Application and Science of Crash Reduction Factors

Fun, fun, fun ‘till your daddy takes the T-bird away

Larry Hagen, P.E., PTOE

“Driving Down Fatalities Through Knowledge Sharing”
## Workshop Series

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<td>Highway Safety Evaluation</td>
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<td>Wed. Nov. 6</td>
<td>Highway Safety Manual</td>
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<tr>
<td>Wed. Nov. 13</td>
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</tr>
</tbody>
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### 2014

<table>
<thead>
<tr>
<th>Date</th>
<th>Topic</th>
</tr>
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<td>Wed. Jan. 8</td>
<td>Safety Projects &amp; The Local Agency Program (LAP)</td>
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<td>Wed. Jan. 29</td>
<td>Key to Successful Safety Programs</td>
</tr>
</tbody>
</table>

**Today’s Presentation**

**Application and Science of Crash Reduction Factors**

“Driving Down Fatalities Through Knowledge Sharing”
What is a CRF?

A CRF is one of the many TLA’s that we use in traffic engineering. Here are some others:

• ADT
• HCM
• HSM
• MOE
TLA

Three Letter Acronym
What is a CRF?

A CRF is one of the many TLA’s that we use in traffic engineering. Here are some others:

- ADT
- HCM
- HSM
- MOE
ADT

Average Daily Traffic
MOE

Measure Of Effectiveness
CRF

Crash Reduction Factor
CRF is a MOE

The Crash Reduction Factor is a measure of how effective you are at reducing crashes.
CRF

Crash Reduction Factor
CMF

Crash Modification Factor
CRF vs CMF

● CRF
A Crash Reduction Factor is an estimate of the percentage reduction in crashes due to a particular countermeasure.

● CMF
A Crash Modification Factor is a multiplicative factor used to compute the expected number of crashes after implementing a given countermeasure.
## CRF vs CMF

<table>
<thead>
<tr>
<th>Range of values</th>
<th>CRF</th>
<th>CMF</th>
</tr>
</thead>
<tbody>
<tr>
<td>-∞ &lt; CRF ≤ 1.0</td>
<td>0 ≤ CMF &lt; ∞</td>
<td></td>
</tr>
<tr>
<td>No change in crashes</td>
<td>0</td>
<td>1.0</td>
</tr>
<tr>
<td>Eliminate all crashes</td>
<td>1.0</td>
<td>0</td>
</tr>
<tr>
<td>Double the number of crashes</td>
<td>-1.0</td>
<td>2.0</td>
</tr>
<tr>
<td>Half the number of crashes</td>
<td>0.5</td>
<td>0.5</td>
</tr>
<tr>
<td>15% less crashes</td>
<td>0.15</td>
<td>0.85</td>
</tr>
<tr>
<td>15% more crashes</td>
<td>-0.15</td>
<td>1.15</td>
</tr>
</tbody>
</table>

\[
CMF = 1 - CRF
\]

“Driving Down Fatalities Through Knowledge Sharing”
Where do I find CRF’s?

- Florida DOT CRF’s
- Highway Safety Manual
- CMF Clearinghouse
  
  www.cmfclearinghouse.org
Florida DOT CRF’s

- Crash Reduction Factors from studies in Florida
- Produced by Lehman Center at FIU
- Crash Reduction Analysis System Hub (CRASH)
- Updated in 2005
- Update to Peter Hsu’s work in graduate school at UF

“Driving Down Fatalities Through Knowledge Sharing”
Tables in the HSM contain CMF’s
Must convert to CRF’s if that is what you need
NOTE: there are separate CMF’s for the predictive models and for project analysis
Typically, the CMF’s for the predictive models should NOT be used for other purposes and the other CMF’s should not be used with the predictive models
Find out more about the Star Quality Ratings for CMFs

Read more about the star quality rating applied to CMFs in the Clearinghouse. The star rating is based on a scale (1 to 5), where a 5 indicates the highest or most reliable rating.

Recently Added CMFs

- Improve pavement friction (increase skid resistance)
  - CMF: 0.865
  - CRF: 13.4
  - Crash type: Rear end
  - Crash location: Interchange

- Installation of a High intensity Activated crossWalk (HAWK) pedestrian-activated beacon at an intersection
  - CMF: 0.309
  - CRF: 69

- Add Two-Way-Left-Turn-Lane (TWLTL) to the major approach of an unsignalized 3-leg intersection
  - CMF: 0.69
  - CRF: 31

A crash modification factor (CMF) is a multiplicative factor used to compute the expected number of crashes after implementing a given countermeasure at a specific site. The Crash Modification Factors Clearinghouse houses a Web-based database of CMFs along with supporting documentation to help transportation engineers identify the most appropriate countermeasure for their safety needs. Using this site, you can search to find CMFs.
WARNING!

