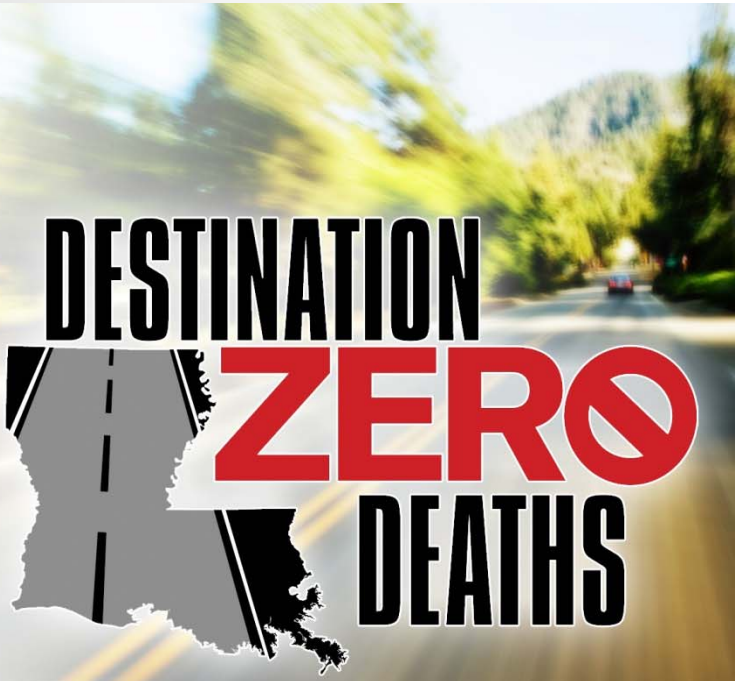
Planning Level CMFs

Data Driven Safety Analysis



presented to

Annual Statewide Traffic Engineers Meeting

presented by

Adriane McRae, PE

DOTD - Highway Safety

July 2016

CM-WHAT?!

