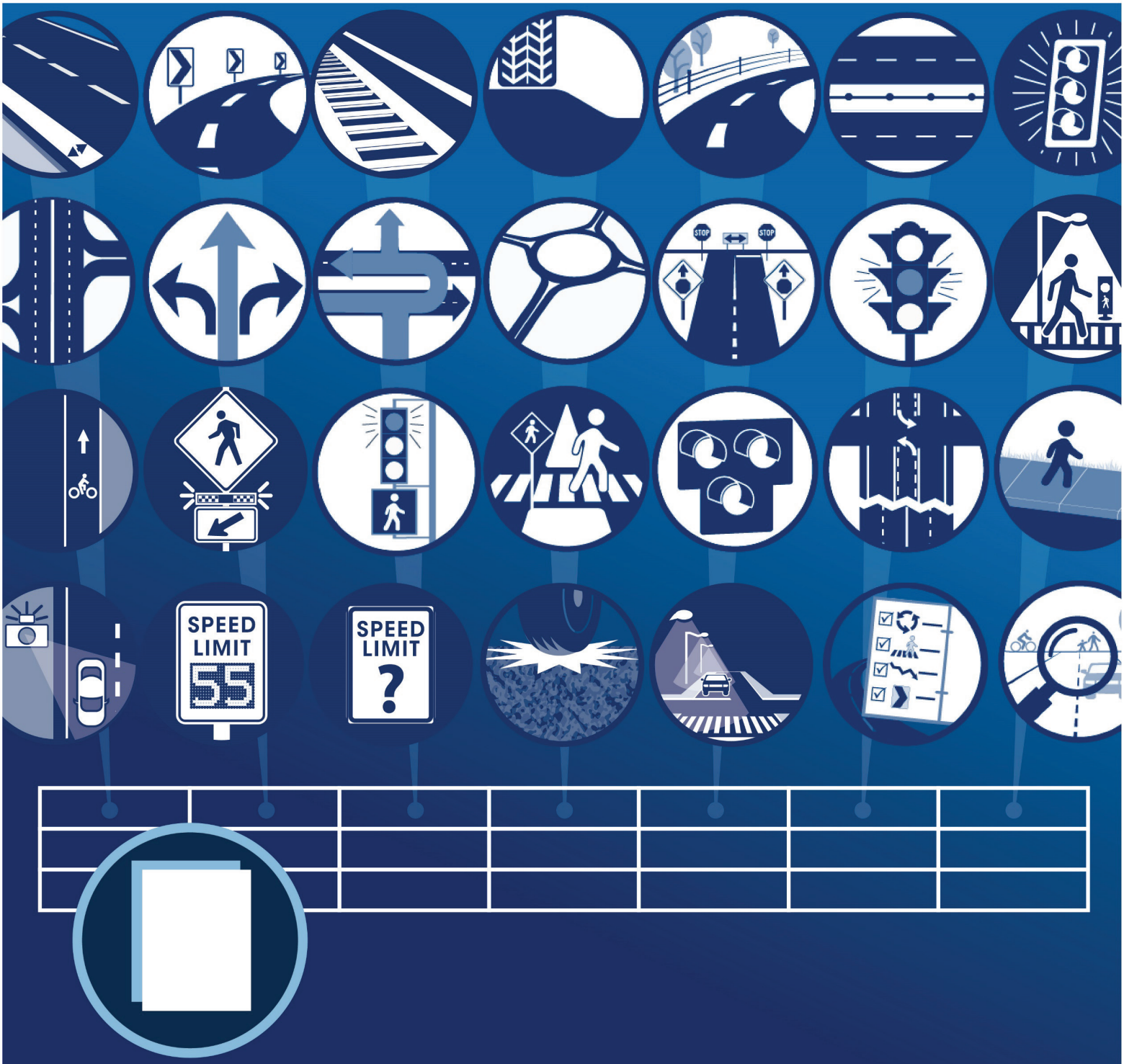

Proven Safety Countermeasures

Funding Scenario Companion Guide

U.S. Department of Transportation
Federal Highway Administration

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Introduction

Imagine your agency's leadership gave you $100 million to improve safety in your community, jurisdiction, or State. How would you spend it? What combinations of improvements can you add to your system with that budget that maximizes the reduction in fatalities and serious injuries?

The Federal Highway Administration (FHWA) developed a Proven Safety Countermeasure (PSC) Investment Tool, Companion Guide (this document), and Funding Scenario Briefing Templates. The tool, companion guide and templates can be used as a starting point and provide high-level planning insights for safety engineers, planners, and program managers to estimate how investments into certain countermeasures will affect safety performance on the system.

