FDM 11-38-1 General

February 18, 2020

The purpose of this section is to introduce the expectations of performing safety analysis under Performance-Based Practical Design (PBPD) (FDM 11-1-10) philosophies through implementation of WisDOT's Safety Certification Process (SCP). The SCP adopts the American Association of State Highway and Transportation Officials (AASHTO) Highway Safety Manual (HSM) analysis methods and economic appraisal process.

1.1 Overview

WisDOT is continuously balancing fiscal realities with competing highway needs. As such, all asset improvements (safety, pavement, structures) must be employed with the right fix at the right time and in the right location. This "right fix, right time, right location" philosophy is fundamental to Performance-Based Practical Design (PBPD) practice.

The safety analysis portion of PBPD places emphasis on substantive safety, i.e., long-term safety performance of a roadway, through consistent identification of safety needs while still considering nominal safety by addressing less than lower minimum design criteria roadway elements. Nominal safety is the safety assumed "built in" to the design criteria. What is important to understand is a roadway's substantive safety does not always correlate to its level of nominal safety. It is not uncommon for a roadway to be nominally safe (i.e., all design elements meet design criteria) but at the same time be substantively unsafe (i.e., has crashes that are higher than expected). Similarly, some roadways that are nominally unsafe (one or more design elements do not meet design criteria) can and do function at a high level of substantive safety. This process will allow for more accurate scoping of the true purpose and need of projects and result in more efficient expenditures throughout the system.

WisDOT's SCP uses network screening tools to identify locations that experience more crashes than similar sites and have a higher potential for safety improvement. These "sites of promise" are then subject to a crash vetting process and ultimately predictive crash modeling and economic appraisal (Benefit-Cost) methodologies, to identify and evaluate safety mitigation alternatives for locations on the highway network.

1.2 Acronyms and Definitions

A list of acronyms used throughout this chapter is in Table 1.1; while brief definitions of key SCP terms are presented in Table 1.2.

***Table 1.1* Acronyms**

Acronym	Definition
AASHTO	American Association of State Highway and Transportation Officials
AADT	Average Annual Daily Traffic
CGA	Contributing Geometric Analysis
CMF	Crash Modification Factor
EA	Economic Appraisal
EB	Empirical Bayes
FDM	Facilities Development Manual
FHWA	Federal Highway Administration
HSM	Highway Safety Manual
IHSDM	Interactive Highway Safety Design Manual
LOSS	Level of Service of Safety
PBPD	Performance-Based Practical Design
RTM	Regression to the Mean
SCD	Safety Certification Document
SCP	Safety Certification Process
SCW	Safety Certification Worksheet
SMCP	Safety Mitigation Certification Process
SPF	Safety Performance Function

***Table 1.2* Definitions**

SCP Element	Definition
Base Case	The base case is the scenario each alternative will be compared to. In most cases, the base case scenario will not include safety improvements and should be modeled as the existing geometric and traffic control conditions for the overall analysis period starting with the construction year.
Calibration Factor	A factor to adjust crash frequency estimates produced from a safety prediction procedure to approximate local conditions. The factor is computed by comparing existing crash data at the state, regional, or local level to estimates obtained from predictive models.
Crash Cost	Crashes result in economic costs including the costs of vehicle repairs, providing emergency services, traffic delays, medical services, workplace productivity losses, and damage to private property and roadway infrastructure. Crashes involving death or severe injury may also result in intangible costs such as physical pain or emotional suffering. These costs are referred to as quality-adjusted life years (QALY). The comprehensive costs of a crash are the sum of the economic and QALY costs. Detailed information regarding FHWA default crash costs can be found in the FHWA Crash Cost for Highway Safety Analysis.
Crash Modification Factor (CMF)	A CMF is a factor estimating the potential changes in crash frequency or crash severity due to installing a specific treatment. The CMFs in the HSM have been developed based on rigorous and reliable scientific process. As an example, a 0.70 CMF corresponds to a 30 percent reduction in crashes. A 1.2 CMF corresponds to a 20 percent increase in crashes.

SCP Element	Definition
Discount Rate	Discount rates, used in the economic appraisal, reflect the time value of money. That is, benefits and costs experienced in the near-term are worth more than benefits and costs experienced at the end of the analysis period. For more information, reference FHWA Highway Safety Benefit-Cost Analysis Guide.
Empirical Bayes (EB)	EB is a statistical method that weights the predicted crash frequency and the observed crash frequency. Weighting the predicted and observed crashes allows us to use the long-term average crash experience of similar sites and bring that prediction closer to the observed crash history of the site being evaluated.
Expected Crash Frequency	The number of crashes obtained by weighting the predicted crash frequency and the observed crash frequency using the EB method.
Facility	This is an HSM term that describes three broad types of roadway facilities for specific application of predictive safety methods. These facilities include Rural Two-Lane, Two - Way Roads, Rural Multilane Highways, and Urban and Suburban Arterials. Within these facility types are several site types that further define project locations. These include diverse types of intersections and segments within the overall facility.
Interactive Highway Safety Design Model (IHSDM)	IHSDM is a suite of software analysis tools used to evaluate the safety operational and economic effects of design decisions on roadways. This software provides a Crash Prediction Module to implement the HSM Part C methodology. Refer to FHWA website for more information.
Intersection Network Screening Spreadsheet	WisDOT's tool for intersection network screening, which contains WisDOT intersection inventory data.
Meta-Manager	WisDOT's facilities asset management database.
Observed Crash Frequency	The number of crashes at a specific, site. Observed crashes are often reported for a 5-year period.
Predicted Crash Frequency	The number of crashes determined by using a safety performance function (SPF).
Regression to the Mean (RTM)	The natural variation in crash data. If regression to the mean is not accounted for, a site might be selected for study when the crashes are at a randomly high fluctuation or overlooked from study when the site is at a randomly low fluctuation.
Safety Flag	Meta-Manager indication for a roadway segment that has a crash rate that is one standard deviation above the statewide average for its peer group. Intersection Network Screening indication for an intersection with a Level of Service of Safety category 4 (LOSS 4).
Safety Performance Function (SPF)	SPFs are equations that predict crash frequency and severity as a function of traffic volume and roadway characteristics (e.g. number of lanes, median type, intersection control, number of approach legs).
Site of Promise	Segment or intersection within a project's limits that have a potential for safety improvement.