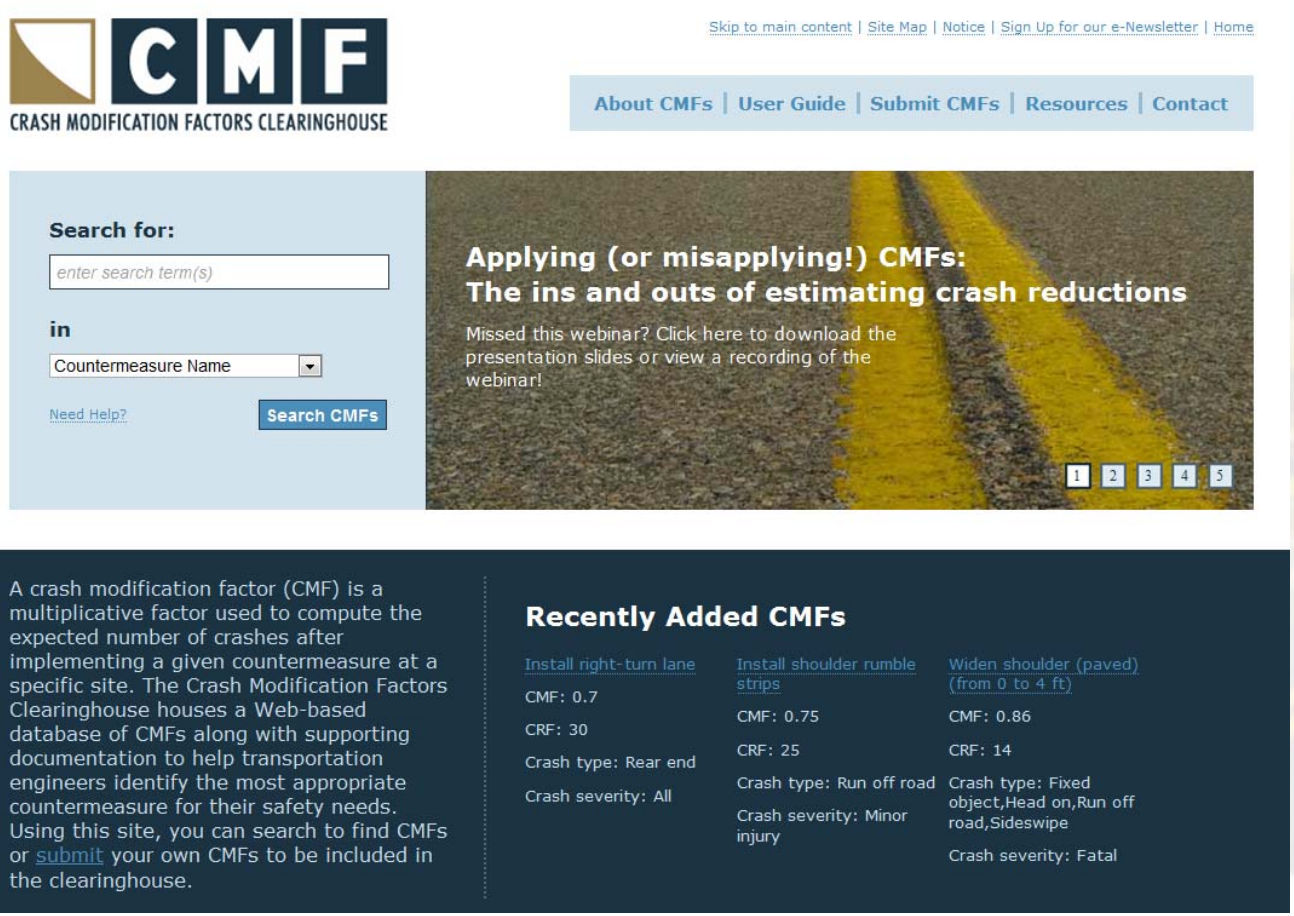
Crash Modification Factor (CMF) =

- Multiplicative factor used to compute the expected number of crashes after implementing a given countermeasure at a specific site

HSM Part	Supporting Tools	
PART B: Roadway Safety Management Process	Safety Analyst (AASHTO Ware)	
PART C: Predictive Method	HSM & ISATe spreadsheets	IHSDM & ISATe
*PART D: Crash Modification Factors (NOTE: will be eliminated with HSM 2nd Edition)	FHWA CMF Clearinghouse	

CMF Clearinghouse

www.CMFclearinghouse.org



- HSM Stamp of Approval – coming soon!

What is a CMF?

$$CMF = \frac{\text{Expected crashes with treatment}}{\text{Expected crashes without treatment}}$$

Where,

CMF > 1 - expected to increase crashes

CMF < 1 - expected to decrease crashes

CMF = 1 - no effect on crash frequency

- **LOW ↓ CMF values means a HIGH ↑ REDUCTION in crashes**
- **CMFs are developed using HSM methods on real projects**
- **Anyone can submit an evaluation study for a new CMF**

What is a CMF?

- **EXAMPLE**
  - » An intersection is experiencing 100 angle crashes and 500 rear end crashes per year.
  - » If you apply a countermeasure that has a CMF of 0.80 for angle crashes, then you can expect to see 80 angle crashes per year following implementation.

    100 angle crashes x 0.80 CMF = 80 angle crashes
  - » If the same countermeasure also has a CMF of 1.10 for rear-end crashes, then you would expect to also see 550 rear end crashes per year following implementation.

    500 rear-end crashes x 1.10 CMF = 550 rear end crashes

- **CMFs are the reverse of Crash Reduction Factor**

  CMF = 0.8 then CRF = 0.2 for same countermeasure

- **CMFs developed using HSM methods on real project**

Critical components of a CMF

- Evaluation Study Quality 
- Standard Error
- Crash Type
- Crash Severity
- Area Type (rural, urban, suburban, # of lanes, etc.)
- Roadway characteristics (arterial, freeway, etc.)
- AADT
- **Best Available!**

Quality of CMFs

- **Evaluation Study**

Score	Star Rating
14 (maximum)	★★★★★
11-13	★★★★☆
7-10	★★★☆☆
3-6	★★☆☆☆
1-2	★☆☆☆☆
0	—

HIGHEST QUALITY

Quality of CMFs

- **Evaluation Study**

Relative Rating	Excellent	Fair	Poor
Study Design	Statistically rigorous study design with reference group or randomized experiment and control	Cross sectional study or other coefficient based analysis	Simple before/after study
Sample Size	Large sample, multiple years, diversity of sites	Moderate sample size, limited years, and limited diversity of sites	Limited homogeneous sample
Standard Error (SE)	Small compared to CMF	Relatively large SE, but confidence interval does not include zero	Large SE and confidence interval includes zero
Potential Bias	Controls for all sources of known potential bias	Controls for some sources of potential bias	No consideration of potential bias
Data Source	Diversity in states representing different geographies	Limited to one state, but diversity in geography within state (e.g., California)	Limited to one jurisdiction in one state