The PSC Investment Tool is a spreadsheet that agencies can use to develop investment strategies for implementation of the FHWA PSCs. The Tool includes options for two economic metrics to optimize high-level planning decisions – benefit-cost ratio (BCR) and countermeasure score (CM Score). Using these metrics can enhance the confidence that a user is allocating their funds in a way that maximizes reductions in fatalities and serious injuries.

This tool facilitates a high-level planning exercise, allowing an agency to estimate the return on investment for a certain countermeasure or combination of countermeasures, including lives saved, serious injuries prevented, and number of treatments which will be installed. Agencies can then take these initial insights and identify the most appropriate sites for each countermeasure, advancing these to the project development process.

This Companion Guide provides an explanation of the methodologies used for investment prioritization and explains how to use the PSC Investment Template spreadsheet tool. Specifically, the Companion Guide includes a description of FHWA's PSCs and how they are incorporated into the tool, how BCR and CM Score are calculated and applied in the Template, the Template's data needs depending on whether an agency is using BCR or CM Score, the step-by-step process of using the Template, and potential applications of the Template for State and local agencies.

Additionally, agencies can update the Funding Scenario Briefing Templates with agency-specific estimates to serve as documentation, which can be shared with leadership and other stakeholders who may be involved in decision-making.

Countermeasures

FHWA maintains a list of 28 PSCs – countermeasures and strategies that are proven effective at reducing fatalities and serious injuries on public roads in the United States. Each PSC includes an estimated crash reduction, most of which are based on a Crash Modification Factor (CMF). CMFs are used to estimate the expected change in safety performance after implementation of a countermeasure. A CMF below 1.0 indicates that the countermeasure is expected to result in a decrease in crashes, while a CMF over 1.0 suggests an increase in crashes. If the CMF is exactly 1.0, it implies that there will be no change in the number of crashes after a countermeasure is implemented. For example, a CMF of 0.8 indicates a 20 percent reduction in crashes, while a CMF of 1.07 signifies a 7 percent increase in crashes. FHWA's CMF Clearinghouse is a searchable database of CMFs documented in highway safety literature.

Each FHWA PSC is listed below. Note that in some cases, FHWA's list of PSCs has combined several related countermeasures within one PSC. In the below list, individual countermeasures are listed separately. As such, while FHWA has a list of 28 PSCs, the Template includes 36 individual countermeasures.

- Speed Management
    - Appropriate speed limits for all road users.
    - Speed safety cameras (SSCs).
    - Variable speed limits (VSLs).
- Pedestrian/Bicyclist
    - Bicycle lanes.
    - Crosswalk visibility enhancements.
    - Leading pedestrian interval (LPI).
    - Medians and pedestrian refuge islands in urban and suburban areas.
    - Pedestrian hybrid beacons (PHB).
    - Rectangular rapid flashing beacons (RRFB).
    - Walkways.
- Roadway departure
    - Enhanced delineation for horizontal curves.
    - Longitudinal rumble strips and stripes on two-lane roads.
        - Centerline rumble strips.
        - Edge line or shoulder rumble strips.
    - Median barriers.
        - Concrete.
        - Metal (i.e., guardrail).
        - Cable.
    - Roadside design improvements at horizontal curves.
        - Widen clear zone.
        - Add or widen shoulder.
        - Install roadside barrier.
        - Flatten sideslopes.
    - SafetyEdge[SM].

    - Wider edge lines.
- Intersections
    - Backplates with retroreflective borders.
    - Corridor access management.
    - Dedicated left- and right-turn lanes at intersections.
        - Left-turn lanes.
        - Right-turn lanes.
    - Reduced left-turn conflict intersections.
    - Roundabouts.
    - Systemic application of multiple low-cost countermeasures at stop-controlled intersections.
    - Yellow change intervals.
- Crosscutting
    - Lighting.
        - Intersection lighting.
        - Segment lighting.
    - Local road safety plans (LRSP).
    - Pavement friction management – High Friction Surface Treatment (HFST).
    - Road safe audit (RSA).

The Template includes default CMF and BCR values for each countermeasure based on literature cited in the tool. Many of these default values come from FHWA's PSC documentation; however, in some cases, this is supplemented by other resources. Additionally, some CMF and BCR values are derived from other data. For instance, a CMF value in the Template may be an aggregation of several CMFs for specific crash types that FHWA then generalized for all crash types – this is indicated in the Notes column where applicable.

This list is meant as a starting point for high-level safety investment planning. Agencies are welcome to add, remove, and modify countermeasures as they see fit. When adding countermeasures, agencies should be sure to include a CMF or BCR value depending on the metric being used, including documentation of the source.