FDM 11-38-3 Policy

February 18, 2020

WisDOT's implementation of Performance-Based Practical Design (PBPD) uses the SCP for determining and approving safety-driven roadway improvements to the system. The SCP incorporates AASHTO's HSM analysis methods into WisDOT's project development process.

Refer to FDM 11-1-5 for WisDOT's *Asset Management by a Practical Design System Preservation Approach* that incorporates the SCP.

The product of the SCP is the Safety Certification Document (SCD). See FDM 11-1 Attachment 10.1 for a table showing when a SCD is required.

Questions regarding this policy should be sent to DOTBTOSafetyEngineering@dot.wi.gov.

FDM 11-38-5 Overview of Safety Quantification in the Project Development Process *February 18, 2020*

Quantifying safety early in the project development process is key to determining safety improvement impacts to projects. Proposed safety improvements in a project must be balanced with other competing fiscal needs of the project such as operational, environmental, and pavement concerns. Historically, safety benefits have been assumed inherent, or "built in", to design policies and practices.

There are methods and tools available to quantify safety benefits in the development and analysis of safety mitigation alternatives in projects. These methods and tools allow analysts to quantify the crash frequency and severity of safety mitigation alternatives which allows safety to be explicitly considered in the evaluation of alternatives on projects.

To facilitate the safety comparison of alternatives, WisDOT employs Performance Based Safety Engineering Analysis (PBSEA) which involves predictive crash modeling and Economic Appraisal (EA) to compare the cost of crashes to the cost of roadway improvements. Predictive crash modeling is used to estimate crash frequencies and severities for safety mitigation alternatives on a project and then economic appraisal techniques assign average costs to the identified crashes for each safety mitigation alternative to monetize safety benefits. In this way, safety can be compared with other costs (construction, real estate) to evaluate alternatives.

FDM 11-38-10 WisDOT Safety Certification Process *May 18, 2020*

10.1 General

The Safety Certification Process (SCP) is a step-by-step process of determining whether safety improvements should be included on a project by quantifying safety mitigation alternatives, monetizing the resulting safety benefits, completing benefit-cost comparisons of the mitigation alternatives, and documenting decisions and judgements throughout the process.

This requires the analyst to use and document sound engineering judgement and experience based on specific project conditions, context, and modal priorities.

The SCP will be used to support all safety improvements on a WisDOT project and generally includes the following steps (Refer to Attachment 10.1 for a process flowchart):

1. **Sites of Promise by System Screening:** Safety screening to identify highway segments and intersections with potential for crash reduction.
2. **Crash Vetting for the Sites of Promise:** Investigation of the Sites of Promise to understand crash trends and patterns, identify the contributing factors to crashes at those sites, and vet crashes where there is no engineering solution.
3. **Contributing Geometric Analysis (CGA):** Analyze how geometric features contributed to the crash history and identify possible countermeasures.
4. **Safety Mitigation Certification Process (SMCP):** This two-part process includes Performance Based Safety Engineering Analysis and Economic Appraisal. This involves predictive crash modeling and application of economic appraisals to determine benefit-cost. Overall these two processes allow direct monetary comparison of mitigation alternatives.
5. **Safety Certification Document (SCD):** The final document that describes the process, engineering judgment, and support for safety improvements for a project.

10.2 Sites of Promise by System Screening

10.2.1 General

All WisDOT projects required to complete a SCD start with a safety screening. The goal of this first step is to identify the project's Sites of Promise, which are roadway segments or intersections along the project corridor that have a high potential to reduce crashes with targeted, cost-effective improvements. Only segments or intersections that are identified as a Site of Promise move forward in the SCP.

10.2.2 Sites of Promise by System Screening Process

The following process shall be used to establish Sites of Promise along a specific project corridor:

For segments:

1. Obtain the Meta-Manager spreadsheet for the Region in which the project is located.
    - Refer to the Meta-Manager User Guide for further information regarding the data within the Meta-Manager spreadsheet and the associated calculations.

2. In the Safety tab, locate the PDP segments that make up the project corridor.
3. Identify flagged segments. Segments are flagged if any of the following conditions are true:
   - The Total Crash Rate (RATEFLAG) is at least one standard deviation above the peer group average (has a value of 1.0 or greater).
   - The KAB Crash Rate (MMGR_KAB_CRSH_RT_FL) is at least one standard deviation above the peer group average (has a value of 1.0 or greater).
   - The Pedestrian Crash Total (MMGR_PED_TOT) has at least one crash.
   - The Bicycle Crash Total (MMRG_BIKE_TOT) has at least one crash.

