INNOVATIVE SAFETY ANALYSIS RESOURCES FROM THE UNITED STATES

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ABSTRACT

In the highway industry, when difficult choices must be made, confidence is often taken in predictions of project cost, operational impacts, and environmental impacts because of the known quantitative tools available to support these decisions. Prior to the first edition of the Highway Safety Manual (HSM) recently published in the United States (U.S.), transportation professionals in the U.S. did not have a recognized national resource for quantifying highway safety impacts. There were no widely accepted tools available for quantifying changes in expected safety performance as a result of transportation system decisions. As a result, safety considerations often carried little weight in the project development process, limiting the ability of transportation professionals to discuss and act upon safety objectively. An effective resource was urgently needed to quantify and predict the expected safety performance of elements considered in road planning, design, construction, operation, and maintenance.

The HSM begins to fill this gap, providing transportation professionals with current knowledge, techniques and methodologies to quantify safety impacts – analogous to the way operational impacts are quantified in the Highway Capacity Manual, and environmental impacts through the National Environmental Policy Act process. The HSM provides the best factual information and tools in a useful form to facilitate roadway decisions based on explicit consideration of the effects of these decisions on potential future crash frequency and severity. The HSM methodologies are primarily supported by two software programs, *SafetyAnalyst* and the Interactive Highway Safety Design Model (IHSDM). *SafetyAnalyst* provides a set of software tools for highway safety management. The IHSDM is a suite of analysis tools for evaluating the safety and the operational effects of geometric design decisions on highways.

This paper will present an overview of the HSM and the corresponding software support tools, *SafetyAnalyst* and IHSDM. Other innovative safety analysis resources will also be highlighted.

1. INTRODUCTION

Since the 1950’s, U.S. transportation professionals have been able to quantitatively assess project alternatives based on mobility and more recently in terms of environmental impact. Unfortunately, limited means existed to assess the safety performance of different design alternatives. Prior to the first edition of the Highway Safety Manual (HSM)[1] published in 2010 in the U.S., transportation professionals did not have a recognized national resource for quantifying highway safety impacts. There were no widely accepted tools available for quantifying changes in expected safety performance as a result of transportation system decisions. As a result, safety considerations often carried little weight in the project development process, limiting the ability of transportation professionals to discuss and act upon safety objectively. An effective resource was urgently needed to quantify and predict the expected crash frequency of elements considered in road planning, design, construction, operation, and maintenance.

The HSM begins to fill this gap by providing transportation professionals with current knowledge, techniques, and methodologies to quantify safety impacts – analogous to the way operational impacts are quantified in the Highway Capacity Manual, and environmental impacts through the National Environment Policy Act process. The HSM provides tools in a useful form to facilitate explicit consideration of the safety effects of roadway decisions. It is a resource that assembles currently available information and methodologies for measuring, estimating, and evaluating safety. The quantitative methods and procedures can be used to estimate highway safety in the project development and road safety management processes.

The use of the HSM is not a requirement in the U.S. However, it's being strongly promoted at the national level for wide scale deployment across the fifty states to make significant advancements. Rather than being prescriptive, the HSM presents knowledge and tools that can be used in planning, programming, design, operations, and maintenance activities. The strengths and limitations of the various tools are presented. The purpose is to convey the latest safety methods and knowledge for use by a broad array of transportation professionals. The HSM is intended for use by state departments of transportation (DOTs), counties, metropolitan and regional planning organizations, cities, and international organizations.

The HSM permits the use of predictive methodologies for assessing alternative designs for highways. The more rigorous methods reduce the vulnerability of statistics to random variations of crash data and provide a means to estimate crashes based on roadway geometry, operational characteristics, and traffic volumes. These techniques provide an opportunity to significant improve common practices such as: 1) screening a road network to target the most promising locations for safety investments, and 2) conducting safety assessments of different alternative designs for upgrading existing highways and constructing new highways.