Note that several of these countermeasures treat the same crash types, and FHWA expects that multiple countermeasures may be installed at the same locations. The benefits estimated by this tool do not reflect any diminishing effect that might result from the implementation of overlapping countermeasures. This effect is typically insignificant at the planning level; however, if greater precision is needed, users should consider finding or calculating a CMF value for the combined countermeasures. As always, countermeasure decisions should be confirmed with site-level review and diagnosis efforts.

Economic Analysis

Most agencies include some level of economic analysis in their safety program, typically using a BCR approach. BCR represents the ratio of expected benefits from implementation of an improvement to costs required to implement the improvement. Figure 1 shows the general formulation of how to calculate a BCR.

$$BCR = \frac{Service\ Life\ Benefits}{Service\ Life\ Costs}$$

Figure 1. General calculation of BCR.

This tool does not calculate a BCR; rather, it applies a known ratio applicable to countermeasures (estimated based on literature) to prospective future investments. Put simply, once a BCR has been calculated for one project that uses a given countermeasure, a similar return is expected on additional investment in the same countermeasure.

For additional guidelines on how to derive and apply BCR, users can refer to FHWA's *Highway Safety Benefit-Cost Analysis Guide* (Lawrence et al., 2018). For the BCR Template, FHWA selected a BCR for each PSC from the literature to serve as a baseline estimate. FHWA included a source and notes for each selected BCR, although **users can modify the BCR as desired**.

Another option for economic analysis is CM Score. CM Score presents the average cost estimated to produce a one percent reduction in a select crash type and severity. A lower CM Score indicates an investment that is more effective at producing that reduction. Agencies may focus the CM Score to estimate the average cost to produce a one percent reduction in fatal (K) and suspected serious injury (A) crashes. Figure 2 describes various methods of calculating CM Score for KA crashes (CM $Score_{KA}$). The metric can be calculated as a function of:

- A crash reduction factor for KA crashes (CRF_{KA}); or
- A crash modification factor for KA crashes (CMF_{KA}); or
- Expected KA crashes under existing ($N_{exp,KA,existing}$) and proposed ($N_{exp,KA,proposed}$) conditions; and
- Project costs, represented as the present value of capital costs and annual maintenance costs.

$$CM\ Score_{KA} = \frac{Project\ Costs}{CRF_{KA}} = \frac{Project\ Costs}{(1 - CMF_{KA}) * 100} = \frac{Project\ Costs}{\left(1 - \frac{N_{exp,KA,proposed}}{N_{exp.KA,existing}}\right) * 100}$$

Figure 2. Equation. Methods of calculating CM Score for KA crashes.

Additional information about CM Score can be found in FHWA's *Selecting Projects and Strategies to Maximize Highway Safety Improvement Program Performance* (Gross et al., 2021).

For this Template, FHWA selected a representative CMF for each PSC from the literature to provide an estimated reduction in fatal and serious injury crashes. The Template includes a source and notes for each CMF. **FHWA encourages users to modify the CMFs to reflect State specific CMFs, especially if State-preferred CMF values differ from those included in the Template**.

Data Needs and Recommended Resources

The Template has several required and optional data inputs. Default values are included for most inputs. However, FHWA encourages users to modify the inputs to be agency-specific if possible. Required and optional data elements vary based on whether an agency is using BCR or CM Score. Note the KABCO Injury Classification Scale is used to define crash severity for this Template. With this scale, "K" represents a crash in which a fatal injury was the most severe injury in the crash, while "A" represents a crash in which a suspected serious injury was the most severe injury in the crash; "KA" represents a fatal or suspected serious injury crash.

Table 1 lists the data elements for users to input and notes whether they are required or optional based on the chosen approach. For fields based on crash data, FHWA recommends using the five most recent years of available crash data for the agency's footprint or jurisdiction. Table 2 and Table 3 offer additional explanation for each data element used in the BCR and CM score approaches, respectively.

