Data-Driven Safety Improvements:
A Case Study on the Road to Saving Lives

James Ritter
Transportation Project Manger, *Jacobs*

Stephen Georges
Design & Construction Lead, *MoDOT St. Louis District*

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Road to Saving Lives

James Ritter, P.E.
Jacobs

A CASE STUDY ON THE ROAD TO SAVING LIVES

MoDOT Safety Improvements

Design-Build Project

Maximizing lives saved on Missouri roadways

Advancing highway safety engineering

Innovative approach:

- *Data-driven safety analysis*
- *Design-build procurement (fixed-price, maximum scope)*

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MoDOT Safety Improvements

Design-Build Project

AUDIENCE POLL

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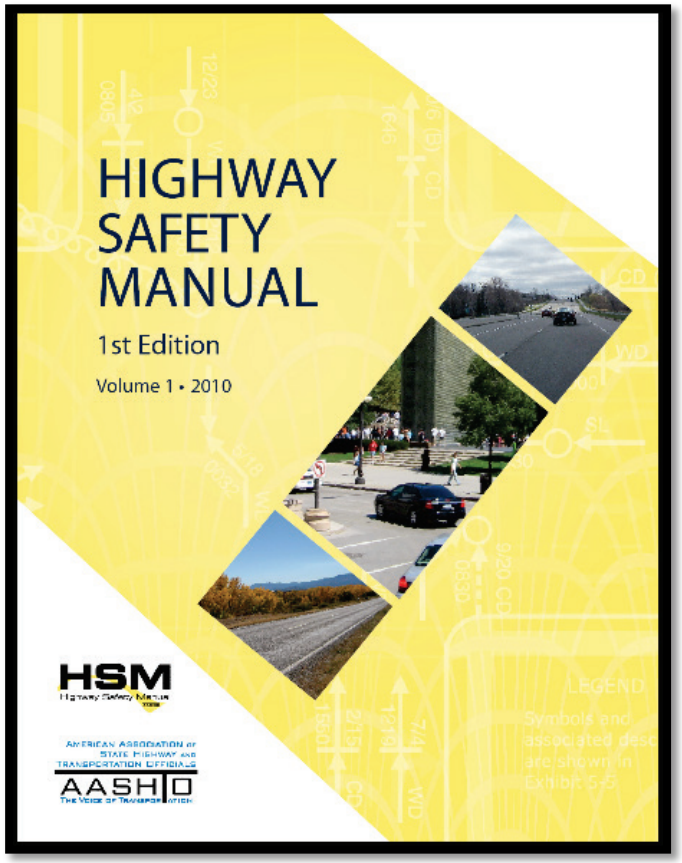
Data-Driven Safety Improvements

A Case Study on the Road to Saving Lives

Focus on Safety

- Context of the MoDOT Safety Improvements Design-Build
- Case study for the program of safety improvements
  - Data-driven location selection
  - Quantified safety analysis of safety improvements
- Challenges & Opportunities



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MoDOT Safety Improvements
Design-Build Project

MoDOT St. Louis District YouTube channel

https://www.youtube.com/watch?v=094XZUPk6w8

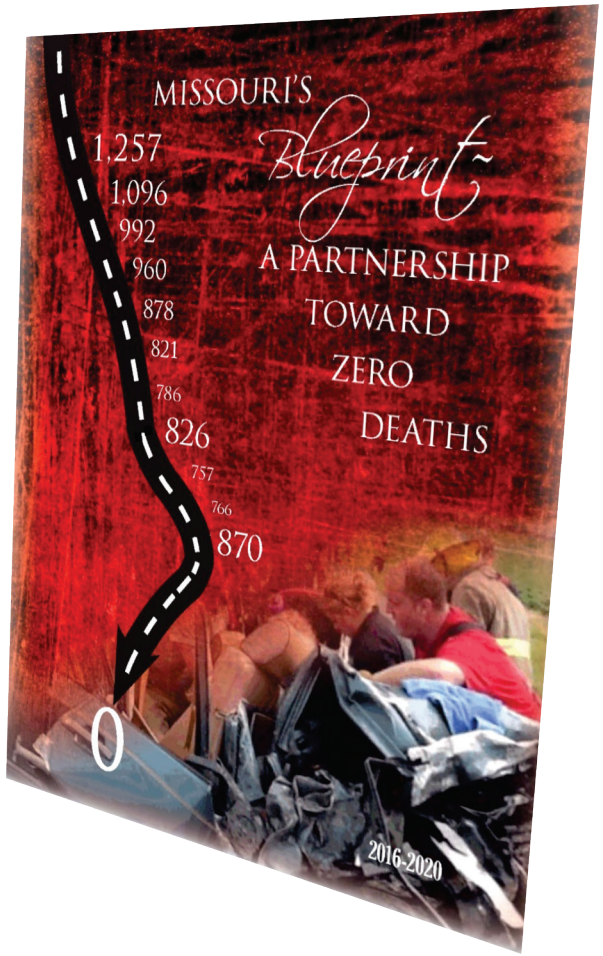
Also linked from MoDOT project website

Road to Saving Lives

Missouri's Blueprint

A Partnership Toward Zero Deaths

"The work required to reduce deaths and serious injuries on our roadways is not an easy job. Missouri has seen a 31 percent reduction in fatalities since 2005 when 1,257 people lost their lives due to traffic crashes…"



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Reducing Fatal Crashes

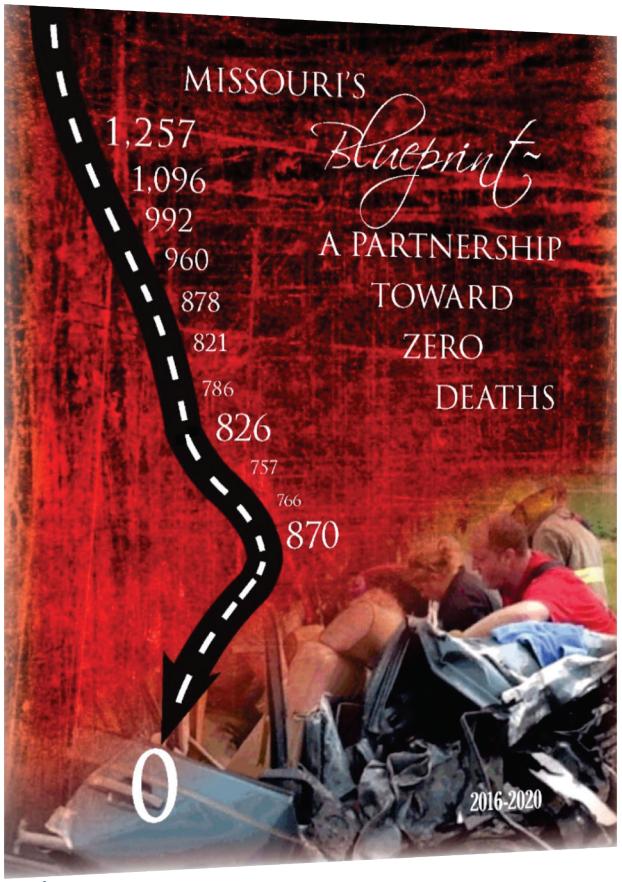
Progress with Safety Improvements

- Systemic Implementation of Targeted Countermeasures
  - Chevron Curve Signs
  - Wider Edgelines
  - Cable Median Barrier
  - Shoulders / Rumble Stripes
- Run Off the Road Crashes

Road to Saving Lives

Missouri's Blueprint

A Partnership Toward Zero Deaths



"Beginning in 2011, these fatality reductions began to plateau. In 2015, Missouri as well as the rest of the nation experienced an increase in fatalities. This means we must refocus and work harder to reverse any upward trend resulting in lives lost."

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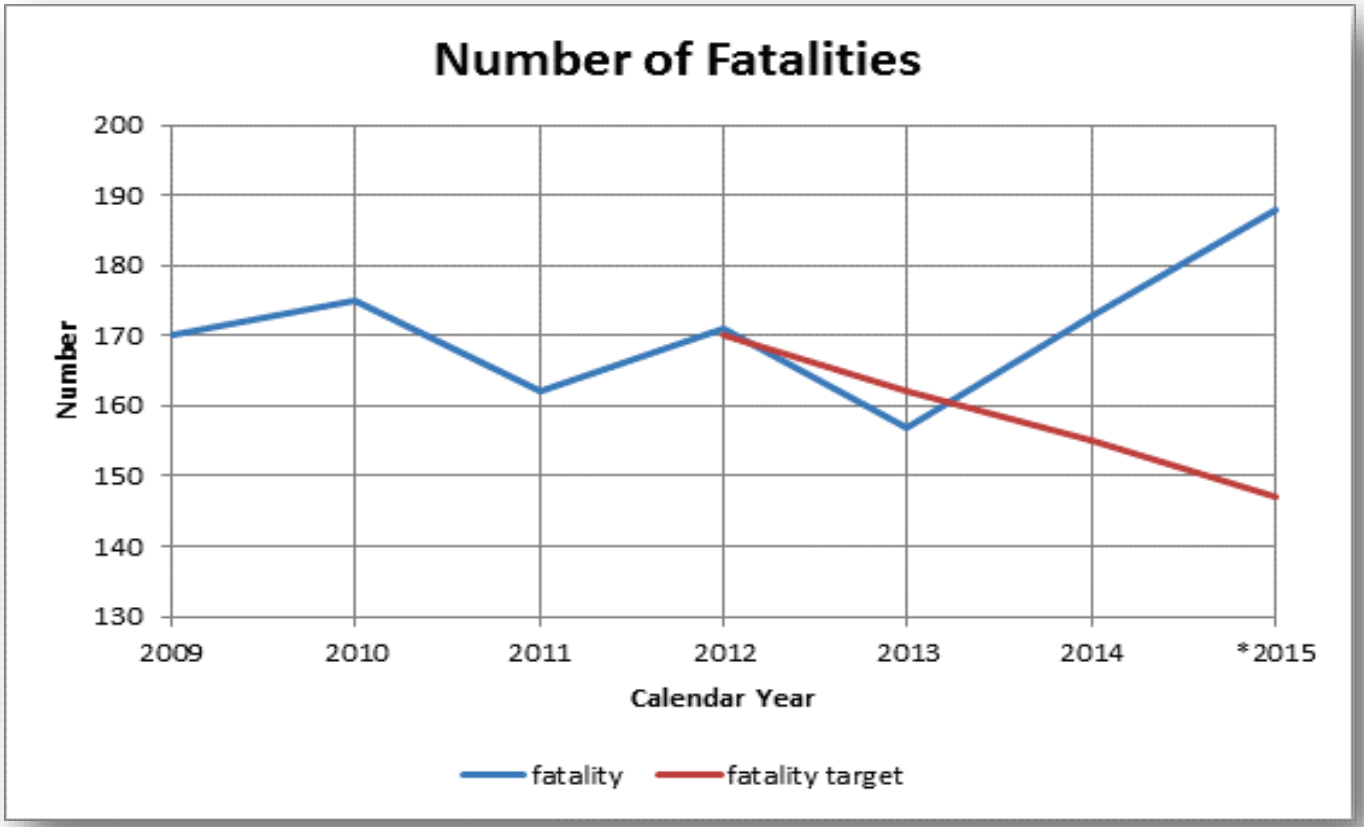
MoDOT & Safety