ALWAYS use caution when looking up or applying CMF’s or CRF’s
## HSM Predictive Models

### Table 1 Facility Types with Safety Performance Functions

<table>
<thead>
<tr>
<th>HSM Chapter</th>
<th>Undivided Roadway Segments</th>
<th>Divided Roadway Segments</th>
<th>Intersections</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Stop Control on Minor Leg(s)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>3-Leg</td>
</tr>
<tr>
<td>10 Rural Two-Lane Roads</td>
<td>✓</td>
<td></td>
<td>✔</td>
</tr>
<tr>
<td>11 Rural Multi-lane Highways</td>
<td>✓</td>
<td>✓</td>
<td>✔</td>
</tr>
<tr>
<td>12 Urban and Suburban Arterials</td>
<td>✓</td>
<td>✓</td>
<td>✔</td>
</tr>
</tbody>
</table>

“Driving Down Fatalities Through Knowledge Sharing”
HSM Predictive Models

- Safety Performance Function for facility type
- Crash Modification Factors (Functions)
- Calibration Factor
- EB Adjustment
HSM Predictive Models

- **What are Safety Performance Functions?**
  - Mathematical Regression Models for Roadway Segments and Intersections:
    - Developed from data for a number of similar sites
    - Developed for specific site types and “base conditions”
    - Function of only a few variables, primarily AADT
    - Used to calculate the expected crash frequency (crashes/year) for a set of base geometric and traffic control conditions

- **Purpose of Crash Modification Factors**
  - Adjusts the calculated SPF predicted value for base conditions to actual or proposed conditions
  - Accounts for the difference between base conditions and site specific conditions

“Driving Down Fatalities Through Knowledge Sharing”
HSM Predictive Models

SPF Prediction Model for Base Conditions:

Rural Two-Lane Roadway Segments

\[ N_{spf-rs} = AADT \times L \times 365 \times 10^{-6} \times e^{-0.312} \]

- \( N_{spf-rs} \) = predicted total crash frequency for roadway segment base conditions (crashes/year)
- \( AADT \) = average annual daily traffic volume (vpd)
- \( L \) = length of roadway segment (miles)
HSM Predictive Models

Base Conditions for Rural Two-Lane Roadway Segments:

- Lane Width: 12 feet
- Shoulder Width: 6 feet
- Shoulder Type: Paved
- Roadside Hazard Rating: 3
- Driveway Density: <5 driveways/mile
- Grade: < 3%
- Horizontal Curvature: None
- Vertical Curvature: None
- Centerline rumble strips: None
- TWLTL, climbing, or passing lanes: None
- Lighting: None
- Automated Speed Enforcement: None

“Driving Down Fatalities Through Knowledge Sharing”
HSM Predictive Models

Apply CMFs to the SPF Base Model

\[ N_{\text{predicted-rs}} = N_{\text{spf-rs}} \times (\text{CMF}_{1r} \ldots \text{CMF}_{xr}) \times C_r \]

Where:

- \( N_{\text{predicted-rs}} = \) predicted average crash frequency for an individual roadway for a specific year (crashes per year)
- \( N_{\text{spf-rs}} = \) predicted average crash frequency for base conditions for an individual roadway segment (crashes per year)
- \( \text{CMF}_{1r} \ldots \text{CMF}_{xr} = \) Crash Modification Factors for individual design elements
- \( C_r = \) calibration factor

“Driving Down Fatalities Through Knowledge Sharing”
HSM Predictive Models

Crash Modification Factor - Lane Width

Table 10-8. CMF for Lane Width on Roadway Segments (CMF_{ra})

<table>
<thead>
<tr>
<th>Lane Width</th>
<th>AADT (veh/day)</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>&lt; 400</td>
<td>400 to 2000</td>
<td>&gt; 2000</td>
</tr>
<tr>
<td>9-ft or less</td>
<td>1.05</td>
<td>1.05 + 2.81 \times 10^{-4}(AADT-400)</td>
<td>1.50</td>
</tr>
<tr>
<td>10-ft</td>
<td>1.02</td>
<td>1.02 + 1.75 \times 10^{-4}(AADT-400)</td>
<td>1.30</td>
</tr>
<tr>
<td>11-ft</td>
<td>1.01</td>
<td>1.01 + 2.5 \times 10^{-5}(AADT-400)</td>
<td>1.05</td>
</tr>
<tr>
<td>12-ft or more</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
</tr>
</tbody>
</table>

NOTE: The collision types related to lane width to which this CMF applies include single-vehicle run-off-the-road and multiple-vehicle head-on, opposite-direction sideswipe, and same-direction sideswipe crashes.

\[ CMF_{1r} = (CMF_{ra} - 1.0)p_{ra} + 1.0 \]

- \( p_{ra} \) = proportion of related crashes. Default value = 0.574

District 7 has good data: use CDMS to get factors

“Driving Down Fatalities Through Knowledge Sharing”
WARNING!

Always use caution when looking up or applying CMF’s or CRF’s. The table on the previous slide is ONLY applicable for use with the predictive model for rural two-lane roadway segments!
Multiplication of CMFs in Part C

In the *Part C predictive method*, an SPF estimate is multiplied by a series of CMFs to adjust the estimate of crash frequency from the base condition to the specific conditions present at a site. The CMFs are multiplicative because the effects of the features they represent are presumed to be independent. However, little research exists regarding the independence of these effects, but this is a reasonable assumption based on current knowledge. The use of observed crash frequency data in the EB Method can help to compensate for bias caused by lack of independence of the CMFs. As new research is completed, future HSM editions may be able to address the independence (or lack of independence) of these effects more fully.
Multiplication of CMFs in Part D