Quality of CMFs

CMF / CRF Details

CMF ID: 4194

Conversion of signalized intersection into single- or multi-lane roundabout

Description:

Prior Condition: Signalized intersection

Category: Intersection geometry

Study: Safety Effectiveness of Converting Signalized Intersections to Roundabouts, Gross e

Star Quality Rating:	★★★★☆ [View score details]

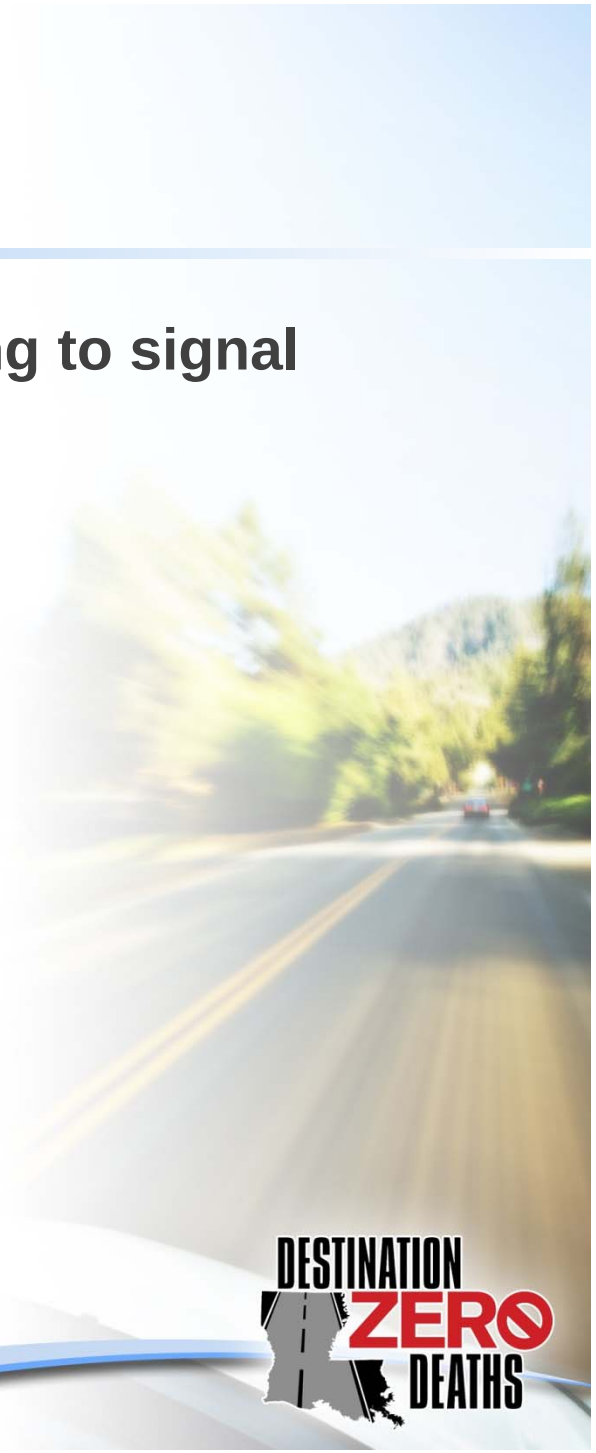
Crash Modification Factor (CMF)	
Value:	0.81
Adjusted Standard Error:	
Unadjusted Standard Error:	0.06

Crash Reduction Factor (CRF)	
Value:	19 *(This value indicates a **decrease** in crashes)*

DESTINATION ZERO DEATHS

DEMO on Researching CMFs

- Add 3 inch yellow retro-reflective sheeting to signal backplates
- Install dynamic signal warning flashers
- Install a traffic signal
- Remove unwarranted signal



Louisiana Fact Sheets

DOTD Highway Safety Webpage at "Safety Analysis Toolbox"

Guidance for Using Crash Modification Factors (CMF)

What is a CMF?

A Crash Modification Factor (CMF) is a value that quantifies the expected change in crash frequency at a site as a result of implementing a specific countermeasure or treatment.

$$CMF = \frac{\text{Expected crashes with treatment}}{\text{Expected crashes without treatment}}$$

Where,

CMF > 1 - expected to increase crashes

CMF < 1 - expected to decrease crashes

CMF = 1 - no effect on crash frequency

CMFs can be used in the transportation project development process to:

- Estimate the expected change in crash frequency associated with various countermeasures.
- Select among alternative countermeasures.
- Estimate safety benefits (crash savings) associated with a particular countermeasure.
- Identify cost-effective safety strategies.

