CMF CLEARINGHOUSE USER GUIDE

INTRODUCTION TO USER GUIDE

The CMF Clearinghouse User Guide provides information about crash modification factor (CMF) basics for those unfamiliar with CMFs and guidance on how to conduct searches on the CMF Clearinghouse. It also provides advanced tips and functionality for more experienced users. This User Guide is organized into the following sections:

- Introduction to Crash Modification Factors – This section provides basic information about what CMFs are and how they are used.
- Introduction to the CMF Clearinghouse – This section informs readers about the purpose and contents of the CMF Clearinghouse.
- Searching for CMFs on the CMF Clearinghouse – This section shows users how to use the search functionality of the Clearinghouse to find CMFs.
- Identifying Appropriate CMFs – This section provides guidance on interpreting search results and selecting the most appropriate CMF for a given situation.
- Information for Advanced Users – This section provides information about CMFs and the Clearinghouse for those with more experience. It includes guidance on downloading extracts of the CMF Clearinghouse database and guidance on developing CMFs.

INTRODUCTION TO CRASH MODIFICATION FACTORS

WHAT IS A CMF?

A Crash Modification Factor (CMF) is a multiplicative factor that indicates the proportion of crashes that would be expected after implementing a countermeasure. Examples of countermeasures include installing a traffic signal, increasing the width of edgelines, and installing a median barrier. CMFs with a value less than 1.0 indicate an expected decrease in crashes. CMFs greater than 1.0 indicate an expected increase in crashes.

> Example: A particular stop-controlled intersection is expected to experience 5.2 total crashes per year. The city is considering installing a traffic signal and has identified a CMF for installing a traffic signal of 0.56 for total (or "all") crashes (Harkey et al., 2008). The expected total crashes after installing the signal would be 5.2 x 0.56 = **2.9** total crashes per year.

A Crash Reduction Factor (CRF) is another way of representing the expected effect of a countermeasure in terms of the percentage decrease in crashes. A CRF is equal to 100*(1-CMF). In the example above, the CRF of the countermeasure would be 100*(1-0.56) = 44. The CRF terminology has traditionally been

used by departments of transportation around the U.S., but in recent years, the safety field has moved to using CMFs. A major reason for this is the confusion that can arise when a countermeasure is expected to increase crashes. For instance, a newly installed traffic signal would be expected to increase rear end crashes. A CMF for this countermeasure would be a value larger than 1.0 (e.g., 1.58) whereas the CRF would need to be confusingly represented as a negative reduction (e.g., -58).

Another way of representing the safety effect of a countermeasure is through a Crash Modification Function (CMFunction). A CMFunction is an equation used to calculate a CMF based on the characteristics of the site where it will be applied. For example, this CMFunction is used to express the effect of changing lane width on rural frontage roads:

$$CMF = e^{-0.188(LW_{new} - LW_{existing})}$$

Where:
LW_{new} = new (or proposed) average lane width in feet
$LW_{existing}$ = existing average lane width in feet

Using this CMFunction, the CMF for converting a 10 foot lane to a 12 foot lane would be equal to e^(-0.188(12-10)) = 0.687, which represents an expected decrease in crashes.

Often a study develops CMFs for other crash types, such as all (or total) crashes, rear end, and left turn. It is important to use a CMF that was developed for the same crash type as the crashes to which it will be applied. For instance, it would be incorrect to use another CMF from the study in the example, such as the CMF of 0.23 for angle crashes. Applying that CMF, which is lower than the 0.56 for total crashes, would overestimate the benefit of installing the traffic signal, and would be incorrect since it should only be applied to angle crashes.

Other examples of applying CMFs can be found in the CMFs in Practice series, the Highway Safety Manual, or the Application of Crash Modification Factors online training course.

HOW ARE CMFS USED?

A CMF provides a quantitative estimate of the effectiveness of a countermeasure. This allows a CMF user to:

- Identify the most cost-effective strategy when considering various countermeasures. CMFs can indicate which countermeasure will have the greatest impact on decreasing crashes and quantify the benefits for each alternative under consideration.
- Identify the most cost-effective locations for using safety funding. CMFs can assist in determining where to deploy countermeasures in order to yield the most crash savings.

- Compare the results of new analyses to existing CMFs. CMFs can assist researchers by giving a context to newly produced CMFs to check for reasonableness in the results.
- Check validity of assumptions in cost-benefit analyses. CMFs provide a basis for conducting cost-benefit analysis to determine if a proposed project is worth undertaking.

INTRODUCTION TO THE CMF CLEARINGHOUSE

WHAT IS THE PURPOSE OF THE CMF CLEARINGHOUSE?

The CMF Clearinghouse serves three important roles for the transportation safety field.

1. Provides CMF Data. The CMF Clearinghouse is a comprehensive and searchable database of published CMFs. It contains all CMFs published in 2010 or after as well as many CMFs published before that date, such as those compiled in the first edition of the AASHTO Highway Safety Manual and the FHWA Desktop Reference for Crash Reduction Factors. It provides information on all available CMFs, such as the CMF value and all published details about the CMF; citations and related information about the study that produced each CMF; and a star rating that provides an indication of the quality of each CMF. It is regularly updated to include newly published CMFs.