CMFs are also used in estimating the anticipated effects of proposed future treatments or countermeasures (e.g., in some of the methods discussed in Section C.8). The limited understanding of interrelationships between the various treatments presented in Part D requires consideration, especially when more than three CMFs are proposed. If CMFs are multiplied together, it is possible to overestimate the combined affect of multiple treatments when it is expected that more than one of the treatments may affect the same type of crash. The implementation of wider lanes and wider shoulders along a corridor is an example of a combined treatment where the independence of the individual treatments is unclear, because both treatments are expected to reduce the same crash types. When CMFs are multiplied, the practitioner accepts the assumption that the effects represented by the CMFs are independent of one another. Users should exercise engineering judgment to assess the interrelationship and/or independence of individual elements or treatments being considered for implementation.
Compatibility of Multiple CMFs

Engineering judgment is also necessary in the use of combined CMFs where multiple treatments change the overall nature or character of the site; in this case, certain CMFs used in the analysis of the existing site conditions and the proposed treatment may not be compatible. An example of this concern is the installation of a roundabout at an urban two-way stop-controlled or signalized intersection. The procedure for estimating the crash frequency after installation of a roundabout (see Chapter 12) is to estimate the average crash frequency for the existing site conditions (as a SPF for roundabouts in currently unavailable) and then apply an CMF for a conventional intersection to roundabout conversion. Installing a roundabout changes the nature of the site so that other CMFs applicable to existing urban two-way stop controlled or signalized intersections may no longer be relevant.
WARNING!

You **ALWAYS** use extreme care and caution when looking up or applying CMF’s! NEVER try to combine CMF’s or CRF’s.
Combining CRFs

- Just DON’T do it!
- Certainly not additive

25% + 35% ≠ 60% for CRFs
Combining CRFs

- Just DON’T do it!
- Certainly not additive
- Convert to CMFs
- Multiply if applicable
Combining CMFs

- Multiply if applicable
- Consider independence
- No more than three
Find out more about the Star Quality Ratings for CMFs

Read more about the star quality rating applied to CMFs in the Clearinghouse. The star rating is based on a scale (1 to 5), where a 5 indicates the highest or most reliable rating.

A crash modification factor (CMF) is a multiplicative factor used to compute the expected number of crashes after implementing a given countermeasure at a specific site. The Crash Modification Factors Clearinghouse houses a Web-based database of CMFs along with supporting documentation that is described in publications and technical reports.

Recently Added CMFs

- Improve pavement friction (increase skid resistance)
  
  CMF: 0.855

- Installation of a High-intensity Activated crossWalk (HAWK) pedestrian-activated beacon at an
  
  CMF: 0.319

- Convert minor-road stop control to all-way stop control

Enter search term(s) in

Countermeasure Name

Search CMFs

Need Help?
A crash modification factor (CMF) is a multiplicative factor used to compute the expected number of crashes after implementing a given countermeasure at a specific site. The Crash Modification Factors Clearinghouse houses a Web-based database of CMFs along with supporting documentation to help transportation engineers identify the most appropriate countermeasure for their safety needs. Using this site, you can search to find CMFs or submit your own CMFs to be included in the clearinghouse.

Recently Added CMFs

- **Improve pavement friction (increase skid resistance)**
  - CMF: 0.055
  - CRF: 13.4
  - Crash type: Rear end
  - Crash severity: All

- **Installation of a High Intensity Activated crossWalk (HI-ACW) pedestrian-activated beacon at an intersection**
  - CMF: 0.009
  - CRF: 69
  - Crash type: Vehicle/pedestrian
  - Crash severity: All

- **Convert minor-road stop control to all-way stop control**
  - CMF: 0.519
  - CRF: 98.1
  - Crash type: All
  - Crash severity: All
Installation of a High intensity Activated crossWalk (HAWK) pedestrian-activated beacon at an intersection

Description: Installation of a High intensity Activated crossWalk (HAWK) pedestrian-activated beacon at an intersection

Prior Condition: Minor-road stop-controlled intersection

Category: Pedestrians

Study: Safety Effectiveness of the HAWK Pedestrian Crossing Treatment, Fitzpatrick, K., and Park, E.S., 2010

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

Crash Modification Factor (CMF)

Value: 0.309

Adjusted Standard Error:

Unadjusted Standard Error: 0.156

Crash Reduction Factor (CRF)

Value: 69 (This value indicates a decrease in crashes)
Submitted studies are ranked in the following categories:

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

2 points | 1 point | 0 points
Star Quality Rating

- Final quality rating is based on weighted score:
  \[ \text{Score} = (2 \times \text{study design}) + (2 \times \text{sample size}) + \text{standard error} + \text{potential bias} + \text{data source} \]

- Star rating based on the score

<table>
<thead>
<tr>
<th>Score</th>
<th>Star Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>14 (max possible)</td>
<td>5 Stars</td>
</tr>
<tr>
<td>11 – 13</td>
<td>4 Stars</td>
</tr>
<tr>
<td>7 – 10</td>
<td>3 Stars</td>
</tr>
<tr>
<td>3 – 6</td>
<td>2 Stars</td>
</tr>
<tr>
<td>1 – 2</td>
<td>1 Star</td>
</tr>
<tr>
<td>0</td>
<td>0 Stars</td>
</tr>
</tbody>
</table>
Installation of a High intensity Activated crossWalk (HAWK) pedestrian-activated beacon at an intersection

Description: Installation of a High intensity Activated crossWalk (HAWK) pedestrian-activated beacon at an intersection