No. 1 Tangible Result

Keep Customers and MoDOT Staff Safe



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Common Challenges

To Addressing Safety Issues

- Increasing fatalities
- Limited funds
- Sizable highway system
- Long project development cycles
- Limited safety toolbox
- Limited proven-effective safety improvements

→ Need for Innovation

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The Solution

A Bold & Innovative Approach

- Utilize MoDOT's proven, successful best-value Design-Build procurement model
  - Leverage collective knowledge, expertise, and experience
  - Consultant and construction industries
- Data-Driven Project Location & Countermeasure Identification
  - Evidence-based, quantified safety modeling
  - Highway Safety Manual (HSM) analysis tools
  - Collective research behind CMF Clearinghouse

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The Solution

A Bold & Innovative Approach

A Program of Safety Improvements

- $24.1 M Budget
- Reduce Fatal and Serious Injury Crashes
- St. Charles and Franklin Counties, Missouri
- Quantified Safety Analysis / Data-Driven
  - Objective
  - Eliminate politics

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DATA-DRIVEN LOCATION IDENTIFICATION

Highest Crash Severity Locations Identified

Horizontal Curve Analysis

Wet Crash Analysis

Shoulder Analysis

Crossed Centerline Analysis

Expressway Intersection Analysis

High Severity Analysis

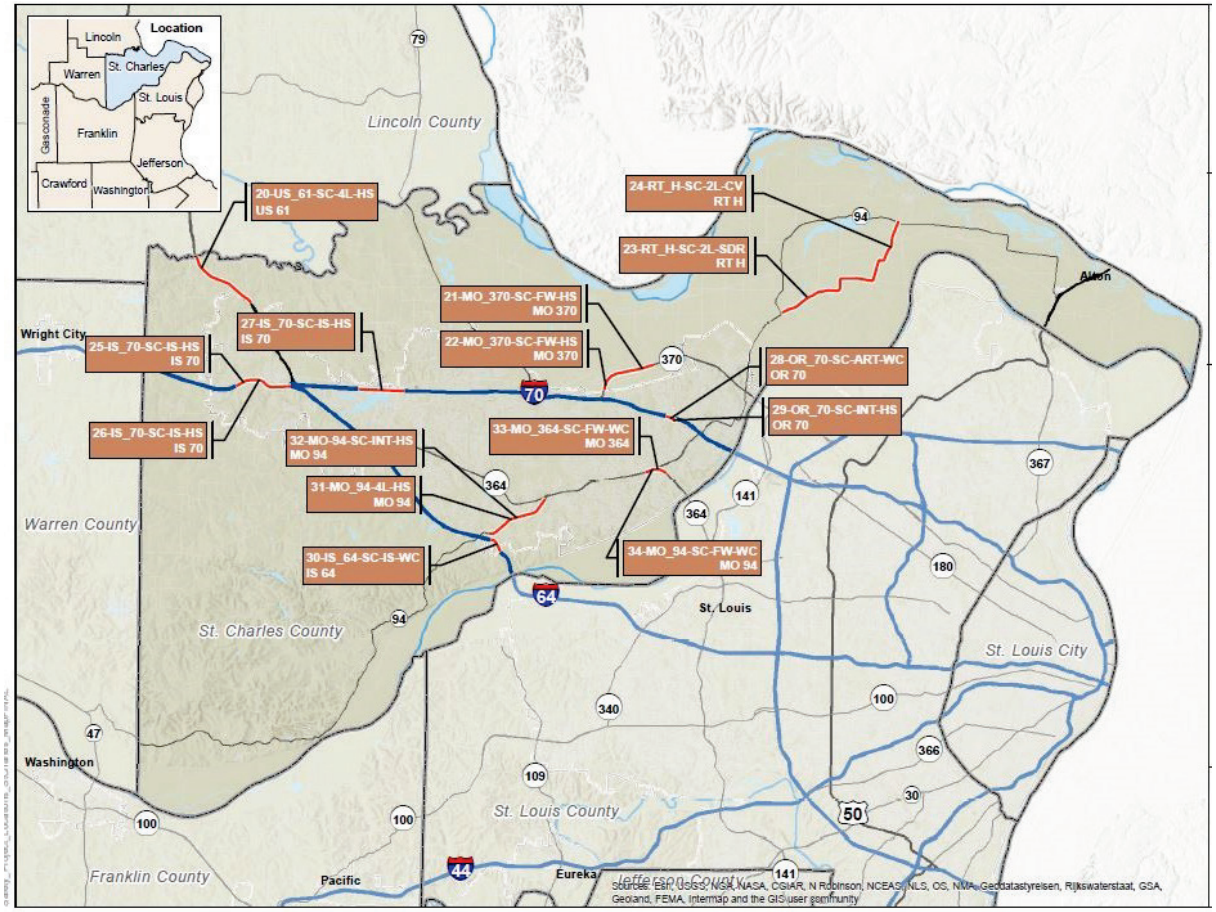
- Data-Driven Selection
- 2013-2015 MSHP Records
- Fatal and Serious Injury Crash History
- High Severity & Target Crash Types
- Top 31 Locations

Traffic Safety List

Road to Saving Lives

St. Charles County

15 High Severity Locations



Routes Include:

- I-70
- I-64
- U.S. 61
- Route H
- MO 94
- MO 364
- MO 370
- Outer Road 70

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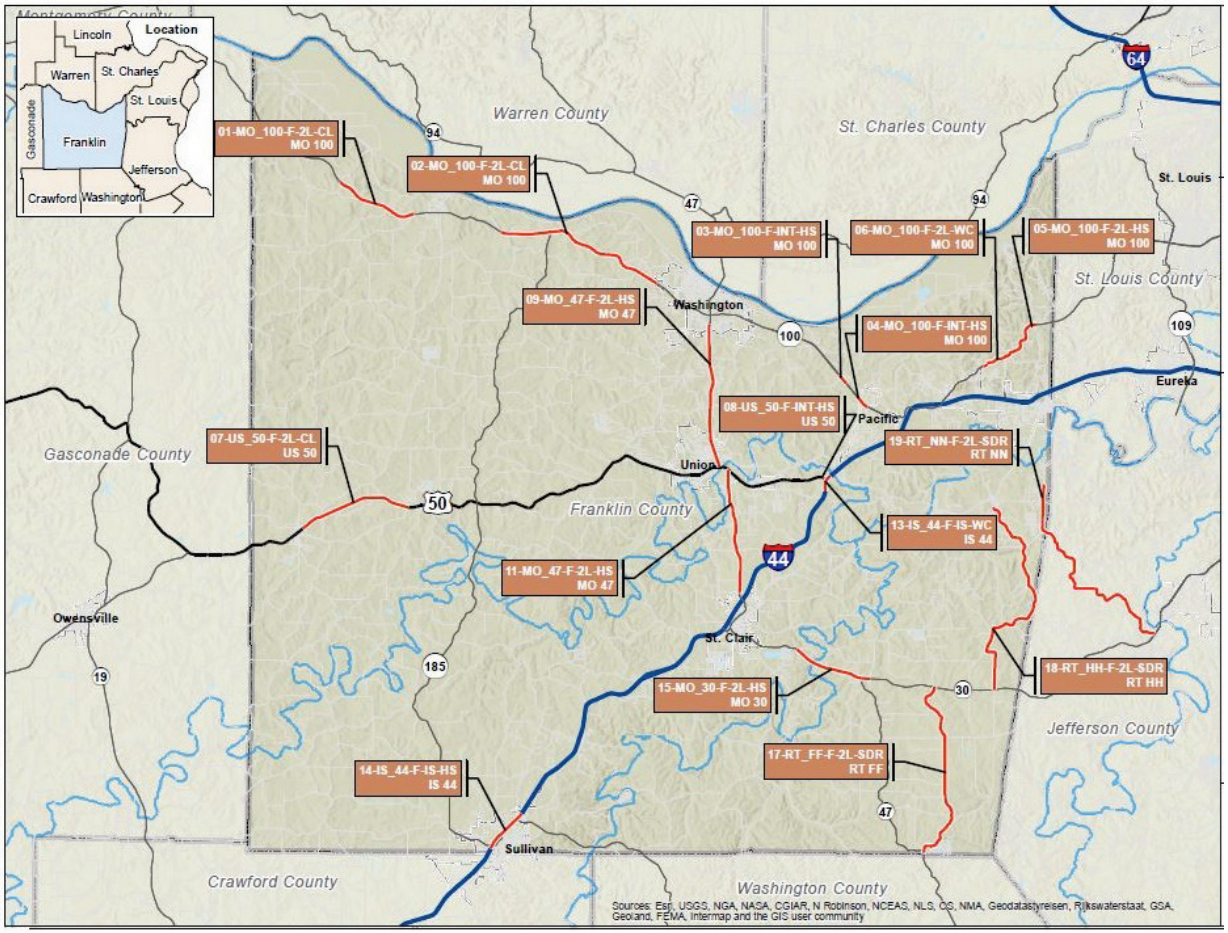
Franklin County

