Expected Roadway Project Crash Reductions for HB2 Safety Factor Evaluation

August 2015

HB2 Safety Factors Evaluation

1. Using Crash Modification Factors for HB2 Safety Evaluation
2. What are CMFs and how are they used?
3. Developing Planning Level CMFs
4. CMFs for HB2
5. Example HB2 use of CMFs

1. Using Crash Modification Factors for HB2 Safety Evaluation

HB2 Safety Factors Evaluation

ID	Measure Name (% Weight)	Measure Description	Measure Objective
S.1	Number of Fatal and Severe Injury Crashes (50%)*	Number of fatal and severe injury crashes expected to be avoided due to project implementation	Estimate number of fatal and severe injury crashes at the project location and the expected effectiveness project specific counter-measures in reducing crash occurence.
S.2	Rate of Fatal and Severe Injury Crashes (50%)	Number of fatal and severe injury crashes per 100 M VMT expected to be avoided due to project	Similar to S1, but by focusing on the change in crashes per VMT, considers projects that address areas with a high rate of crashes that may be outside of high-volume roadways.

Source: HB2 Policy Guide (Note- * Transit projects are weighted 100% on S.1)

Determining Project Expected Crash Reductions

Safety Factors and Measures Approach for Roadway Improvements Based on the HB2 Policy Guide :

Roadway projects on existing alignments -

- Project potential or expected crash reduction percentage developed using FHWA's Crash Modification Factors (CMF) Clearinghouse website, related safety research and Virginia crash rate summaries and models.

Roadway projects on new alignments –

- The crash reduction is difference between the expected crashes on the alternative route(s) due to changes in vehicle miles traveled and the expected crashes on the build corridor.

Transit; Travel Demand Management; and Freight Rail Improvement Project measures approach are explained in the HB2 Policy Guide.

2. What are CMFs and how are they used?

What is a CMF?

A Crash Modification Factor (CMF) is:

- **How much a project is expected to change the crash occurrences**
- **A multiplier used to compute the expected number of crashes after implementing a given improvement at a specific site.**
- **An index of how much a crash experience is expected to reduce following a modification in design or traffic control.**

Who uses CMFs?

CMFs are used by transportation professionals to:

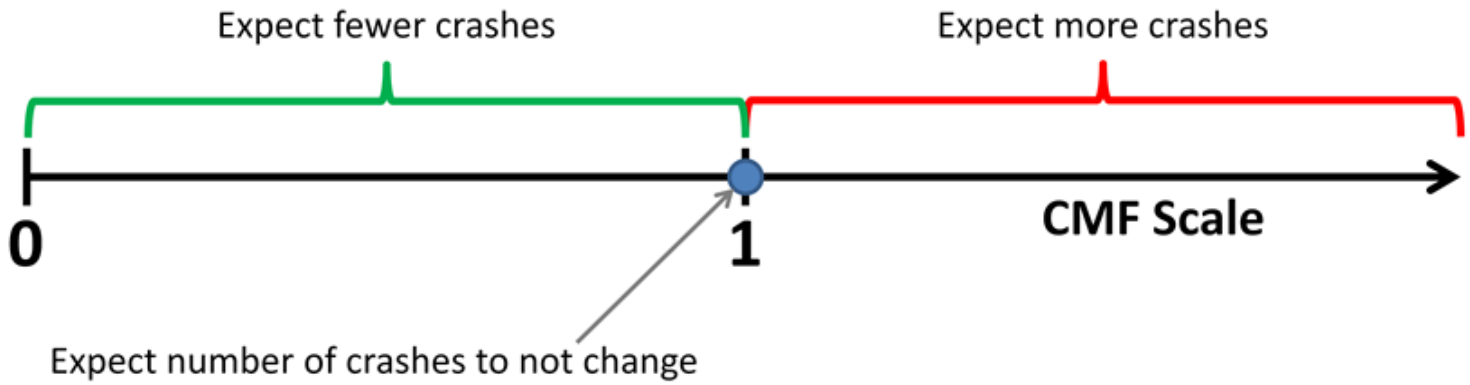
- **Compare safety consequences among various alternatives and locations**
- **Capture the greatest safety gain with limited funds**
- **Identify cost-effective improvement strategies and locations**

Application of CMFs

CMFs are applied to the location annual actual crashes *without* improvement to compute the estimated crashes *with* improvement.