Table 1. Required and Optional Data Element Inputs

Data Element	**Worksheet for Input[1]**	**Element is Applicable for BCR**	**Element is Applicable for CM Score**
Countermeasure Investment	Template	Required	Required
Average K Crash Cost	Customization	Not Applicable	Required
Average A Crash Cost	Customization	Not Applicable	Required
Service Life Unit Cost Estimate	Template	Required	Required
Average Number of Fatal Injuries per KA Crash	Customization	Not Applicable	Required
Average Number of Suspected Serious Injuries per KA Crash	Customization	Not Applicable	Required
Average Number of Fatal Injuries per Crash	Customization	Required	--
Average Number of Suspected Serious Injuries per Crash	Customization	Required	--
Number of K Crashes	Customization	Not Applicable	Required
Number of A Crashes	Customization	Not Applicable	Required
Weighted Average Crash Cost for All Severities	Customization	Required	--
Average Cost of an LRSP	Customization	Required	--
Average LRSP Implementation Funds	Customization	Required	
Average KA Crash Frequency per Unit (e.g., mile, intersection, crossing).	Template	Not Applicable	Required
Number of Intersections on the System	Customization	Optional	Optional
Centerline Miles of Road on the System	Customization	Optional	Optional
Proportion of KA Intersection Crashes that Involve a Pedestrian	Customization	Not Applicable	Optional
Proportion of KA Intersection Crashes in which Manner of Collision is Angle, Head-On, Left-Turn, Rear-End, Right-Turn, or Sideswipe	Customization	Not Applicable	Optional
Proportion of KA Segment Crashes that Involve a Pedestrian	Customization	Not Applicable	Optional
Proportion of KA Mid-Block Crashes that Involve a Pedestrian	Customization	Not Applicable	Optional
Proportion of KA Intersection Crashes in the Manner of Collision is Angle	Customization	Not Applicable	Optional
Average Countermeasure BCR for Agency	Template	Optional	--
Average Countermeasure KA CMF for Agency	Template	Not Applicable	Optional

[1] Indicates whether the input is relevant to the "Template" worksheet or "Agency Customization" worksheets in the Investment Tool.

Table 2. Data Element Summary for BCR

Data Element	Purpose	Recommended Source(s)
Investment	Needed to generate the total investment in a countermeasure.	Choose an investment value that maximizes lives saved and serious injuries prevented while presenting a realistic number of units (e.g., intersection, miles) which can be treated.
Weighted Average Crash Cost for All Severities.	Needed to estimate crashes prevented when using BCR.	Use crash-level, person-level, and guidelines from FHWA to estimate average crash cost.
Average Cost of an LRSP.	Needed to estimate BCR for a Local Road Safety Plan (LRSP).	Discuss with Local Technical Assistance Program (LTAP) or survey local agencies who have completed an LRSP.
Average LRSP Implementation Funds.	Needed to estimate BCR for an LRSP.	Discuss with Local Technical Assistance Program (LTAP) or survey local agencies who have completed an LRSP.
Service life unit cost estimate.	Needed to estimate number of units to be built based on the investment.	Use State historical bid tab data, agency guidance, HSIP reports, document research, or other resources to identify unit costs for similar efforts. The Template includes a "PSC Cost Information" worksheet with example unit cost values.
Average Number of Fatal Injuries per Crash.	Needed to generate an estimate of lives saved when using BCR.	Using crash-level and person-level data, divide the number of total fatal injuries by the total number of all severity crashes.
Average Number of Suspected Serious Injuries per Crash.	Needed to generate an estimate of suspected serious injuries prevented when using BCR.	Using crash-level and person-level data, divide the number of total suspected serious injuries by the total number of all severity crashes.
Number of Intersections on the System	Optional to provide a check for users to determine if the proposed number of treated intersections is realistic.	Use intersection inventory data if available. Otherwise, use a road inventory in GIS to generate a rough estimate of the number of intersections based on conflicts in the line work.
Centerline Miles of Road on the System	Optional to provide a check for users to determine if the proposed mileage to be treated is realistic.	Use roadway inventory data to calculate total centerline mileage.
BCR	Optional to customize the BCR template to agency-specific experience.	Evaluate safety and economic performance of similar projects.

Table 3. Data Element Summary for CM Score

Data Element	Purpose	Recommended Source
Investment	Needed to generate the total investment in a countermeasure.	Choose an investment value that maximizes lives saved and serious injuries prevented while presenting a realistic number of units (e.g., intersection, miles) which can be treated.
Average Number of Fatal Injuries per KA Crash.	Needed to generate an estimate of lives saved when using CM Score.	Using crash-level and person-level data, divide the number of total fatal injuries by the number of crashes in which the Maximum Injury Severity Reported is K or A.
Average Number of Suspected Serious Injuries per KA Crash.	Needed to generate an estimate of suspected serious injuries prevented when using CM Score.	Using crash-level and person-level data, divide the number of total suspected serious injuries by the number of crashes in which the Maximum Injury Severity Reported is K or A.
Number of K Crashes.	Needed to estimate an average KA crash cost when using CM Score.	Obtain the total number of fatal crashes in the sample.
Number of A Crashes.	Needed to estimate an average KA crash cost when using CM Score.	Obtain the total number of suspected serious injury crashes in the sample.
Service life unit cost estimate.	Needed to estimate CM Score.	Use State historical bid tab data, agency guidance, HSIP reports, document research, or other resources to identify unit costs for similar efforts. The Template includes a "PSC Cost Information" worksheet with example unit cost values.
Average KA Crash Frequency	Needed to estimate KA crash reduction when using CM Score.	Conflate crash and roadway or intersection data to determine the average KA crash frequency per unit site (e.g., mile, signalized intersection, etc.).
Proportion of KA Intersection Crashes that Involve a Pedestrian.	Needed to adjust the Crosswalk Visibility Enhancement CMF and Intersection Lighting CMF when using CM Score.	Calculate the proportion of reportable KA intersection crashes which involved a pedestrian.