16 High Severity Locations



Routes Include:

- I-44
- U.S. 50
- MO 100
- MO 47
- MO 30
- Route FF
- Route HH
- Route NN

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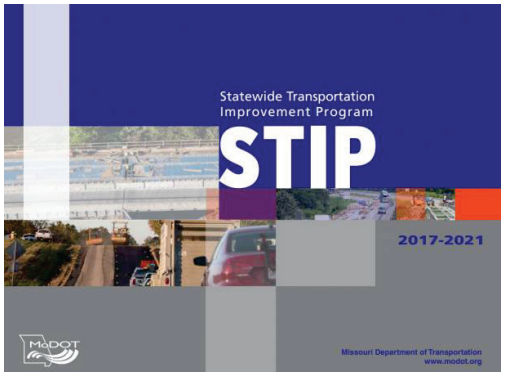
Data-Driven Location Identification

CHALLENGES

- (STIP) State Transportation Improvement Program



- Unknown Solutions
- Politics (Internal/External)

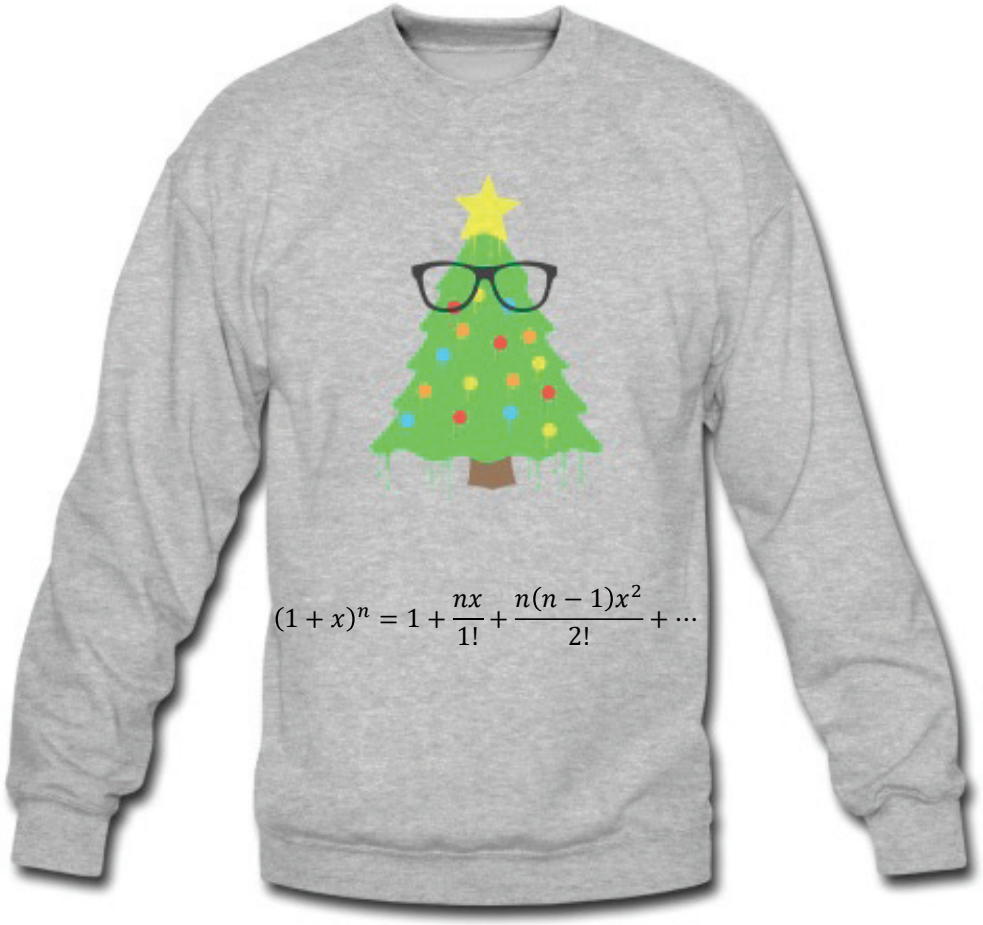
OPPORTUNITIES

- Compliance and Systemic Improvements
- Crash Reduction Potential
  - Beyond Quantity of High Severity Crashes
  - Disparity between Crash History and Predicted, Expected Crashes
- County Level vs. District
- Local System

HSM SAFETY ANALYSIS & COUNTERMEASURE EVALUATION

“Nerd Christmas”

For Traffic Safety Engineers



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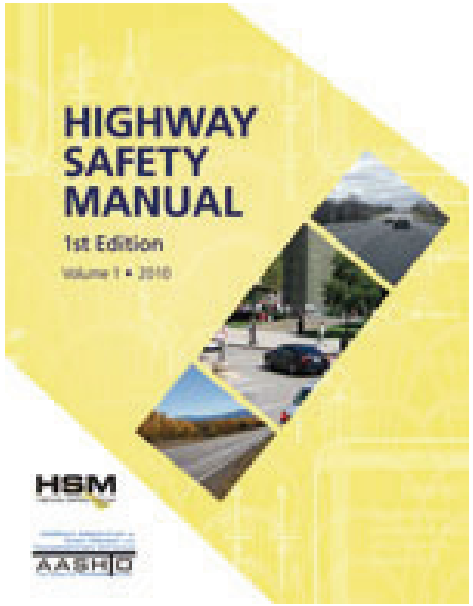
Safety Analysis Tools

- HSM Spreadsheets (NCHRP 17-38)
  - Rural two-lane
  - Rural multi-lane
  - Urban arterial
  - Modified for Fatal Serious Injury, CMFs, Input & Output Summaries



- ISATe Spreadsheets
  - Freeways, Interstates
  - Unmodified
  - Supplemented w/ CMF post-processing worksheet

Spreadsheets

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Safety Analysis
Data and Inputs

For reference and use in Data-Driven Analysis

- Concept Reports with existing conditions and baseline safety improvements
- No-Build/Existing HSM & ISATe Spreadsheets reflecting existing conditions for each project location
- List of MoDOT-Approved Crash Modification Factors (CMFs)
- HSM & ISATe Spreadsheets to populate with proposed improvements

Opportunities for Innovation

Additional Applicable Standards (AAS)

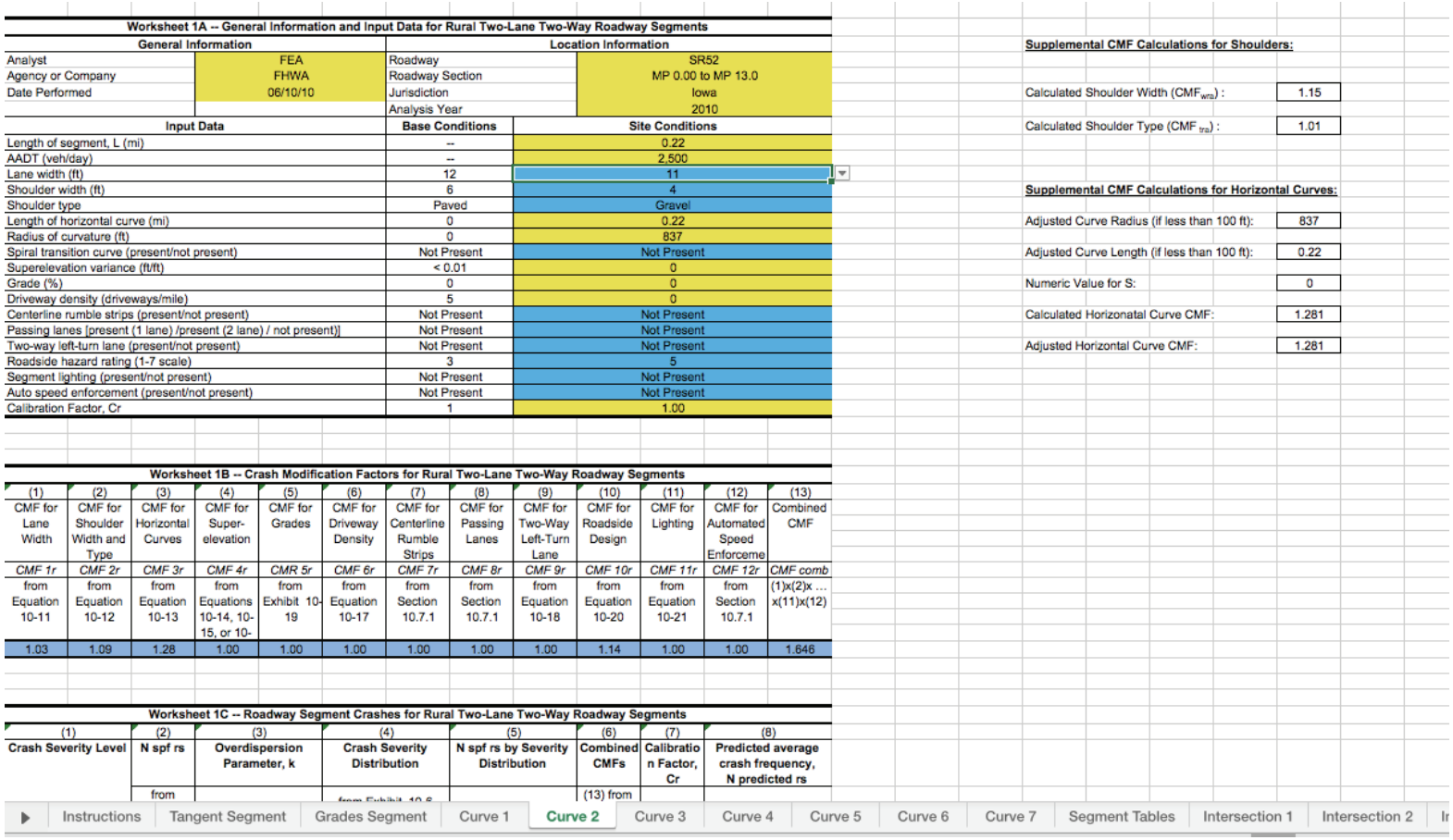
- Additional Applicable Standards
- Products, Designs, Specifications not currently utilized by MoDOT
- To be submitted and approved by MoDOT and FHWA