   Refer to Figure 10.1 for a sample screenshot of the Meta-Manager safety worksheet and presentation of crash flags.

PDP_ID	ACSI_INTS_NM	HWY&DIR	RATEFLAG	MMGR_BIKE_CRSH_TOT	MMGR_PED_CRSH_TOT	MMGR_KAB_CRSH_RT_FL
845	USH 66 EB	010E	10.78	1	0	3.86
846		010E	7.81	0	0	0.00
847	OLD HWY 18	010E	1.06	2	0	0.00
848	BRILOWSKI RD	010E	0.00	1	1	0.00
849	BADGER AVE	010E	0.00	0	0	0.00
850	ALGOMA ST	010E	0.00	0	0	0.00
851	STOCKTON RD	010E	0.00	0	0	0.00
852		010E	0.00	0	0	0.00
853	CTH K	010E	1.03	0	0	1.16
854	CTH QQ	010E	1.27	0	0	0.00
872		010E	0.00	0	0	1.01

Figure10.1 Sample Screenshot of Meta-Manager Safety Worksheet

4. Review and validate input data. This includes checking the roadway type (peer group) and annual average daily traffic (AADT) volume for consistency along a corridor. Refer to Figure 10.2 and Figure 10.3 for example screenshots of Meta-Manager data and how to validate the data. If inputs are not accurate, revise the data and recalculate the associated flags.

PDP_ID	PDP_FRM	PDP_TO	PDP_MILE	HWY&DIR	RATEFLAG	HSTL_AADT_5_YR
140	002E126 000	002E128 000	1.08	002E	0.00	3440
141	002E128 000	002E129 000	1.08	002E	0.00	3440
142	002E129 000	002E131 000	1.07	002E	1.29	3440
143	002E131 000	002E132 000	0.30	002E	0.00	4600
144	002E132 000	002E132 029	0.29	002E	0.00	4600
145	002E132 029	002E132 072	0.43	002E	0.00	4600
146	002E132 072	002E133M000	0.28	002E	0.00	4852
148	002E134 000	002E136 000	1.02	002E	0.00	3566

Review the flagged AADT and look for significant inconsistency with adjacent segments

Figure 10.2 Review Flagged Segments for Potential Faulty AADTs

PDP_ID	SPOT_RP_KY	FEATURE_NEAR	SFTY_TRVL_CLS
141	002E128 000	PARK RD (COUNTY PIT 1.6 MI)	420: Rural 2-lane Highways with 2,000 < AADT = 7,000
141	002E128 030		420: Rural 2-lane Highways with 2,000 < AADT = 7,000
141	002E128 080		420: Rural 2-lane Highways with 2,000 < AADT = 7,000
142	002E129 000	DEFER RD	420: Rural 2-lane Highways with 2,000 < AADT = 7,000
142	002E129 010		420: Rural 2-lane Highways with 2,000 < AADT = 7,000
142	002E129 050		420: Rural 2-lane Highways with 2,000 < AADT = 7,000
142	002E129 060		420: Rural 2-lane Highways with 2,000 < AADT = 7,000
142	002E129 070	KIVA TIA RD	420: Rural 2-lane Highways with 2,000 < AADT = 7,000
142	002E129 080		420: Rural 2-lane Highways with 2,000 < AADT = 7,000
142	002E129 090	COMCL DRWY	420: Rural 2-lane Highways with 2,000 < AADT = 7,000
143	002E131 000	N STATELINE RD	310: Multilane Divided Highways Posted at 45 mph or highe
143	002E131 020	COMCL DRWY	420: Rural 2-lane Highways with 2,000 < AADT = 7,000

For flagged location, look for inconsistent peer group

***Figure 10.3* Review Peer Groups for Inconsistencies**

5. Validated flagged segments are identified as Sites of Promise and shall continue the SCP.
6. Document all Meta-Manager PDP segments in the Safety Certification Worksheet. Provide additional documentation for flagged segments in the System Screening - Sites of Promise section of the Safety Certification Worksheet (Attachment 10.2).

For intersections:

1. Obtain the Intersection Network Screening spreadsheet.
2. Identify the INT_IDs for the project intersections using the maps linked in the Intersection Maps tab.
3. Locate the project intersections in the Network Screening tab using the INT_IDs.
4. Review and validate input data. This includes checking the control type and AADT for each intersection. If inputs are incorrect, revise the data and confirm the calculations were updated.
5. Identify flagged intersections. These are Sites of Promise and shall continue the SCP.
   - Intersections are flagged when the Level of Service of Safety (LOSS) is a category 4 for either Total Crashes or KABC Crashes. Refer to the Intersection Network Screening User Guide for more information about LOSS and the Intersection Network Screening spreadsheet.
6. Document all intersections within the project corridor in the Safety Certification Worksheet. Provide additional documentation for flagged intersections in the System Screening – Sites of Promise section of the Safety Certification Worksheet (Attachment 10.2).

A web-based application called the Safety Certification Mapping (SCM) tool is available on the WisTransPortal to assist analysts with documenting Sites of Promise in the Safety Certification Worksheet.

