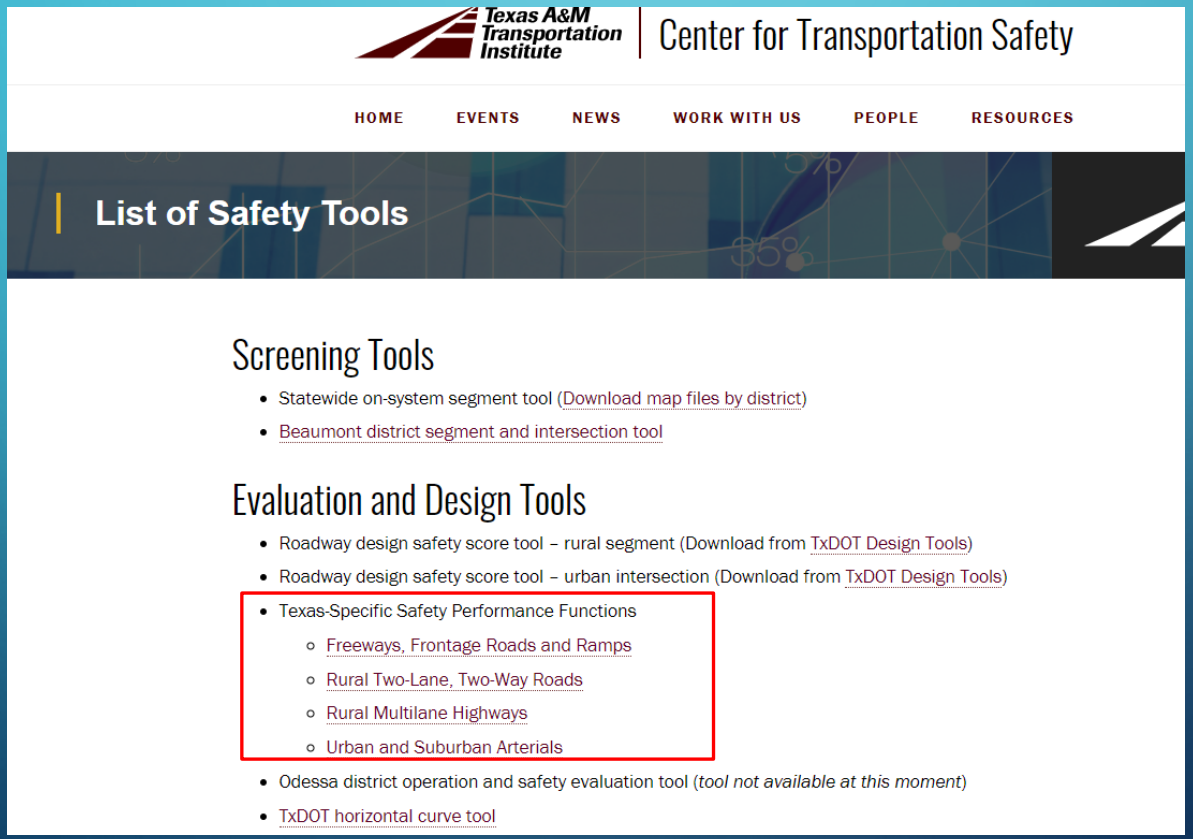
SPREADSHEET TOOLS

https://cts.tti.tamu.edu/project/list-of-safety-tools/



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RURAL TWO-LANE HIGHWAYS

Highway Safety Manual 1st Edition, Volume 2, Chapter 10 -- Predictive Method for Rural Two-Lane, Two-Way Roads -- Analysis Spreadsheet Summary
Updated for Texas Roadways based on TxDOT Research Projects 0-7083 & 5-7083
Release date: 1/11/2024

Overview

This spreadsheet has been developed to demonstrate the predictive models for rural two-lane highways as contained in the Highway Safety Manual. The content was developed for training purposes and all users should verify that the answers that they obtain with these worksheets correctly represent their target analysis.

The worksheet tabs shown at the bottom of this file represent the various analyses that can be performed using this spreadsheet tool and the HSM predictive methods. A user can evaluate an individual road segment or intersection as well as analyze multiple road segments and intersections. If more than one segment type requires analysis, the user should create a blank worksheet and then copy the contents of the segment worksheet into the blank sheet and name the worksheet accordingly.

The analysis worksheets provide the base condition for each input variable. If the user does not have data to describe the site conditions for the variable of interest, he or she should enter a value equal to the base condition for the variable.

The current contents of this spreadsheet include the following worksheets:

Worksheet Name	Contents
Instructions	Current worksheet displaying overview, summary of spreadsheet worksheets, and description of color coding included in the worksheets.
Segment 1	Analysis for the rural 2-lane segments that uses lookup tables from exhibits included in the worksheet "Segment Tables." The associated HSM worksheets are 1A, 1B, 1C, 1D, and 1E.
Segment 2	Duplicate segment worksheet for additional highway segments.
Segment Tables	Includes segment tables used for analysis of HSM-provided crash trends as well as locally-derived crash information. These are HSM Tables 10-3, 10-4, and 10-12. This worksheet also includes tables used for CMF calculations. These tables

Color Coding in the Worksheets

The worksheets include five specific color options to help users identify locations where input data is required or output data is provided. In some cases, the shaded cells require the user to input specific numbers. In other cases the input is restricted to a select set of options included in pull-down lists. The respective color coding is as follows:

Color Used	Type of Information Required from User
	Required input data as identified in the HSM.
	Input data required from the user but restricted to options provided in drop-down menus.
	Optional input data that can be used to supplement the analysis if this information is available. This optional input data is reserved for locally-derived crash information. These values are determined from a query of crash data and should be altered with caution only if justified based on an updated data analysis. If the user elects to use this option to improve analysis for local crash distribution trends, each of the Tables with the locally-derived input also include a drop-down menu where the user should indicate he or she is using locally-derived crash information. The worksheets will then use the local values instead of the HSM default values.
	Optional input data used to describe the analysis. These values do not affect calculation results.
	Key output data, including predicted crash frequency, expected crash frequency, or combined CMF.

Instructions | Segment 1 | Segment 2 | Segment Tables | Intersection 1 | Intersection 2 | Intersection Tables | Rural 2-Lane Site Total

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RURAL TWO-LANE HIGHWAYS

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	Required input data as identified in the HSM.
	Input data required from the user but restricted to options provided in drop-down menus.
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	Optional input data used to describe the analysis. These values do not affect calculation results.
	Key output data, including predicted crash frequency, expected crash frequency, or combined CMF.