2. Educates CMF Users. The CMF Clearinghouse provides guidance material to instruct users about the appropriate use of CMFs. Through a series of Frequently Asked Questions, the Clearinghouse provides answers to many important CMF-related questions posed by city and state transportation engineers, planners, and researchers. The CMF Clearinghouse also sponsors an annual webinar to provide guidance on appropriate use of CMFs and best practices from state agencies. In addition to the guidance provided from the Clearinghouse, the website also provides links to many external resources in categories such as "How to Develop and Use CMFs", "Cost-Benefit Analyses", and "Training".

3. Facilitates CMF Research. Researchers often use CMF Clearinghouse data to determine if there are any CMFs existing on a potential research topic and where research gaps are present. To direct future research, the CMF Most Wanted List is provided to show researchers and funding agencies the countermeasures and topics that are high priority to Clearinghouse users but not present in the Clearinghouse data. The CMF Clearinghouse also provides safety researchers with a mechanism to submit CMFs for inclusion in the Clearinghouse.

WHAT KIND OF CMFS DOES THE CMF CLEARINGHOUSE INCLUDE?

It is important to understand what the Clearinghouse does and does not include. The CMF Clearinghouse presents CMFs from studies that meet the following criteria:

1. The study must be based on **crash data**, not surrogate measures of safety such as speed reductions, near misses, or yielding behavior.
2. The study must have the objective of **quantifying the safety effect** of a roadway feature or characteristic (i.e., as opposed to an academic exercise of comparing model forms).
3. The study must be focused on determining the safety effect of an **infrastructure** characteristic, feature, or modification that would fall under engineering responsibilities (e.g., not planning-level or area-wide characteristics such as land use or demographics; not safety efforts unrelated to engineering such as public safety awareness campaigns or law enforcement efforts).
4. The study must **explicitly present** quantified CMF values or CMFunctions (i.e., the Clearinghouse team does not derive CMFs if they are not explicitly reported by the author).The Clearinghouse presents the CMFs as they are presented by the author in the original source document. There is no modification made to the CMF value or adjustment to any reported standard error.

WHERE DO CMFS COME FROM?

The CMF Clearinghouse team, which consists of engineers with many years of safety research experience, identifies eligible CMFs through a regular review process of published reports and professional journals. The review cycle is conducted four times per year and consists of reviewing papers from the following sources:

Quarter 1	• Transportation Research Board Annual Meeting Compendium of Papers (past meeting) • User-submitted studies (past 3 months)
Quarter 2	• American Society of Civil Engineers Journal of Transportation Engineering (past 6 months) • Institute of Transportation Engineers Journal (past 6 months) • Accident Analysis and Prevention (past 6 months) • Journal of Safety Research (past 6 months) • User-submitted studies (past 3 months)
Quarter 3	• Searches on the Transport Research International Documentation (TRID, formerly TRIS) • User-submitted studies (past 3 months)
Quarter 4	• American Society of Civil Engineers Journal of Transportation Engineering (past 6 months) • Institute of Transportation Engineers Journal (past 6 months) • Accident Analysis and Prevention (past 6 months) • Journal of Safety Research (past 6 months) • User-submitted studies (past 3 months)

The process for each review cycle is:

1. Study Identification. The Clearinghouse team reviews the resources (published reports, journal articles, etc.) for the appropriate quarter and identifies papers that appear eligible based on title and abstract.
2. Preliminary Review. The Clearinghouse team performs an in-depth review of each identified study to determine if it meets the eligibility criteria and if so, to record all CMFs from the study into an administrative database.
3. Critical Review. The Clearinghouse team performs a critical review on the recorded CMFs to assign a star quality rating to each CMF.
4. Review by FHWA Subject Matter Experts. The final reviewed list of CMFs is submitted for review by a team of subject matter experts (SMEs) at FHWA for a final check.
5. Add to CMF Clearinghouse. With concurrence from FHWA, the final CMFs are posted to CMF Clearinghouse on a quarterly basis.

Prior to its launch in 2010 and the start of a regular review cycle, the Clearinghouse was initially populated with CMFs from two major resources, the first edition of the AASHTO Highway Safety Manual (HSM) and the FHWA Desktop Reference for Crash Reduction Factors. The Clearinghouse provides a page of information on the relationship to the HSM, including the scopes of the two resources and details on how star ratings were applied to CMFs from the HSM.

SEARCHING FOR CMFS ON THE CMF CLEARINGHOUSE

WHAT IS THE BEST WAY TO USE SEARCH TERMS AND SEARCH TYPES?

Searching the Clearinghouse for CMFs is the most important and often the most challenging task for Clearinghouse users. With thousands of CMFs in the database, it is critical to use the best search techniques to find the most appropriate CMF information. The Clearinghouse provides various options to assist users in searching effectively, such as searching by countermeasure, study title, or keywords in the study abstract.