Information about the HSM can be found at http://www.highwaysafetymanual.org . At this site, there are many resources related to training, technical assistance, and outreach.

2. PARTS OF THE HSM

The HSM is organized into four parts:

"Part A, Introduction, Human Factors, and Fundamentals" describes the purpose and scope of the HSM, and explains the relationship of the HSM to planning, design, operations, and maintenance activities. It introduces the fundamentals of key processes and tools outlined in the manual. The chapter provides background information needed to apply the predictive methods, crash modification factors, and evaluation methods provided in Parts B, C, and D.

The chapters in Part A are:

- Chapter 1 – Introduction and Overview
- Chapter 2 – Human Factors
- Chapter 3 – Fundamentals

“Part B, Roadway Safety Management” presents steps for monitoring and reducing crash frequency and severity on existing roadway networks. It includes methods useful for: 1) identifying sites with the most potential for achieving safety gains; 2) diagnosis of safety concerns; 3) countermeasure selection; 4) economic appraisal; 5) project prioritization, and 6) effectiveness evaluation.

The chapters in Part B are:

- Chapter 4 – Network Screening
- Chapter 5 – Diagnosis
- Chapter 6 – Select Countermeasures
- Chapter 7 – Economic Appraisal
- Chapter 8 – Prioritize Projects
- Chapter 9 – Safety Effectiveness Evaluation

“Part C, Predictive Methods” describes the predictive methods for estimating safety performance (i.e., expected crash frequencies by severity) of a network, facility or individual site. Part C is a source for safety performance functions (SPFs). SPFs estimate crash frequency as a function of traffic volume and roadway characteristics (e.g., number of lanes, median type, traffic control, number of approach legs).

As shown in Table 1, the chapters in Part C provide the predictive methods for segments and intersections for the following facility types:

- Chapter 10 – Rural Two-Lane Roads
- Chapter 11 – Rural Multilane Highways
- Chapter 12 – Urban and Suburban Arterials

Table 1 - Facility Types with Safety Performance Functions

HSM Chapter	Undivided Roadway Segments	Divided Roadway Segments	Intersections			
			Stop Control on Minor Leg(s)		Signal Control	
			3-Leg	4-Leg	3-Leg	4-Leg
10 Rural Two-Lane, Two-Way Roads	X		X	X		X
11 Rural Multilane Highways	X	X	X	X		X
12 Urban and Suburban Arterials	X	X	X	X	X	X

Note: X denotes the facility types with a safety performance function

Predicting average crash frequency as a function of traffic volume and roadway characteristics is an approach that can be readily applied in a variety of ways, including design projects, corridor planning studies, and intersection studies. The approach is applicable for both safety specific studies and as an element of a more traditional transportation study or environmental analysis.

Part D, Crash Modification Factors, provides a catalog of crash modification factors (CMFs), which represent the change in crash frequency due to a particular countermeasure or treatment. CMFs are used to estimate the change in the expected average crash frequency plus or minus the standard error. CMFs are developed by research studies that evaluate and quantify the crash effects of countermeasures. Such studies can be designed in a variety of ways and can range in terms of quality, depth, and statistical rigor, leading to CMFs of varying quality and reliability. CMFs are central to the predictive method presented in Part C of the HSM. The broad set of CMFs in Part D covers various safety treatments and changes in design and traffic control features organized within the following chapters:

- Chapter 13 – Roadway Segments
- Chapter 14 – Intersections
- Chapter 15 – Interchanges
- Chapter 16 – Special Facilities
- Chapter 17 – Road Networks

Table 2 provides an example of a set of CMFs for a median on multi-lane roads.

Table 2 - Sample Crash Modification Factors

Potential Crash Effects of Providing a Median on Multi-lane Roads

Treatment	Setting (Road Type)	Traffic Volume	Accident Type (Severity)	CMF	Standard Error
Provide a median	Urban (Arterial Multilane)	Unspecified	All types (Injury)	0.78	0.02
			All types (Non-injury)	1.09	0.02
	Rural (Multilane)		All types (Injury)	0.88	0.03
			All types (Non-injury)	0.82	0.03

Base Condition: Absence of raised median

A CMF of 0.78 implies a 22 percent reduction in the set of target crashes that were evaluated.