Data Element	Purpose	Recommended Source
Proportion of KA Intersection Crashes in which the Manner of Collision is Angle, Head-on, Left-turn, Rear-end, Right turn, or Sideswipe.	Needed to adjust the Crosswalk Visibility Enhancement CMF when using CM Score.	Calculate the proportion of reportable KA intersection crashes in which the manner of collision matched those listed.
Proportion of KA Segment Crashes that Involve a Pedestrian.	Needed to adjust the Sidewalk and Walkways CMF when using CM Score.	Calculate the proportion of reportable KA segment crashes which involved a pedestrian.
Proportion of KA Mid-Block Crashes that Involve a Pedestrian.	Needed to adjust the RRFB CMF when using CM Score.	Calculate the proportion of reportable KA mid-block crossing crashes which involved a pedestrian.
Proportion of KA Intersection Crashes in which the Manner of Collision is Angle.	Needed to adjust the Intersection Lighting CMF when using CM Score.	Calculate the proportion of reportable KA intersection crashes in which the manner of collision was Angle.
Average Countermeasure KA CMF for Agency	Optional to customize the CM Score template to agency-specific experience.	Evaluate safety and economic performance of similar projects.

Template Workbook Layout

The PSC Template includes a cover as well as eight worksheets:

1. Instructions: includes a description of the spreadsheet tool, contents, workflow, and legend for cell styles.
2. Agency Customization – BCR: includes the opportunity for users to customize inputs related to BCR analysis.
3. BCR Template: includes the ability to prioritize PSC investments based on BCR.
4. BCR Results: includes a summary of results for BCR-focused investments.
5. Agency Customization – CM Score: includes the opportunity for users to customize inputs related to CM Score analysis.
6. CM Score Template: includes the ability to prioritize PSC investments based on CM Score.
7. CM Score Results: includes a summary of results for CM Score-focused investments.
8. PSC Cost Information: includes recommended unit costs for PSCs for users lacking agency-specific estimates.

Instructions

The “Instructions” worksheet describes the purpose and recommended use of the template. The general workflow is as follows:

1. Determine whether you will use the BCR or CM Score.
2. Review and update the relevant State Customization worksheet ("Agency Customization - BCR" when using BCR and "Agency Customization - CM Score" when using CM Score) to incorporate State-specific data. Note that input cells are currently occupied with default values from FHWA.
3. Enter required inputs in the relevant BCR Template or CM Score Template. Sort countermeasures by BCR (Highest to Lowest) or CM Score (Lowest to Highest).
4. Refine investments based on realistic infrastructure investments.
5. Review results in "BCR Results" or "CM Score Results".
6. If preferred, transfer results to Countermeasure Investment Briefing Templates.

Additionally, the worksheet includes a cell legend, noting the styles used throughout the workbook and what each style means.

Agency Customization – BCR

The "Agency Customization - BCR" worksheet allows users to focus on the estimates for lives saved and serious injuries prevented. It also estimates the BCR for an LRSP. Several required and optional input fields are available to help tailor the analysis to specific State, local, or regional conditions. While the spreadsheet comes with pre-populated fields, agencies should replace these default inputs with agency-specific information, where available, to improve the accuracy and relevance of the analysis.

Agency Customization - CM Score

The " Agency Customization - CM Score" worksheet involves inputs related to safety performance and crash costs. It also includes the ability to enter optional data elements for the proportions of specific types of crashes that involve specific circumstances to refine average CMFs for various countermeasures. This customization ensures a more accurate prediction of changes in crash frequency and severity following the implementation of specific safety countermeasures. The inputs help tailor the analysis to better reflect local conditions and improve the relevance of the findings. Similar to the “Agency Customization – BCR” worksheet, all fields are pre-populated with default data but agencies should replace these defaults with their own data to enhance the accuracy and applicability of the analysis.