Instructions | Segment 1 | Segment 2 | Segment Tables | Intersection 1 | Intersection 2 | Intersection Tables | Rural 2-Lane Site Total

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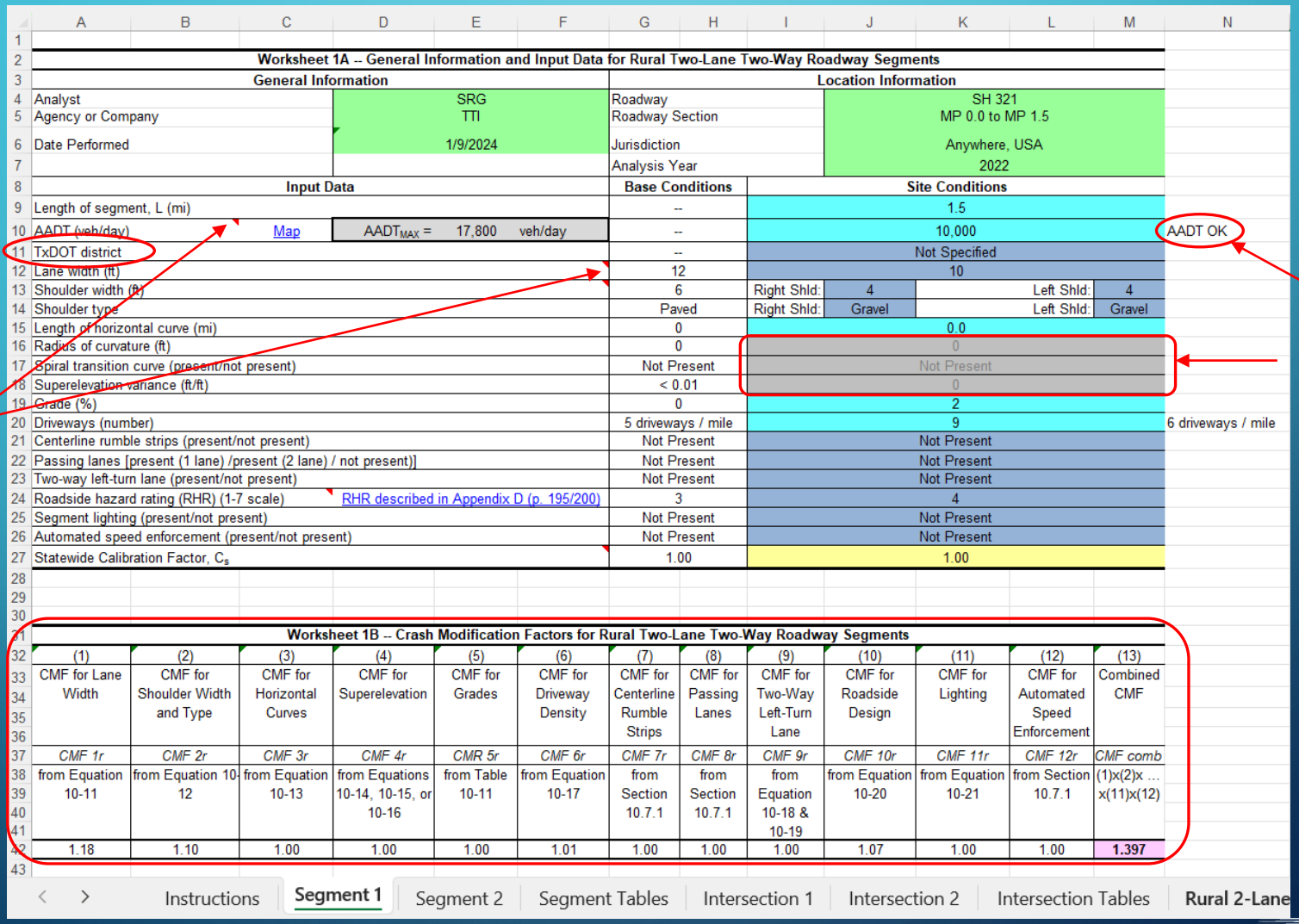
RURAL TWO-LANE HIGHWAYS



Worksheet 1A -- General Information and Input Data for Rural Two-Lane Two-Way Roadway Segments

General Information		Location Information	
Analyst	SRG	Roadway	SH 321
Agency or Company	TTI	Roadway Section	MP 0.0 to MP 1.5
Date Performed	1/9/2024	Jurisdiction	Anywhere, USA
		Analysis Year	2022

Input Data		Base Conditions	Site Conditions				
Length of segment, L (mi)		--	1.5				
AADT (veh/day)	Map; $AADT_{MAX}$ = 17,800 veh/day	--	10,000				AADT OK
TxDOT district		--	Not Specified				
Lane width (ft)		12	10				
Shoulder width (ft)		6	Right Shld:	4	Left Shld:	4	
Shoulder type		Paved	Right Shld:	Gravel	Left Shld:	Gravel	
Length of horizontal curve (mi)		0	0.0				
Radius of curvature (ft)		0	0				
Spiral transition curve (present/not present)		Not Present	Not Present				
Superelevation variance (ft/ft)		< 0.01	0				
Grade (%)		0	2				
Driveways (number)		5 driveways / mile	9				6 driveways / mile
Centerline rumble strips (present/not present)		Not Present	Not Present				
Passing lanes [present (1 lane) /present (2 lane) / not present)]		Not Present	Not Present				
Two-way left-turn lane (present/not present)		Not Present	Not Present				
Roadside hazard rating (RHR) (1-7 scale)	RHR described in Appendix D (p. 195/200)	3	4				
Segment lighting (present/not present)		Not Present	Not Present				
Automated speed enforcement (present/not present)		Not Present	Not Present				
Statewide Calibration Factor, C_s		1.00	1.00				

Worksheet 1B -- Crash Modification Factors for Rural Two-Lane Two-Way Roadway Segments

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
CMF for Lane Width	CMF for Shoulder Width and Type	CMF for Horizontal Curves	CMF for Superelevation	CMF for Grades	CMF for Driveway Density	CMF for Centerline Rumble Strips	CMF for Passing Lanes	CMF for Two-Way Left-Turn Lane	CMF for Roadside Design	CMF for Lighting	CMF for Automated Speed Enforcement	Combined CMF
CMF 1r	*CMF 2r*	*CMF 3r*	*CMF 4r*	*CMR 5r*	*CMF 6r*	*CMF 7r*	*CMF 8r*	*CMF 9r*	*CMF 10r*	*CMF 11r*	*CMF 12r*	*CMF comb*
from Equation 10-11	from Equation 10-12	from Equation 10-13	from Equations 10-14, 10-15, or 10-16	from Table 10-11	from Equation 10-17	from Section 10.7.1	from Section 10.7.1	from Equation 10-18 & 10-19	from Equation 10-20	from Equation 10-21	from Section 10.7.1	(1)x(2)x … x(11)x(12)
1.18	1.10	1.00	1.00	1.00	1.01	1.00	1.00	1.00	1.07	1.00	1.00	**1.397**

Instructions | Segment 1 | Segment 2 | Segment Tables | Intersection 1 | Intersection 2 | Intersection Tables | Rural 2-Lane

Guidance

Validation

Conditional formatting

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RURAL TWO-LANE HIGHWAYS

Worksheet 1C -- Roadway Segment Crashes for Rural Two-Lane Two-Way Roadway Segments

(1) Crash Severity Level	(2) N spf rs	(3) Overdispersion Parameter, k	(4) Crash Severity Distribution	(5) N spf rs by Severity Distribution	(6) Combined CMFs	(7) State/Region Adjustment, $C_s * AF_r$	(8) Predicted average crash frequency, $N_{predicted\ rs}$ (crashes/year)
	from Equation 10-6	from Equation 10-7	from Table 10-3 (proportion)	(2)TOTAL x (4)	(13) from Worksheet 1B		(5)x(6)x(7)
Total	2.566	0.247	1.000	2.566	**1.40**	1.00	**3.584**
Fatal and Injury (FI)	--	--	0.344	0.883	**1.40**	1.00	**1.233**
Property Damage Only (PDO)	--	--	0.656	1.683	**1.40**	1.00	**2.351**