3. INTEGRATING THE HSM WITH THE PROJECT DEVELOPMENT PROCESS

The project development process involves the typical stages from planning, design, post-construction operations, and maintenance activities. The HSM can be applied to each step of the process. Figure 1 shows the relationship between a generalized project development process and the HSM.

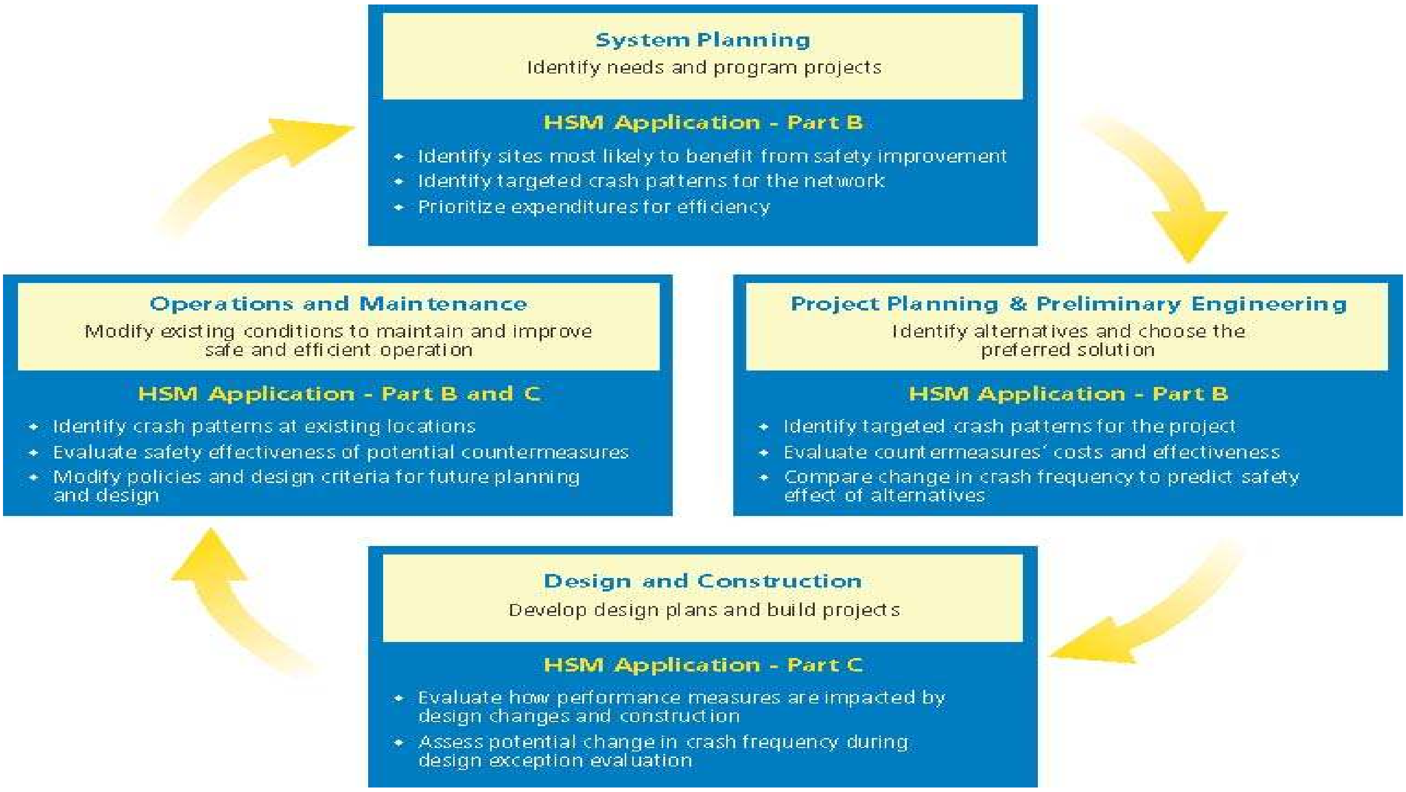

Figure 1 – Applications of the HSM in the Project Development Process

System planning is the first stage of the project development process. This stage is an opportunity to identify system safety priorities and to integrate safety with other project types (e.g., corridor studies, streetscape enhancements). Chapter 4, “Network Screening,” is used to identify sites most likely to benefit from safety improvements. Chapter 5, “Diagnosis,” is used to identify crash patterns to target for improvement at each site. Chapter 6, “Select Countermeasures,” is used to identify the factors that may be contributing to the observed crash patterns and to select the corresponding countermeasures. Chapter 7, “Economic Appraisal,” is used to perform an evaluation of costs and benefits of a specific countermeasure or several alternative countermeasures for a specific site. Chapter 8, “Prioritize Projects,” is used to prioritize expenditures by identifying the projects that will likely result in the greatest safety gains from certain improvements at targeted locations.

During the project planning stage, alternatives are developed and analyzed to enhance a specific performance measure or a set of performance measures, such as, capacity, multimodal amenities, transit service, and safety. Each alternative is evaluated across these multiple performance measures by weighing project costs versus project benefits.

These projects can include extensive redesign (e.g., altering the base number of lanes on an existing roadway and other changes that would substantially change the operational characteristics of the site) or design of new facilities. For this stage, Part C provides for a quantitative safety assessment of different design alternatives. The result of this stage is selecting the alternative to carry forward into preliminary design.

During the design phases, Chapters 5 through 7 of Part B and Part D and can be used to diagnose safety issues, select countermeasures, and conduct economic evaluations. The preliminary and final designs and the construction stage include iterations and reviews for modifications to the preferred design. As modifications are made, their potential safety effects should be assessed to confirm that the changes are consistent with the ultimate project goal and intent.