The CMF Clearinghouse search function allows a user to search the database for CMFs related to the topic of interest. A user should enter a search term in the text box on the home page and select an option in the pull-down menu as to what field to search. The search term to be entered depends on what field is being searched. The default search field is “Countermeasure Name”. Users can leave the search field on this default setting to get a more focused set of results. Users with more experience may wish to use one of the other search fields. Table 1 below presents additional information on each search field.

Table 1. Types of Search Fields Available on the CMF Clearinghouse

Search field	Description	Example search terms that could be used	Example of actual entry from CMF Clearinghouse
Countermeasure Name	Only the countermeasure name and related keywords will be searched. Related keywords are assigned by the Clearinghouse team to aid searches in finding countermeasure that may be called by various names (e.g., HAWK signal and Pedestrian Hybrid Beacon)	*roundabout* or *signal*	Convert signalized intersection to modern roundabout
Study Abstract	Only the study abstract field will be searched. The abstract is a paragraph or two of text summarizing the study that produced the CMF.	*converted*, *intersections*, or *empirical Bayes*	(excerpt) "…Several States helped to identify signalized intersections that were converted to roundabouts in the recent past. In total, 28 conversions were identified in the United States. The empirical Bayes (EB) method was employed in an observational before-after study to estimate the safety effects…."
Study Citation	Only the study citation field will be searched. This may be useful if you want to search a particular author's name.	*Uddin* or *roundabouts*	Uddin, W., J. Headrick, and J.S. Sullivan. "Performance Evaluation of Roundabouts for Traffic Flow Improvements and Crash Reductions at a Highway Interchange in Oxford, MS." Transportation Research Board 91st Annual Meeting Compendium of Papers, Washington, D.C., 2012.
Single CMF ID	Each CMF has a unique ID number in the Clearinghouse. Using this search field means that only	213	213

	the CMF ID field will be searched. This is intended to allow you to jump straight to a particular CMF if you know the ID number.		
All Fields	All of the above fields except CMF ID will be searched. This will provide the widest set of search results, but many of them may not be closely related to the topic of interest.	Any of the above examples except CMF ID.	Any of the above examples except CMF ID.

Multiple Search Terms

When more than one search term is used (e.g., *wide edgeline*), the Clearinghouse applies an AND condition between the words. In the example of searching *wide edgeline*, the search would return CMFs for countermeasures containing the word *wide* AND the word *edgeline*. More search terms means a more specific search and thus fewer results.

Solutions for Too Few or Too Many Results

There may be several reasons that a search is producing too few or no CMFs. The following options may help expand the search to relevant CMFs:

- Use fewer search terms (e.g. *rumble* instead of *centerline and edgeline rumble strips*).
- Use search terms that refer to a countermeasure name instead of the setting or the crash problem (e.g., *roundabout* instead of *urban intersection* or *angle crash*).
- Search in all fields instead of just the countermeasure name.

If these options have been tried and the search is still not producing any results, it is likely that the CMF Clearinghouse does not contain any CMFs for that search term. This reflects the fact that the safety research field still has many topics and countermeasures in need of good quality, crash-based research.

If a search produces too many results, using additional search terms will reduce the number of results. For example, if the initial search used the term *lane*, the user should try something more specific, such as *lane width*.

Blank Searches to See All CMFs in the Clearinghouse

Some users prefer to peruse the Clearinghouse contents rather than searching for a specific countermeasure. The Clearinghouse search tool is designed so that a blank search (i.e., no search term) will return all CMFs in the Clearinghouse. On the search results page, the expandable search results allows users to explore CMFs in the various categories and subcategories of the Clearinghouse data, as described below.

HOW ARE SEARCH RESULTS PRESENTED IN THE CMF CLEARINGHOUSE?

After a search is initiated on the front page of the Clearinghouse, the user will be brought to the search results page where all CMFs meeting the search criteria are displayed. The CMFs are organized into an expanding/collapsing structure beginning with a broad countermeasure category (e.g., roadway) followed by subcategories (e.g., number of lanes, lane width, etc.) and then specific countermeasures (e.g., widen lanes from 10 to 12 feet). Expanding any countermeasure shows the CMFs available for that countermeasure. Each CMF is displayed with certain summary details, including the CMF value, star quality rating, crash type, crash severity, area type, a link to the study reference page, and comments, which display special notes for CMFs as needed.

Categories and Subcategories

In order to organize numerous CMFs into a manageable set of results, the Clearinghouse places each countermeasure into a category that best describes the overall topic of the countermeasure, such as Alignment or Intersection Geometry. Users can expand a category and subcategory to view all the countermeasures, and then expand any particular countermeasure to view all the CMFs related to that countermeasure.

Only one category is assigned to each countermeasure; countermeasures are not placed into two different categories. Table 2 provides a list of the categories used by the Clearinghouse with a description of each category.