Crash Modification Factors (CMF)

- Statistically determines how an improvement reduces crashes
- MoDOT included pre-approved countermeasure and CMFs
- Encouraged to propose other CMFs for review and approval
- CMF Clearinghouse (primary source)

Modified HSM Spreadsheet

Individual Segment Input Tab



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

General Information		Location Information	
Analyst	FEA	Roadway	SR52
Agency or Company	FHWA	Roadway Section	MP 0.00 to MP 13.0
Date Performed	06/10/10	Jurisdiction	Iowa
		Analysis Year	2010

Input Data	Base Conditions	Site Conditions
Length of segment, L (mi)	--	0.22
AADT (veh/day)	--	2,500
Lane width (ft)	12	11
Shoulder width (ft)	6	4
Shoulder type	Paved	Gravel
Length of horizontal curve (mi)	0	0.22
Radius of curvature (ft)	0	837
Spiral transition curve (present/not present)	Not Present	Not Present
Superelevation variance (ft/ft)	< 0.01	0
Grade (%)	0	0
Driveway density (driveways/mile)	5	0
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 (1-7 scale)	3	5
Segment lighting (present/not present)	Not Present	Not Present
Auto speed enforcement (present/not present)	Not Present	Not Present
Calibration Factor, Cr	1	1.00

Supplemental CMF Calculations for Shoulders:

Calculated Shoulder Width (CMF_{wra}) :	1.15
Calculated Shoulder Type (CMF_{tra}) :	1.01

Supplemental CMF Calculations for Horizontal Curves:

Adjusted Curve Radius (if less than 100 ft):	837
Adjusted Curve Length (if less than 100 ft):	0.22
Numeric Value for S:	0
Calculated Horizonatal Curve CMF:	1.281
Adjusted Horizontal Curve CMF:	1.281

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 Super-elevation	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 Enforceme	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-	from Exhibit 10-19	from Equation 10-17	from Section 10.7.1	from Section 10.7.1	from Equation 10-18	from Equation 10-20	from Equation 10-21	from Section 10.7.1	(1)x(2)x … x(11)x(12)
1.03	1.09	1.28	1.00	1.00	1.00	1.00	1.00	1.00	1.14	1.00	1.00	1.646

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

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Crash Severity Level	**N spf rs**	**Overdispersion Parameter, k**	**Crash Severity Distribution**	**N spf rs by Severity Distribution**	**Combined CMFs**	**Calibration Factor, Cr**	**Predicted average crash frequency, N predicted rs**
	from				(13) from		

Instructions | Tangent Segment | Grades Segment | Curve 1 | Curve 2 | Curve 3 | Curve 4 | Curve 5 | Curve 6 | Curve 7 | Segment Tables | Intersection 1 | Intersection 2

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Modified HSM Spreadsheet

Consolidated Input Summary Tab

General Information				
Project Description	No Build			
Project Location ID	01-MO_100-F-2L-CL			
Analyst	MM/STL	Date:	2/27/2017	

Segment Input Summary Table

Input Item/Segment Number	1	2	3	4	5	6	7	8
Analyst	MM/STL	MM/STL	MM/STL	MM/STL	MM/STL	MM/STL	MM/STL	MM/STL
Agency or Company	CH2M	CH2M	CH2M	CH2M	CH2M	CH2M	CH2M	CH2M
Date Performed	2/27/2017	2/27/2017	2/27/2017	2/27/2017	2/27/2017	2/27/2017	2/27/2017	2/27/2017
Roadway	MO 100	MO 100	MO 100	MO 100	MO 100	MO 100	MO 100	MO 100
Roadway Section	LM 52.588 to LM 53.09	LM 53.09 to LM 53.3	LM 53.3 to LM 53.41	LM 53.41 to LM 53.91	LM 53.91 to LM 54.68	LM 54.68 to LM 54.88	LM 54.88 to LM 55.4	LM 55.4 to LM 55.93
Jurisdiction	Franklin, MO	Franklin, MO	Franklin, MO	Franklin, MO	Franklin, MO	Franklin, MO	Franklin, MO	Franklin, MO
Analysis Year	2015	2015	2015	2015	2015	2015	2015	2015
Length of segment, L (mi)	0.502	0.210	0.110	0.500	0.770	0.200	0.520	0.530
AADT (veh/day) (max - 17,800)	4210	4210	4210	4210	4210	4210	4210	4210
Lane width (ft)	11	11	11	11	11	11	11	11
Shoulder width (ft)								
Right	2	2	2	2	2	2	2	2
Left	2	2	2	2	2	2	2	2
Shoulder type								
Right	Gravel	Gravel	Gravel	Gravel	Gravel	Gravel	Gravel	Gravel
Left	Gravel	Gravel	Gravel	Gravel	Gravel	Gravel	Gravel	Gravel
Length of horizontal curve (mi)	0	0.21	0	0.5	0	0.2	0	0.53
Radius of curvature (ft)	0	2286	0	3747	0	3231	0	2854
Spiral transition curve (present/not present)	Not Present	Not Present	Not Present	Not Present	Not Present	Not Present	Not Present	Not Present
Superelevation variance (ft/ft)	0	0	0	0	0	0	0	0
Grade (%)	0	0	0	0	0	0	0	0
Driveway density (driveways/mile)	7.97	9.52	0.00	4.00	14.29	20.00	15.38	18.87
Centerline rumble strips (present/not present)	Not Present	Not Present	Not Present	Not Present	Not Present	Not Present	Not Present	Not Present
Passing lanes (present (1 lane) /present (2 lane) / not present)	Not Present	Not Present	Not Present	Not Present	Not Present	Not Present	Not Present	Not Present
Two-way left-turn lane (present/not present)	Not Present	Not Present	Not Present	Not Present	Not Present	Not Present	Not Present	Not Present
Roadside hazard rating (1-7 scale)	2	2	2	2	2	2	2	2
Segment lighting (present/not present)	Not Present	Not Present	Not Present	Not Present	Not Present	Not Present	Not Present	Not Present
Additional Safety Treatment 1								
Additional Safety Treatment 2								
Additional Safety Treatment 3								
Observed crashes	0.8	0.4	0	0.8	0.6	0.6	0.4	0.6

Intersection Input Summary Table

Input Item/Intersection Number	1	2	3	4	5
Analyst	MM/STL	MM/STL	MM/STL		
Agency or Company	CH2M	CH2M	CH2M		
Date Performed	2/27/2017	2/27/2017	2/27/2017		
Roadway	MO 100	MO 100	MO 100		
Intersection	Highway E	Olive Street	Olive Rd		
Jurisdiction	Franklin, MO	Franklin, MO	Franklin, MO		
Analysis Year	2015	2015	2015	2015	2015

Road to Saving Lives

Modified HSM Spreadsheet

CMF Input Tab

Table 1 CMF for Rural Two-lane Roads (Segment)

CMF Source	Number	Abbreviated Improvement Name (For Input Summary Tab)	Improvement Name (From CMF Clearinghouse, if applicable)	CMF Value			
				K	A	BC	PDO
MoDOT CMF Table	1	HFST	Improve pavement friction using High-friction surface treatment (HFST)	0.380	0.380	0.380	0.380
MoDOT CMF Table	2	Open graded friction course	Open graded friction course	0.959	0.959	0.959	0.959
MoDOT CMF Table	3	Ultra thin bonded wearing course	Ultra thin bonded wearing course	0.956	0.956	0.956	0.956
MoDOT CMF Table	4	Centerline and shoulder rumble strips	Install centerline and shoulder rumble strips	0.770	0.770	0.770	0.770
MoDOT CMF Table	5	Rumble, 2-ft shoulder, resurfacing	Install shoulder rumble stripe, widen shoulder from 0 to 2 feet, and pavement resurfacing	0.822	0.822	0.822	0.822
MoDOT CMF Table	6	Centerline rumble strips	Install centerline rumble strips	0.880	0.880	0.880	0.880
MoDOT CMF Table	7	Shoulder rumble strips	Install shoulder (or edgeline) rumble strips	0.940	0.940	0.940	0.940
MoDOT CMF Table	8	Safety edge treatment	Installation of safety edge treatment	0.983	0.983	0.983	0.983
MoDOT CMF Table	9	TWLTL	Install TWLTL (two-way left turn lane) on two lane road	0.739	0.739	0.739	0.739
<<Placeholder>>	10	<<User Input per CMF Request Form>>	<<User Input per CMF Request Form>>	1.000	1.000	1.000	1.000
<<Placeholder>>	11	<<User Input per CMF Request Form>>	<<User Input per CMF Request Form>>	1.000	1.000	1.000	1.000
<<Placeholder>>	12	<<User Input per CMF Request Form>>	<<User Input per CMF Request Form>>	1.000	1.000	1.000	1.000
<<Placeholder>>	13	<<User Input per CMF Request Form>>	<<User Input per CMF Request Form>>	1.000	1.000	1.000	1.000
<<Placeholder>>	14	<<User Input per CMF Request Form>>	<<User Input per CMF Request Form>>	1.000	1.000	1.000	1.000
<<Placeholder>>	15	<<User Input per CMF Request Form>>	<<User Input per CMF Request Form>>	1.000	1.000	1.000	1.000
<<Placeholder>>	16	<<User Input per CMF Request Form>>	<<User Input per CMF Request Form>>	1.000	1.000	1.000	1.000
<<Placeholder>>	17	<<User Input per CMF Request Form>>	<<User Input per CMF Request Form>>	1.000	1.000	1.000	1.000
<<Placeholder>>	18	<<User Input per CMF Request Form>>	<<User Input per CMF Request Form>>	1.000	1.000	1.000	1.000
<<Placeholder>>	19	<<User Input per CMF Request Form>>	<<User Input per CMF Request Form>>	1.000	1.000	1.000	1.000