Activities related to operations and maintenance focus on evaluating roadway network performance, identifying near-term improvements to the system, implementing improvements to the existing network, and evaluating the effectiveness of policies and projects. These activities can be conducted from a safety perspective using Chapter 5, to identify crash patterns at an existing location, and, Chapter 6 and Chapter 7, to select and appraise countermeasures. Throughout this process, Part D serves as a resource for CMFs. Chapter 9 provides methods to conduct an effectiveness evaluation of countermeasures. The results of these evaluations can contribute to the implementation of changes to changes to policy, and to the development of design criteria for future transportation system planning.

4. BENEFITS OF HSM

The HSM provides a set of proven analysis tools to encourage explicit consideration of the safety-related effects of transportation decisions. Many of the methods in the HSM can compensate for the variability of crash data to provide more stable and reliable results. These results will lead to better safety investment decisions. The HSM also provides opportunities to realize cost savings during project development, operations, and maintenance activities. Decisions made based on quantitative evaluations that predict changes in safety performance instill more confidence that safety funds are being applied effectively. Time spent justifying a safety decision should be reduced by conducting a definitive, statistical analysis. As noted, the tools in the HSM make it possible to integrate safety analysis into the project development process.

Specific benefits exist for a wide range of transportation practitioners. For safety engineers, the HSM provides tools to identify locations needing safety improvements. It supports the identification of crash patterns, contributing factors, and countermeasures most likely to reduce the frequency and severity of crashes. Safety engineers can also use the HSM tools to better evaluate the economic viability of individual projects and prioritize projects across a system. The HSM helps guide them in making investment decisions to achieve maximum reductions of fatalities and injuries.