BCR Template

This worksheet is used to develop an investment package centered around a BCR for each PSC. Agencies are free to customize the BCR Template and adjust a BCR based on local estimations by changing a BCR to an agency-specific or agency-preferred value. Table 4 describes the columns used in the BCR Template, noting the name of the column, what type of data it is, a description of the column, and sample data.

Table 4. Data Columns for the BCR Template

Data Column	Data Type	Description	Sample Data
PSC Category	Descriptor	Notes the category that FHWA uses to organize the PSC	Roadway Departure; Crosscutting
Proven Safety Countermeasure	Descriptor	Defines the specific PSC	Safety Edge; Roundabouts
BCR	Optional Input	Default is the average estimated BCR for the PSC; however, agencies can replace the default value with an agency-specific estimate	2; 4.5; 500
Source	Optional Input	Source of the default BCR value – agencies should update if they change the BCR	https://rosap.ntl.bts.gov/view/dot/60218; Based on BCR for RSAs
Notes	Optional Input	Provides additional explanation of the source of the default BCR value – agencies should update if they change the BCR	Low end of reported BCR; Average BCR reported for total crashes in Table 7 of source
Installation Unit	Optional Input	Unit of measure for the PSC – agencies can update if modifying the countermeasure or the BCR	Mile; Signalized Intersection; Horizontal Curve
Service Life	Optional Input	Average service life for the countermeasures – agencies can update to reflect agency-specific experience[2]	5 years; 10 years; 25 years
Service Life Unit Cost Estimate	Required Input	Average unit cost for a PSC over the service life- agencies can update to reflect agency-specific experience	$1,000 per mile; $5,000 per intersection; $200,000 per horizontal curve
Investment	Required Input	Total proposed investment into the PSC	$100,000; $5,000,000
Sites Treated	Calculation	Calculates the number of units (e.g., miles, intersections) to be treated based on the investment and unit cost	2 intersections, 100 crosswalks, 500 miles

[2] FHWA's *Countermeasure Service Life Guide* provides recommended estimates for service life for many typical infrastructure countermeasures.

Data Column	Data Type	Description	Sample Data
Estimated Benefits	Calculation	Calculates the estimated benefit based on the investment and BCR	$70,000,000; $12,100,000
Estimated Crashes Prevented	Calculation	Estimates the total number of crashes prevented based on estimated benefits and average crash cost	100; 550; 2,000
Lives Saved	Calculation	Estimates the number of lives saved over the service life based on estimated crashes prevented	1.0; 2.5; 10.1
Serious Injuries Prevented	Calculation	Estimates the number of serious injuries prevented over the service life based on estimated crashes prevented	5.5; 75.1; 100.0

The default BCR Template worksheet is sorted (in descending order) by default BCR values. Agencies should begin by reviewing the default BCR values and making any changes to use agency-specific or preferred BCR values. Users should then sort the PSCs by BCR if they make any changes to the BCR values. This can be done in Excel by selecting all of the data, choosing Custom Sort, then setting the sort to sort by BCR from largest to smallest.

The next step is assigning investments to each countermeasure. FHWA recommends that agencies use the following steps:

- Assign preferred level of investment to the countermeasure with the highest BCR. The investment should produce the maximum number of sites which could be treated reasonably or reach the desired level of investment for the target crash type.
- Analysts then work their way down through each row repeating the above step. Analysts follow this process until the entire budget has been assigned.

As an example, consider the default values – SafetyEdge is the highest rated PSC based on BCR. If an agency has $100 million to invest, then this would return $70 billion in benefits. However, assuming a service life of unit cost of $2,500 per mile, that $100 million investment would treat 40,000 centerline miles of road. After a brief review of the road inventory, the agency noted that there are only 2,000 miles of road that would benefit from Safety Edge. As such, the agency refines the investment the value that accommodates those 2,000 miles - $5,000,000. The agency now has $95,000,000 remaining for investment and will repeat this process with the countermeasure with the next highest BCR until the entire investment budget has been expended.

Since the benefits, number of lives saved, and number of serious injuries prevented are dependent on the BCR, and thus not sensitive to predictions or actual site crash frequency, it is important to consider scenarios where adjustments to the BCR are warranted. Specifically, when unit costs differ significantly from default values, it may result in fewer sites treated while expecting similar benefits. In this case, adjusting the default BCR by the same percentage difference can help make the resulting benefits closer to reality. This iterative process should involve updating the BCR for the agency's preference, inputting costs into the Template, and refining the BCR over time based on

new default costs. Recognize that while adjustments to the BCR can help align the metrics, there may still be limitations due to the Template's current constraints on how unit cost changes do not directly impact estimated crashes.