Modified HSM Spreadsheet

Output Summary Tab

Safety Performance - Output Summary

General Information			
Project Description:	No Build		
Project Location ID:	01-MO_100-F-2L-CL		
Analyst	MM/STL	Date:	2/27/2017

Project Description		Expected Number of Crashes	
Segment ID	Log Mile	K	A
ROADWAY SEGMENTS			
Segment 1	LM 52.588 to LM 53.09	0.012	0.046
Segment 2	LM 53.09 to LM 53.3	0.006	0.022
Segment 3	LM 53.3 to LM 53.41	0.002	0.007
Segment 4	LM 53.41 to LM 53.91	0.011	0.044
Segment 5	LM 53.91 to LM 54.68	0.017	0.066
Segment 6	LM 54.68 to LM 54.88	0.007	0.028
Segment 7	LM 54.88 to LM 55.4	0.012	0.045
Segment 8	LM 55.4 to LM 55.93	0.014	0.053
Segment 9	LM 55.93 to LM 56.14	0.005	0.020
Segment 10	LM 56.14 to LM 56.212	0.001	0.005
Segment 11		0.000	0.000
Segment 12		0.000	0.000
Segment 13		0.000	0.000
Segment 14		0.000	0.000
Segment 15		0.000	0.000
Segment 16		0.000	0.000
Segment 17		0.000	0.000
Segment 18		0.000	0.000
Segment 19		0.000	0.000
Segment 20		0.000	0.000
INTERSECTIONS			
Intersection 1	3ST	0.006	0.067
Intersection 2	4ST	0.010	0.038
Intersection 3	3ST	0.003	0.036
Intersection 4		0.000	0.000
Intersection 5		0.000	0.000
Estimated Number of Crashes by Year		0.107	0.478

Modified HSM Spreadsheet

Project Specific Instructions

Safety Improvements (MoDOT J6P3194) - Instructions to Users for the Customized Highway Safety Manual Spreadsheet Tool

This spreadsheet tool is customized using the HSM spreadsheets developed as part of the NCHRP 17-38. Exhibit 1 at the bottom of this worksheet provides the original instructions that were provided as part of the source spreadsheets that are available for download at www.highwaysafetymanual.org. Instructions are provided below for use by the HSM users for MoDOT St. Louis District Safety Design Build Project (J6P3194). Please contact the project director, James Gremaud, with any questions or requests for clarifications.

James R. Gremaud
Project Manager
Project Director – SL Safety
1590 Woodlake Drive
Chesterfield, MO 63017
636-279-4524
James.Gremaud@modot.mo.gov

Project Specific Instructions for HSM Spreadsheet Users

HSM Spreadsheet modifications for the proposed conditions

HSM analyses for the proposed condition is shall be conducted using the "Proposer" copies of the No-Build condition spreadsheets. This section outlines the various steps in the process of quantifying the safety benefits of the proposed improvements.

In addition to the CMFs built into the standard HSM tool, there is a provision to apply up to three additional non-HSM incorporated CMFs into the spreadsheets. However, it should be noted that there are specific criteria and requirements for the application of non-HSM CMFs that can be used in these spreadsheets. The user should refer to the ITP and contact the MoDOT project director with any questions or requests for clarification.

Guidance in the selection of non-HSM CMFs is provided by the following FAQ from cmfclearinghouse.org:

How can I apply multiple CMFs?
If multiple countermeasures are implemented at one location, then common practice is to multiply the CMFs to estimate the combined effect of the countermeasures.

ISATe Spreadsheet

Unmodified

Input Worksheet for Freeway Segments

Clear | Echo Input Values (View results in Column AV) | Check Input Values (View results in Advisory Messages)

		Segment 1		Segment 2		Segment 3		Segment 4		Segment 5		Segment 6		Segment 7		Segment 8	
		Crash Period	Study Period	Crash Period	Study Period	Crash Period	Study Period	Crash Period	Study Period	Crash Period	Study Period	Crash Period	Study Period	Crash Period	Study Period	Crash Period	S P
Basic Roadway Data																	
Number of through lanes (n):		4	4	4	4	4	4	4	4	4	4	4	4	4	4		
Freeway segment description:		WB01	WB01	WB02	WB02	WB03	WB03	WB04	WB04	WB05	WB05	WB06	WB06	WB07	WB07		
Segment length (L), mi:		0.115411	0.115411	0.040748	0.040748	0.090445	0.090445	0.033756	0.033756	0.074782	0.074782	0.102593	0.102593	0.182494	0.182494		
Alignment Data																	
Horizontal Curve Data	See note																
1	Horizontal curve in segment?:	No	No	Both Dir.	Both Dir.	Both Dir.	Both Dir.	Both Dir.	Both Dir.	Both Dir.	Both Dir.	Both Dir.	Both Dir.	No	No		
	Curve radius (R_1), ft:			2088	2088	1533	1533	3584	3584	2296	2296	2296	2296				
	Length of curve (L_{c1}), mi:			0.040748	0.040748	0.090445	0.090445	0.033756	0.033756	0.177375	0.177375	0.177375	0.177375				
	Length of curve in segment ($L_{c1,seg}$), mi:			0.040748	0.040748	0.090445	0.090445	0.033756	0.033756	0.074782	0.074782	0.102593	0.102593				
2	Horizontal curve in segment?:			No	No	No	No	No	No	No	No	No	No				
	Curve radius (R_2), ft:																
	Length of curve (L_{c2}), mi:																
	Length of curve in segment ($L_{c2,seg}$), mi:																
3	Horizontal curve in segment?:																
	Curve radius (R_3), ft:																
	Length of curve (L_{c3}), mi:																
	Length of curve in segment ($L_{c3,seg}$), mi:																
Cross Section Data																	
Lane width (W_l), ft:		12	12	12	12	12	12	12	12	12	12	12	12	12	12		
Outside shoulder width (W_s), ft:		10	10	10	10	10	10	10	10	10	10	10	10	10	10		
Inside shoulder width (W_{is}), ft:		6	6	12	12	12	12	12	12	6	6	10	10	5.5	5.5		
Median width (W_m), ft:		40	40	52	52	60	60	56	56	43	43	28	28	14	14		
Rumble strips on outside shoulders?:		Yes	Yes	No	No	No	No	Yes	Yes	Yes	Yes	No	No	Yes	Yes		
	Length of rumble strips for travel in increasing milepost direction, mi:	0.013447	0.013447					0.024905	0.024905	0.050568	0.050568			0.182494	0.182494		
	Length of rumble strips for travel in decreasing milepost direction, mi:	0.013447	0.013447					0.024905	0.024905	0.050568	0.050568			0.182494	0.182494		
Rumble strips on inside shoulders?:		Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes		
	Length of rumble strips for travel in increasing milepost direction, mi:	0.115411	0.115411	0.040748	0.040748	0.040341	0.040341	0.024527	0.024527	0.074782	0.074782	0.102593	0.102593	0.182494	0.182494		
	Length of rumble strips for travel in decreasing milepost direction, mi:	0.115411	0.115411	0.040748	0.040748	0.040341	0.040341	0.024527	0.024527	0.074782	0.074782	0.102593	0.102593	0.182494	0.182494		
Presence of barrier in median:		Some	Some	Some	Some	Some	Some	Some	Some	Some	Some	Some	Some	Center	Center		
1	Length of barrier ($L_{ib,1}$), mi:	0.115411	0.115411	0.004167	0.004167	0.083712	0.083712	0.033756	0.033756	0.074782	0.074782	0.102593	0.102593		0		
	Distance from edge of traveled way to barrier face ($W_{off,ib,1}$), ft:	34	34	38	38	16	16	44	44	35	35	18	18		0		
2	Length of barrier ($L_{ib,2}$), mi:	0.115411	0.115411	0.004167	0.004167	0.083712	0.083712	0.033756	0.033756	0.074782	0.074782	0.102593	0.102593		0		
	Distance from edge of traveled way to barrier face ($W_{off,ib,2}$), ft:	34	34	38	38	16	16	44	44	35	35	18	18		0		
3	Length of barrier ($L_{ib,3}$), mi:		0	0.036553	0.036553	0.005871	0.005871		0		0		0		0		

... | Main | Input Freeway Segments | Input Ramp Segments | Input Ramp Terminals | Output Summary | Output Freeway Segments | Output Ramp Segments | Output Ramp Terminals | Calibration Factors

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ISATe Spreadsheet

Separate Post-Processing to CMFs

Highway Safety Manual (ISATe) Output Processing and Additional CMFs

for Freeway / Interstate Project Locations

General Information *(Proposer should input this data)*			
Project Description:			
Project Location ID: *(select from list)*			
Proposer Analyst / Point of Contact		Date:	

Estimated Crash Statistics - Output from ISATe *(Proposer should copy output for Fatal (K) and Serious Injury (A) crashes directly from ISATe file that has been modified based on proposed improvements)*		
Crashes for Entire Facility by Year	**K**	**A**
Estimated number of crashes by year		