Traffic operations engineers can use the HSM to more accurately assess the effects of operational decisions on safety. Specifically, the HSM provides information on the safety effects of traffic signal timing adjustments, the addition of left- and right-turn lanes at intersections, the addition of intersection lighting, and the presence or absence of on-street parking on a roadway facility.

During the project design stage, the HSM can assist the designer to determine the expected crash frequency and severity outcomes of design alternatives related to changes in roadway cross-section, alignment, and intersection configuration or operations. The designer can use predictive methods for evaluating and comparing safety of situations such as:

- Existing facilities under past or future traffic volumes
- Alternative designs (e.g., roadway widening alternatives) for an existing facility under past or future traffic volumes
- Designs for a new facility under future (forecast) traffic volumes
- The estimated effectiveness of proposed countermeasures on an existing facility (prior to implementation)
- Estimated effectiveness of countermeasures after a period of implementation
- Effect of design exceptions

The HSM also supports planners' efforts to identify and select projects to achieve the greatest return from a safety investment perspective. This information can be used to identify projects for safety funding, incorporate safety into long-range plans, and evaluate previously funded programs and projects. As future transportation improvement plans are developed, the planner can more effectively balance the system's safety needs with other considerations during project programming.

5. SOFTWARE TOOLS SUPPORTING HSM

The HSM methodologies are supported primarily by two software tools: 1) *SafetyAnalyst*, and 2) Interactive Highway Safety Design Model (IHSDM).

SafetyAnalyst[2] incorporates state-of-the-art safety management approaches into computerized analytical tools for guiding the decision-making process to identify safety improvement needs and develop a system-wide program of site-specific improvement projects. *SafetyAnalyst* is applicable to Part B of the HSM. The tool has a strong basis in cost-effectiveness analysis. *SafetyAnalyst* was developed as a cooperative effort by the Federal Highway Administration (FHWA) and twenty-seven state departments of transportation and two local agencies.

Research over the last 20 years has developed new statistical methodologies for network screening to identify locations in need of improvement to overcome the drawbacks of several procedures used in practice and the *SafetyAnalyst* software implements these new approaches. *SafetyAnalyst* uses an Empirical Bayes (EB) approach that combines observed and expected accident frequencies to provide estimates of the safety performance of specific sites that are not biased by regression to the mean. The EB approach incorporates non-linear regression relationships between traffic volume and expected accident frequency. The sites identified by the network screening methodology are referred to as "sites with potential for safety improvement" because they will be sites that have potential as locations where improvements can result in substantial crash reduction.

One new measure that has been proposed for network screening application is the potential for safety improvement (PSI) index. PSI is a measure of the excess accident frequency, above the expected value, that might be reduced if a safety improvement were implemented. Tables 3 and 4 present some simple numerical examples with actual data for signalized intersections from a particular city to show that PSI provides site rankings that differ from those based on accident frequency and accident rate.

In Table 3, a group of signalized intersections has been ranked according to their accident frequencies during a five-year period. The last column in the table shows the ranking based upon the PSI. It should be noted that, based on the crash frequency rankings, the city would improve the highest-volume location first. Based on PSI, the highest-ranking intersection would be a lower-volume intersection, ranked sixth in accident frequency, showing a greater potential for accident reduction.

Table 3 - Comparison of rankings by accident frequency and PSI for signalized intersections in a particular city

Intersection	Total Accident Frequency (1995-99)	Average Annual Daily Traffic (vehicles/day)	Accident Frequency Ranking	Potential for Safety Improvement (PSI) Ranking
A	131	63502	1	2
B	104	35284	2	3
C	77	57988	3	11
D	75	46979	4	6
E	66	51933	5	10
F	51	48427	6	1
G	51	20423	7	15
H	46	34759	8	5
I	42	53396	9	61
J	38	25223	10	17

In Table 4, the intersections in the same city have been ranked according to accident rate. The last column in the table shows the ranking based upon the PSI. It should be noted that, if the city improved the five highest-ranking intersections based on accident rate, it would not improve any of the three highest-ranking intersections based on the potential improvement benefits. It should also be noted that scarce financial resources will be allocated to sites ranked 33rd and 35th in PSI, while over 30 intersections with greater potential for safety improvements might go untreated.

