HIGHWAY SAFETY MANUAL

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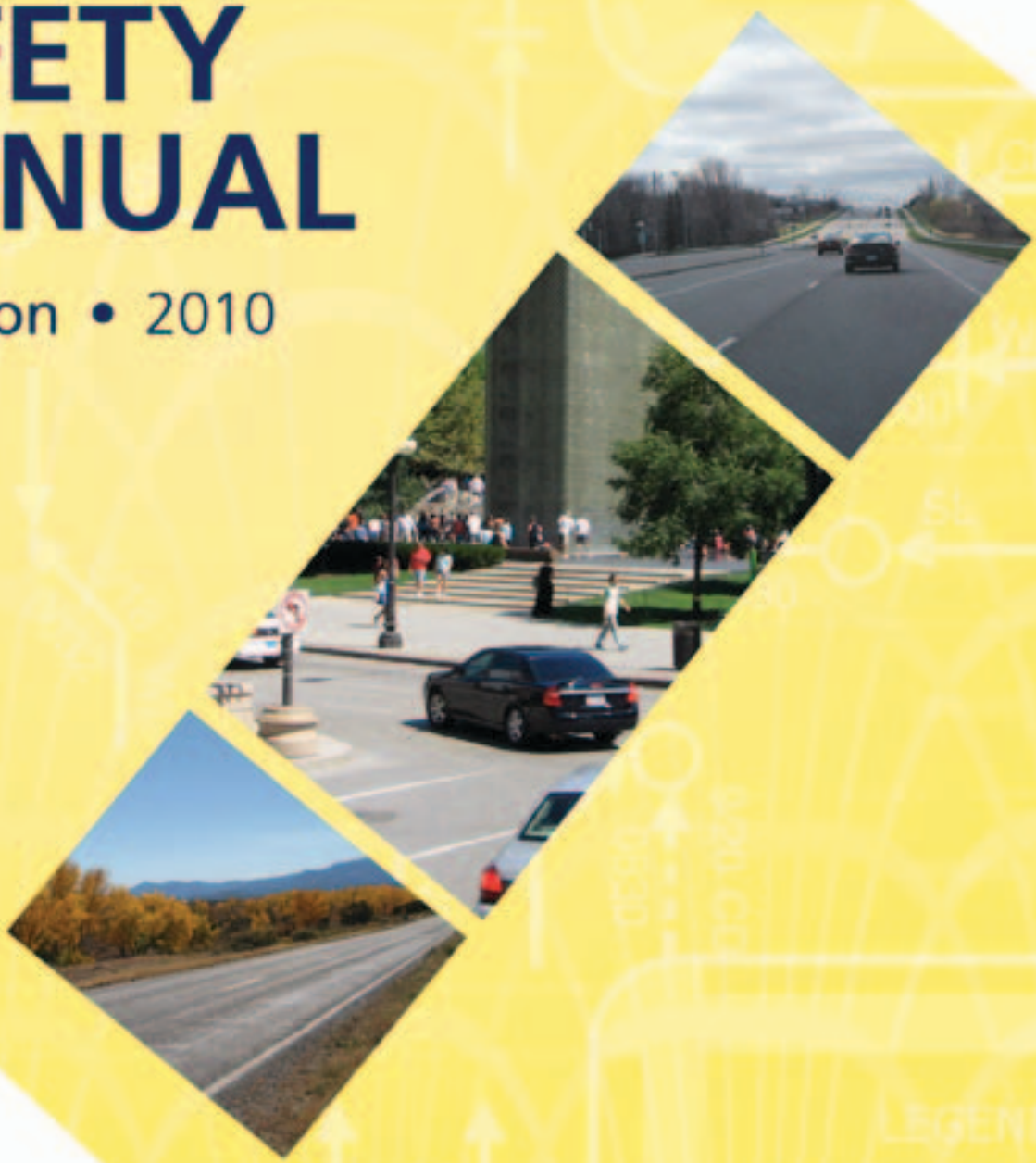

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- NCHRP 17-18(04): Development of an HSM—Draft Table of Contents for the HSM
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- NCHRP 17-25: Crash Reduction Factors for Traffic Engineering and ITS Improvements
  (Published as NCHRP Report 617)
  University of North Carolina—Chapel Hill (David Harkey, Principal Investigator)
- NCHRP 17-26: Methodology to Predict the Safety Performance of Urban and Suburban Arterials
  Midwest Research Institute (Doug Harwood, Principal Investigator)
- NCHRP 17-27: Prepare Parts I and II of the HSM
  iTrans Consulting Ltd. (Geni Bahar, Principal Investigator)
- NCHRP 17-29: Methodology to Predict the Safety Performance of Rural Multilane Highways
  Texas A&M Research Foundation (Dominique Lord, Principal Investigator)
- NCHRP 17-34: Prepare Parts IV and V of the *Highway Safety Manual*
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Preface to the *Highway Safety Manual*

PURPOSE OF THE HSM

The *Highway Safety Manual* (HSM) is a resource that provides safety knowledge and tools in a useful form to facilitate improved decision making based on safety performance. The focus of the HSM is to provide quantitative information for decision making. The HSM assembles currently available information and methodologies on measuring, estimating and evaluating roadways in terms of crash frequency (number of crashes per year) and crash severity (level of injuries due to crashes). The HSM presents tools and methodologies for consideration of "safety" across the range of highway activities: planning, programming, project development, construction, operations, and maintenance. The purpose is to convey present knowledge regarding highway safety information for use by a broad array of transportation professionals.