Table 2. Countermeasure Category Descriptions

Category	Description
Access management	Relates to managing access to the roadway, including median presence, left turn restricting designs such as left-overs, access point density, and driveway reduction
Advanced technology and ITS	Relates to technology-driven strategies, including such things as red light cameras, speed cameras, and dynamic warning signs
Alignment	Relates to vertical or horizontal alignment of the roadway, including such things as grade, curve radius, and spirals
Bicyclists	Relates to bicycle safety
Delineation	Relates to delineation of the travelway
Highway lighting	Relates to lighting along the roadway
Interchange design	Relates to interchange design, including such things as conversion to another type of interchange, ramp design, and acceleration/deceleration lanes
Intersection geometry	Relates to geometric and physical design of an intersection
Intersection traffic control	Relates to traffic control at intersections
On-street parking	Relates to parking on the street, including such things as prohibitions, time of day restrictions, and parking design
Pedestrians	Relates to pedestrian safety
Railroad grade crossings	Relates to railroad grade crossings, including such things as signals, gate arms, and warning devices
Roadside	Relates to anything beyond the shoulder on either side of the road, including median area. This includes such things as slopes, ditches, culverts, abutments, guardrails, and sight distance
Roadway	Relates to the traveled surface of the roadway, including all types of lanes (through, turning, passing), and the roadway surface
Shoulder treatments	Relates to anything on the paved or unpaved shoulder of the roadway
Signs	Relates to signing
Speed management	Relates to the management of vehicle speeds
Transit	Relates to transit issues involving buses, light rail, and other transit vehicles
Work zone	Relates to work zones, including such things as lane closures, times of activity, and traffic operations

Some categories, such as Roadway and Intersection Traffic Control, include a broad range of countermeasures. This can make it difficult for a user to sort through a large number of search results. In order to place these countermeasures into logical groups, the Clearinghouse also provides subcategories

in the search results. Table 3 provides an overview of each subcategory and an example of the type of countermeasure which would be found in that subcategory. Some categories, such as Pedestrian, have few CMFs and therefore have no subcategories. The search results will display these as "Subcategory: None".

Table 3. Countermeasure Categories and Subcategories with Examples

Category	Subcategory	Example Types of Countermeasures
Access management	None	Create directional median openings to allow left-turns and u-turns
Advanced technology and ITS	None	Install red-light camera
Alignment	None	Flatten horizontal curve
Bicyclists	None	Install bicycle lanes
Delineation	On-pavement markings	Install centerlines, edgelines, stop ahead markings
	Supplemental delineation	Add pavement reflective markers, post mounted delineators
	Visibility of existing markings	Widen lines, change marking material, increase reflectivity
	Other	Distance markers (angle symbols) on roadway segments
Highway lighting	None	Install intersection lighting
Interchange design	None	Extend deceleration lane
Intersection geometry	Turn lanes	Add turn lane, extend turn lane, channelize turn lane
	Number of intersection legs	Presence of three leg intersection vs. four leg intersection
	Intersection geometry reconfiguration	Convert intersection to superstreet, convert intersection to roundabout, align a skewed intersection, implement other alternative or nonconventional designs
	Other	Change roundabout intersection sight distance from X to Y
Intersection traffic control	Traffic control type	Installation or removal of signals
	Traffic control visibility	Install dual red head, double stop sign, flashing beacon, backplate, larger stop sign
	Signal phasing or timing	Convert permissive to protected left turn signal
	Turn prohibitions/permissions	Prohibit RTOR, allow RTOR, prohibit left turns, prohibit U-turns
	Other	Convert signal from pedestal-mounted to mast arm
On-street parking	None	Convert angle parking to parallel parking
Pedestrians	None	Install high-visibility crosswalk
Railroad grade crossings	None	Install flashing lights and sound signals
Roadside	Roadside barriers	Install barrier, install guardrail, change barrier type

	Median barriers	Install barrier, install guardrail, change barrier type
	Clear zone	Flatten side slope, modify ditches
	Fixed object	Remove fixed object, change fixed object density
	Other	Modify roadside hazard rating
Roadway	Lane width	Widen lanes, decrease lane width
	Number of lanes	Add TWLTL, add passing lane, convert 4-lane to 6-lane
	Lane restrictions	HOV, HOT, truck lane restrictions, one-way vs. two-way
	Pavement condition and friction	Resurface, add high friction treatment, change type of pavement material
	Winter weather treatment	Use of salt or chemicals, improve winter maintenance
	Roadway rumble strips	Install centerline rumble strips
	Other	Removing mainline barrier toll plazas on highways
Shoulder treatments	Shoulder rumble strips	Install shoulder rumble strips
	Shoulder type	Pave an unpaved shoulder
	Shoulder width	Widen shoulder by paving, widen or narrow shoulder by restriping
	Other	Installation of safetyedge treatment
Signs	None	Advance static curve warning signs
Speed management	None	Lower posted speed by 10 mph
Transit	None	Install transit signal priority (TSP) technology
Work zone	None	Modify work zone length

Non star rated secondary results

The CMF Clearinghouse contains some CMFs that are not star rated. This is because these CMFs were derived from a survey of one or more state transportation agencies to determine what CMF values were being used by states for particular countermeasures at that time. The resulting responses were averaged or summarized to arrive at a "most commonly used" value. The Clearinghouse star rating review process could not be applied to these CMFs since the estimates were not the results of crash-based research.