Table 4 - Comparison of rankings by accident rate and PSI for signalized intersections in a particular city

Intersection	Total Accident Frequency (1995-99)	Average Annual Daily Traffic (vehicles/day)	Accident Frequency Ranking	Potential for Safety Improvement (PSI) Ranking
N	18	5063	1	33
M	22	7009	2	9
L	27	8152	3	8
R	14	4402	4	35
K	33	10458	5	4
B	104	35284	6	3
O	18	4242	7	14
A	131	63502	8	2
P	16	7815	9	19
J	38	25223	10	17

These comparisons show that state-of-the-art analysis tools can help highway agencies make better decisions about where to invest the funds available for safety improvement. American Association of State Highway Transportation Officials (AASHTO) manages distribution, technical support, maintenance, and enhancement of *SafetyAnalyst* as a licensed AASHTOWare product. Additional information can be found at www.safetyanalyst.org

The IHSDM[3] is a suite of software analysis tools for evaluating the safety and operational effects of geometric design decisions on highways. As a decision-support tool, it checks existing or proposed highway designs against relevant policy values and provides estimates of a design's expected safety and operational performance. The IHSDM performs the predictive method for the facilities in Part C of the HSM (i.e., two-lane rural highways, rural multilane highways, and urban and suburban arterials). IHSDM currently includes six evaluation modules (Crash Prediction, Design Consistency, Intersection Review, Policy Review, Traffic Analysis, and Driver/Vehicle). The IHSDM website (www.tfhrc.gov/safety/ihsdm/ihsdm.htm) summarizes the capabilities and applications of the evaluation modules and provides a library of the research reports documenting their development.

Another important software tool is the Crash Modification Factors (CMFs) Clearinghouse which houses a web-based database of CMFs along with supporting documentation to help transportation professionals identify the most appropriate countermeasure for their safety needs. Using this site at www.cmfclearinghouse.org, users are able to search on CMFs or submit their own CMFs to be included in the clearinghouse. While the HSM provides only the best available research-based CMFs, the CMF Clearinghouse is a comprehensive listing of available CMFs. The CMF Clearinghouse does include all of the CMFs listed in the HSM which meet strict inclusion criteria as described in *Transportation Research Circular E-C142, Methodology for the Development and Inclusion of Crash Modification Factors in the First Edition of the Highway Safety Manual*[4] *(http://onlinepubs.trb.org/onlinepubs/circulars/ec142.pdf)*.

Both the HSM and the CMF Clearinghouse have a review process for CMFs and assign a "confidence" in the CMF based on the quality of the study that produced it. The HSM review process applies an adjustment factor to the study's CMF (to correct for regression-to-the-mean and traffic volume bias) and a method correction factor to the study's standard error (to correct for the study design and method selected, sample size, confounding factors, and other study characteristics documented during the critical review of each study). The CMF Clearinghouse review process rates the CMF according to five categories — study design, sample size, standard error, potential biases, and data source — and judges the CMF according to its performance in each category. It assigns a star rating (one through five) based on the cumulative performance in the five categories. It differs from the HSM process in that it does not attempt to adjust the standard error, but similarly to the HSM it explicitly considers similar criteria such as data source, which examines whether a study used data from just one locality or from multiple locations across the state or nation, among others.

6. OTHER RESOURCES

Another software tool worth mentioning which is not tied directly to the HSM is PlanSafe (http://www.trb.org/Main/Blurbs/PLANSAFE_Forecasting_the_Safety_Impacts_of_SocioDe_163790.aspx.) This tool provides an analytical set of algorithms to forecast the safety impacts of engineering and behavioral countermeasure investments at the planning-level. The software is generally compatible with planning-level data inputs to incorporate the analytical procedures for forecasting safety. Guidance materials are available to support the use of the analytical procedures and software. PlanSafe estimates crashes at the planning level based on socio-demographic changes, network related changes (such as traffic volumes and large scale projects), and engineering & behavioral countermeasures. It allows users to compare different crash outcomes for different growth scenarios.