Prior Condition: Minor-road stop-controlled intersection

Category: Pedestrians

Study: Safety Effectiveness of the HAWK Pedestrian Crossing Treatment, Fitzpatrick, K., and Park, E.S., 2010

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

Crash Modification Factor (CMF)

Value: 0.309

Adjusted Standard Error:

Unadjusted Standard Error: 0.156

Crash Reduction Factor (CRF)

Value: 69 (This value indicates a decrease in crashes)
<table>
<thead>
<tr>
<th><strong>Value:</strong></th>
<th>69 (This value indicates a <em>decrease</em> in crashes)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Adjusted Standard Error:</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Unadjusted Standard Error:</strong></td>
<td>15.6</td>
</tr>
</tbody>
</table>

### Applicability

- **Crash Type:** Vehicle/pedestrian
- **Crash Severity:** All
- **Roadway Types:** Not Specified
- **Number of Lanes:** 4 to 6
- **Road Division Type:** All
- **Speed Limit:** 30 to 40 mph
- **Area Type:** Urban and suburban
- **Traffic Volume:**  
- **Time of Day:** All

*If countermeasure is intersection-based*
A crash modification factor (CMF) is a multiplicative factor used to compute the expected number of crashes after implementing a given countermeasure at a specific site. The Crash Modification Factors Clearinghouse houses a Web-based database of CMFs along with supporting documentation including technical reports.

Recently Added CMFs

- Improve pavement friction (increase skid resistance)
  - CMF: 0.865
- Installation of a High Intensity Activated crossWalk (HAWK) pedestrian-activated beacon at an
  - CMF: 0.61
- Install raised median
  - CRF: 39
Search Results

There were 3 CMFs returned for your search on "HAWK". [modify your search].

Having trouble deciding between similar CMFs? Check out our FAQs.

Results Control: Collapse All | Expand All

Click on the links below to expand individual categories.

- Category: Pedestrians (3)
There were 3 CMFs returned for your search on "HAWK". [modify your search].

Having trouble deciding between similar CMFs? Check out our FAQs.

Results Control: Collapse All | Expand All

Click on the links below to expand individual categories.

Category: Pedestrians (3)

Countermeasure: Installation of a High intensity Activated crossWalk (HAWK) pedestrian-activated beacon at an intersection

<table>
<thead>
<tr>
<th>CMF</th>
<th>CRF(%)</th>
<th>Quality</th>
<th>Crash Type</th>
<th>Crash Severity</th>
<th>Area Type</th>
<th>Reference</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.712</td>
<td>29</td>
<td>☆☆☆☆☆</td>
<td>All</td>
<td>All</td>
<td>Urban and suburban</td>
<td>Fitzpatrick, K., and Park, E.S., 2010</td>
<td>The authors of this study... [read more]</td>
</tr>
<tr>
<td>0.049</td>
<td>15</td>
<td>☆☆☆☆☆</td>
<td>All</td>
<td>Fatal Serious</td>
<td>Urban and suburban</td>
<td>Fitzpatrick, K., and Park, E.S., 2010</td>
<td>The authors of this study... [read more]</td>
</tr>
<tr>
<td>0.309</td>
<td>69</td>
<td>☆☆☆☆☆</td>
<td>Vehicle/pedestrian</td>
<td>All</td>
<td>Urban and suburban</td>
<td>Fitzpatrick, K., and Park, E.S., 2010</td>
<td>The authors of this study... [read more]</td>
</tr>
</tbody>
</table>
How do I choose between CMFs in my search results that have the same star rating but different CMF values?

It's true that two or more CMFs for a particular countermeasure may have the same star rating but differing CMF values. It will be necessary for you to examine the information related to the applicability of the CMFs to determine how they differ. This could involve examining the brief data shown on the search results page (i.e., crash type, crash severity, roadway type, and area type) or looking at all the information about the CMFs by viewing the CMF details page for each one.

You should select the CMF that is most applicable to the situation in which you would like to apply the CMF (i.e., the characteristics associated with the CMF should closely match the characteristics of the scenario at hand). For example, CMFs often vary by crash type and crash severity. While it is useful to determine the change in crashes by type and severity, this should only be done when applicable CMFs are available for the specific crash type and severity of interest.

The figure below shows a snapshot of results for the countermeasure of "Installation of left-turn lane on single major road approach". You can see that the three CMFs listed in this figure all have 5-star ratings. However, the CMF values (0.65, 0.71, and 0.91) are all different.

![Countermeasure: Installation of left-turn lane on single major road approach](image)

From this initial view of the search results, it is relatively easy to tell the difference between the first CMF and the other two. Although all three are similar in crash type, crash severity, and roadway type, the first one (CMF of 0.65) is identified as being developed for a "Rural" area type, whereas the other two were developed for an "Urban" area type.
You can see that the three CMFs listed in this figure all have 5-star ratings. However, the CMF values (0.65, 0.71, and 0.91) are all different.