The following table illustrates a CMF (HSM Table 13-21) for increasing the distance to roadside features for rural two-lane roads and freeways.

CMF Resources

Treatment	Setting (Road Type)	Traffic Volume	Crash Type (Severity)	CMF	Standard Error
Increase distance to roadside features from 3.3 feet to 16.7 feet	Rural two-lane roads and freeways	Unspecified	All Types (All Severities)	0.78	0.02
Increase distance to roadside features from 16.7 feet to 30.0 feet				0.56	0.01
Base condition: Distance to roadside features of 3.3 feet or 16.7 feet depending on geometry.					

CMFs can be found in several different resources, but two of the main resources include the FHWA CMF Clearinghouse (www.cmfclearinghouse.com) and the AASHTO Highway Safety Manual (HSM). While the HSM provides only the best available research-based CMFs, the CMF Clearinghouse is a comprehensive database of available CMFs, including all of the CMFs listed in the HSM. The CMF Clearinghouse is updated regularly, with new CMFs from researchers and state agencies.

Key Considerations in Selecting CMFs

When selecting CMFs it is imperative to consider the evaluation study method used to develop the CMF, the quality of the CMF, and the applicability to the site of interest.

Evaluation Study Design

The evaluation study design (i.e., how the study was conducted to calculate the CMF) plays a critical role in the quality of the CMF and should be considered when evaluating CMFs. Depending on the evaluation study design used to develop a CMF, the CMF could over or underestimate the effectiveness of a safety treatment. When a period with a comparatively high crash frequency is observed, it is statistically probable that the following period will have a comparatively low crash frequency. This statistical phenomenon is known as regression to the mean and also applies to the converse situation; a low crash frequency period will probably be followed by a high crash frequency period. The most reliable CMFs are those developed using statistical methods that account for regression to the mean.

Most agencies currently use the simple (or naïve) before-after study to estimate changes in crash frequency due to a specific change (safety treatment) at a site. However, this method doesn't account for regression to the mean or other changes (e.g., traffic volumes, weather, or driver behavior) that may have impacted the site. The HSM presents methods for estimating changes in crash frequency using statistical methods that address these issues. The methods are observational

DESTINATION ZERO DEATHS

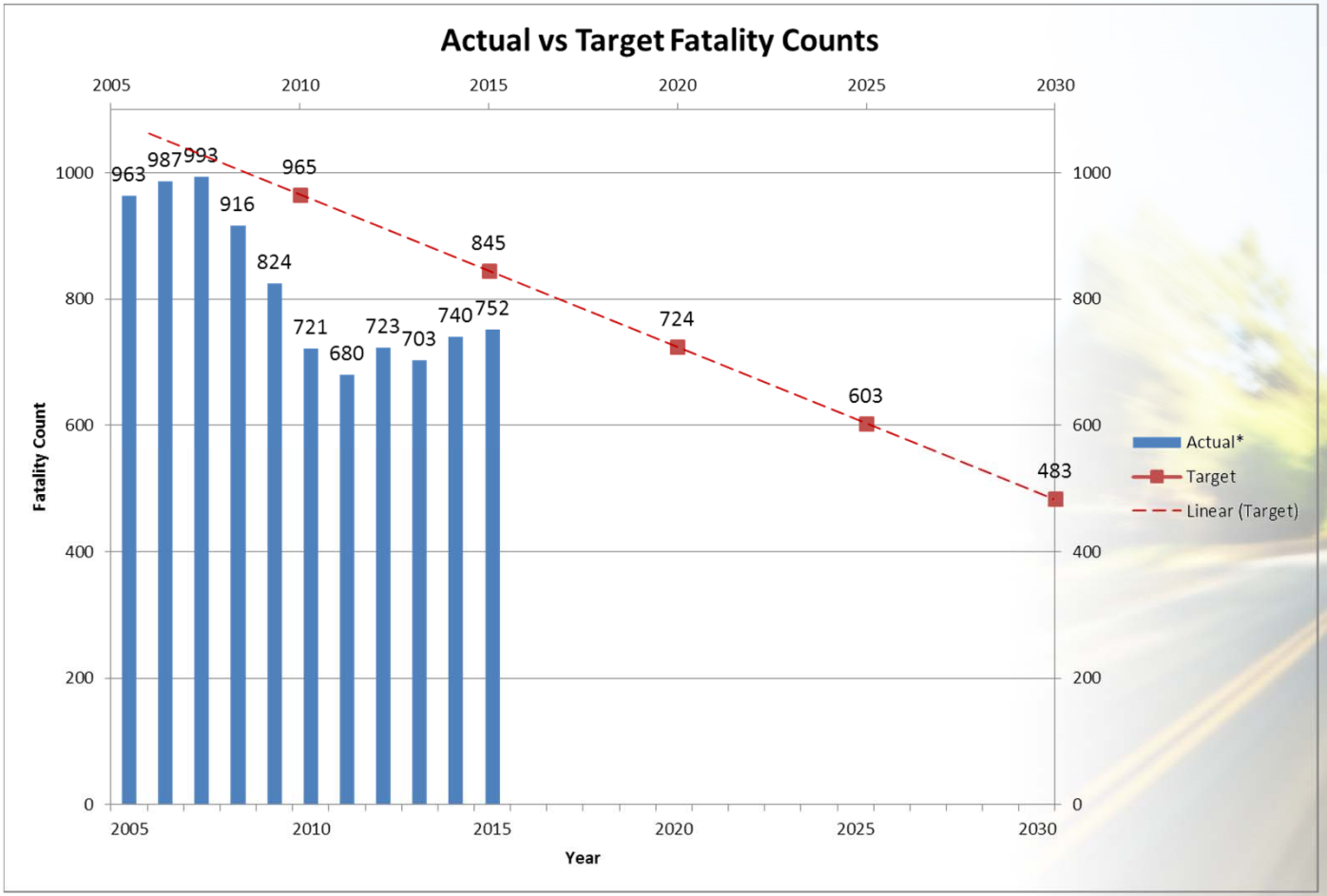
Highway Safety Manual Project Applications