After assigning the budget, the spreadsheet will provide several estimates for each PSC, including:

- Number of sites to be treated by the investment.
- Estimated benefit derived from the investment per countermeasure.
- Estimated number of crashes prevented over the service life of the investment.
- Estimated number of lives saved over the service life of the investment.
- Estimated number of suspected serious injuries prevented over the service life of the investment.

Users can visit the BCR Results worksheet to view a summary of the estimated safety performance of the proposed investment. This worksheet includes:

- Total investment – sum of individual PSC investments.
- Total estimated benefit – sum of individual PSC benefits.
- Total lives saved – sum of lives saved for each individual PSC.
- Total serious injuries prevented – sum of serious injuries prevented for each individual PSC.
- Average BCR – overall BCR based on the comparison of total estimated benefit and total investment.

The default countermeasures included under the BCR Template worksheet are based on FHWA's PSCs. Agencies can add additional countermeasures to those already included as they see fit, simply by adding another row to the table and inputting relevant information (e.g., countermeasure name and category, BCR, supporting documentation, etc.). After adding new countermeasures, FHWA again recommends that users sort the countermeasures from largest to smallest BCR value before assigning investments.

CM Score Template

The "CM Score Template" worksheet is used to develop an investment package prioritized using the CM Score for each countermeasure. Agencies can customize this worksheet by adjusting values. Potential adjustments include adding or removing a countermeasure, replacing a CMF (for instance, applying a crash-type specific CMF), changing a CMF to an agency-specific value or State/region-specific estimate of safety benefits, lives saved, and suspected serious injuries prevented or an agency-preferred value. Table 5 summarizes the columns in the CM Score template, noting if the column includes descriptors, inputs (required or optional), or calculations; a description of the column; and sample data for the column.

Table 5. Data Columns for the CM Score Template

Data Column	Data Type	Description	Sample Data
PSC Category	Descriptor	Notes the category that FHWA uses to organize the PSC	Roadway Departure; Crosscutting
Proven Safety Countermeasure	Descriptor	Defines the specific PSC	Safety Edge; Roundabouts
CMF for KA Crashes	Optional Input	CMF for KA crashes associated with the countermeasure – agencies can update based on agency-preferred values	0.75; 0.1; 0.99
Target Crash Type for CMF	Optional Input	Crash type for which the CMF is applicable – agencies can update if choosing a CMF for a specific crash type	All; Vehicle-Pedestrian
CMF Clearinghouse ID(s)	Optional Input	CMF Clearinghouse ID for the CMF(s) – agencies should update if changing the CMF	191; 5000; n/a[3]
Source	Optional Input	Source of the default CMF value – agencies should update if they change the CMF	https://www.cmfclearinghouse.org/detail.php?facid=9917
Notes	Optional Input	Provides additional explanation of the source of the default CMF value – agencies should update if they change the CMF	Cited in the PSC documentation; Average of 5-star CMFs reported in PSC-cited report (CMF ID 3362, 3347, 3350) - all crash types, KABC severity
Installation Unit	Optional Input	Average unit for the countermeasure – agencies can update if modifying the countermeasure or the CMF	Mile; Signalized Intersection; Horizontal Curve
Service Life	Optional Input	Average service life for the countermeasures – agencies can update to agency-specific experience	5 years; 10 years; 25 years
Service Life Unit Cost Estimate	Required Input	Average unit cost for a PSC over the service life- agencies can update based on agency-preferred values	$1,000 per mile; $5,000 per intersection; $200,000 per horizontal curve
CM Score	Calculation	Calculated CM Score based on unit cost estimate and CMF	$3,500; $10,000
Investment	Required Input	Total proposed investment into the PSC	$100,000; $5,000,000

[3] N/A denotes that the CMF is not available in the CMF Clearinghouse.