Worksheet 1D -- Crashes by Severity Level and Collision Type for Rural Two-Lane Two-Way Roadway Segments

(1) Collision Type	(2) Proportion of Collision Type(TOTAL)	(3) $N_{predicted\ rs}$ (TOTAL) (crashes/year)	(4) Proportion of Collision Type(FI)	(5) $N_{predicted\ rs}$ (FI) (crashes/year)	(6) Proportion of Collision Type(PDO)	(7) $N_{predicted\ rs}$ (PDO) (crashes/year)
	from Table 10-4	(8)TOTAL from Worksheet 1C	from Table 10-4	(8)FI from Worksheet 1C	from Table 10-4	(8)PDO from Worksheet 1C
Total	1.000	3.584	1.000	1.233	1.000	2.351
		(2)x(3)TOTAL		(4)x(5)FI		(6)x(7)PDO
SINGLE-VEHICLE						
Collision with animal	0.113	0.405	0.035	0.043	0.154	0.362
Collision with bicycle	0.004	0.014	0	0.000	0.006	0.014
Collision with pedestrian	0.000	0.000	0	0.000	0	0.000
Overturned	0.000	0.000	0	0.000	0	0.000
Ran off road	0.530	1.899	0.635	0.783	0.475	1.117
Other single-vehicle collision	0.065	0.233	0.071	0.088	0.062	0.146
Total single-vehicle crashes	0.712	2.552	0.741	0.914	0.697	1.639
MULTIPLE-VEHICLE						
Angle collision	0.028	0.100	0.035	0.043	0.025	0.059
Head-on collision	0.045	0.161	0.035	0.043	0.049	0.115
Rear-end collision	0.057	0.204	0.071	0.088	0.049	0.115
Sideswipe collision	0.020	0.072	0.012	0.015	0.025	0.059
Other multiple-vehicle collision	0.138	0.495	0.106	0.131	0.154	0.362
Total multiple-vehicle crashes	0.288	1.032	0.259	0.319	0.302	0.710

Instructions | Segment 1 | Segment 2 | Segment Tables | Intersection 1 | Intersection 2 | Intersection Tables | Rural 2-Lane

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RURAL TWO-LANE HIGHWAYS

Tables Affiliated with Crash Statistics:

Table 10-3: Distribution for Crash Severity Level on Rural Two-Lane Two-Way Roadway Segments plus Locally-Derived Values

Crash severity level	Percentage of total roadway segment crashes	
Locally-Derived Values? Yes	HSM-Provided Values	Locally-Derived Values (Texas)
Fatal	1.3	3.6
Incapacitating Injury	5.4	6.1
Nonincapacitating Injury	10.9	11.3
Possible Injury	14.5	13.4
Total Fatal Plus Injury	32.1	34.4
Property Damage Only	67.9	65.6
TOTAL	100.0	100.0

Note: HSM-provided crash severity data based on HSIS data for Washington (2002-2006)

Table 10-4: Default Distribution by Collision Type for Specific Crash Severity Levels on Rural Two-Lane Two-Way Roadway Segments plus Locally-Derived Values

	Percentage of total roadway segment crashes by crash severity level					
	HSM-Provided Values			Locally-Derived Values (Texas)		
Collision type	Total fatal and injury	Property damage only	TOTAL (all severity levels combined)	Total fatal and injury	Property damage only	TOTAL (all severity levels combined)
Locally-Derived Values? Yes						
SINGLE-VEHICLE CRASHES						
Collision with animal	3.8	18.4	12.1	3.5	15.4	11.3
Collision with bicycle	0.4	0.1	0.2	0.0	0.6	0.4
Collision with pedestrian	0.7	0.1	0.3	0.0	0.0	0.0
Overturned	3.7	1.5	2.5	0.0	0.0	0.0
Ran off road	54.5	50.5	52.1	63.5	47.5	53.0
Other single-vehicle crash	0.7	2.9	2.1	7.1	6.2	6.5
Total single-vehicle crashes	63.8	73.5	69.3	74.1	69.7	71.2
MULTIPLE-VEHICLE CRASHES						
Angle collision	10.0	7.2	8.5	3.5	2.5	2.8
Head-on collision	3.4	0.3	1.6	3.5	4.9	4.5
Rear-end collision	16.4	12.2	14.2	7.1	4.9	5.7
Sideswipe collision	3.8	3.8	3.7	1.2	2.5	2.0
Other multiple-vehicle collision	2.6	3.0	2.7	10.6	15.4	13.8
Total multiple-vehicle crashes	36.2	26.5	30.7	25.9	30.2	28.8
TOTAL CRASHES	100.0	100.0	100.0	100.0	99.9	100.0

Note: HSM-provided values based on crash data for Washington (2002-2006); includes approximately 70 percent opposite-direction sideswipe and 30 percent same-direction sideswipe collisions.

Table 10-12: Nighttime Crash Proportions for Unlighted Roadway Segments plus Locally-Derived Values

HSM Default Values	Locally-Derived Values

SPF Coefficients

Locally-Derived Values? Yes					
HSM-Provided Values			Locally-Derived Values (Texas)		
Constant	AADT	Overdispersion	Constant	AADT	Overdispersion
-0.312	1	0.236	-7.025	0.821	0.247

Region Adjustment Factors

Region	Adjustment Factor
Not Specified	1.00
East	1.01
North	1.15
South	0.73
West	1.00

Districts and Regions

District	Region
Not Specified	Not Specified
Abilene	West
Amarillo	West
Atlanta	North
Austin	South
Beaumont	East
Brownwood	North
Bryan	East
Childress	West
Corpus Christi	South
Dallas	North
El Paso	West
Fort Worth	North
Houston	East
Laredo	South
Lubbock	West
Lufkin	East
Odessa	West
Paris	North
Pharr	South
San Angelo	West

Instructions | Segment 1 | Segment 2 | Segment Tables | Intersection 1 | Intersection 2 | Intersection Tables | Rural 2-Lane Site Total

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RURAL TWO-LANE HIGHWAYS

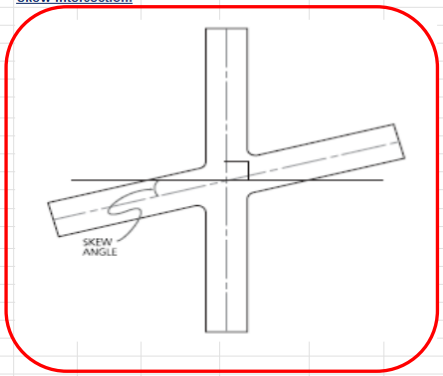
Worksheet 2A -- General Information and Input Data for Rural Two-Lane Two-Way Roadway Intersections

General Information		Location Information	
Analyst	SRG	Roadway	SH 321
Agency or Company	TTI	Intersection	Main Street at 1st Street
Date Performed	1/9/2024	Jurisdiction	Anywhere, USA
		Analysis Year	2022