<table>
<thead>
<tr>
<th>CMF</th>
<th>CRF(%)</th>
<th>Quality</th>
<th>Crash Type</th>
<th>Crash Severity</th>
<th>Roadway Type</th>
<th>Area Type</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.65</td>
<td>35</td>
<td>★★★★</td>
<td>All</td>
<td>Fatal,Serious Injury</td>
<td>Not specified</td>
<td>Rural</td>
<td>Harwood et al., 2002</td>
</tr>
<tr>
<td>0.71</td>
<td>29</td>
<td>★★★★</td>
<td>All</td>
<td>Fatal,Serious Injury</td>
<td>Not specified</td>
<td>Urban</td>
<td>Harwood et al., 2002</td>
</tr>
<tr>
<td>0.91</td>
<td>9</td>
<td>★★★★★</td>
<td>All</td>
<td>Fatal,Serious Injury</td>
<td>Not specified</td>
<td>Urban</td>
<td>Harwood et al., 2002</td>
</tr>
</tbody>
</table>

From this initial view of the search results, it is relatively easy to tell the difference between the first CMF and the other two. Although all three are similar in crash type, crash severity, and roadway type, the first one (CMF of 0.65) is identified as being developed for a "Rural" area type, whereas the other two were developed for an "Urban" area type.

However, all information given on the search results page is identical for the second and third CMF. Therefore, it is necessary to examine the details of each CMF (by clicking on the CMF value to go to the CMF details page). When the details of each CMF are examined, it can be seen that the CMF of 0.71 is intended for stop-controlled intersections, and the CMF of 0.91 is intended for signalized intersections.

It may be the case that two CMFs are exactly the same with respect to crash and roadway applicability. In these cases, it will be necessary to examine some of the other fields related to how and where the CMF was developed, such as:

1. **Score details.** The reviewers who established the star quality rating did so by giving scores of excellent, fair, or poor to five categories: study design, sample size, standard error, potential bias, and data source. Many CMFs in the Clearinghouse are accompanied by details of the scores behind the star rating as shown in the image below.
Frequently Asked Questions

- What is the purpose of the CMF Clearinghouse?
- What is a CMF?
- The CMF Clearinghouse presents both Crash Modification Factors and Crash Reduction Factors. What's the difference?
- I've seen the term "Accident Modification Factor" (AMF) before. Is that different than a Crash Modification Factor?
- How can I apply multiple CMFs?
- What does the star quality rating mean?
- How is the star quality rating different from the notations (bold, italics, etc.) in the Highway Safety Manual?
- How can I submit my own CMF for inclusion in the CMF Clearinghouse?
- Are there available trainings related to the application of CMFs?
- How does the CMF Clearinghouse relate to the Highway Safety Manual?
- How do you determine statistical significance?
- Who uses CMFs and how are they used?
- How are CMFs added to the Clearinghouse and what is the process for review?
- How do I choose between CMFs in my search results that have the same star rating but different CMF values?
Search Results

There were 67 CMFs returned for your search on "Protected left turn". [modify your search].

Having trouble deciding between similar CMFs? Check out our FAQs.

Overwhelmed by too many results? See our Search Tips.

Results Control: Collapse All | Expand All

Click on the links below to expand individual categories.

- Category: Intersection geometry (3)
- Category: Intersection traffic control (64)
Category: Intersection traffic control (64)

- Countermeasure: Change from permitted or permitted-protected to protected
- Countermeasure: Change from permitted to protected on minor approach
- Countermeasure: Change from permitted-protected to protected on major approach
- Countermeasure: Change from permitted-protected to protected on minor approach
- Countermeasure: Change from protected/permits permitted to protected only left turn signal control during special time-of-day (left turn crashes)
- Countermeasure: Change left-turn phase from permissive to protected/permits permissive or protected phasing on one or more approaches
- Countermeasure: Change left-turn phase to protected phasing on one or more approaches
- Countermeasure: Change permissive left-turn phasing to protected only
- Countermeasure: Change permissive left-turn phasing to protected only or protected/permits
- Countermeasure: Change permissive left-turn phasing to protected/permits
- Countermeasure: Change permitted to protected/permits or permitted/protected
- Countermeasure: Changed permitted to permitted/protected on minor approach
- Countermeasure: Changing left turn phasing from protected to flashing yellow arrow
### Countermeasure: Change from permitted to protected on minor approach

<table>
<thead>
<tr>
<th>CMF</th>
<th>CRF(%)</th>
<th>Quality</th>
<th>Crash Type</th>
<th>Crash Severity</th>
<th>Area Type</th>
<th>Reference</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.01</td>
<td>99</td>
<td>★★★★★</td>
<td>Angle</td>
<td>All</td>
<td>Urban</td>
<td>Davis and Aul, 2007</td>
<td></td>
</tr>
<tr>
<td>0.83</td>
<td>18</td>
<td>★★★★★</td>
<td>all</td>
<td>All</td>
<td>Urban</td>
<td>Davis and Aul, 2007</td>
<td></td>
</tr>
</tbody>
</table>

### Countermeasure: Change from permitted-protected to protected on major approach

<table>
<thead>
<tr>
<th>CMF</th>
<th>CRF(%)</th>
<th>Quality</th>
<th>Crash Type</th>
<th>Crash Severity</th>
<th>Area Type</th>
<th>Reference</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.01</td>
<td>99</td>
<td>★★★★★</td>
<td>Angle</td>
<td>All</td>
<td>Urban</td>
<td>Davis and Aul, 2007</td>
<td></td>
</tr>
<tr>
<td>0.58</td>
<td>42</td>
<td>★★★★★</td>
<td>All</td>
<td>All</td>
<td>Urban</td>
<td>Davis and Aul, 2007</td>
<td></td>
</tr>
</tbody>
</table>