Project Type	Highway Safety Manual Project Application	
Alternatives Evaluation Stage 0 – Planning Stage 1 – Environmental	Predictive Method Part C – Chapters 10-12[2]	As alternative cross-sections are considered and evaluated, the associated impact to crash frequency or severity can be calculated with the predictive method. There are methods for two-lane rural highways, rural multilane highways, and urban and suburban arterials – freeways will be available soon.
	Crash Modification Factors Part D – Chapters 13-17[3]	Crash modification factors (CMF) can also be used in an alternatives evaluation to evaluate the safety impacts (changes in crash frequency or severity) of various countermeasures. Impacts to safety can then be considered alongside other performance measures such as mobility, accessibility, or environmental impacts.
	Benefit-Cost Analysis Part B – Chapters 7-8	The change in expected crash frequency or severity (safety impact) of various alternatives determined using the predictive method or CMFs can be converted to monetary costs and benefits and incorporated into a benefit-cost analysis.
Locations with Potential for Safety Improvement	Diagnosis and Countermeasure Selection Part B – Chapters 5 and 6	Chapter 5 of the HSM outlines the diagnosis process which can be used to provide an understanding of crash patterns and physical characteristics of sites listed in the abnormal location listing. Chapter 6 then provides information to help identify potential contributing factors to the crashes and outlines steps for selecting countermeasures.
	Crash Modification Factors Part D – Chapters 13-17[3]	The Part D CMFs provide an indication of the effectiveness of various countermeasures in reducing crash frequency. CMFs also provide a quantitative estimate of the safety benefits (crash reduction) to use in a benefit-cost analysis.
	Benefit-Cost Analysis Part B – Chapters 7-8	The estimated change in crash frequency or severity of different roadway modification concepts can be converted to dollars and incorporated into a benefit-cost analysis. Chapter 7 of the HSM outlines methods to do this. The project prioritization methods in Chapter 8 can be used to prioritize projects for implementation.
Access Management Studies	Diagnosis and Countermeasure Selection Part B – Chapters 5 and 6	When conducting an access management study, the diagnosis process in Chapter 5 can be used to identify existing crash patterns and assess the site conditions. Chapter 6 can be used to identify potential contributing crash factors and outlines steps for selecting countermeasures.
	Predictive Method Part C – Chapters 10-12[2]	Depending on the type of road being evaluated, the Part C predictive method can be used to compare the expected safety performance of different access management alternatives.
	Crash Modification Factors Part D – Chapters 13-17[3]	Part D CMFs can also be used to identify and assess the effectiveness of potential countermeasures.

DESTINATION ZERO DEATHS

WHY USE CMFS?