The CMF Arithmetic:

Estimated Crashes WITH Improvement = CMF X Crashes Experienced WITHOUT Improvement



CMFs below 1.0 are good

A CMF less than 1.0 indicates that a treatment has the potential to **reduce crashes**.

A CMF for total crashes for installing centerline rumble strips on rural major collector roads has been estimated to be **0.86**.

- This CMF indicates that the frequency of total crashes with the treatment is estimated to be **86 percent** of the crash frequency without the treatment.
- In other words, the CMF indicates that there will be a **14 percent reduction** in total estimated crash frequency.

A CMF greater than 1.0 indicates that a treatment has the potential to **increase crashes**.

3. Developing Planning Level CMFs

Developing Planning Level CMFs

Each project extent has several improvement categories -

Project Extents:

1. Intersection
2. Interchange
3. Segments
4. Bicycle and Pedestrian
5. Bridges

1. Intersection: Improvement Features

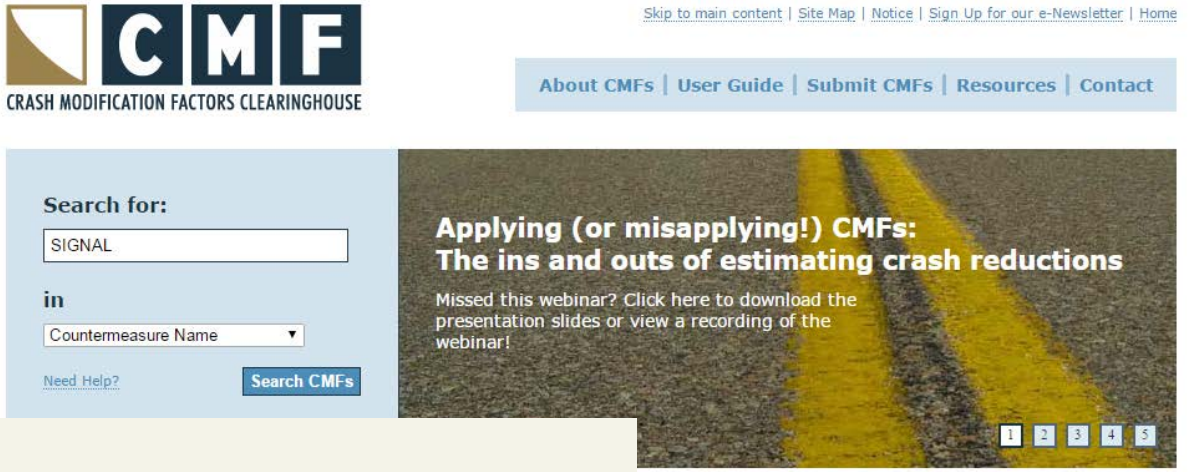
- Signal: New
- Roundabout: New
- New Turn Lane
- Add Turn Lane
- Remove minor approach left-turns (use right-turn and downstream u-turn)
- Improve skew angle

Developing Planning Level CMFs

Compile improvement category values In the CMF Clearinghouse

1. Intersection

- **Signal: New**



▼ Countermeasure: Install a traffic signal

CMF	CRF(%)	Quality	Crash Type	Crash Severity	Area Type	Reference	Comments
0.56 [B]	44	★★★★★	All	All	Rural	Harkey et al., 2008	Countermeasure name has been slightly ... [*read more*]
0.23 [B]	77	★★★★★	Angle	All	Rural	Harkey et al., 2008	Countermeasure name changed to match ... [*read more*]
0.33	67	★★★★☆	Angle	Fatal,Serious Injury,Minor Injury	Urban	McGee et al., 2003	Countermeasure name has been slightly ... [*read more*]

Developing Planning Level CMFs

Select appropriate CMFs for HB2 application

For all crash types

Want to use CMFs with higher quality rating

And fatal and injury crashes

▼ Countermeasure: Install a traffic signal

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Developing Planning Level CMFs

Define range of CMFs for various conditions to select applicable planning level value.