### Countermeasure: Change from permitted-protected to protected on minor approach

<table>
<thead>
<tr>
<th>CMF</th>
<th>CRF(%)</th>
<th>Quality</th>
<th>Crash Type</th>
<th>Crash Severity</th>
<th>Area Type</th>
<th>Reference</th>
<th>Comments</th>
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</thead>
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<tr>
<td>0.04</td>
<td>97</td>
<td>★★★★★</td>
<td>Angle</td>
<td>All</td>
<td>Urban</td>
<td>Davis and Aul, 2007</td>
<td></td>
</tr>
<tr>
<td>0.99</td>
<td>1</td>
<td>★★★★</td>
<td>all</td>
<td>All</td>
<td>Urban</td>
<td>Davis and Aul, 2007</td>
<td></td>
</tr>
</tbody>
</table>

### Countermeasure: Change from protected/permited to protected only left turn signal control during special time-of-day (left turn crashes)
Precision vs Accuracy

- Precise but not Accurate
- Neither Precise nor Accurate
Search Results

There were 134 CMFs returned for your search on "Roundabout". [modify your search].

Having trouble deciding between similar CMFs? Check out our FAQs.

Overwhelmed by too many results? See our Search Tips.

Results Control: Collapse All | Expand All

Click on the links below to expand individual categories.

- Category: Bicyclists (6)
- Category: Intersection geometry (113)
- Category: Intersection traffic control (8)
- Category: Speed management (7)
Category: Intersection geometry (113)

- Countermeasure: Change roundabout circulating sight distance from X to Y
- Countermeasure: Change roundabout intersection sight distance from X to Y
- Countermeasure: Conversion of intersection into high-speed roundabout
- Countermeasure: Conversion of intersection into low-speed roundabout
- Countermeasure: Conversion of intersection into multi-lane roundabout
- Countermeasure: Conversion of intersection into single-lane roundabout
- Countermeasure: Conversion of no control/yield intersection into single- or multi-lane roundabout
- Countermeasure: Conversion of signalized intersection into single- or multi-lane roundabout
- Countermeasure: Conversion of stop-controlled intersection into multi-lane roundabout
- Countermeasure: Conversion of stop-controlled intersection into single-lane roundabout
- Countermeasure: Conversion of two-way stop-controlled intersection into single- or multi-lane roundabout
- Countermeasure: Convert all-way, stop-controlled intersection to roundabout
### Countermeasure: Conversion of no control/yield intersection into single- or multi-lane roundabout

<table>
<thead>
<tr>
<th>CMF</th>
<th>CRF(%)</th>
<th>Quality</th>
<th>Crash Type</th>
<th>Crash Severity</th>
<th>Area Type</th>
<th>Reference</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.242</td>
<td>24.18</td>
<td>★★★★★</td>
<td>All</td>
<td>All</td>
<td>All</td>
<td>Qin et al., 2013</td>
<td>- Study included three-year before... [read more]</td>
</tr>
<tr>
<td>0</td>
<td>100</td>
<td>★★★★★</td>
<td>All</td>
<td>Fatal,Serious injury,Minor injury</td>
<td>All</td>
<td>Qin et al., 2013</td>
<td>- Study included three-year before... [read more]</td>
</tr>
</tbody>
</table>

### Countermeasure: Conversion of signalized intersection into single- or multi-lane roundabout

<table>
<thead>
<tr>
<th>CMF</th>
<th>CRF(%)</th>
<th>Quality</th>
<th>Crash Type</th>
<th>Crash Severity</th>
<th>Area Type</th>
<th>Reference</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.81</td>
<td>19</td>
<td>★★★★★</td>
<td>All</td>
<td>All</td>
<td>Urban and suburban</td>
<td>Gross et al., 2012</td>
<td>Conversion to 2-lane roundabout... [read more]</td>
</tr>
<tr>
<td>0.29</td>
<td>71</td>
<td>★★★★★</td>
<td>All</td>
<td>Serious injury,Minor injury</td>
<td>Urban and suburban</td>
<td>Gross et al., 2012</td>
<td>Conversion to 2 lane roundabout... [read more]</td>
</tr>
<tr>
<td>0.74</td>
<td>26</td>
<td>★★★★★</td>
<td>All</td>
<td>All</td>
<td>Urban and suburban</td>
<td>Gross et al., 2012</td>
<td>Conversion to one lane roundabout... [read more]</td>
</tr>
<tr>
<td>0.055</td>
<td>4.54</td>
<td>★★★★★</td>
<td>All</td>
<td>All</td>
<td>All</td>
<td>Qin et al., 2013</td>
<td>- Study included three-year before... [read more]</td>
</tr>
<tr>
<td>0.65</td>
<td>35</td>
<td>★★★★★</td>
<td>All</td>
<td>All</td>
<td>Urban</td>
<td>Persaud et al, 2001</td>
<td></td>
</tr>
</tbody>
</table>
### Countermeasure: Conversion of stop-controlled intersection into single-lane roundabout