Louisiana Statistics



Fatalities per 100 MVMT (2014)*
- Louisiana = 1.53
- US = 1.08
- Best State = 0.57

Fatalities per 100,000 Pop (2014)*
- Louisiana = 15.85
- US = 10.25
- Best State = 3.49

*Per National Highway Traffic Safety Admin. (NHTSA)

Purpose of CMFs

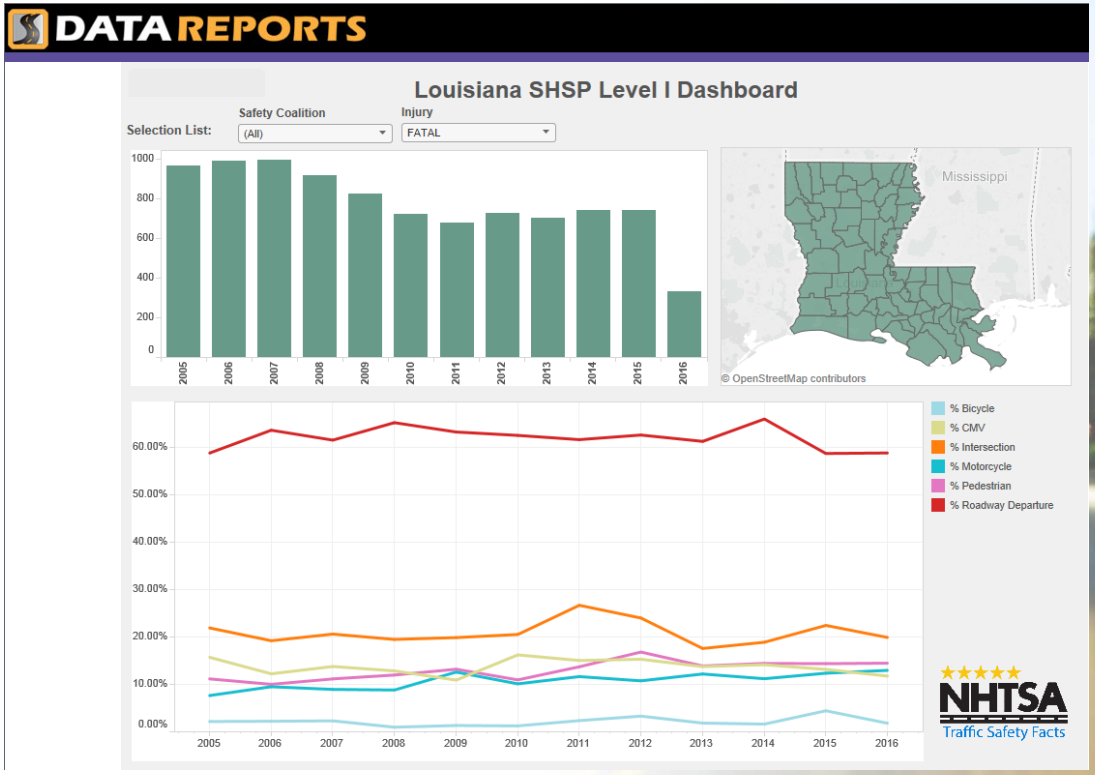
- Select potential countermeasures
- Obtain the expected effectiveness of countermeasures (HSM Part D)
- Compare alternative treatments
- Assist with benefit cost analysis

Challenges with CMFs

- Many, many to choose from
- Consistency is difficult across large agency
- Studies include roadways with various features
- Various studies of similar countermeasures have various results
- Finding the “perfect” CMF takes time & expertise

Louisiana Specific - Planning Level CMFs

- **PRIORITY CATEGORIES**
  - » **Roadway Segments**
  - » **Intersections**
  - » **Non-Motorized Users**