With respect to other CMF resources, a Guide to Developing Quality Crash Modification Factors Clearinghouse[5] (http://safety.fhwa.dot.gov/tools/crf/resources/fhwasa10032/) was developed. The purpose of this guide is to provide direction to organizations and professionals 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.

The guide opens with a background of CMFs, including the definition of CMFs and related terms, purpose and application, and general issues. The guide then introduces various methods for developing CMFs. Discussion of these methods is not intended to provide step-by-step instruction for application. Rather, this guide discusses study designs and methods for developing CMFs, including an overview of each method, sample size considerations, and strengths and weaknesses. A resources section is provided to help users identify an appropriate method for developing CMFs based on the available data and characteristics of the treatment in question.

Building from the guidance developed, a new project has started to prepare a recommended protocol for the development of CMFs to ensure their accuracy and their suitability for use in planning safety improvement programs. The protocol will establish acceptable and consistent methods for developing CMFs that are statistically rigorous, free of biases, and will meet the CMF quality criteria for inclusion in the HSM and the CMF

Clearinghouse. The protocol will build on the guidance developed in the “A Guide to Developing Quality Crash Modification Factors.”

At a minimum, the protocol will accomplish the following:

- Identify statistical methods that are acceptable for the development of CMFs and will emphasize methods that are most likely to provide accurate and unbiased CMFs.
- Emphasize those evaluation methods that have the capability to compensate for potential biases due to regression-to-the-mean. The guideline will highlight observational before-after evaluations using the Empirical Bayes (EB) method for developing CMFs. The protocol should also suggest what approach (es) should be considered when the EB method is not feasible.
- Present study methods in sufficient detail that researchers and evaluators can understand the methods and apply them properly; material from Chapter 9 of the HSM will be used as appropriate.
- Identify existing software tools, with a brief description of the methods used, such as the *SafetyAnalyst* software that may be available to implement the evaluation methods.
- Encourage the reporting of the results of evaluations that quantify CMFs in an appropriate form so that their accuracy and acceptability can be readily and independently assessed. Such reporting should include a complete description of the countermeasure, treatment, or change in design or traffic control element evaluated; the type of study methodology used; the numbers, types, locations, and characteristics of sites used in the evaluation; sample sizes of analysis datasets, standard errors of CMFs; statistical significance of the results; and any recognized potential biases with the results.
- Encourage development of CMF values that indicate differences in the safety effects of countermeasures or treatments between various crash severity levels and between various crash or collision types.
- Address the situations in which CMFs should be presented as tabulated values and situations in which a mathematical function may be used to quantify the value of a CMF.
- Present and explain the criteria used to establish star quality ratings for CMFs for the CMF clearinghouse and the criteria established by the Transportation Research Board Committee on Highway Safety Performance to assess the acceptability of CMFs for inclusion in the HSM, so that researchers and evaluators understand how their results will be judged.

The protocol will be made available to agencies that sponsor or fund countermeasure evaluations and to researchers and evaluators who develop CMFs to increase the likelihood that accurate and unbiased CMFs will be obtained. The goal of the protocol is to ensure future CMFs will achieve high quality ratings when incorporated into the CMF Clearinghouse and will be judged acceptable for incorporation in future editions of the HSM.