<table>
<thead>
<tr>
<th>CMF</th>
<th>CRF(%)</th>
<th>Quality</th>
<th>Crash Type</th>
<th>Crash Severity</th>
<th>Area Type</th>
<th>Reference</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.28</td>
<td>72</td>
<td>⭐⭐⭐⭐⭐</td>
<td>All</td>
<td>All</td>
<td>Urban</td>
<td>Persaud et al., 2001</td>
<td></td>
</tr>
<tr>
<td>0.42</td>
<td>59</td>
<td>⭐⭐⭐⭐⭐</td>
<td>All</td>
<td>All</td>
<td>Rural</td>
<td>Persaud et al., 2001</td>
<td></td>
</tr>
<tr>
<td>0.12</td>
<td>88</td>
<td>⭐⭐⭐⭐⭐</td>
<td>All</td>
<td>Serious injury, Minor injury</td>
<td>Urban</td>
<td>Persaud et al., 2001</td>
<td></td>
</tr>
<tr>
<td>0.18</td>
<td>82</td>
<td>⭐⭐⭐⭐⭐</td>
<td>All</td>
<td>Serious injury, Minor injury</td>
<td>Rural</td>
<td>Persaud et al., 2001</td>
<td></td>
</tr>
</tbody>
</table>

### Countermeasure: Conversion of two-way stop-controlled intersection into single- or multi-lane roundabout

### Countermeasure: Convert all-way, stop-controlled intersection to roundabout

<table>
<thead>
<tr>
<th>CMF</th>
<th>CRF(%)</th>
<th>Quality</th>
<th>Crash Type</th>
<th>Crash Severity</th>
<th>Area Type</th>
<th>Reference</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.114</td>
<td>-11.36</td>
<td>⭐⭐⭐⭐⭐</td>
<td>All</td>
<td>All</td>
<td>All</td>
<td>Qin et al., 2013</td>
<td>- Study included three-year before (read more)</td>
</tr>
<tr>
<td>1.03</td>
<td>-3</td>
<td>⭐⭐⭐⭐⭐</td>
<td>All</td>
<td>All</td>
<td>All</td>
<td>Rodegerdts et al., 2007</td>
<td></td>
</tr>
<tr>
<td>0.544</td>
<td>45.6</td>
<td>⭐⭐⭐⭐⭐</td>
<td>All</td>
<td>Fatal, Serious injury, Minor injury</td>
<td>All</td>
<td>Qin et al., 2013</td>
<td>- Study included three-year before (read more)</td>
</tr>
</tbody>
</table>
Accuracy & Precision?

Study of Two-Lane Rural Roads in Colorado

Source: Figure 3B-1 and Figure 10-3 HSM

“Driving Down Fatalities Through Knowledge Sharing”
Example – Enhance delineation

- 2-lane rural roadway, AADT = 16,000
- Nighttime + wet-weather crashes
- County-maintained roadway
- Currently, no RPM’s
Example: Add RPMs on 2-lane

- Look up enhanced delineation in Part D of HSM:

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Setting (Road type)</th>
<th>Traffic Volume AADT</th>
<th>Accident Type (Severity)</th>
<th>CMF</th>
<th>Std. Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>Install snowplowable permanent RPMs</td>
<td>Rural (Two-lane with radius &gt; 1640 ft)</td>
<td>0 to 5,000</td>
<td>Nighttime All types (All severities)</td>
<td>1.16</td>
<td>0.03</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5,001 to 15,000</td>
<td></td>
<td>0.99*</td>
<td>0.06</td>
</tr>
<tr>
<td></td>
<td></td>
<td>15,001 to 20,000</td>
<td></td>
<td>0.76</td>
<td>0.08</td>
</tr>
<tr>
<td></td>
<td>Rural (Two-lane with radius ≤ 1640 ft)</td>
<td>0 to 5,000</td>
<td></td>
<td>1.43</td>
<td>0.1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5,001 to 15,000</td>
<td></td>
<td>1.26</td>
<td>0.1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>15,001 to 20,000</td>
<td></td>
<td>1.03*</td>
<td>0.1</td>
</tr>
</tbody>
</table>

Base Condition: Absence of raised pavement markers.
WARNING!

**ALWAYS** use caution when looking up or applying CMF’s or CRF’s
Is this applicable?

- Text in the HSM study clearly says “installation of snowplowable, permanent RPM’s”

- But isn’t every RPM installed in Florida resistant to every snowplow typically used in Florida?

- Proceed with CAUTION!

“Driving Down Fatalities Through Knowledge Sharing”
Check the notes...

NOTE: **Bold** text is used for the most reliable CMFs. These CMFs have a standard error or 0.1 or less.

* Observed variability suggests that this treatment could result in an increase, decrease or no change in crashes. See Part D Introduction and Applications Guidance.
Example: Add RPMs on 2-lane

- Look up enhanced delineation in Part D of HSM:

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Setting (Road type)</th>
<th>Traffic Volume AADT</th>
<th>Accident type (Severity)</th>
<th>CMF</th>
<th>Std. Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>Install snowplowable permanent RPMs</td>
<td>Rural (Two-lane with radius &gt; 1640 ft)</td>
<td>0 to 5,000</td>
<td>Nighttime All types (All severities)</td>
<td>1.16</td>
<td>0.03</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5,001 to 15,000</td>
<td>0.99*</td>
<td>0.03</td>
<td>0.06</td>
</tr>
<tr>
<td></td>
<td></td>
<td>15,001 to 20,000</td>
<td>0.76</td>
<td>0.08</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Rural (Two-lane with radius ≤ 1640 ft)</td>
<td>0 to 5,000</td>
<td>1.43*</td>
<td>0.1</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>5,001 to 15,000</td>
<td>1.26*</td>
<td>0.1</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>15,001 to 20,000</td>
<td>1.03*</td>
<td>0.1</td>
<td></td>
</tr>
</tbody>
</table>

Base Condition: Absence of raised pavement markers.