Modified Output for Project - Adjustment for Single Direction of the Freeway / Interstate *(Calculated by formula based on above inputs)*		
Estimated Crash Statistics		
Crashes for Analysis Direction by Year	**K**	**A**
Estimated number of crashes by year	0.000	0.000

Application of Non-ISATe CMFs *(Proposer is required to consult with MoDOT to determine permissibility and applicability of all CMFs not included in the ISATe spreadsheet tool)*

From Project CMF Table (or as determined in consultation with MoDOT)				Application of CMF by Severity *(see comment)*				
CMF Name	**Clearing-house ID**	**Crash Type**	**Crash Severity**	**CMF_K**	**CMF_A**		**$Weight_K$**	**$Weight_A$**
						CMF #1 - Weighted CMF Value -->	1.000	1.000
<<CMF 2>>								
						CMF #2 - Weighted CMF Value -->	1.000	1.000
<<CMF 3>>								
						CMF #3 - Weighted CMF Value -->	1.000	1.000
Combined Non-ISATe CMFs by Severity							1.000	1.000

Project Summary - Additional CMFs Applied *(Calculated by formula based on above inputs)*		
Estimated Crash Statistics		
Crashes for Analysis Direction by Year (with Additional CMFs)	**K**	**A**
Estimated number of crashes by year	0.000	0.000

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Analysis Constraints

Predicted Crash Frequency Equation

Calibration Factor for Missouri

$$N_{predicted\ ru} = N_{spf\ ru} (CMF_1 \times CMF_2 \times \ldots.) C_r$$

Proposers Limited to 3 CMFs for Safety Improvements not included in HSM/ISATe Models

Expected Crash Frequency

→ **Observed crash data was input into spreadsheet tools**

Reduction in Expected Crash Frequency

→ **Scored on difference between Existing/No-Build and Proposed**

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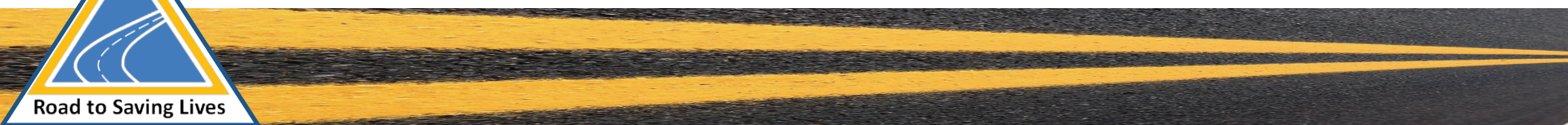
Safety Analysis

Maximize Cost-Benefit

Seek to maximize reduction of expected fatal and serious injury crashes

- Provide maximum safety benefit across project locations
- Submit Alternative Applicable Standards (AASs) and Crash Modification Factors (CMF) Requests for MoDOT approval
- Use HSM & ISATe Spreadsheets to reflect proposed safety improvements
- Consider all project goals



Best Value Proposal

Proposed Safety Improvements

# of Safety Locations Improved	# of Distinct Safety Improvements	# of Approved Crash Modification Factors (CMF)	# of Additional Applicable Standards (AAS)	# Serious Injuries Reduced Annually	# Fatal Crashes Reduced Annually
31 of 31	25	45	13	5.0	1.2

Best Value Proposal – NB West

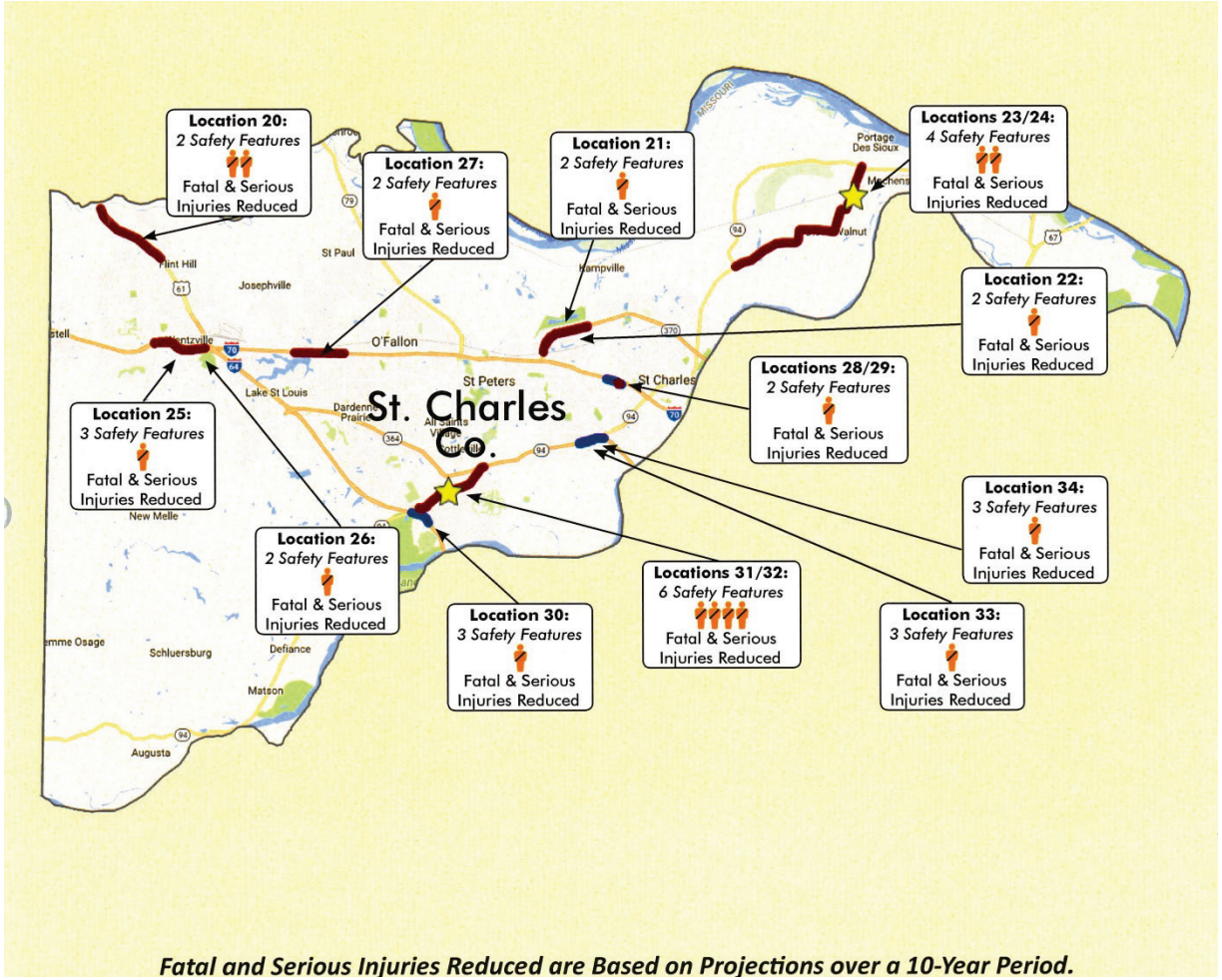
St. Charles County Improvements

WEST Contracting

HORNER SHIFRIN

LOCHMUELLER GROUP

EDSI
ENGINEERING DESIGN SOURCE, INC.



Fatal and Serious Injuries Reduced are Based on Projections over a 10-Year Period.

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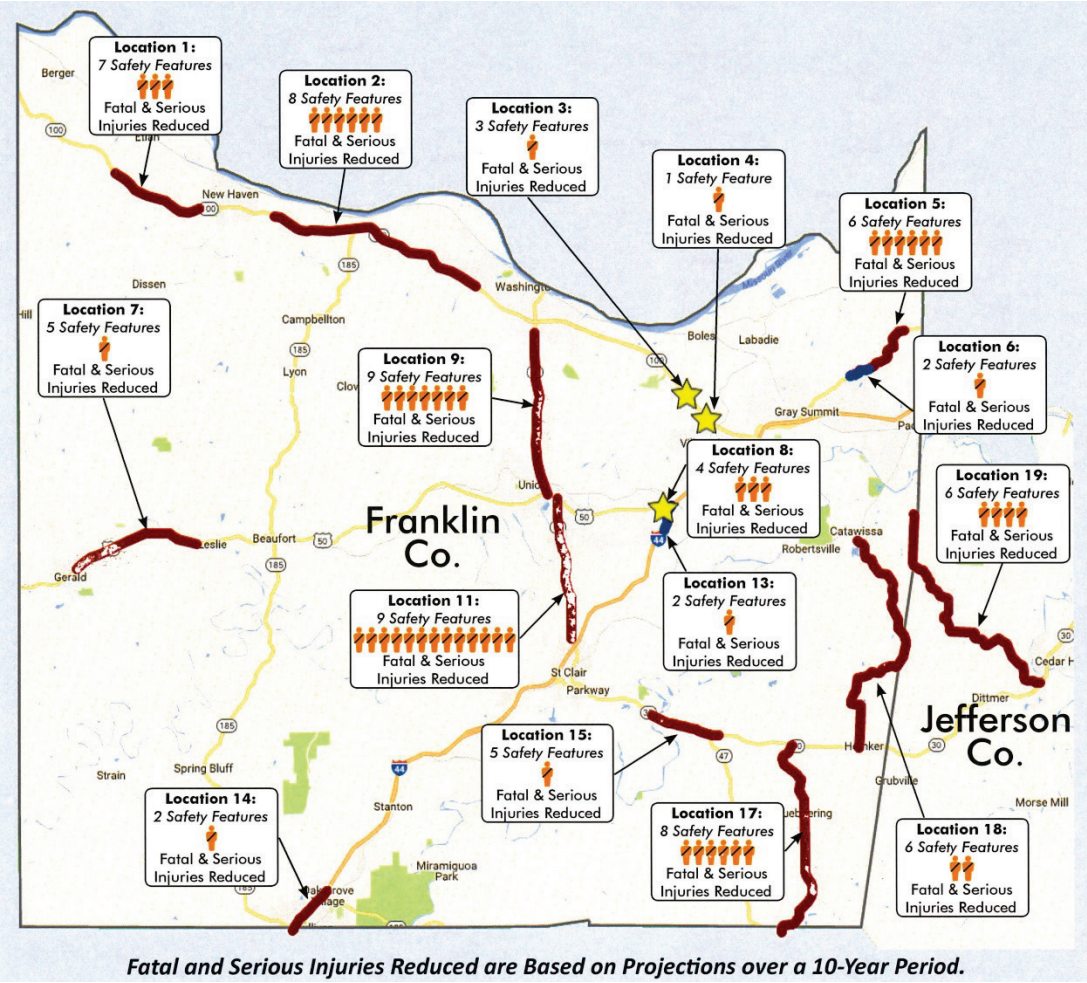
Best Value Proposal – NB West

Franklin County Improvements



Fatal and Serious Injuries Reduced are Based on Projections over a 10-Year Period.