These non-star rated CMFs are provided in a secondary results page. The link to the secondary results is found at the bottom of the initial search results page, under the heading “Search Results Without Star Ratings”. These CMFs should only be used if there are no star rated CMFs available for the countermeasure of interest. If they are used, the user should be cautious and use engineering judgement when applying the CMF to a particular situation.

CMF Details Page

Because of limited screen space, the initial search results page can only display a limited amount of detail for each CMF, such as the crash type and severity. Occasionally, CMFs in the search results can look identical if a user is judging solely on the few fields displayed. However, the Clearinghouse contains much more information for most CMFs. Clicking on the CMF value on the search results will bring up the details page for that CMF. The information on the CMF details page informs the user about:

- Star rating – many CMFs have a link called "View score details" which will provide a pop-up window with the breakdown of the scores for the five rating criteria
- CMF and CRF – the values of the CMF and CRF are provided along with a standard error, if provided by the authors. CMFunctions will appear as images.
- Applicability – this section provides details about the sites that were used to develop the CMF. These details are particularly important to ensure that a selected CMF will be applied to a site that matches the same conditions under which it was developed.
- Development details – the details about the study are provided, including the years of data and the geographic area where the CMF was developed.
- Other details – this section provides other relevant details about the CMF, particularly the comments field, where information about special notes on the CMF is occasionally provided.

IDENTIFYING APPROPRIATE CMFS

HOW DO I INTERPRET SEARCH RESULTS?

Filtering Search Results

The search results page provides filters on the left side to enable users to narrow the search results to eliminate CMFs whose details do not match the conditions of the site of interest. For example, if a user is searching for a CMF to use at an urban intersection, the user may use the area type filter to remove all rural CMFs from the displayed results.

To use the filters, a user simply expands the filter using the small triangle, checks one or more boxes, and clicks "Filter Results". The search results page will reload, showing a smaller group of the previous results that meet the selected criteria. If a CMF has multiple values in the field being filtered (e.g., CMF for crash types of Angle and Left Turn), it will show up in the filtered results as long as one of the crash types is checked. The numbers in parentheses within each filter option indicate how many CMFs from the search have that characteristic.

Understanding the Star Rating

The star rating indicates the quality or confidence in the results of the study producing the CMF. The star rating is based on a scale (1 to 5), where a 5 indicates the highest or best rating. The review process to determine the star rating judges the accuracy and precision as well as the general applicability of the study results. The Clearinghouse team consider five categories for each study — study design, sample size, standard error, potential bias, and data source — and judge each CMF according to its performance in each category. Read more detailed information on the star quality rating system.

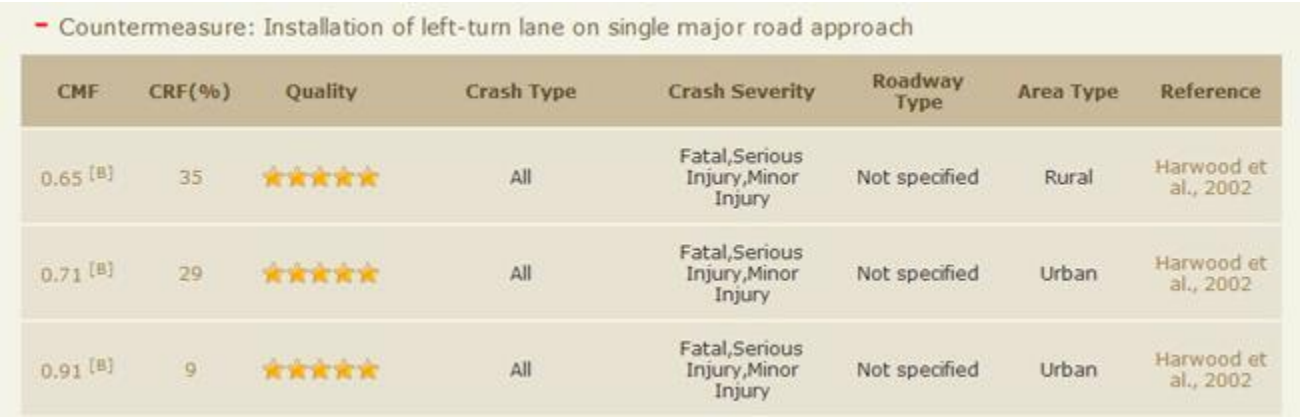
HOW DO I SELECT THE MOST APPROPRIATE CMF?

A search for CMFs will often return multiple results, sometimes hundreds of CMFs. Even after identifying a particular countermeasure of interest, a user must often make a decision about which CMF under that countermeasure to select and use.

Selecting a CMF by Matching on Major Factors

The primary goal is to select a CMF that was developed under the same conditions as the site of interest to which it will be applied. A user must examine the information related to the applicability of the CMFs to determine how they differ. Some major characteristics are shown on the search results page (i.e., crash type, crash severity, roadway type, and area type). More characteristics can be seen by viewing the CMF details page.