Does this make sense?
The crash effects of installing snowplowable RPMs on low volume (AADT of 0 to 5,000), medium volume (AADT of 5,001 to 15,000), and high volume (AADT of 15,001 to 20,000) roads are shown in Table 13-411 (2).

The varying crash effect by traffic volume is likely due to the lower design standards (e.g., narrower lanes, narrower shoulders, etc.) associated with low volume roads (2). Providing improved delineation, such as RPMs, may cause drivers to increase their speeds. The varying crash effect by curve radius is likely related to the negative impact of speed increases (2). The base condition of the CMFs (i.e., the condition in which the CMF = 1.00) is the absence RPMs.
Example: Add RPMs on 2-lane

- Look up enhanced delineation in Part D of HSM:

Table 13-41. Potential Crash Effects of Installing Snowplowable, Permanent RPMs

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Setting (Road type)</th>
<th>Traffic Volume AADT</th>
<th>Accident type (Severity)</th>
<th>CMF</th>
<th>Std. Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>Install snowplowable permanent RPMs</td>
<td>Rural (Two-lane with radius &gt; 1640 ft)</td>
<td>0 to 5,000</td>
<td>All types (All severities)</td>
<td>1.16</td>
<td>0.03</td>
</tr>
<tr>
<td></td>
<td>Rural (Two-lane with radius ≤ 1640 ft)</td>
<td>5,001 to 15,000</td>
<td></td>
<td>0.99*</td>
<td>0.06</td>
</tr>
<tr>
<td></td>
<td></td>
<td>15,001 to 20,000</td>
<td></td>
<td>0.76</td>
<td>0.08</td>
</tr>
<tr>
<td></td>
<td>Rural (Two-lane with radius &gt; 1640 ft)</td>
<td>0 to 5,000</td>
<td></td>
<td>1.43</td>
<td>0.1</td>
</tr>
<tr>
<td></td>
<td>Rural (Two-lane with radius ≤ 1640 ft)</td>
<td>5,001 to 15,000</td>
<td></td>
<td>1.26</td>
<td>0.1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>15,001 to 20,000</td>
<td></td>
<td>1.03*</td>
<td>0.1</td>
</tr>
</tbody>
</table>

Base Condition: Absence of raised pavement markers.

Note which crash types this applies to.
Example – Enhance delineation

- 2-lane rural roadway, AADT = 16,000
- Nighttime + wet-weather crashes
- County-maintained roadway
- Currently, no RPM’s
Example: Add RPMs on 2-lane

- Look up enhanced delineation in Part D of HSM:

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Setting (Road type)</th>
<th>Traffic Volume AADT</th>
<th>Accident type (Severity)</th>
<th>CMF</th>
<th>Std. Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>Install snowplowable permanent RPMs</td>
<td>Rural (Two-lane with radius &gt; 1640 ft)</td>
<td>0 to 5,000</td>
<td>Nighttime (All types (All severities))</td>
<td>1.16</td>
<td>0.03</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5,001 to 15,000</td>
<td></td>
<td>0.99*</td>
<td>0.06</td>
</tr>
<tr>
<td></td>
<td></td>
<td>15,001 to 20,000</td>
<td></td>
<td>0.76</td>
<td>0.08</td>
</tr>
<tr>
<td></td>
<td>Rural (Two-lane with radius ≤ 1640 ft)</td>
<td>0 to 5,000</td>
<td>All types (All severities)</td>
<td>1.43</td>
<td>0.1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5,001 to 15,000</td>
<td></td>
<td>1.26</td>
<td>0.1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>15,001 to 20,000</td>
<td></td>
<td>1.03*</td>
<td>0.1</td>
</tr>
</tbody>
</table>

Base Condition: Absence of raised pavement markers.
So what do we do?

- CMF = 0.76  =>  CRF = 0.24
- Nighttime crashes only
- Perhaps use 20%
- Perform before – after
- Submit your results to the CMF Clearinghouse

“Driving Down Fatalities Through Knowledge Sharing”
Application and Science of Crash Reduction Factors

Fun, fun, fun ‘till your daddy takes the T-bird away

Questions?

Please type your questions into the chat box
Workshop Series

Upcoming Presentation: November 20, 2013
Requirements for HSIP Applications

- Wed. Oct. 30: Highway Safety Evaluation
- Wed. Nov. 20: Requirements for HSIP Applications
- Wed. Dec. 4: Safety Funding Categories/Requirements/Conditions
- Wed. Dec. 11: Is Your Project Feasible? What’s Next and How Do We Move Forward?

2014

- Wed. Jan. 8: Safety Projects & The Local Agency Program (LAP)
- Wed. Jan. 15: Development of the Safety/LAP Project Schedule for Funding Purposes
- Wed. Jan. 29: Key to Successful Safety Programs

“Driving Down Fatalities Through Knowledge Sharing”