Input Data			Base Conditions	Site Conditions			
Intersection type (3ST, 4ST, 4SG)			--	3ST			Unsignalized three-leg (stop control on minor-road approaches)
$AADT_{major}$ (veh/day)	Map	$AADT_{MAX}$ = 19,500 veh/day	--	8,000			AADT OK
$AADT_{minor}$ (veh/day)		$AADT_{MAX}$ = 4,300 veh/day	--	1,000			AADT OK
TxDOT district			--	Not Specified			
Intersection skew angle (degrees)			0	Skew for Leg 1 (All):	30	Skew for Leg 2 (4ST only):	30
Number of signalized or uncontrolled approaches with a left-turn lane (0, 1, 2, 3, 4)			0	0			
Number of signalized or uncontrolled approaches with a right-turn lane (0, 1, 2, 3, 4)			0	0			
Intersection lighting (present/not present)			Not Present	Present			
Statewide Calibration Factor, C_s			1.00	1.00			

3ST, 4ST, or 4SG

Skew Intersection:



Worksheet 2B -- Crash Modification Factors for Rural Two-Lane Two-Way Roadway Intersections

(1) CMF for Intersection Skew Angle CMF_{1i} from Equations 10-22 or 10-23	(2) CMF for Left-Turn Lanes CMF_{2i} from Table 10-13	(3) CMF for Right-Turn Lanes CMF_{3i} from Table 10-14	(4) CMF for Lighting CMF_{4i} from Equation 10-24	(5) Combined CMF CMF_{COMB} (1)*(2)*(3)*(4)
1.13	1.00	1.00	0.90	**1.02**

Worksheet 2C -- Intersection Crashes for Rural Two-Lane Two-Way Roadway Intersections

(1) Crash Severity Level	(2) $N_{spf\ 3ST,\ 4ST\ or\ 4SG}$ from Equations 10-8, 10-9, or 10-10	(3) Overdispersion Parameter, k from Section 10.6.2	(4) Crash Severity Distribution from Table 10-5	(5) $N_{spf\ 3ST,\ 4ST\ or\ 4SG}$ by Severity Distribution $(2)_{TOTAL}$ * (4)	(6) Combined CMFs from (5) of Worksheet 2B	(7) State/Region Adjustment, C_s * AF_r	(8) Predicted average crash frequency, $N_{predicted\ int}$ (5)*(6)*(7)
Total	0.461	0.405	1.000	0.461	**1.02**	1.00	**0.468**
Fatal and Injury (FI)	--	--	0.335	0.154	**1.02**	1.00	**0.157**
Property Damage Only (PDO)	--	--	0.665	0.307	**1.02**	1.00	**0.311**

Worksheet 2D -- Crashes by Severity Level and Collision Type for Rural Two-Lane Two-Way Road Intersections

(1) Collision Type	(2) Proportion of Collision $Type_{(TOTAL)}$	(3) $N_{predicted\ int\ (TOTAL)}$ (crashes/year)	(4) Proportion of Collision $Type_{(FI)}$	(5) $N_{predicted\ int\ (FI)}$ (crashes/year)	(6) Proportion of Collision $Type_{(PDO)}$	(7) $N_{predicted\ int\ (PDO)}$ (crashes/year)

Instructions | Segment 1 | Segment 2 | Segment Tables | Intersection 1 | Intersection 2 | Intersection Tables | Rural 2-Lane Site Total

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RURAL TWO-LANE HIGHWAYS

Worksheet 3A -- Predicted and Observed Crashes by Severity and Site Type Using the Site-Specific EB Method

(1) Site type and description		(2) Predicted average crash frequency (crashes/year) $N_{predicted}$ (TOTAL)	(3) Predicted average crash frequency (crashes/year) $N_{predicted}$ (FI)	(4) Predicted average crash frequency (crashes/year) $N_{predicted}$ (PDO)	(5) Observed crashes, $N_{observed}$ (crashes/year)	(6) Overdispersion Parameter, k	(7) Weighted adjustment, w Equation A-5 from Part C Appendix	(8) Expected average crash frequency, $N_{expected}$ Equation A-4 from Part C Appendix
ROADWAY SEGMENTS								
Segment 1	From worksheet	3.584	1.233	2.351	10	0.247	0.530	**6.597**
Segment 2	From worksheet	0.302	0.104	0.198	2	0.247	0.931	**0.419**
Segment 3								**0.000**
Segment 4								**0.000**
Segment 5								**0.000**
Segment 6								**0.000**
Segment 7								**0.000**
Segment 8								**0.000**
INTERSECTIONS								
Intersection 1	From worksheet	0.468	0.157	0.311	3	0.405	0.841	**0.872**
Intersection 2	From worksheet	2.535	0.826	1.708	2	0.599	0.397	**2.212**
Intersection 3								**0.000**
Intersection 4								**0.000**
Intersection 5								**0.000**
Intersection 6								**0.000**
Intersection 7								**0.000**
Intersection 8								**0.000**
COMBINED (sum of column)		6.889	2.320	4.569	17	--	--	**10.100**

Worksheet 3B -- Site-Specific EB Method Summary Results

(1) Crash severity level	(2) $N_{predicted}$	(3) $N_{expected}$
Total	$(2)_{COMB}$ from Worksheet 3A	$(8)_{COMB}$ from Worksheet 3A
	6.889	**10.1**
Fatal and Injury (FI)	$(3)_{COMB}$ from Worksheet 3A	$(3)_{TOTAL} * (2)_{FI} / (2)_{TOTAL}$
	2.320	**3.4**
Property Damage Only (PDO)	$(4)_{COMB}$ from Worksheet 3A	$(3)_{TOTAL} * (2)_{PDO} / (2)_{TOTAL}$
	4.569	**6.7**

Instructions | Segment 1 | Segment 2 | Segment Tables | Intersection 1 | Intersection 2 | Intersection Tables | Rural 2-Lane Site Total

RURAL MULTI-LANE HIGHWAYS

Worksheet 1A -- General Information and Input Data for Rural Multilane Divided Roadway Segments

General Information		Location Information	
Analyst	SRG	Roadway	SH 123
Agency or Company	TTI	Roadway Section	MP 0.0 to MP 1.5
Date Performed	1/9/2024	Jurisdiction	Anywhere, USA
		Analysis Year	2010

Input Data		Base Conditions	Site Conditions
Roadway type (divided)		Divided	Divided
Length of segment, L (mi)		--	1.5
AADT (veh/day)	Map; $AADT_{MAX}$ = 89,300 veh/day	--	10,000
TxDOT district		--	Not Specified
Lane width (ft)		12	12
Average right shoulder width (ft)		8	0
Right shoulder type		Paved	Paved
Median width (ft)		30	20
Lighting (present/not present)		Not Present	Not Present
Automated speed enforcement (present/not present)		Not Present	Not Present
Statewide Calibration Factor, C_s		1.00	1.00

Worksheet 1B (a) -- Crash Modification Factors for Rural Multilane Divided Roadway Segments

(1)	(2)	(3)	(4)	(5)	(6)
CMF for Lane Width	CMF for Right Shoulder Width	CMF for Median Width	CMF for Lighting	CMF for Automated Speed Enforcement	Combined CMF
CMF 1rd	*CMF 2rd*	*CMF 3rd*	*CMF 4rd*	*CMF 5rd*	*CMF comb*
from Equation 11-16	from Table 11-17	from Table 11-18	from Equation 11-17	from Section 11.7.2	(1)*(2)*(3)*(4)*(5)
1.00	1.18	1.02	1.00	1.00	**1.20**