The user should select the CMF that is most applicable to the situation in which it will be applied. That is, the major characteristics associated with the CMF (e.g., crash type, crash severity, intersection or roadway type) should closely match the characteristics of the scenario at hand. The figure below shows a snapshot of results for the countermeasure of "Installation of left-turn lane on single major road approach". 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

CMF	CRF(%)	Quality	Crash Type	Crash Severity	Roadway Type	Area Type	Reference
0.65 [B]	35	★★★★★	All	Fatal,Serious Injury,Minor Injury	Not specified	Rural	Harwood et al., 2002
0.71 [B]	29	★★★★★	All	Fatal,Serious Injury,Minor Injury	Not specified	Urban	Harwood et al., 2002
0.91 [B]	9	★★★★★	All	Fatal,Serious Injury,Minor Injury	Not specified	Urban	Harwood et al., 2002

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.

Selecting a CMF when Major Factors are the Same

It may be the case that multiple CMFs are exactly the same with respect to crash and roadway or intersection applicability. In these cases, it will be necessary to examine some of the other fields to decide which CMF to use:

1. Star quality rating. The star quality rating reflects the reliability of the CMF, based on five criteria: study design, sample size, standard error, potential bias, and data source. If a user is considering two or more CMFs that are the same on all major factors (e.g., crash type, crash severity, etc.), the star quality rating can be used to indicate which CMF is the highest quality and therefore should be selected. More stars means higher quality. Some departments of transportation have set “minimum acceptable” star rating thresholds. However, the CMF Clearinghouse does not make any recommendation to this effect.

2. Score details. The star quality rating consists of scores of excellent, fair, or poor for each of the five rating criteria. Many CMFs in the Clearinghouse are accompanied by details of the scores behind the star rating. Clicking on the “View score details” link will display a window showing the scores that the CMF received in each category. Users of the Clearinghouse may desire to examine the score details to compare two or more similar CMFs. For instance, although two CMFs may have received the same star rating, one may have a study design score of "Excellent" while the other is "Poor". It may be the case that a user may highly value study design and may use that category to decide between CMFs. Similarly, a user may prioritize some other category in their selection process and use that score to select the most appropriate a CMF.

   It may also be useful to examine the fields in the CMF details pertaining to the scores, specifically sample size and standard error. It may be the case that two CMFs both received a score of "Excellent" for sample size, but one has a sample size of 1,000 while the other has a sample size of 3,000. Both of these sample sizes are large enough to qualify for an "Excellent" rating, however, all other factors being equal, the larger sample size would be preferred. Likewise, two CMFs may have both received a score of "Poor" for standard error, but one has a

standard error of 0.75 while the other has a standard error of 0.90. In this case, the smaller standard error would be preferred.

3. Similarity in locality of data used. The fields for "Municipality", "State", and "Country" indicate the area(s) from which data were used in developing the CMF. Many agencies prefer CMFs that were developed in locations that are similar or nearby to their own area, for reasons of terrain, weather, and other characteristics. For example, a state department of transportation in a mid-western state may prefer using a CMF developed in Kansas over a CMF developed in West Virginia.

4. Traffic volume range. The fields for "Major Road Traffic Volume" and "Minor Road Traffic Volume" indicate the range of traffic volumes that were used to develop the CMF. Users should examine these fields to see which CMF has a traffic volume range that best fits the site of interest.

5. Age of data. The field for "Date Range of Data Used" on the CMF details page indicates the age of the data used in developing the CMF. Generally speaking, more recent data would be preferred (all other factors being equal). Studies conducted more recently typically use more advanced techniques, higher precision data, and have other advantages related to the progression of knowledge, data quality, and study methods that develop over time in the field of highway safety research. More recent data will also better reflect changes in vehicle fleet characteristics and technology.

6. Original study report. In addition to providing the citation of the study, the Clearinghouse provides a link, where possible, to the original study document for any CMF. This original document will typically be the final report or published article on the study that developed the CMF. A user of the Clearinghouse who is attempting to select between two similar CMFs may find it useful to refer to the original study report to understand the background of the CMF development. There may be details in the study report that would assist in the CMF selection process. Although the Clearinghouse contains extensive data for each CMF, it does not contain every detail from the study report. For example, the report may discuss details about the roadside character of the roads used in the CMF development. If the roadside character is significantly different from the roads in the user's jurisdiction, he or she may decide to select another CMF that was developed on roads with more similar roadside character to his or her jurisdiction.

Users interested in more information about assessing the quality and usability of CMFs may be interested in the Science of Crash Modification Factors course. The course covers the concepts underlying the measurement of safety and the development of CMFs, the key statistical issues that affect the development of quality CMFs, the key methodological issues that affect the development of quality CMFs, and the general and methodological issues and statistical thresholds used to recognize quality CMFs.

HOW CAN I SUBMIT CMFS TO BE INCLUDED ON THE CLEARINGHOUSE?