Project corridors that do not have any flagged segments or intersections require no further safety evaluation and shall be documented as such in the SCD. Refer to FDM 11-38-10.6 for information on the SCD.

Attachment 10.3 visually depicts the process of discerning Sites of Promise by System Screening, as described above.

10.3 Crash Vetting for the Sites of Promise

10.3.1 General

After determining the project corridor includes at least one Site of Promise, a comprehensive crash data verification process, “crash vetting”, ensues. Historical crash data are reviewed to verify the crashes are relevant to the project and require further safety analysis.

10.3.2 Crash Vetting for the Sites of Promise Process

1. Obtain crash reports (MV4000 or DT4000) for all the flagged segments and intersections (from the Sites of Promise step).
2. Crash vetting: Review each crash report. Identify which crashes should be targeted for engineering

improvements and which crashes should be vetted out and considered in other safety programs.

Engineering judgement should be applied in this step and documented as described later in this section.

- Vet out crashes involving deer and other animals unless the origins of the crash are unrelated to the animal. For example, if a driver ran off the road and hit an animal but the animal was not the root cause of the crash.
- Vet out crashes outside the flagged segment limits (document points of judgment)
- Vet out crashes relating to roadway conditions not affiliated with the highway or geometric conditions (debris in road, etc.).
- Evaluate crashes relating to driver/pedestrian conditions to determine if human error was the primary contributing factor to the crash. Examples of this include:
    - Use of drugs/alcohol, distracted driving, driver fell asleep, pedestrian entered roadway without proper right of way, etc.
    - Crash that resulted from an obvious case of “road rage”
    - Crash resulted from driver following too close to the vehicle in the lead for the roadway conditions (tailgating, inattentiveness, etc.)
    - Secondary crashes that resulted from a motorist’s inattentive driving while moving through an incident zone, such as a crash in the opposite lanes. Often secondary crashes occur as a result of motorists looking at the first crash.
    - Crash resulting from a motorist excessively speeding
    - Crashes resulting from improper lane changes or violating the rules of the road such as making a U-turn on a two-lane roadway
- Crashes flagged as human error should also be compared to identify any crash trends for potential roadway condition impacts. This evaluation will help to determine if these crashes are impacted by roadway characteristics.
    - For example, a crash where an impaired driver drove off the road along a curved segment should not be removed if there are frequent occurrences of run off the road crashes without the influence of drugs or alcohol.
- Evaluate vehicle factors (e.g., blown tire, defective equipment, engine fires) to determine if they were the primary contributing factor to the crash. Determine if roadway geometric conditions also contributed to the crash. If yes, keep the crash for further data analysis. If not, vet out the crash record for the safety evaluation and document the decision.

3. Analyze the remaining crash data for patterns and trends to identify targeted countermeasures. Consider sorting the remaining crash records of flagged segments and intersections by:
    - Type
    - Severity
    - Contributing factors (geometric conditions, pavement quality conditions, etc.)
    - Daylight condition (day, night)
    - Road condition (dry, wet, snow, ice)
    - Time of day/year
4. At this stage of the process, the analyst should use their judgment to vet out crashes with contributing factors that cannot be linked to a pattern or element correctible by an engineering solution. Document these decisions in the Vetted Comments column in the WisTransPortal crash data spreadsheet. Refer to Figure 10.4 for a screenshot illustrating an example of how an analyst may save their “vetted” comments within the WisTransPortal crash data spreadsheet.

ACCDNMBR	ONHWY	ATSTR	ACCDDATE	NTFYHOUR	MNRCOLL	ROADCOND	ACCDSVR	Vetted Comments
130204427	8		2/14/2013	18	REAR	WET	PD	Inattentive driving, following too close
130301806	8		3/9/2013	18	NO	WET	PD	swerved to avoid object in road
130507368	8		5/24/2013	15	ANGL		PD	Miscoded, not on project corridor
130808069	8		8/30/2013	15	ANGL		INJ	
130808676	8		8/26/2013	5	NO	WET	INJ	Poor visibility and too fast for conditions
131210811	8	SWANSON RD	12/22/2013	20	NO	SNOW	PD	Snowy road, too fast for conditions
140110952	8		1/25/2014	9	NO	ICE	PD	Icy road, too fast for conditions
140210998	8		2/23/2014	2	NO	SNOW	INJ	Snowy road, too fast for conditions
140706007	8		7/25/2014	14	ANGL		INJ	
140909842	8		9/12/2014	9	ANGL		INJ	

***Figure 10.4* Sample WisTransPortal Crash Data Spreadsheet with Vetting Comments**

5. After vetting, are there remaining segmental or intersection crashes that can be mitigated with engineering solutions?
   - No. Further safety evaluation is not required. Include the WisTransPortal crash data spreadsheet with the vetted comments in the Safety Certification Document.
   - Yes. Proceed to step 6.
6. Identify the number of crashes reviewed and the number of crashes correctible by an engineering solution in the Crash Vetting - Sites of Promise section of the Safety Certification Worksheet. The crashes correctible by an engineering solution shall be further evaluated in the Contributing Geometric Analysis (CGA) process.