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Best Value Proposal – NB West
Summary of Improvements

Improvement Description	Quantity Proposed
Guardrail Replacement (upgrading to MASH)	26,400+ LF
Crashworthy End Terminals (upgrading to MASH)	90+ each
High Friction Surface Treatment	72 curves, 2 intersections
Transverse Rumbles	11 locations
Centerline Rumbles	43.5 miles
Edgeline Rumbles	30.8 miles
Roundabout	MO 100 @ Bluff Rd
Improve channelized right turn lane	8 locations
Fluorescent Curve Signs	192 curves
Inlaid pavement markers	22.8 miles
Wet reflective pavement markings	11.2 miles
Intersection Conflict Warning System	6 locations
Flashing Beacons	10 locations
1” Asphalt Overlay (BP-1)	17.0 miles

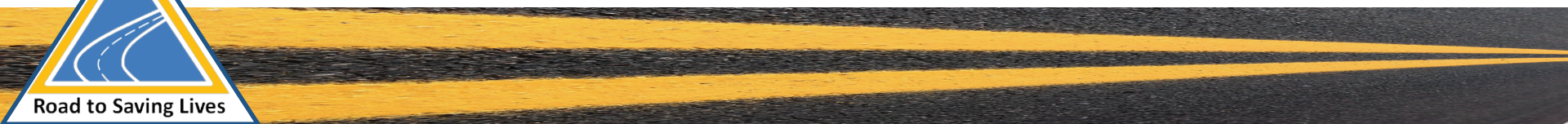
Safety Analysis & Countermeasure Evaluation

CHALLENGES

- Application of multiple countermeasures and CMFs
- ISATe and CMFs for countermeasures on freeways
- Acceptability of countermeasures
  - Location or roadway type
  - Devices or materials
- Design-Build Constraints

OPPORTUNITIES

- Multiple CMF Guidance in HSM2?
- Customized CMFs in 2019 release of IHSDM?
- Develop accepted list of countermeasures and CMFs
- Measured implementation of new countermeasures
- Develop program goals; retain oversight; be nible

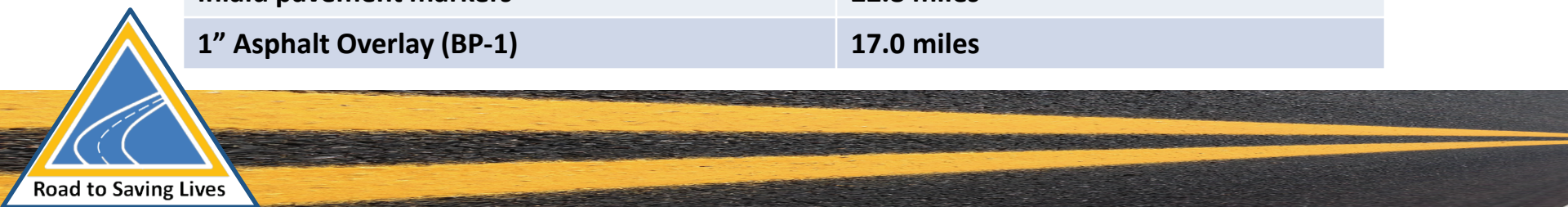


Stephen Georges, P.E.
Missouri Department of Transportation

PROJECT RESULTS: SAFETY IMPROVEMENTS

Rapid Implementation of Safety Improvements

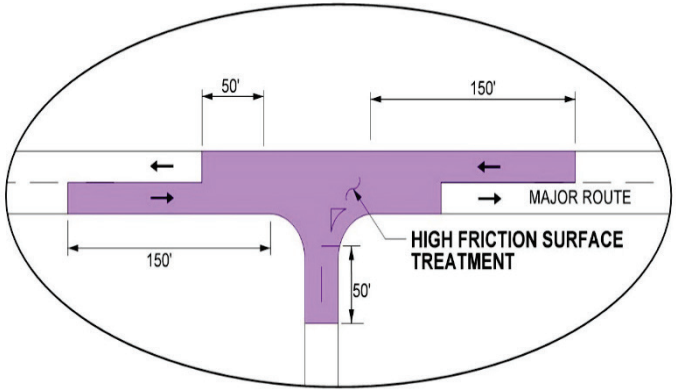
Improvement Description	Quantity
High Friction Surface Treatment	101 curves, 26 tangents, 13 intersections
Improve channelized right turn lane	9 locations
Flashing Beacons	10 locations
Transverse Rumbles	11 locations
Centerline Rumbles	43.5 miles
Edgeline Rumbles	30.8 miles
Fluorescent Curve Signs	192 curves
Intersection Conflict Warning System	6 locations
Crashworthy End Terminals (upgrading to MASH)	90+ each
Guardrail Replacement (upgrading to MASH)	26,400+ LF
Wet reflective pavement markings	11.2 miles
Inlaid pavement markers	22.8 miles
1” Asphalt Overlay (BP-1)	17.0 miles



High Friction Surface Treatment (HFST)

Improve Friction

- **Biggest safety improvement for project**
- **Aggregates**
  - Chinese Bauxite – required for interstates
  - Phonolite – approved for all other routes
- **Contract Quantity**
  - 101 curves, 26 tangents, 13 intersections
  - 265,000 square yards (40 lane miles)



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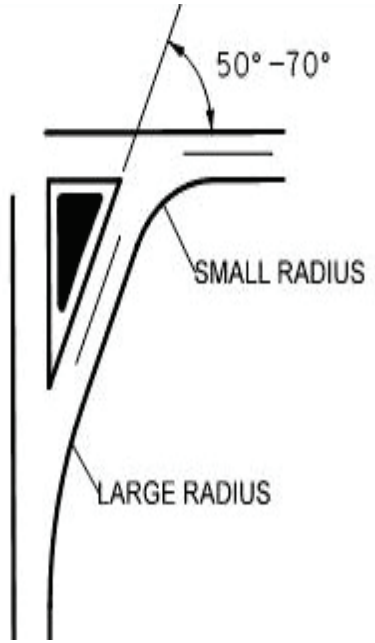
Improved Channelized Right Turn Lane

Straighter angle to improve sight distance

Encourages drivers to stop

- 24 locations
- CMF: 0.564



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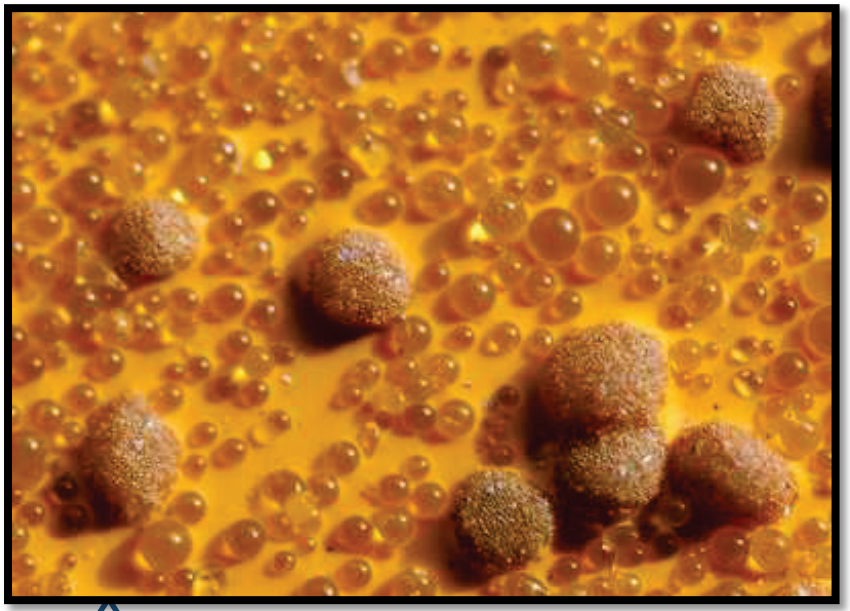
Wet-Reflective Pavement Markings

- CMF: 0.595 (Multilane) or CMF: 0.881 (Freeway)
- AAS – Combining 3M beads with Ennis-Flint Striping



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Intersection Conflict Warning System

Detection of vehicle on minor crossing route to notify drivers on major highway that vehicle is approaching intersection

2-lane highway

- CMF: 0.450

4-lane highway

- CMF: 0.734

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Dynamic Signal Warning Flashers (DSWF)