Worksheet 1C (a) -- Roadway Segment Crashes for Rural Multilane Divided Roadway Segments

(1)	(2)	(3)	(4)	(5)	(6)	(7)

Instructions | Rural Divided Multilane Seg | Rural Undivided Multilane Seg | Segment Tables | Rural Multilane Intersection | Intersection Tables

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URBAN ARTERIALS

Worksheet 2A -- General Information and Input Data for Urban and Suburban Arterial Intersections

General Information		Location Information	
Analyst	SRG	Roadway	SH 123
Agency or Company	TTI	Intersection	Main St at 4th Avenue
Date Performed	1/9/2024	Jurisdiction	Anywhere, USA
		Analysis Year	2010

Input Data			Base Conditions	Site Conditions	
Intersection type (3ST, 3SG, 4ST, 4SG)			--	3SG	Signalize
AADT $_{major}$ (veh/day)	Map	$AADT_{MAX}$ = 58,100 veh/day	--	15,000	AADT OK
AADT $_{minor}$ (veh/day)		$AADT_{MAX}$ = 16,400 veh/day	--	9,000	AADT OK
TxDOT district			--	Not Specified	
Roadway type for major road			--	5T	Five-lane
Intersection lighting (present/not present)			Not Present	Present	
Statewide Calibration Factor, C_s			1.00	1.00	
Data for unsignalized intersections only:			--	--	
Number of major-road approaches with left-turn lanes (0,1)			0	0	
Number of major-road approaches with right-turn lanes (0,1)			0	0	
Data for signalized intersections only:			--	--	
Number of approaches with left-turn lanes (0,1,2)			0	2	
Number of approaches with right-turn lanes (0,1,2)			0	2	
Number of approaches with left-turn signal phasing (0,1,2)			--	2	
Type of left-turn signal phasing for Leg #1			Permissive	Protected / Permissive	
Type of left-turn signal phasing for Leg #2			--	Protected / Permissive	
Type of left-turn signal phasing for Leg #3 (if applicable)			--	Not Applicable	
Type of left-turn signal phasing for Leg #4 (if applicable)			--	Not Applicable	
Number of approaches with right-turn-on-red prohibited (0,1,2)			0	0	
Intersection red light cameras (present/not present)			Not Present	Not Present	
Sum of all pedestrian crossing volumes (PedVol) (1 - 34,200)				1,500	
Maximum number of lanes crossed by a pedestrian (n_{lanesx})			--	4	
Number of bus stops within 300 m (1,000 ft) of the intersection			0	2	
Schools within 300 m (1,000 ft) of the intersection (present/not present)			Not Present	Present	
Number of alcohol sales establishments within 300 m (1,000 ft) of the intersection			0	6	

Instructions | Segment 1 | Segment 2 | Segment Tables | Intersection 1 | Intersection 2 | Intersection Tables | Urban Site Total | Urban Project Total

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URBAN ARTERIALS

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1														
2	**Worksheet 1A -- General Information and Input Data for Urban and Suburban Roadway Segments**													
3	**General Information**							**Location Information**						
4	Analyst				SRG			Roadway				SH 123		
5	Agency or Company				TTI			Roadway Section				MP 0.0 to MP 1.5		
6	Date Performed				1/9/2024			Jurisdiction				Anywhere, USA		
7								Analysis Year				2010		
8	**Input Data**							**Base Conditions**			**Site Conditions**			
9	Roadway type (2U, 3T, 4U, 4D, 5T)							--			5T			
10	Length of segment, L (mi)							--			1.5			
11	AADT (veh/day)		Map		$AADT_{MAX}$ =	53,800	veh/day	--			11,000			
12	TxDOT district							--			Not Specified			
13	Type of on-street parking (none/parallel/angle)							None			Parallel (Comm/Ind)			
14	Proportion of curb length with on-street parking							--			0.66			
15	Median width (ft) - for divided only							15			Not Present			
16	Lighting (present / not present)							Not Present			Present			
17	Automated speed enforcement (present / not present)							Not Present			Not Present			
18	Major commercial driveways (number)							--			0			
19	Minor commercial driveways (number)							--			10			
20	Major industrial / institutional driveways (number)							--			0			
21	Minor industrial / institutional driveways (number)							--			3			
22	Major residential driveways (number)							--			2			
23	Minor residential driveways (number)							--			15			
24	Other driveways (number)							--			0			
25	Speed Category							--			Posted Speed Greater than 30 mph			
26	Roadside fixed object density (fixed objects / mi)							0			10			
27	Offset to roadside fixed objects (ft)							30			6			
28	Statewide Calibration Factor, C_s							1.00			1.00			
29														
30														
31														
32	**Worksheet 1B -- Crash Modification Factors for Urban and Suburban Roadway Segments**													
33	(1)			(2)			(3)	(4)			(5)			(6)
34	CMF for On-Street Parking			CMF for Roadside Fixed Objects			CMF for Median Width	CMF for Lighting			CMF for Automated Speed Enforcement			Combined CMF
35														
36	*CMF 1r*			*CMF 2r*			*CMF 3r*	*CMF 4r*			*CMF 5r*			*CMF comb*
37	from Equation 12-32			from Equation 12-33			from Table 12-22	from Equation 12-34			from Section 12.7.1			(1)*(2)*(3)*(4)*(5)
38	1.47			1.00			1.00	0.94			1.00			**1.38**
39														
40														
41														

Instructions | Segment 1 | Segment 2 | Segment Tables | Intersection 1 | Intersection 2 | Intersection Tables | Urban Site

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URBAN ARTERIALS

Worksheet 2A -- General Information and Input Data for Urban and Suburban Arterial Intersections

General Information		Location Information	
Analyst	SRG	Roadway	SH 123
Agency or Company	TTI	Intersection	Main St at 3rd Avenue
Date Performed	1/9/2024	Jurisdiction	Anywhere, USA
		Analysis Year	2010

Input Data			Base Conditions	Site Conditions
Intersection type (3ST, 3SG, 4ST, 4SG)			--	3ST
AADT $_{major}$ (veh/day)	Map	$AADT_{MAX}$ = 45,700 veh/day	--	14,000
AADT $_{minor}$ (veh/day)		$AADT_{MAX}$ = 9,300 veh/day	--	4,000
TxDOT district			--	Not Specified
Roadway type for major road			--	3T
Intersection lighting (present/not present)			Not Present	Not Present
Statewide Calibration Factor, C_s			1.00	1.00
Data for unsignalized intersections only:			--	--
Number of major-road approaches with left-turn lanes (0,1)			0	1
Number of major-road approaches with right-turn lanes (0,1)			0	0
Data for signalized intersections only:			--	--
Number of approaches with left-turn lanes (0,1,2)			0	0
Number of approaches with right-turn lanes (0,1,2)			0	0
Number of approaches with left-turn signal phasing (0,1,2)			--	0
Type of left-turn signal phasing for Leg #1			Permissive	Not Applicable
Type of left-turn signal phasing for Leg #2			--	Not Applicable
Type of left-turn signal phasing for Leg #3 (if applicable)			--	Not Applicable
Type of left-turn signal phasing for Leg #4 (if applicable)			--	Not Applicable
Number of approaches with right-turn-on-red prohibited (0,1,2)			0	0
Intersection red light cameras (present/not present)			Not Present	Not Present
Sum of all pedestrian crossing volumes (PedVol) (1 - 34,200)				10
Maximum number of lanes crossed by a pedestrian (n_{lanesx})			--	0
Number of bus stops within 300 m (1,000 ft) of the intersection			0	0
Schools within 300 m (1,000 ft) of the intersection (present/not present)			Not Present	Not Present
Number of alcohol sales establishments within 300 m (1,000 ft) of the intersection			0	0