10.4 Contributing Geometric Analysis (CGA)

10.4.1 General

If there are crashes that can be mitigated with engineering countermeasures, they are evaluated further to determine if existing geometric features contributed to the type and severity of those crashes. If existing geometric features did not contribute to the crashes, other possible countermeasures should be identified to target the contributing factors. This is done through the Contributing Geometric Analysis (CGA) process.

10.4.2 Contributing Geometric Analysis (CGA) Process

1. Determine if geometric features contribute to the type or severity of the crashes.
2. Document the geometric features that contributed to the crashes and the countermeasures identified to target those factors in the Contributing Geometric Analysis columns of the Safety Certification Worksheet (Attachment 10.2).
3. If existing geometric features did not contribute to the type and severity of the crashes, identify possible countermeasures to target the contributing factors identified in the vetted WisTransPortal crash data spreadsheet and summarized for each flagged segment in the Crash Vetting – Sites of Promise section of the Safety Certification Worksheet (Attachment 10.2). See Attachment 10.4 for a Safety Improvement Prompt List that target specific crash types and contributing factors. If no practical countermeasures exist, document in the SCD.

10.5 Safety Mitigation Certification Process (SMCP)

10.5.1 General

The Safety Mitigation Certification Process (SMCP) is initiated if safety improvements were identified in the CGA. Each safety improvement identified shall be evaluated to determine the cost-effectiveness of improving the safety performance at the flagged location(s). The SMCP includes two components:

1. Performance Based Safety Engineering Analysis
2. Economic Appraisal

10.5.2 Performance Based Safety Engineering Analysis (PBSEA)

10.5.2.1 General

The Performance Based Safety Engineering Analysis (PBSEA) process uses predictive modeling when possible to evaluate the future safety performance of each safety improvement alternative. This modeling should be completed using the Interactive Highway Safety Design Model (IHSDM) software. Predictive modeling has the following advantages:

- It allows safety to be quantified so investments in infrastructure improvements have the highest potential to improve long term safety performance.
- It allows for the effects of various design alternatives on crash frequency and severity to be quantified.

10.5.2.2 Performance Based Safety Engineering Analysis Process

This process evaluates the safety impacts of the countermeasures identified in the CGA. The performance based safety engineering analysis process is outlined below:

1. Determine the base case scenario.
2. Determine the analysis method for the base case and each alternative.
3. Compare the analysis methods and determine an overall method for the evaluation.
4. Develop the required data for analysis.
5. Perform the safety analysis.
6. Document the results.

Step 1. Determine the base case scenario.

The base case is the scenario each alternative will be compared to. In most cases, the base case scenario will not include safety improvements and should be modeled as the existing geometric and traffic control conditions for the overall analysis period starting with the construction year.

Step 2. Determine the analysis method for the base case and each alternative.

When determining which analysis method to use, it is important to know the distinction between the types of crash modification factors (CMFs). There are two types of CMFs used throughout this process:

1. HSM Part C CMFs, called CMF adjustment factors herein. CMF adjustment factors are used in conjunction with the HSM Safety Performance Functions (SPFs). These CMFs adjust the base conditions of the SPFs.
2. HSM Part D CMFs, called external CMFs herein. External CMFs are used to modify the SPF prediction to more closely represent the site conditions.

Attachment 10.6 is a flowchart to guide analysts through determining the correct analysis method. Assign each scenario an analysis method.

Method 1: CMF Applied to Observed Crashes

- This method multiplies the Observed Crash Frequency with external CMFs.
- Use when the site configuration or traffic volumes are outside of the applicable ranges of the Safety Performance Functions (SPFs).
- This method does not account for regression-to-the-mean (RTM) bias which is when the short-term crash trend does not reflect the long-term average. RTM can over or under estimate the effect of safety improvements. Figure 10.5 illustrates RTM bias in observed crash frequencies.
- The Highway Safety Benefit-Cost Analysis Tool is used to implement this method.
- This is the least reliable method and should be used only if no other method is appropriate. Attachment 10.5 contains a chart illustrating which design elements are covered by the HSM SPFs.
- The results obtained with this method should be called the “Estimated Crash Frequency”.

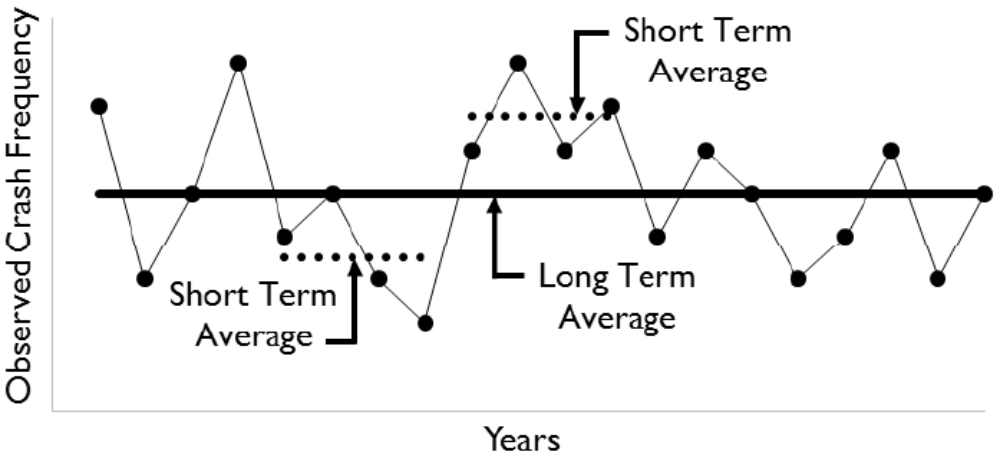

***Figure 10.5** Variation in Short Term Observed Crash Frequency to Illustrate RTM Bias*

Method 2: SPF without External CMFs (2A) and SPF with External CMFs (2B)