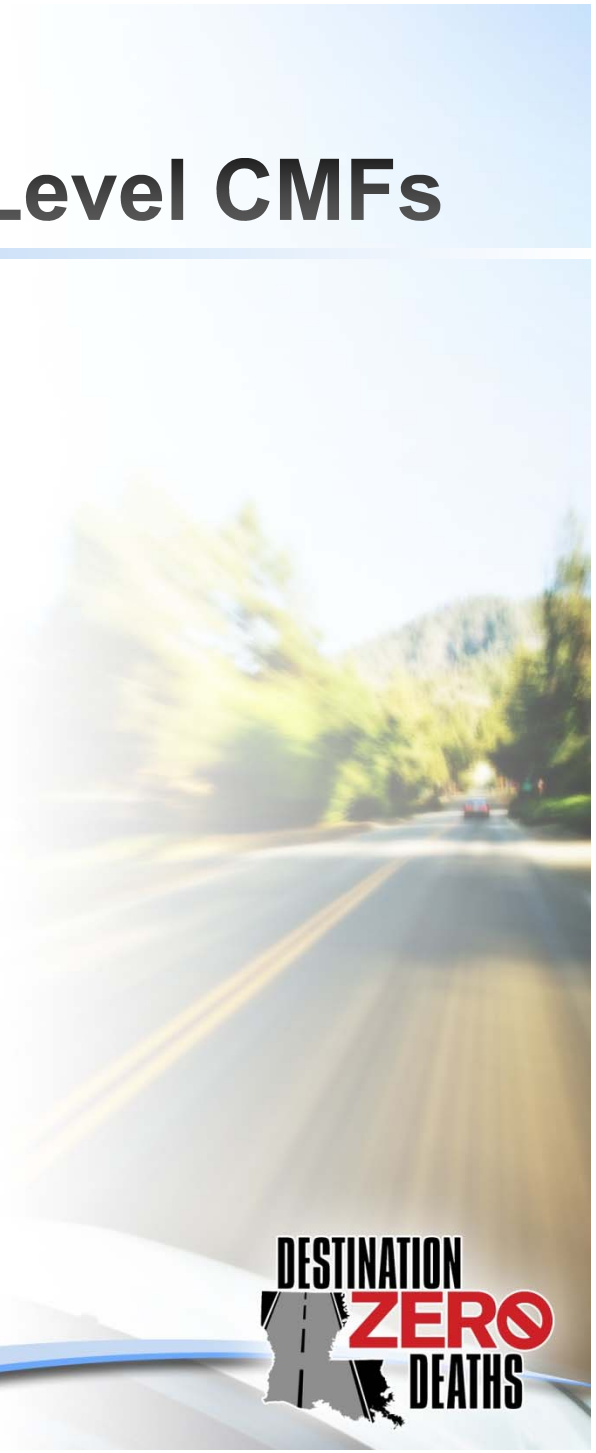


- **POTENTIAL CATEGORIES FOR FUTURE**
  - » **Bridges**
  - » **Interchanges**

DESTINATION ZERO DEATHS

Louisiana Specific - Planning Level CMFs

- **Roadway Segments**
  - » **Rumble Strips/stripes**
  - » **Safety edge**
  - » **Enhanced Delineation of Horizontal Curves**
  - » **High Friction Surface Treatment**
  - » **Shoulder/Curve widening**
  - » **Tree Removal**
  - » **Fixed object removal**
  - » **Guardrail**
  - » **Cable Median Barrier**
  - » **Access Management Improvements**
  - » **Road diets**