Any CMF Clearinghouse user can submit a study to be reviewed by the Clearinghouse team for potential inclusion in the Clearinghouse. The top navigation bar provides a link to "Submit CMFs". The submitted study will be reviewed during the next review cycle.

INFORMATION FOR ADVANCED USERS

The following sections provide additional information for users who already have some experience with the CMF Clearinghouse and searching for CMFs. These sections provide more advanced information about:

- Referencing individual CMFs
- Downloading data from the CMF Clearinghouse
- Understanding standard error and confidence interval
- Applying multiple CMFs
- Understanding the relationship of the CMF Clearinghouse to the HSM
- Developing high quality CMFs

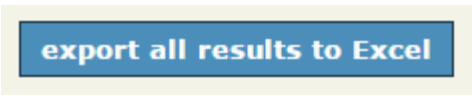
HOW DO I REFERENCE INDIVIDUAL CMFS?

Users should always reference the exact CMF they have used when writing reports or communicating with others about their analysis. To facilitate this, the CMF Clearinghouse assigns each CMF a unique ID number (i.e., 3127). This CMF ID is listed at the top of the CMF details page (the page that provides all the details about a particular CMF). Additionally, the CMF details page for each CMF has a unique URL (internet address). For example, the link to the details page for CMF #3127 would be http://www.cmfclearinghouse.org/detail.cfm?facid=3127. The CMF ID is noticeable as the final characters at the end of that URL.

There are two methods to locate a specific CMF using the CMF ID number. First, the Clearinghouse search mechanism provides an option for searching for a "Single CMF ID" via a checkbox under the search box. A user must simply type in the CMF ID number, check the box for "Single CMF ID", and hit submit. Second, a user can modify the URL of any CMF details page by replacing the final numbers with the ID number of the CMF of interest.

HOW DO I DOWNLOAD DATA FROM THE CMF CLEARINGHOUSE?

Some users may prefer to download the results of a CMF search into Excel in order to filter and sort the data on their own. At the bottom of the search results screen is a button to



allow users to export the results of their search as an Excel file. The Excel output contains 47 attribute fields for each CMF, including such fields as the star rating, study methodology, roadway type, and the geographic area where the CMF was developed.

WHAT IS THE STANDARD ERROR AND CONFIDENCE INTERVAL?

It is important to understand that CMFs are developed as *estimates* of the effect on crashes, and each CMF has a range which may contain the true value, referred to as the confidence interval. A larger confidence reflects more uncertainty about the true value of the CMF. This could be due to the fact that the CMF was developed using only a small sample of sites or a set of sites whose data varied widely. A small confidence interval reflects more certainty about the true value and would reflect a CMF that was developed using a large dataset that had more consistent results.

The confidence interval is used to determine whether the CMF is statistically significant and is based on the standard error of the CMF, a measurement of the potential variability in the CMF value. A CMF is determined to be statistically significant if the specified confidence interval of the CMF does not include 1.0, since a value of 1.0 indicates no effect from the countermeasure. For a given CMF and standard error, the confidence interval will depend on the significance level that is used. The two most common significance levels are 0.05 (corresponds to 95% confidence interval) and 0.10 (corresponds to 90% confidence interval).

For the 95% confidence level, the confidence interval is equal to the CMF ± 1.96 * (standard error).
For the 90% confidence level, the confidence interval is equal to the CMF ± 1.64 * (standard error).

Example 1:

The CMF for countermeasure A is 0.80 with a standard error of 0.15. The lower and upper limits of the 95% confidence interval are the following:

Lower limit: 0.80 – 1.96*0.15 = 0.80 – 0.294 = **0.51**
Upper limit: 0.80 + 1.96*0.15 = 0.80 + 0.294 = **1.10**

Since the 95% confidence interval (0.51, 1.10) includes 1.0, this CMF is not statistically different from 1.0 (at the significance level 0.05, i.e., confidence level 0.95).

Example 2:

On the other hand, if the same CMF had a standard error or 0.09, then the lower and upper limits of the 95% confidence interval will be the following:

Lower limit: 0.80 – 1.96*0.09 = 0.80 – 0.1764 = **0.62**
Upper limit: 0.80 + 1.96*0.09 = 0.80 + 0.1764 = **0.98**

Since the 95% confidence interval (0.62, 0.98) does not include 1.0, this CMF is statistically different from 1.0 (at the significance level 0.05, i.e., confidence level 0.95).

If a CMF is not statistically significant, a user should be cautious and use engineering judgment when applying the CMF to a particular situation. Users should also know that the standard error is used as part of the star rating criteria, so CMFs that are not statistically significant will receive fewer points on the rating scale.

HOW DO I APPLY MULTIPLE CMFS?

It is often the case that an agency will implement more than one countermeasure in a location. If multiple countermeasures are implemented at one location, the common practice is to multiply the CMFs to estimate the combined effect of the countermeasures. However, there is limited research documenting the combined effect of multiple countermeasures. Although implementing several countermeasures might be more effective than just one, it is unlikely the full effect of each countermeasure would be realized when they are implemented concurrently, particularly if the countermeasures are targeting the same crash type.