- These methods use SPFs to predict the crash frequency.
    - Method 2A is used if only the SPF and its adjustment factors are needed.
    - Method 2B is used if an external CMF is needed in addition to the SPF to more accurately model the conditions or safety improvements.
- Use these methods when Empirical Bayes is not applicable, which the HSM defines as:
    - Projects in which a new alignment is developed for a substantial proportion of the project length.
    - Intersections at which the basic number of legs or type of traffic control is changed as part of the project.
    - Segments where the number of through lanes changes, other than short passing lane sections.
    - Any other major geometric improvement where the observed crash data for the existing conditions is not indicative of the crash experience that is likely to occur in the future.
- The Interactive Highway Safety Design Model (IHSDM) is used to implement these methods.
- These methods are more reliable than Method 1, but less reliable than Methods 3A or 3B.
- The results obtained with these methods should be called the “Predicted Crash Frequency”.

Method 3: SPF without External CMFs weighted by Observed Crashes (3A) and SPF with External CMFs weighted by Observed Crashes (3B)

- These methods utilize Empirical Bayes (EB), which weights the predicted crashes from SPFs with the observed crashes, to obtain the most reliable results. When performing EB, all observed crashes are included, not just the remaining crashes identified in the CGA process.
    - Method 3A is used if only the SPF and its adjustment factors are needed.
    - Method 3B is used if an external CMF is needed, in addition to the SPF, to more accurately model the conditions or safety improvements.
- Use this method when EB is applicable, which the HSM defines as:
    - Sites at which the roadway geometrics and traffic control are not being changed (e.g. the future no-build alternative).
    - Projects in which the roadway cross section is modified but the basic number of through lanes remains the same.

  - Projects in which minor changes in alignment are made, such as flattening individual horizontal curves while leaving most of the alignment intact.
  - Projects in which a passing lane or a short four-lane section is added to a rural two-lane, two-way road to increase passing opportunities.
- The Interactive Highway Safety Design Model (IHSDM) is used to implement these methods.
- These are the most reliable methods and should be used unless EB is not applicable.
- The results obtained with these methods should be called the "Expected Crash Frequency".

Table 10.1 Required Inputs to Safety Mitigation Certification Process (SMCP)

Method			Inputs for Each Analysis Method
1	2	3	
Required	Required	Required	Geometry and traffic control for each segment or intersection with remaining crashes as determined in FDM 11-38-10.4.2
Required	Required	Required	Roadway segment AADTs or intersection approach AADTs for all years in the evaluation period and historical years when using EB.
Required		Required	All observed crash data for each segment or intersection being analyzed.
	Required	Required	SPFs contained in IHSDM.
	Required	Required	WisDOT calibration factors, stored in IHSDM Admin file.
Required	As Needed	As Needed	CMFs for countermeasures.

Step 3. Compare the analysis methods and determine an overall method for evaluation.

Results generated using different methods should not be compared so careful planning is needed to ensure the most reliable analysis method is used at a specific project location. In some rare cases, it may make sense to apply one method at one project location and another method at a separate project location. This should be documented in the SCD and the results should not be compared to one another.

Step 4. Develop the required data for analysis.

Compile the necessary data for your project.

- Determine the years of the observed crash period.
  - Use up to five of the most recent years of crash data.
  - Confirm no geometric or traffic control changes have occurred over the duration of the crash data. If changes have occurred, utilize only the years of crash data after the change, with a minimum of two years of data.
- Obtain the crash data for the observed crash period.
  - Identify the number, type, and severity of the crashes.
- Obtain the AADTs for the observed crash period.
- Determine the years of the evaluation period.

  - The evaluation period is ten years for all safety analyses.
  - The first year of the evaluation period is the construction year.
- Determine the AADTs for the evaluation period.
  - Obtain, at a minimum, the forecasted volumes for the first year and last year of the evaluation period. The analysis tools will automatically interpolate between the two volumes for each year.
  - If additional forecasted volumes are known, they should be included in the analysis.
- If external CMFs are needed for the base case or any alternative, obtain the appropriate CMFs from the WisDOT CMF Table. Refer to TEOpS 12-3 for WisDOT's CMF policy.
  - For each CMF, document the treatment name and CMF# in IHSDM.
  - For each countermeasure, assume the Start CMF Year is the construction year and the End CMF Year is the last year of the analysis period.
- For each analysis location, identify the largest "footprint" for all the alternatives. This is the area that should be evaluated for all alternatives, including the base case.
- For each alternative, obtain roadway characteristics and geometric inputs.

Step 5. Perform the safety analysis.

For the base case and each alternative, perform the safety analysis with the method identified in Step 3. At a minimum, determine the number of total crashes, fatal and injury (KABC) crashes, and property damage only (PDO) crashes.

- Method 1 uses the Highway Safety Benefit-Cost Analysis Tool.
- Methods 2A/2B and 3A/3B use the IHSDM for analysis.