Worksheet 2B -- Crash Modification Factors for Urban and Suburban Arterial Intersections

(1)	(2)	(3)	(4)	(5)	(6)	(7)
CMF for Left-Turn Lanes	CMF for Left-Turn Signal Phasing	CMF for Right-Turn Lanes	CMF for Right Turn on Red	CMF for Lighting	CMF for Red Light Cameras	Combined CMF

Instructions | Segment 1 | Segment 2 | Segment Tables | Intersection 1 | Intersection 2 | Intersection Tables | Urban Site Tot

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QUESTIONS – COMMENTS?

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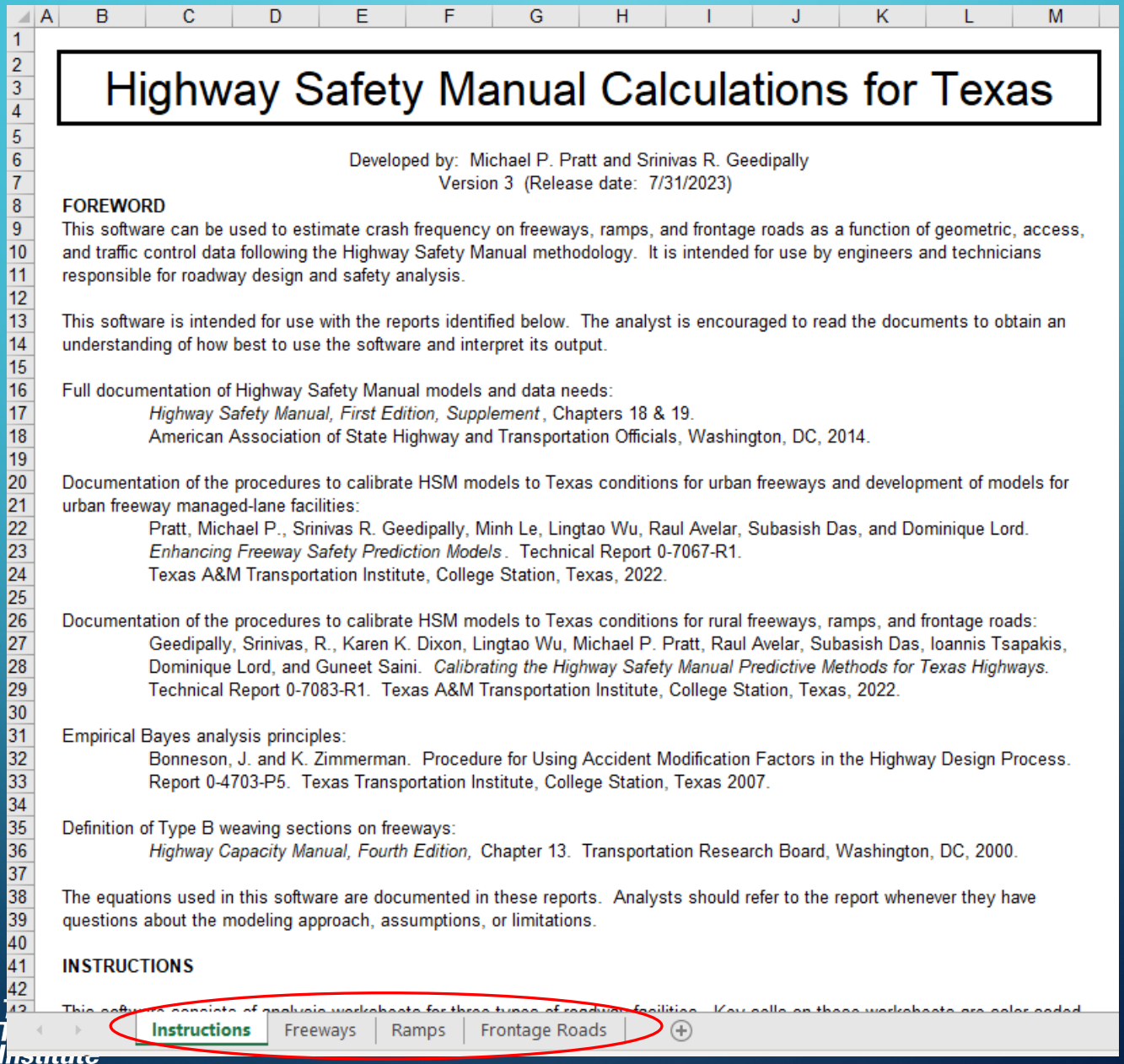
FREEWAYS



Highway Safety Manual Calculations for Texas

Developed by: Michael P. Pratt and Srinivas R. Geedipally
Version 3 (Release date: 7/31/2023)

FOREWORD

This software can be used to estimate crash frequency on freeways, ramps, and frontage roads as a function of geometric, access, and traffic control data following the Highway Safety Manual methodology. It is intended for use by engineers and technicians responsible for roadway design and safety analysis.

This software is intended for use with the reports identified below. The analyst is encouraged to read the documents to obtain an understanding of how best to use the software and interpret its output.

Full documentation of Highway Safety Manual models and data needs:

Highway Safety Manual, First Edition, Supplement, Chapters 18 & 19.
American Association of State Highway and Transportation Officials, Washington, DC, 2014.

Documentation of the procedures to calibrate HSM models to Texas conditions for urban freeways and development of models for urban freeway managed-lane facilities:

Pratt, Michael P., Srinivas R. Geedipally, Minh Le, Lingtao Wu, Raul Avelar, Subasish Das, and Dominique Lord. *Enhancing Freeway Safety Prediction Models*. Technical Report 0-7067-R1.
Texas A&M Transportation Institute, College Station, Texas, 2022.

Documentation of the procedures to calibrate HSM models to Texas conditions for rural freeways, ramps, and frontage roads:

Geedipally, Srinivas, R., Karen K. Dixon, Lingtao Wu, Michael P. Pratt, Raul Avelar, Subasish Das, Ioannis Tsapakis, Dominique Lord, and Guneet Saini. *Calibrating the Highway Safety Manual Predictive Methods for Texas Highways.* Technical Report 0-7083-R1. Texas A&M Transportation Institute, College Station, Texas, 2022.

Empirical Bayes analysis principles:

Bonneson, J. and K. Zimmerman. Procedure for Using Accident Modification Factors in the Highway Design Process. Report 0-4703-P5. Texas Transportation Institute, College Station, Texas 2007.

Definition of Type B weaving sections on freeways:

Highway Capacity Manual, Fourth Edition, Chapter 13. Transportation Research Board, Washington, DC, 2000.