For example, shoulder rumble strips and enhanced edgeline retroreflectivity would both target roadway departure crashes, so the CMFs for these treatments would be highly related. Other examples of related CMFs would be the use of increased lighting and installation of pavement reflectors, both of which would target nighttime crashes; and chevrons and advanced curve warning signs, both of which would target curve-related crashes.

Countermeasures that would be considered independent are those that target different crash types. For example, the installation of a pedestrian signal would be relatively independent of the installation of a left turn phase at an adjacent intersection, since the one addresses pedestrian-vehicle crashes while the other addresses left-turn opposite-direction crashes. Likewise, the conversion of a left turn phase from permissive to protected along with the installation of an exclusive right turn lane would be fairly independent in that they target different crash types.

Therefore, unless the countermeasures act completely independently, multiplying several CMFs is likely to overestimate the combined effect. The likelihood of overestimation increases with the number of CMFs that are multiplied. Therefore, much caution and engineering judgment should be exercised especially when estimating the combined effect of more than three countermeasures at a given location.

This topic was presented by Frank Gross at the 2013 CMF Clearinghouse Webinar. More detailed information is presented in a paper entitled "Investigation of Existing and Alternative Methods for Combining Multiple CMFs" by Gross and Hamidi, 2011.

WHAT IS THE RELATIONSHIP OF THE CMF CLEARINGHOUSE TO THE HSM?

The first edition of the AASHTO Highway Safety Manual was published in 2010 and serves as a major source of information and guidance on many aspects of road safety, including CMFs. The CMF Clearinghouse incorporates all CMFs from the first edition of the HSM. This includes CMFs used to adjust crash predictions in safety performance functions in Part C and CMFs used to estimate safety effects of various countermeasures in Part D.

Although both the CMF Clearinghouse and the HSM Part D provide CMF information for countermeasures, there are some notable differences:

- The HSM and the CMF Clearinghouse use different methods for determining and indicating the reliability of a CMF. The HSM uses a system of notations (e.g., bold, italics, etc.) to indicate a reliability based primarily on an adjusted standard error, whereas the Clearinghouse uses a star rating as described previously.
- The HSM and the CMF Clearinghouse are different in scope. The HSM presents a single CMF for each countermeasure, whereas the Clearinghouse presents all published CMFs.
- The HSM adjusts both the CMF and the standard error to account for biases, whereas the CMF CH presents both as they are reported by the study author (with a star rating to indicate reliability).

When the Clearinghouse added CMFs from the HSM, star quality ratings were assigned to those CMFs based on the adjusted standard error as listed in the HSM. Go here to see more information about that process and how the HSM and the CMF Clearinghouse compare to each other.

HOW DO I DEVELOP HIGH QUALITY CMFS?

Researchers who develop CMFs play a critical role in providing valuable information to the transportation community. It is important that CMF development studies are conducted in such a way as to produce high-quality CMFs that are based on solid data and good methodology and free of biases. Common characteristics of a high-quality CMF are:

- statistically rigorous study design with reference group or randomized experiment and control
- large sample size that covers multiple years with a diversity of sites
- small standard error compared to the value of the CMF
- controlled for all sources of known potential bias
- based on a diverse data source, including states representing different geographies

The Resources section of the Clearinghouse offers a page with several resources on developing CMFs.

- Better CMFs, safer roadways: Tips for building high-quality CMFs. This two-page flyer provides a basic overview on how to develop high-quality CMFs, with information on questions such as, “What does a quality CMF study look like?” and “Why is documentation important?”

- A Guide to Developing Quality Crash Modification Factors. The purpose of this guide is to provide direction to agencies interested in developing crash modification factors (CMFs). Specifically, this guide discusses the process for selecting an appropriate evaluation methodology and the many issues and data considerations related to various methodologies.
- Recommended Protocols for Developing Crash Modification Factors. The CMF Protocols provide guidance for the development and documentation of research studies that develop CMFs. The major goal of these protocols is to describe what pieces of the research study should be documented by the study authors and how various potential biases should be addressed.

The Clearinghouse also provides ideas and inspiration for future CMF research with the CMF Most Wanted List. This list represents areas or specific countermeasures for which the CMF Clearinghouse does not have much good quality information. These areas have been shown to be of interest to users of the Clearinghouse based on an analysis of searches conducted. Essentially, the question posed was, "what are people searching for but not finding?" Examples include realignment of road segments, curb extensions (also called bulb-outs or bump-outs), rectangular rapid flashing beacons, and dynamic feedback speed signs.

CONCLUSION

The CMF Clearinghouse serves as a valuable resource to the transportation safety community. The CMFs made available through the Clearinghouse assist safety practitioners in estimating the safety effectiveness of many different countermeasures and support the safety investment decision-making process. CMFs can be a valuable tool if used and applied correctly. The CMF Clearinghouse user guide provides information for users to locate the CMFs they need and gain the knowledge to apply them appropriately and best address critical safety issues.