When using IHSDM, select the WisDOT Calibration File, as shown in Figure 10.6.

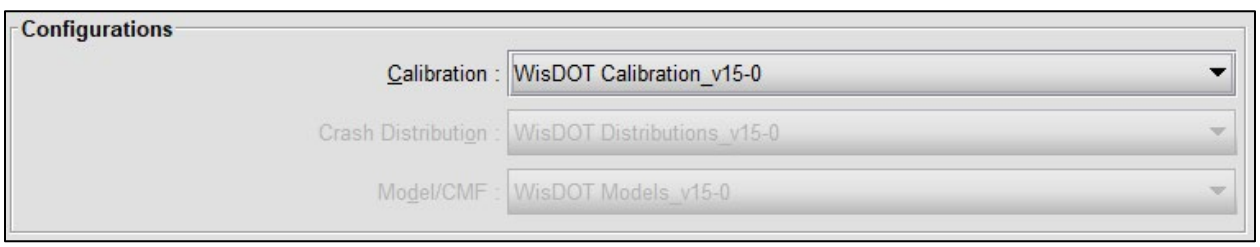

Figure 10.6 IHSDM Crash Analysis Configurations

Step 6. Document the results.

For the base case and each alternative, document the number of total crashes, fatal and injury (KABC) crashes, and property damage only (PDO) crashes in the Safety Certification Document (SCD). Also, document any External CMFs that were used and any other assumptions or judgements pertinent to the analysis.

10.5.3 Economic Appraisal

10.5.3.1 General

The purpose of the economic appraisal process is to compare the estimated benefits of a proposed safety improvement with the estimated costs of that improvement. The economic appraisal process can be used to determine the cost-effectiveness of proposed safety improvements, identify and prioritize improvements with the highest return on investment, and help select an alternative in the decision-making process. To ensure projects are compared consistently, the analysis period (i.e. return on investment period) is assumed to be ten (10) years; the construction year plus nine (9). Key outputs of this process include an estimated benefit-cost ratio and the net-present value of each safety improvement alternative. Each of these outputs should be considered when selecting the most appropriate improvement option. Refer to Table 1.2 for definitions of terms used in the Economic Appraisal process.

Table 10.2 lists the potential benefits of a safety improvements that can be monetized for benefit-cost analysis:

***Table 10.2* Benefits of Safety Improvements**

Element of Benefit	Description
Crash Benefits	Calculates the monetary benefit for annual crash reductions resulting from a reduction in crash frequency and severity.
Travel Time Benefits	Currently not applicable
Reliability Benefits	Currently not applicable
Vehicle Operating Cost Benefits	Currently not applicable
Emission Benefits	Currently not applicable

Table 10.3 lists the descriptions of the safety improvement costs:

***Table 10.3* Costs of Safety Improvements**

Element of Cost	Description
Project Support	Currently not applicable
Construction	Costs of materials and construction to build the improvement.
Real Estate	Costs to acquire property necessary to build the improvement.
Maintenance and Operation	Currently not applicable
Rehabilitation	Currently not applicable
Mitigation	Currently not applicable

The Safety Certification Process focuses on evaluating safety impacts and does not cover any other benefits or costs to a project, such as vehicle travel time, delay, vehicle operating costs, or vehicle emissions.

10.5.3.2 Crash Costs

Crash costs are estimated monetary values that a state agency adopts to quantify the impact of a change in safety performance as part of a benefit-cost analysis.

Table 10.4 summarizes the approved crash costs for use in the economic appraisal process.

***Table 10.4* Crash Costs for Benefit-Cost Analysis in 2016 Dollars**

Crash Severity (WisDOT terminology)	KABCO Abbreviation (Most severe injury in crash)	Crash Severity (HSM Terminology)	WisDOT Crash Cost
Fatal	K	Fatal	$10,897,580
Suspected Serious Injury	A	Serious Injury or Disabling	$613,781
Suspected Minor Injury	B	Evident Injury or Non-disabling	$194,022
Possible Injury	C	Possible Injury	$110,830
Property Damage Only (PDO)	O	No Injury	$10,173

Wisconsin-specific crash costs were developed using the methods described in FHWA's Crash Costs for

Highway Safety Analysis guide. These crash costs were developed along with the Highway Safety Benefit-Cost Analysis tool described in FDM 11-38-10.5.3.2 and can be download for use in IHSDM in the Tools section below. Crash costs are periodically updated to reflect changes in economic measures.

10.5.4 Safety Mitigation Certification Process Tools

The following tools should be used when conducting the SMCP:

1. **IHSDM** – The Interactive Highway Safety Design Model (IHSDM) applies the HSM analysis methods and economic appraisal process. WisDOT created state-specific files to improve the reliability of the crash analysis and economic appraisal results. Analysts shall use the following files:

File Purpose	File Name
Calibration Data Sets	WisDOT_Calibration_v15-0
Crash Distribution Data Sets	WisDOT_Distributions_v15-0
Model Data Sets	WisDOT_Models_v15-0
Economic Analysis Model Data Sets	WisDOT_Economics_v15-0

   These files can be downloaded from WisDOT's website under the "Safety and Speed" section. To utilize these files within IHSDM save a copy in the "config" folder.

   Additional information and detailed tutorials can be found at www.ihsdm.org.