The equations used in this software are documented in these reports. Analysts should refer to the report whenever they have questions about the modeling approach, assumptions, or limitations.

INSTRUCTIONS

Instructions | Freeways | Ramps | Frontage Roads

Texas Department of Transportation

FREEWAYS

General Information

Analyst:	MP	Highway Number:		
Agency:	TTI	Roadway Segment:		
Date:	August 16, 2023	Analysis Period:	2018-2021	
Notes:				

Color-Coding Legend

Blue = basic input cell (manual or drop-down menu)
Green = optional input cell
Rose = analysis results

Output Summary

Expected crash frequency (cr/yr)	Crash Period	Analysis Period	*Combined CMFs*	Crash Period	Analysis Period
MV FI or speed-change lane:	22.102	17.376	MV FI or speed-change lane:	1.798	1.798

Input Dat

Basic Roa

Area type		
TxDOT district	Not specified	Not specified
Number of general-purpose lanes	8	8
Number of managed lanes	1	1
Managed lane configuration	Non-reversible	Non-reversible
Managed lane separation type	Barrier	Barrier
Segment length (mi)	1	1

Number of general-purpose lanes	8	8
Number of managed lanes	1	1
Managed lane configuration	Non-reversible	Non-reversible
Managed lane separation type	Barrier	Barrier
Segment length (mi)	1	1

Access Data

Basic Segment

Type B weaving section length (mi)		$L_{wevB,inc}$	0.1	0.1
		$L_{wevB,dec}$	0.1	0.1
Weaving section length (all weaving section types) (mi)		$L_{wev,inc}$	0.15	0.15
		$L_{wev,dec}$	0.15	0.15
Upstream entrance, increasing milepost direction	Ramp side		Right	Right
	Distance to ramp (mi)	$X_{b,ent}$	0.2	0.2
	Ramp number of lanes	$n_{l,b,ent}$	1	1
	Ramp volume (veh/day)	$AADT_{b,ent}$		
Downstream exit, decreasing milepost direction	Ramp side		Right	Right
	Distance to ramp (mi)	$X_{b,ext}$	0.2	0.2

Definition of Type B weaving section from Highway Capacity Manual 2000 Chapter 13:

One weaving movement can be made without making any lane changes.
One weaving movement requires at most one lane change. See HCM 2000 Exhibit 13-9 →

Map the ramp data to the relevant ramps as shown in HSM Figure 18-8a:

Instructions | Freeways | Ramps | Frontage Roads

Texas A&M Transportation Institute

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FREEWAYS

Access Data				
Basic Segment				
Type B weaving section length (mi)		$L_{wevB,inc}$	0.1	0.1
		$L_{wevB,dec}$	0.1	0.1
Weaving section length (all weaving section types) (mi)		$L_{wev,inc}$	0.15	0.15
		$L_{wev,dec}$	0.15	0.15
Upstream entrance, increasing milepost direction	Ramp side		Right	Right
	Distance to ramp (mi)	$X_{b,ent}$	0.2	0.2
	Ramp number of lanes	$n_{l,b,ent}$	1	1
	Ramp volume (veh/day)	$AADT_{b,ent}$		
Downstream exit, decreasing milepost direction	Ramp side		Right	Right
	Distance to ramp (mi)	$X_{b,ext}$	0.2	0.2
	Ramp number of lanes	$n_{l,b,ext}$	1	1
	Ramp volume (veh/day)	$AADT_{b,ext}$		
Upstream entrance, decreasing milepost direction	Ramp side		Right	Right
	Distance to ramp (mi)	$X_{e,ent}$	0.2	0.2
	Ramp number of lanes	$n_{l,e,ent}$	1	1
	Ramp volume (veh/day)	$AADT_{e,ent}$		
Downstream exit, increasing milepost direction	Ramp side		Right	Right
	Distance to ramp (mi)	$X_{e,ext}$	0.2	0.2
	Ramp number of lanes	$n_{l,e,ext}$	1	1
	Ramp volume (veh/day)	$AADT_{e,ext}$		
Speed-Change Lane				
Ramp type			None	None
Ramp side				
Ramp number of lanes				
Ramp volume (veh/day)				
Managed-Lane Segment				
Number of access ramp gores			0	0
Number of access weaving sections			0	0

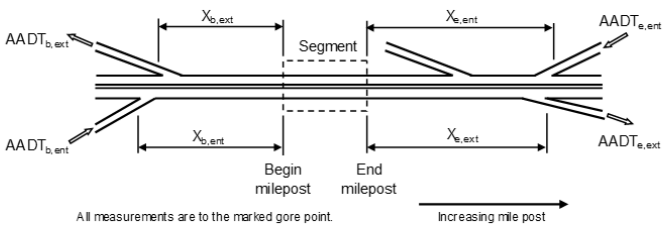
Traffic Data		
AADT in general-purpose lanes (veh/day)	200,000	200,000
% of high-volume hours in general-purpose lanes		
AADT in managed lanes (veh/day)	20,000	20,000

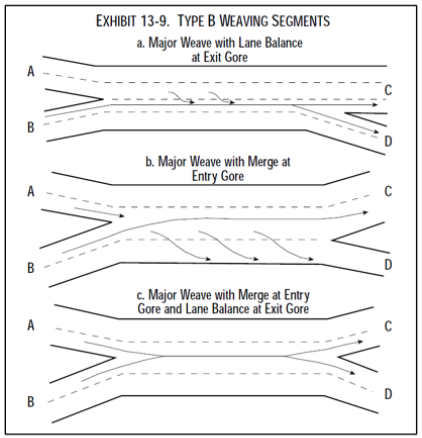
Definition of Type B weaving section from Highway Capacity Manual 2000 Chapter 13:

One weaving movement can be made without making any lane changes.

One weaving movement requires at most one lane change. See HCM 2000 Exhibit 13-9 ⟶

Map the ramp data to the relevant ramps as shown in HSM Figure 18-8a:





Texas AADT data are available from the TxDOT Statewide Planning Map:
https://www.txdot.gov/apps/statewide_mapping/StatewidePlanningMap.html

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FREEWAYS

Geometric Data			
Total curve length (mi)	L_c	0.1	0.1
Average curve radius (ft)	R	99999	99999

Cross Section Data			
Lane width (ft)	W_l	12	12
Outside shoulder width (ft)	W_s	10	10
Inside shoulder width (ft)	W_{is}	8	8
Median width, including inside shoulders (ft)	W_m	30	30
Continuous median barrier present?		Yes	Yes
Short median barrier length (mi)	L_{ib}	0	0
Average short median barrier offset from inside shoulder edge (ft)	W_{icb}	2	2
Average median barrier width (ft)	W_{ib}	2	2
Outside shoulder rumble strip proportion	P_{or}	1	1
Inside shoulder rumble strip proportion	P_{ir}	1	1

Roadside Data			
Clear zone width (ft)	W_{hc}	30	30
Roadside barrier length (mi)	L_{ob}	0	0
Average roadside barrier offset from outside shoulder edge (ft)	W_{ocb}	10	10