Data Column	Data Type	Description	Sample Data
Sites Treated	Calculation	Calculates the number of units (e.g., miles, intersections) to be treated based on the investment and unit cost	2 intersections, 100 crosswalks, 500 miles
Average KA Crash Frequency per Unit	Required Input	Provides the baseline safety performance estimate without the CMF	0.01 KA crashes per mile per year; 0.001 KA crashes per intersection per year; 0.2 crashes per mid-block crossing per year
KA Crashes Prevented	Calculation	Estimates KA crash reduction based on baseline crash frequency and CMF	1; 5; 0.2
Lives Saved	Calculation	Estimates the number of lives saved over the service life based on estimated crashes prevented	1.0; 2.5; 10.1
Serious Injuries Prevented	Calculation	Estimates the number of serious injuries prevented over the service life based on estimated crashes prevented	5.5; 75.1; 100.0
Estimated Benefits from KA Crash Reduction	Calculation	Estimated benefits derived over the service life of the investment based on KA crash reduction and average KA crash cost	$1,000,000; $100,000
Estimated BCR from KA Crashes	Calculation	Estimates the BCR based on the benefits derived by the reduction in KA crashes	1.1; 5.0; 10.4

After completing the "Agency Customization – CM Score" worksheet, agencies should begin completing the "CM Score Template" worksheet by reviewing the default CMF values and making any changes to incorporate agency-preferred values. Users should then enter a service life unit cost estimate for each potential countermeasure. After entering unit costs, the spreadsheet automatically calculates a CM Score for each countermeasure. To prioritize the countermeasures in CM Score priority order, users should sort the data on CM Score from smallest to largest value. This can be done in Excel by selecting all of the data, choosing Custom Sort, then setting the sort to sort by CM Score from smallest to largest. This will result in the countermeasures being listed from the most cost efficient to the least.

The next step is assigning investments to each countermeasure. Theoretically, assigning the full available budget to the most cost-effective countermeasure would produce the most efficient investment plan; however, there are likely not enough sites eligible for treatments to accommodate the investment. Further, the anticipated expenditure may not align with funding targets and program goals. As such, FHWA recommends that analysts use the following iterative process, following the same guidelines and example described for the BCR Template:

- Assign preferred level of investment to the countermeasure with the lowest CM Score. The investment should produce the maximum number of sites which could be treated reasonably or reach the desired level of investment for the target crash type.
- Analysts then work their way down through each row repeating the above step. Analysts follow this process until the entire budget has been assigned.

After entering investment data, analysts should input Average KA Crash Frequency per Unit (e.g., 0.005 KA crashes per mile per year, 0.01 KA crashes per intersection per year) for each PSC with planned improvements. Users can estimate an average crash frequency using agency-wide crash and asset data, normalizing the number of segment crashes per unit of analysis for the respective PSC. If these values are unavailable, agencies should consider reviewing the safety performance at 50 or 100 sites to develop a sample value which can be used in place of an agency-wide estimate.

After refining investment decisions, the spreadsheet will provide several estimates, including:

- Number of sites treated.
- An estimated number of lives saved over the service life of the investment.
- An estimated number of suspected serious injuries prevented over the service life of the investment.
- An estimated BCR based on the reduction in fatal and suspected serious injury crashes.

Users can visit the CM Score Results worksheet to view a summary of the estimated safety performance of the proposed investment. This worksheet includes:

- Total investment – sum of individual PSC investments.
- Total estimated benefit for KA crashes – sum of individual PSC benefits.
- Total lives saved – sum of lives saved for each individual PSC.
- Total serious injuries prevented – sum of serious injuries prevented for each individual PSC.
- Average BCR – overall BCR based on the comparison of total estimated benefit and total investment.

The default countermeasures included in the "CM Score Template" worksheet are based on FHWA's PSCs. Agencies can add additional countermeasures to this list as they see fit, simply by adding another row to the table and inputting relevant information (e.g., countermeasure name and category, CM Score, supporting documentation, etc.). After adding new countermeasures, FHWA recommends that users sort the countermeasures from smallest to largest CM Score value before assigning investments.

State and Local Applications

This tool is general in its format and can be applied to any context – State, local, Tribal, and regional. If users desire to analyze applications by separate contexts, they can simply save separate versions of the tool and input data specific to those contexts.

Agencies at varying levels may have different levels of data availability. If required data for an input are unavailable, consider working with a neighboring agency, peer agency, or State or regional agency (for local and Tribal agencies) to identify methods of obtaining the data for your agency or obtain estimates from those agencies to use as a surrogate estimate for your agency.

Countermeasure Investment Briefing Templates

Along with this Companion Guide, FHWA provides a series of "Countermeasure Investment Briefing Templates" – one-page templates agencies can use to enter relevant data and share the expected outcome of their investments with leadership and other stakeholders. The Templates identify areas where users can input investment information as well as expected safety performance results. Agencies can access the templates at: https://highways.dot.gov/safety/proven-safety-countermeasures/proven-safety-countermeasures-funding-scenario-briefing and the tool at: https://highways.dot.gov/safety/proven-safety-countermeasures/proven-safety-countermeasures-funding-scenario-tool.

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Proven Safety Countermeasures