Provides drivers with advance notice of a signal phase change

- CMF: 0.82

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Median Guard Cable

Reduces crossover crashes for divided highways

- CMF: 0.70

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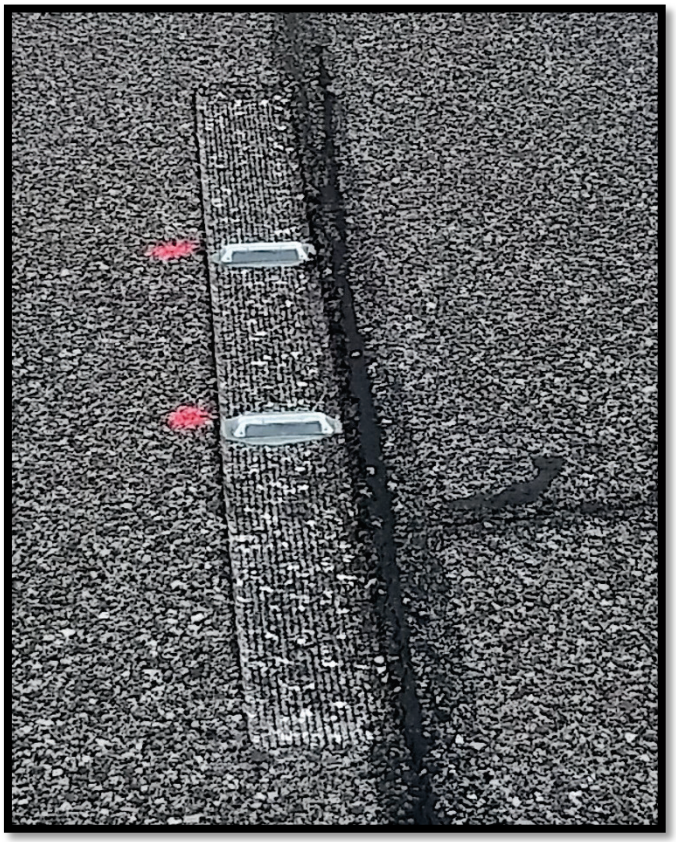
Inlaid Pavement Markers

- CMF: 0.81 (ADT<60,000)
- CMF: 0.87 (ADT>60,000)



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Rumbles

Centerline & Edgeline

Provide feedback to driver (sound & feel) for lane departures

- **Centerline Rumbles**
  - 42 miles
  - CMF: 0.88
- **Edgeline Rumbles**
  - 38 miles
  - CMF: 0.94

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Transverse Rumbles

Provide feedback to driver (sound & feel) to alert driver of approaching intersection

- 23 locations
- CMF: 0.90

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James Ritter, P.E.
Jacobs

RESULTS, FINDINGS, & ADDITIONAL THOUGHTS

Results & Findings

Data supported smaller improvements spread system wide to deliver maximum safety results

- *High Friction Surface Treatments* delivered most safety benefits per dollar
- All teams had extensive rumbles, striping, guard cable, guard rail, and pavement treatments to increase friction
- Shoulder widening and rumbles not proposed

Results & Findings

Be deliberate in program goals and decisions.

In the Design-Build procurement format, the RFP details and parameters rule

- Minimum service life (5 years of safety service life)
- Approval of AASs and CMFs
  - HFST Alternate Aggregate
- All teams had extensive rumbles, striping, guard cable, guard rail, and pavement treatments to increase friction

Results & Findings

Lessons Learned & Additional Opportunities

- *Further enhance data-driven location identification*
  - Locations were identified largely by quantity of fatal & serious injury crashes
  - Potential to analyze locations for crash disparity
- *Enhance scoring of safety element by introducing measure of solution alignment with crash history*
  - Entirely quantitative approach to safety resulted in chasing the numbers; potential loss of context

Results & Findings

Highway Safety Manual, 2nd Edition will provide opportunities and new guidance

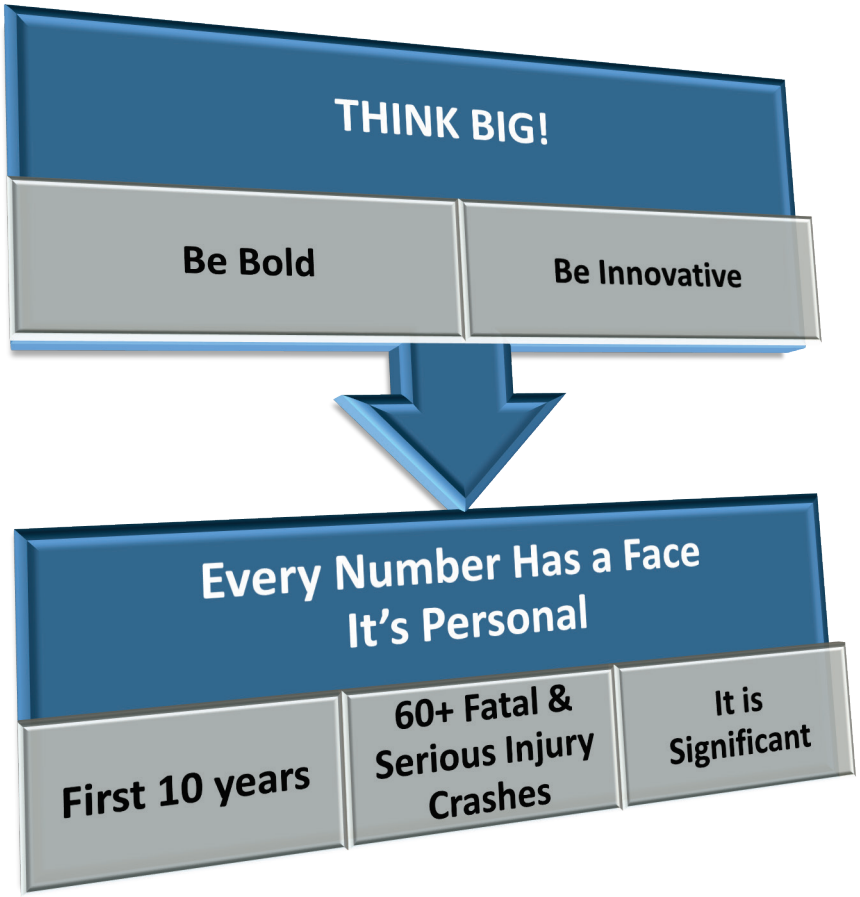
- Application of Multiple CMFs
- One-Way Roadways
- Revised CMF Rating System

HSM2

Second Edition of the Highway Safety Manual

Road to Saving Lives

Results & Findings



Road to Saving Lives

National Roadway Safety Award

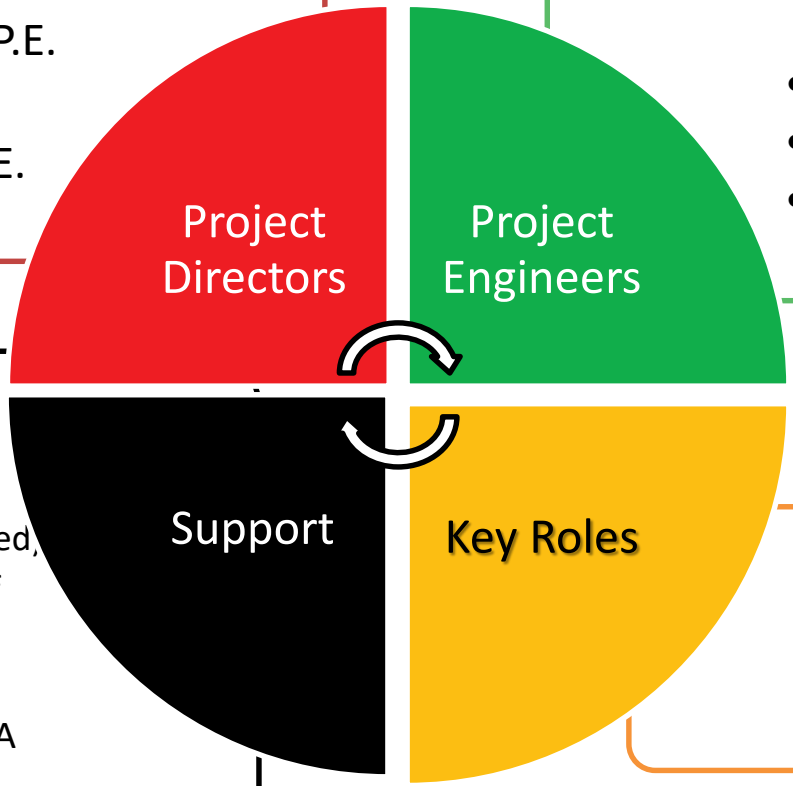
Jointly Sponsored by FHWA and the Roadway Safety Foundation

- 2017 Award for Program Planning, Development, & Evaluation

Road to Saving Lives

Project Team

- Tim Hellebusch, P.E.
- Vince Kaimann, P.E.
- Bill Schnell, P.E.
- Jim Gremaud, P.E. (retired)



- Heather Copeland, P.E. Deputy Director
- Stephen Georges, P.E.
- Tao Liao, P.E.
- Eric Trupiano, P.E.

- Jon Nelson, P.E.
- Ray Shank, P.E
- Jim Smith, P.E. (retired)
- Jacobs (CH2M) Staff
- Bryce Gamblin, Attorney
- Dawn Perkins, FHWA
- Jessica Hochlan
- St. Louis and CO Staff

- Teresa Krenning, P.E.
- Eddie Watkins
- David Simmons, P.E.
- Stacey Smith, P.E.

Road to Saving Lives

Project Website

For More Information

http://contribute.modot.mo.gov/stlouis/major_projects/SLSafetyDBProject/

Road to Saving Lives

Questions & Answers

Data-Driven Safety Improvements:

A Case Study on the Road to Saving Lives

James Ritter, P.E.

Transportation Project Manger, *Jacobs (CH2M)*

James.Ritter@jacobs.com

Stephen Georges, P.E.

Design & Construction Lead, *MoDOT St. Louis District*

Stephen.Georges@modot.mo.gov

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