Crash Data					
Number of years of crash history data	1	Enter zero to analyze two segments or scenarios for a segment.	*Weights*	*Predicted*	*Expected*
MV FI or speed-change lane crash count	15		0.3345	22.102	17.376
MV PDO or speed-change lane crash count	50		0.2244	49.375	49.860
MV managed-lane crash count	3		0.6476	1.183	1.823
SV FI crash count	2		0.7175	3.937	3.390
SV PDO crash count	9		0.5577	7.209	8.001
SV managed-lane crash count	2		0.8016	0.825	1.058

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FREEWAYS

Calculations

Safety Performance Functions

			Type	k
Base MV FI / SC lane crash frequency (cr/yr):	12.294	12.294	MV,FI	0.09
Base MV PDO / SC lane crash frequency (cr/yr):	31.276	31.276	MV,PDO	0.07
Base managed-lane MV crash frequency (cr/yr):	1.506	1.506	MV	0.46
Base SV FI crash frequency (cr/yr):	5.264	5.264	SV,FI	0.1
Base SV PDO crash frequency (cr/yr):	10.682	10.682	SV,PDO	0.11
Base managed-lane SV crash frequency (cr/yr):	0.889	0.889	SV	0.3

Crash Modification Factors

MV FI crashes and speed-change lane crashes

1	Horizontal curve	1.000	1.000		
2	Lane width	1.000	1.000		
3	Inside shoulder width	0.966	0.966	*Lane change CMF terms*	
4	Median width	1.115	1.115	$f_{wev,inc}$	1.221 1.221
5	Median barrier	1.022	1.022	$f_{wev,dec}$	1.221 1.221
6	High volume	1.328	1.328	$f_{lc,inc}$	1.007 1.007
7	Lane change	1.230	1.230	$f_{lc,dec}$	1.007 1.007
12	Ramp entrance				
13	Ramp exit				

MV PDO crashes and speed-change lane crashes

1	Horizontal curve	1.000	1.000		
2	Lane width	1.000	1.000		
3	Inside shoulder width	0.970	0.970	*Lane change CMF terms*	
4	Median width	1.110	1.110	$f_{wev,inc}$	1.127 1.127
5	Median barrier	1.029	1.029	$f_{wev,dec}$	1.127 1.127
6	High volume	1.258	1.258	$f_{lc,inc}$	1.005 1.005
7	Lane change	1.133	1.133	$f_{lc,dec}$	1.005 1.005
12	Ramp entrance (speed-change lanes)				
13	Ramp exit (speed-change lanes)				

MV crashes (managed lanes)

47	Non-reversible	Outside shoulder width	0.786	0.786
48	Non-reversible	Access weaving section	1.000	1.000
49	Non-reversible	Access ramp	1.000	1.000
53	Reversible	Number of lanes	1.000	1.000
54	Reversible	Average shoulder width	0.095	0.095
55	Reversible	Access ramp	1.000	1.000

HSM CMF numbers

0-7067 CMF equation numbers

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FREEWAYS

SV FI crashes			
1	Horizontal curve	1.000	1.000
2	Lane width	1.000	1.000
3	Inside shoulder width	0.966	0.966
4	Median width	0.964	0.964
5	Median barrier	1.022	1.022
6	High volume	0.947	0.947
8	Outside shoulder width	1.000	1.000
9	Shoulder rumble strip	0.830	0.830
10	Outside clearance	1.000	1.000
11	Outside barrier	1.000	1.000
SV PDO crashes			
1	Horizontal curve	1.000	1.000
2	Lane width	1.000	1.000
3	Inside shoulder width	0.970	0.970
4	Median width	1.110	1.110
5	Median barrier	1.029	1.029
6	High volume	0.610	0.610
8	Outside shoulder width	1.000	1.000
11	Outside barrier	1.000	1.000
SV crashes (managed lanes)			
46	Non-reversible	Inside shoulder width	0.928	0.928
49	Non-reversible	Access ramp	1.000	1.000
52	Reversible	Number of lanes	1.000	1.000
55	Reversible	Access ramp	1.000	1.000

HSM CMF numbers

0-7067 CMF equation numbers

Severity Distribution Functions (basic segments and speed-change lanes)

Expected crash frequency by severity (cr/yr)			*Proportions*			*Systematic components*		
Fatal (K):	0.560	0.447	K	0.022	0.022	V_K	-3.838	-3.838
Incapacitating injury (A):	1.532	1.222	A	0.059	0.059	V_A	-2.831	-2.831
Non-incapacitating injury (B):	8.094	6.455	B	0.311	0.311	V_B	-1.167	-1.167
Possible injury (C):	15.852	12.642	C	0.609	0.609	C_{sdf}	1.64	1.64

Intermediate calculations

P_c	Proportion of length with curve	0.1	0.1	W_{iob}	Average median barrier offset (ft)	6	6
P_{ib}	Proportion of length with inside barrier	1	1	$AADT_{b,ent}$	Volume of entrance ramp at Xb,ent (veh/day)	8900	8900
P_{ob}	Proportion of length with outside barrier	0	0	$AADT_{b,ext}$	Volume of exit ramp at Xb,ext (veh/day)	8900	8900
P_{hv}	Percentage of high-volume hours	0.81	0.81	$AADT_{e,ent}$	Volume of entrance ramp at Xe,ent (veh/day)	8900	8900
$P_{wevB,inc}$	Type B weave proportion, increasing milepost direction	0.1	0.1	$AADT_{e,ext}$	Volume of exit ramp at Xe,ext (veh/day)	8900	8900
$P_{wevB,dec}$	Type B weave proportion, decreasing milepost direction	0.1	0.1	$AADT_r$	Entrance ramp volume (veh/day)	21200	21200

FREEWAYS

General Information					
Analyst:	MP	Highway Number:		Color-Coding Legend	
Agency:	TTI	Roadway Segment:		Blue = basic input cell (manual or drop-down menu)	
Date:	August 16, 2023	Analysis Period:	2018-2021	Green = optional input cell	
Notes:				Rose = analysis results	

Output Summary						
Expected crash frequency (cr/yr)	Crash Period	Analysis Period	*Combined CMFs*	Crash Period	Analysis Period
MV:	0.205	0.299	MV:	1.000	1.000
SV:	0.030	0.042	SV:	1.143	1.143
Total:	0.235	0.341			

Input Data

Basic Roadway Data				
Ramp type		Entrance	Entrance	Entrance or Exit
TxDOT district		Not specified	Not specified	
Ramp length (mi)		0.2	0.2	

Traffic Data				
Ramp AADT (veh/day)		10,000	10,000	If the ramp volume is not available, leave the green input cell blank & populate the cells in the next two row
Ramp area type & number of lanes				
AADT in general-purpose lanes (veh/day)				

Geometric Data			
Number of horizontal curves on ramp	n_{hc}	0	0

Cross Section Data			
Right shoulder width (ft)	W_{rsw}	6	6
Left shoulder width (ft)	W_{lsw}	2	2

Roadside Data			
Roadside barrier present?		Yes	Yes
Average shoulder width where barrier is present (ft)	W_{sw}	2	2

Crash Data					
Number of years of crash history data	2	Enter zero to analyze two segments or scenarios for a segment.	*Weights*	*Predicted*	*Expected*
MV crash count	1		0.6801	0.205	0.299
SV crash count	1		0.9750	0.030	0.042

Instructions | Freeways | **Ramps** | Frontage Roads

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QUESTIONS – COMMENTS?

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WRAP-UP

- Thank you for your time!

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