One last analysis resource to mention is related to sustainability. The FHWA is launching an initiative to support transportation agencies in making projects more sustainable. A sustainable highway should satisfy the functional requirements of societal development and economic growth while reducing the negative impacts on the environment and consumption of natural resources. This new program provides practical tools for integrating sustainability best practices in transportation projects and programs. It encompasses the entire life cycle of a transportation project – from system and project planning through system and project planning through design, construction, and operations and maintenance. The principal feature of the program is a web-based tool that helps transportation professionals evaluate or score projects, programs, or agency practices. The tool assigns a weight or point value to each sustainable practice on the basis of relative impact on roadway sustainability. One goal incorporated into the tool is safety with respect to improving human health by implementing projects that reduce serious injuries and fatalities. Points are earned by incorporating the use of science-based analysis tools such as the HSM into all aspects of the project development process. More information about this tool can be found at http://www.sustainablehighways.org/

7. SUPPORTING DATA EFFORTS

Given the data requirements of the various analysis tools, the FHWA has initiated new efforts to support state and local agencies with their data programs. One of the biggest gaps in state and local safety data systems pertains to roadway data (such as the design characteristics of the cross section and alignment). The FHWA is conducting a data capability assessment of all fifty states' safety data systems with a focus on their roadway data. This project will assist states in identifying gaps in their own programs, while simultaneously collecting the information necessary to provide an understanding of the national state of roadway data systems in the U.S. A methodology will be developed that states can use to perform cost benefit analyses for evaluating investment options in data systems. The methodology will allow data investment needs to be weighed against other highway investment needs through a quantitative analysis.

FHWA will also develop and pilot a Roadway Data Improvement Program. The program will provide States with technical assistance and training on the development of a system for collecting and using roadway data in decision making. One resource currently available to highway agencies is MIRE, the Model Inventory of Roadway Elements (http://www.mireinfo.org/), which provides a recommended listing of roadway inventory and traffic elements critical to safety management. MIRE provides a data dictionary with definitions and attributes for each listed element. Over the past decade, efforts to develop a model and minimum set of crash data elements resulted in the Model Minimum Uniform Crash Criteria (MMUCC) which has become the de facto standard for crash data variables. MIRE was developed as a companion to MMUCC — intended to serve as the recommended de facto standard for roadway and traffic data.

8. FUTURE EDITIONS OF THE HSM

The first edition of the HSM provides state-of-the art knowledge and analysis techniques related to roadway safety management. Furthermore, the U.S. highway safety community recognizes that knowledge and methods of analysis are evolving and improving with new research and lessons learned in practice. The evolution in professional practice and knowledge will be influenced by the first edition because it introduces new methods, techniques, and information to transportation professionals. The knowledge base will continue to grow and to enhance transportation professionals' understanding of how decisions related to planning, design, operations, and maintenance affect crash frequency and severity. The transportation profession will continue to take the opportunity to learn more about safety relationships on various types of facilities. This will be facilitated as agencies improve the processes used to collect and maintain data for crashes, roadway geometry, traffic volumes, land use, and many other useful data to assess the roadway environment and context in which crashes are occurring. These and other potential enhancements in analysis techniques and knowledge will be reflected in future editions of HSM. Also, other facilities such as freeways beyond the roadway types (two-lane rural roads, multi-lane rural highways, and urban and suburban arterials) currently covered will be included.

A work plan for the 2nd edition of the HSM has been created. A draft prioritized list of topics and work items to address in the next edition has been developed. Once the list has been finalized, groups of topical experts will analyze individual issues and develop research problem statements consisting of scopes, brief descriptions of possible work tasks, and estimates of time and funding. It's expected the second edition of the HSM will be produced in the 2014-2016 timeframe.

HSM and the other tools aforementioned will raise the bar for safety by using a science-driven approach. HSM will become the source document for safety in the U.S. covering the multiple perspectives of those involved in transportation planning, safety, and design, and from those responsible for management of the highway transportation system.

The impacts of the HSM use over time will become obvious to all users for any strategy under consideration. It will quantify safety to a level to where it is used in all decisions affecting new and upgraded facilities. Through future development and use, it will have the capacity to apply to any facility or project. The HSM will eventually be institutionalized and in active use in the project development process.

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