1. Intersection

- **Signal: New**

Countermeasure: Install a traffic signal

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0.4 [B]	60	★★★★☆	Left turn	All	Rural	Harkey et al., 2008
1.58	-58	★★★★☆	Rear end	All	Rural	Harkey et

Project Extent	Improvement Type	MIN	MAX	AVE	MEDIAN	STDEV	Planning Level CMF
Intersection							
	Signal: New	0.33	0.86	0.65	0.67	0.18	0.65

Developing of Planning Level CMFs

Some improvement categories required review of countermeasures combinations:

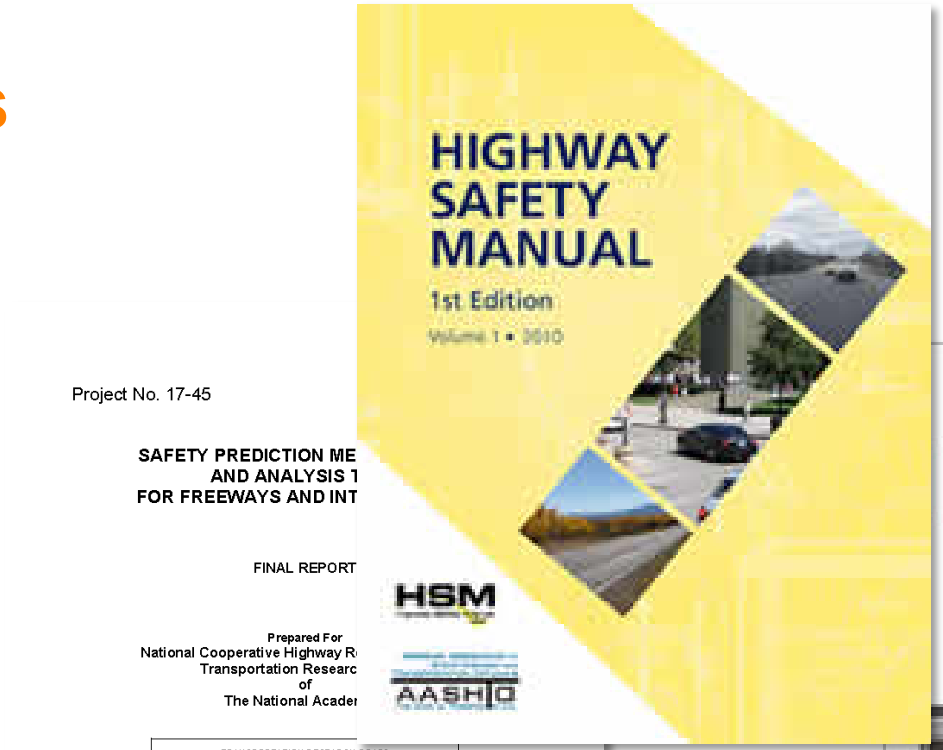
- **For project types with multiple improvement choices, countermeasures were grouped and combined into broader categories with the CMF chosen from the range.**

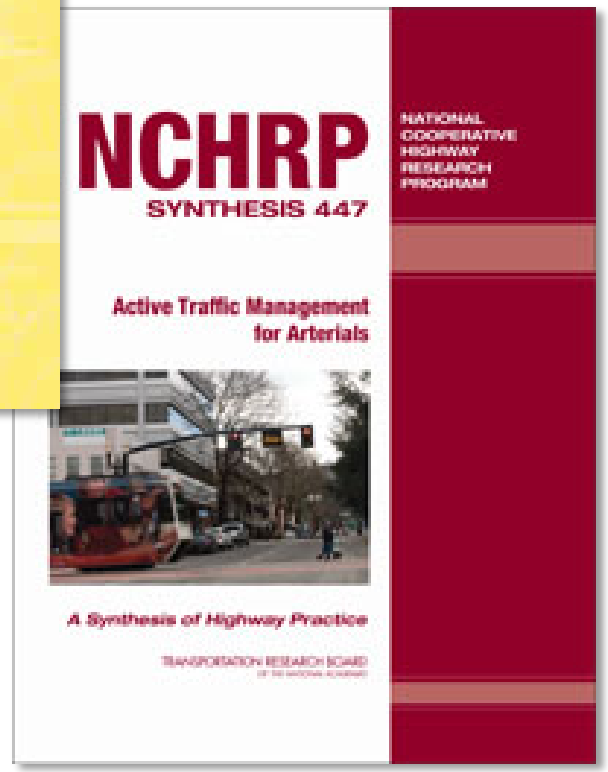
Project Extent	Improvement Type	MIN	MAX	AVE	MEDIAN	STDEV	Planning Level CMF
Segments							
	Non-Freeway: Access Control/Management						0.75
	Install median	0.24	1.70	0.71	0.71	0.27	
	Install directional median	0.76	0.82	0.79	0.80	0.03	
	Install RCUT	0.38	0.73	0.61	0.67	0.16	
	Close/relocate driveways	0.69	0.75	0.72	0.71	0.03	