2. Highway Safety Benefit-Cost Analysis Tool – Used only for Method 1. The calculations for the EA are completed in the same manner as those implemented in the IHSDM.

3. **WisDOT CMF Table** – Contains a list of WisDOT approved crash modification factors (CMFs) as well as a CMF calculator to combine CMFs. For more information regarding WisDOT's CMF policy, go to TEOpS 12-3.

Both IHSDM and the Highway Safety Benefit-Cost Analysis Tool can conduct the Economic Appraisal.

10.6 Safety Certification Document (SCD)

10.6.1 General

This section explains the requirements for the Safety Certification Document (SCD), the product of the Safety Certification Process (SCP). The purpose of the SCD is to:

1. Summarize the process consistently across projects.
2. Provide data, assumptions, and details of engineering judgment used throughout the process.
3. Document the safety performance and economic appraisal of safety improvement alternatives.
4. Document formal approval.

The SCD should not state a definitive recommendation for an alternative since safety is only one aspect of the project decision-making process. It is possible that new alternatives may need to be evaluated later in the project development process or an alternative without the highest safety benefit-cost ratio is preferred. A template for the SCD is in Attachment 10.7.

10.6.2 Content

The first piece of the SCD is a summary narrative that is consistent across projects.

Important process outputs shall be attached to the narrative to complete the details of the document. Those important elements associated with each of the process steps as outlined in FDM 11 38-10 are shown in Table 10.5. This table presents the data that the analyst should save from each step of the SCP. The analyst should use judgment to document and save additional data as project-specific issues arise that are beyond the needs described in the table.

***Table 10.5* Documentation Needs and Format**

Step in SCP	Data to Include in SCD Attachments	Format
Sites of Promise by System Screening	Tabular data illustrating safety flags for segments and intersections. This could include Meta-Manager, a SCM report, or the Intersection Network Screening spreadsheet.	PDF
Crash Vetting for Sites of Promise	WisTransPortal crash data spreadsheet with crash vetting comments	PDF
Contributing Geometric Analysis (CGA) Process	Safety Certification Worksheet	PDF
Safety Mitigation Certification Process	IHSDM Crash Prediction Evaluation Reports	PDF
	IHSDM Economic Analysis Reports	PDF
	Highway Safety Benefit-Cost Analysis Tool results	PDF

10.6.3 Approval Process

Concurrence by the Bureau of Traffic Operations (BTO), Traffic Engineering and Safety Section, is required for all projects that complete the Safety Mitigation Certification Process (SMCP). This review and concurrence process shall occur prior to approval by the Regional Planning Chief. The intent of BTO's review is to ensure the policy, methods, and tools described in FDM 11-38 are applied consistently statewide. Review of detailed inputs and outputs shall be completed by the Region.

Send the SCD and all supporting documents to DOTBTOSafetyEngineering@dot.wi.gov. BTO will review the SCD and provide comments or concurrence to the Region within 15 business days.

Regional Planning Chiefs shall approve all project Safety Certification Documents.

10.7 List of Attachments

Attachment 10.1 Safety Certification Process Flowchart

Attachment 10.2 Safety Certification Worksheet

Attachment 10.3 Sites of Promise by System Screening Process Flowchart

Attachment 10.4 Safety Improvement Prompt List

Attachment 10.5 Design Elements Covered in HSM Predictive Methods

Attachment 10.6 Flowchart for Selecting a Safety Analysis Method

Attachment 10.7 Safety Certification Document

FDM 11-38-15 Examples for Safety Certification Process *November 30, 2018*

15.1 General

Examples for the Safety Certification Process can be found on the Traffic Operations Manuals web page:

https://wisconsindot.gov/Pages/doing-bus/local-gov/traffic-ops/manuals-and-standards/manuals.aspx

The examples include all five Performance Based Safety Engineering Analysis methods and associated Economic Appraisals. These examples are limited in nature and are for demonstrative purposes in exemplifying the Safety Certification Process.

FDM 11-38-99 References *February 18, 2020*

99.1 References

1. Highway Safety Benefit-Cost Analysis Guide. FHWA Safety Program. Federal Highway Administration.

February 2018. https://safety.fhwa.dot.gov/hsip/docs/fhwasa18001.pdf

2. Crash Modification Factors in Practice, Quantifying Safety in the Roadway Safety Management Process. FHWA Office of Safety. Federal Highway Administration.

3. Highway Safety Benefit-Cost Analysis Tool: Reference Guide. FHWA Safety Program. Federal Highway Administration.

4. Crash Modification Factors in Practice, Using CMFs to Quantify Safety in the Development and Analysis of Alternatives. FHWA Office of Safety. Federal Highway Administration.

5. Highway Safety Manual. American Association of State Highway and Transportation Officials. 2010.

6. Highway Safety Manual User Guide. National Cooperative Highway Research Program 17-50. Lead States Initiative for Implementing the Highway Safety Manual. August 2014.

7. Crash Cost for Highway Safety Analysis. FHWA Safety Program. Federal Highway Administration. January 2018. https://safety.fhwa.dot.gov/hsip/docs/fhwasa17071.pdf

8. IHSDM Economic Analyses Tool Help. FHWA Geometric Design Lab. Federal Highway Administration. September 2017. http://www.ihsdm.org/w/images/b/b6/IHSDM_Economic_Analysis_Tool_Help.pdf