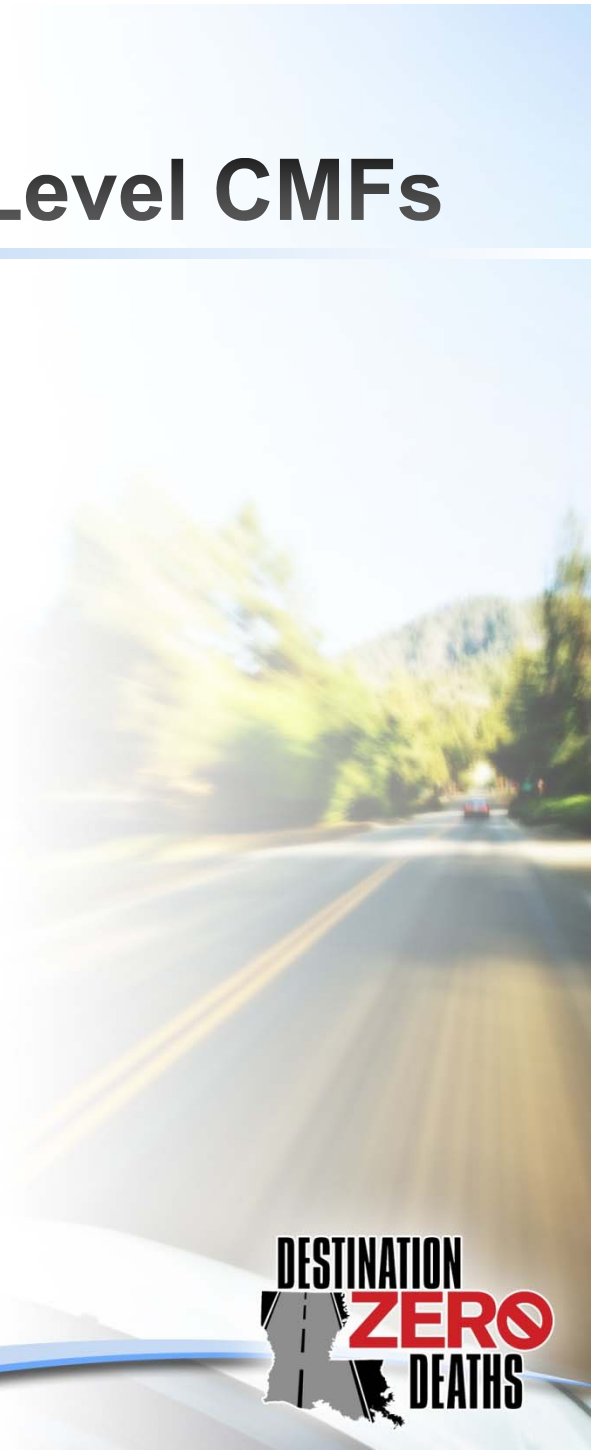


Louisiana Specific - Planning Level CMFs

- **Intersections**
  - » **Enhanced striping/signing**
    - – Backplates, signal head per lane
  - » **Signal upgrades/modifications**
    - – Flashing yellow arrow
  - » **New signal installation**
  - » **Modifications to stop control**
  - » **Add/New Turn lanes**
  - » **Improve skew angle**
  - » **Sight Distance improvements**
  - » **Lighting**
  - » **Roundabouts**
    - – Signal vs Stop controlled
    - – Single vs multi-lane
    - – Rural vs. urban/suburban
  - » **Super streets (J-turns)**

Louisiana Specific - Planning Level CMFs

- **Non-motorized users**
  - » **Crosswalks**
  - » **Pedestrian signals**
  - » **Pedestrian hybrid beacons**
  - » **Bike lanes**
  - » **Shoulder widening**
  - » **Sidewalks**



Louisiana Specific - Planning Level CMFs

- For treatments with multiple CMF's, countermeasures will be combined into broader CMF values
- The process of combining CMFs will result in a single CMF and standard error for treatments using the following process:
  1. Determine estimate of CMF from literature/ CMF clearinghouse
  2. Adjust for regression to the mean (RTM) and traffic volume bias
  3. Determine ideal standard error of safety effect
  4. Apply method correction factor to adjust for study characteristics such as the analytical method used
  5. Adjust ideal standard error for RTM and traffic volume bias
  6. Combine CMFs using weighted sums based on std. error.

DRAFT Example:
Louisiana Specific - Planning Level CMFs

Countermeasure Name	*Description*	*Crash Types*	*CMF*	*Std. Error*
R1A- Centerline Rumble Strips	Installation of rumble strips along undivided road centerlines.	All	0.85	0.02
R1B- Edgeline Rumble Strips	Installation of rumble strips along the edge of roadways.	Fatal, Serious Injury, Minor Injury	0.68	0.19
R2A- Wide Edge Lines	Increase the width of the pavement edgeline markings.	All	0.87	0.05
R2B- Curve Chevron Signing	Installation new chevron signs on horizontal curves.	All	0.86	0.08
R2C- Pavement Markers	Install new permanent raised pavement markers along segments and curves.	All	[illegible]	0.03
R3- HFST	Installation of a high friction surface treatment pavement course at intersections, along straight roadway segments, and along curves.	All	0.25	0.02
R4- Curve Widening	Increase horizontal curvature by one degree.	All	1.04	0.01
R6- Fixed Object Protection	Remove or relocate fixed object outside of clear zone.	All	0.62	0.16
R7- Guardrail Installation	Install new guardrail.	All	0.89	0.02
R8- Cable Median Barrier	Installation of new cable median barrier.	All	0.59	0.09
R9- Access Management				
R10- Road Diet	Reduce the number of travel lanes in a variety of conditions.	All	0.78	0.01
R11- Safety Edge	Installation of new safety edge along existing pavement edge.	All	0.93	0.06

Next Steps

- Finalize list of countermeasures & target crashes
- Prioritize list & focus on highest priority
  - » Roadway Segments – Roadway Departure
  - » Intersections – High severity crashes
  - » Non-Motorized Users
- Compile category values from CMF clearinghouse
- Combine CMFs where necessary
- Present preliminary list - **Fall 2016**
- Publish final list
- Periodically update

QUESTIONS?