Developing Planning Level CMFs

Other sources for CMFs

- Highway Safety Manual
- FHWA
- NCHRP Reports
- VDOT Safety Performance Functions
- Virginia Crash Rates





U.S. Department of Transportation
Federal Highway Administration

CMFs for Roadway Widening Projects

Since roadway widening projects involve multiple improvement CMFs, VA SPF and crash rates were also used to determine planning CMFs:

- A safety performance function (SPF) is an equation for a given roadway type and number of lanes used to predict the average number of crashes per year at a location as a function of exposure (Annual Average Daily Traffic - AADT).
- SPF Predicted # Crashes = Function[AADT, Segment Length]
- Comparison of predicted crashes per mile for adding lanes → CMFs

The CMFs developed using SPFs are dependent on AADT, which is why the min, max, and average were calculated to show the range in CMFs

Improvement Type	MIN	MAX	AVE	Planning Level CMF
Rural Freeway: Widening 2 to 3 Lanes	0.25	1.24	0.66	0.7

CMFs for Roadway Widening Projects

For comparison and selection of appropriate CMF values, VA crash rates were also used :

- Virginia crashes and traffic volume were categorized by rural and urban functional classes to determine crash rates by severity
- The ratio of fatal and severe injury crash rates for widened number of lanes to the existing number of lanes, compared to the SPF derived valuee, was selected as the CMF –

For example, Urban arterial widening from 4 to 6 lanes crash rate ratios ranged from 0.7 to 0.9. A CMF of 0.85 was chosen based on the confidence limits of the estimates, VMT and miles of roadway used to determine the rates, and SPF based widening type CMFs.

4. CMFs for HB2

HB2 Planning Level CMFs

Project Extent	Improvement Type/Features	Planning Level CMF
Intersections		
	Signal: New	
	Convert stop/yield control to signal	0.65
	Roundabout: New	
	Roundabout: New - Convert signal to roundabout	0.40
	Roundabout: New - Convert stop/yield control to roundabout	0.20
	New Turn Lane (none present)	0.85
	Add Turn Lane (to existing)	0.97
	Remove Minor Approach Left Turns (use right turn and downstream U-turn)	0.65
	Improve skew angle	
	3 Leg Intersection	0.70
	4 Leg Intersection	0.60

HB2 Planning Level CMFs

Project Extent	Improvement Type/Feature	Planning Level CMF
Interchange		
	At Grade to New interchange	0.50
	Non-Freeway Segment: Convert Diamond to DDI	0.30
	Non-Freeway Segment: Convert Diamond to SPUI	0.60
	Non-Freeway Segment: Replace Arterial Turns with Loops or Directional Ramps	0.65
	Freeway Segment: Add Freeway Collector-Distributor Roads	0.90
	Add Freeway Independent Loop or Directional Ramp Entrances	0.95
	Extend ramp length	
	Extend ramp acceleration length (250')	0.80
	Extend ramp acceleration length (500')	0.65
	Extend ramp acceleration length (1000')	0.45
	Extend ramp deceleration length (250'-500')	0.85

HB2 Planning Level CMFs

Project Extent	Improvement Type/Feature	Planning Level CMF
Segments	Non-Freeway: (including 2 or more intersections)	
	Non-Freeway: Signal Optimization / Adaptive	0.92
	Non-Freeway: ITS for ATM	0.90
	Non-Freeway: Alignment Reconstruction	0.85
	Non-Freeway: Widen Travel Lanes (by 2 - 3 ft.)	0.80
	Non-Freeway: Shoulder/Clear Zone Improvement	0.65
	Non-Freeway: Pavement Re-utilization (Road Diet)	0.55
	Non-Freeway: Access Management	0.75
	Rural Non-Freeway : Widening 2 lanes to multi-lane divided	0.70
	Urban Non-Freeway : Widening 2 lanes to 4-lane divided	0.80
	Urban Non-Freeway : Widening 2 lanes to 6-lane divided	0.75
	Urban Non-Freeway : Widening 4 lanes to 6+-lane divided	0.85

HB2 Planning Level CMFs

Project Extent	Improvement Type/Feature	Planning Level CMF
Segments	Freeways: (including 2 or more interchanges)	
	Freeway: ITS for Incident Management	0.85
	Freeway: ITS for ATM	0.80
	Freeway: ITS for Variable Speed Limits	0.90
	Freeway: Add Aux Lanes between Ramps	0.80
	Rural Freeway: Directional Widening 2 to 3 Lanes	0.70
	Urban Freeway: Directional Widening 2 to 3 Lanes	0.90
	Urban Freeway: Directional Widening 2 to 4+ Lanes	0.75
	Urban Freeway: Directional Widening 3 to 4+ Lanes	0.80

HB2 Planning Level CMFs

Project Extent	Improvement Type/Feature	Planning Level CMF
Bike and Pedestrian		
	Add Sidewalk	0.90
	Add Bike Lane	0.95
	Add Separate 10ft. Mixed-Use Trail	0.80
	Improve At-Grade Crossing	0.85
Bridges	Widen Shoulders	0.95
	Add Lanes	See segment values

5. Example HB2 use of CMFs

Urban Two Lanes Undivided to Four Lanes Divided

Credit: VDOT

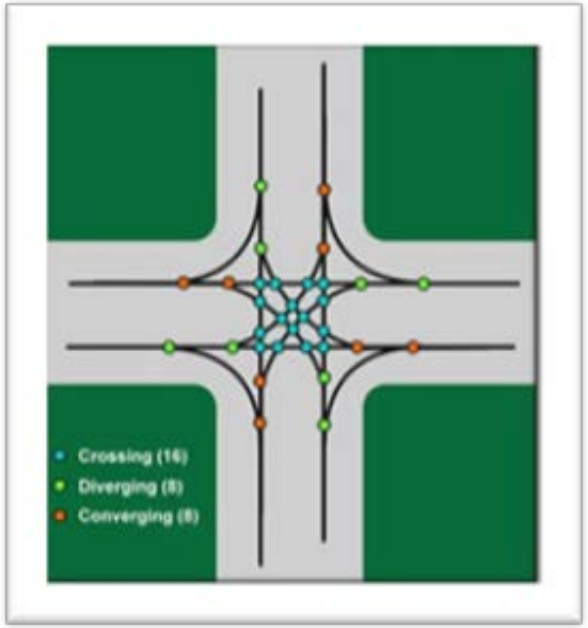
Reduction in F+SI Crashes (1-CMF) = 1- 0.80 = 20%

S.1: **2012-14 F+SI Crashes = 10 / yr**
Project F+SI Avoided = 2 / yr

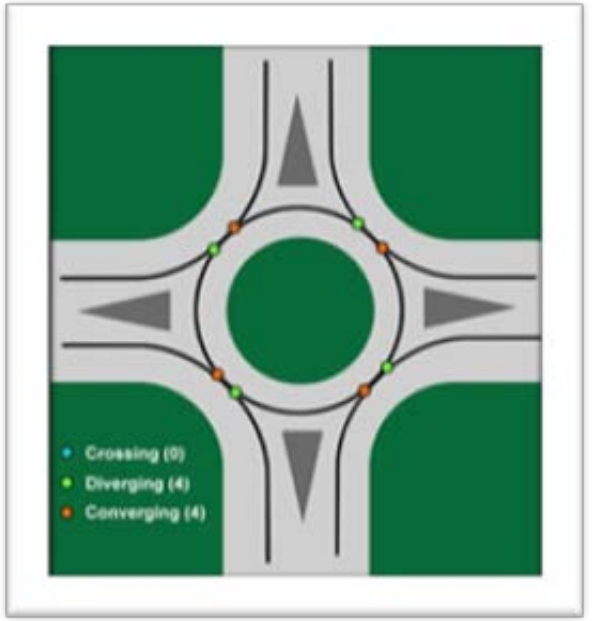
S.2: **F+SI Crash Rate = 0.30 / 100 Million VMT**
Project F+SI Rate Avoided = 0.06 HMVMT

Urban Two Way Stop to Roundabout Control

Before



After



Reduction in F+SI Crashes (1-CMF) = 1- 0.20 = 80%

S1: **2012-2014 F+SI Crashes = 1.5 / yr**
Project F+SI Avoided = 1.2 / yr

S2: **F+SI Crash Rate = 0.17 / 100 M VMT**
Project F+SI Rate Avoided = 0.14 / HMVMT

Credit: FHWA

Urban Corridor Adaptive Traffic Signal Control at Eight Intersections

Credit: Charlottesville Stock Photography

Reduction in F+SI Crashes (1-CMF) = 1- 0.92 = 8%

S1: **2012-2014 F + SI Crashes = 16 / yr**
Project F+SI Avoided = 1.3 / yr

S2: **F+SI Crash Rate = 0.26 /100 M VMT**
Project F+SI Rate Avoided = 0.02 / HMVMT