THE NEED FOR THE HSM

Prior to this edition of the HSM, transportation professionals did not have a single national resource for quantitative information about crash analysis and evaluation. The HSM begins to fill this gap, providing transportation professionals with current knowledge, techniques, and methodologies to estimate future crash frequency and severity and to identify and evaluate options to reduce crash frequency and severity.

In addition to using descriptive methods in better ways, the HSM permits use of predictive methodologies that improve and expand the use of crash estimation methods to new and alternative design or conditions in past or future periods. The more statistically rigorous predictive methods in the HSM reduce the vulnerability of historical crash-based methods to random variations of crash data and provide a means to estimate crashes based on geometry, operating characteristics, and traffic volumes. These techniques provide an opportunity to: 1) improve the reliability of common activities, such as screening a network for sites at which to reduce crashes, and 2) expand analysis to include assessments of new or alternative geometric and operational characteristics.

THE HISTORY OF THE FIRST EDITION OF THE HSM

A special conference session was held at the annual meeting of the Transportation Research Board (TRB) in January 1999 on the subject of predicting highway safety impacts of highway design and operation. The session participants concluded that one reason for a lack of quantitative safety emphasis in decision making is the absence of a single authoritative document to use for quantitatively estimating "safety." In December of 1999, a workshop was held under sponsorship of eight TRB committees and funded by FHWA for the purpose of determining the need for, nature of, and feasibility of producing a highway safety manual. An initial outline and plan for an HSM was produced. This led to the formation of a TRB Joint Subcommittee in May of 2000. Subsequently, the Subcommittee became the Task Force for the Development of a Highway Safety Manual (ANB25T). It was under the direction of this Task Force of volunteers that the materials for this edition were produced. The Task Force formed several subcommittees to oversee various research and development aspects of the task. They also employed independent

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review groups to assess research results before proceeding with final preparation of materials. The majority of the research and development was funded by the NCHRP, with significant supplementary funding and research support provided by the FHWA.

In 2006, the decision was made to publish the HSM as an AASHTO document. A Joint Task Force (JTF) was formed with representatives from the Subcommittees on Design, Traffic Engineering, and Safety Management. The JTF members were tasked with ensuring the HSM meets the needs of the state Departments of Transportation, and with promoting the HSM to their respective subcommittees. In 2009, the subcommittees and parent committees, the Standing Committee on Highways and the Standing Committee on Highway Traffic Safety, balloted and approved the HSM. The AASHTO Board of Directors then approved the HSM.

CONSIDERATIONS AND CAUTIONS WHEN USING THE HSM

The HSM translates analytical tools based upon scientifically based knowledge, methods, and processes into a form that is usable by transportation professionals.

The HSM will be used by individuals with a variety of professional and technical backgrounds, including engineering, planning, field operations, enforcement, and education. They will come to the HSM with different levels of understanding of the fundamentals of roadway safety. Chapter 1, "Introduction and Overview," provides key information and the context for understanding how to apply and integrate safety analysis related to the common activities within highway planning, design, and operations. The HSM includes traditional "safety" analysis techniques and also applies recent developments in crash estimation and evaluation methodologies. A majority of the analytical techniques are new; it is important to fully understand the material presented in Chapter 2, "Human Factors," and Chapter 3, "Fundamentals," to understand reasons for development and use of these techniques.

Because the HSM does not account for jurisdiction-specific differences, it contains calibration techniques to modify tools for local use. This is necessary because of differences in factors, such as driver populations, local roadway and roadside conditions, traffic composition, typical geometrics, and traffic control measures. There are also variations in how each state or jurisdiction reports crashes and manages crash data. Chapter 3, "Fundamentals," discusses this topic and others related to the reliability of crash data. Calibration does not make the crash data uniform across states. Similarly, applying the HSM outside the United States and Canada should be done with caution. The models and research findings presented in this document may not be applicable in other countries as the roadway systems, driver training and behavior, and crash frequencies and severity patterns may be widely different. At a minimum, techniques presented in the HSM should be properly calibrated.

The HSM is not a legal standard of care as to the information contained herein. Instead, the HSM provides analytical tools and techniques for quantifying the potential effects of decisions made in planning, design, operations, and maintenance. There is no such thing as "absolute safety," notwithstanding efforts by government to maintain, improve and operate highway facilities to the highest level that government funding allows. There is risk in all highway transportation. That risk is inherent due to the variability of user behaviors, environmental conditions, and other factors over which the government has no control. A universal objective is to reduce the number and severity of crashes within the limits of available resources, science, technology, and legislatively mandated priorities. Because these considerations are constantly changing, it is unlikely, if not impossible, that any highway facility can be "state of the art". The information in the HSM is provided to assist agencies in their effort to integrate safety into their decision-making processes. The HSM is not intended to be a substitute for the exercise of sound engineering judgment. No standard of conduct or any duty toward the public or any person shall be created or imposed by the publication and use or nonuse of the HSM.

As a resource, the HSM does not supersede publications such as the *Manual on Uniform Traffic Control Devices* (MUTCD), American Association of State Highway Transportation Official's (AASHTO) "Green Book" titled *A Policy on Geometric Design of Highways and Streets*, or other AASHTO and agency guidelines, manuals, and policies. If conflicts arise between these publications and the HSM, the previously established publications should be given the weight they would otherwise be entitled, in accordance with sound engineering judgment. The HSM may provide needed justification for an exception from previously established publications.

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FUTURE EDITIONS OF THE HSM

This first edition of the HSM provides the most current and accepted knowledge and practices relating to roadway safety management. The TRB and AASHTO HSM Task Forces recognize 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 this first edition of the HSM because it introduces new methods, techniques, and information to transportation professionals. The knowledge base will also 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 the relationships between crash occurrences on various types of facilities and the corresponding geometry and operational characteristics of those facilities that may affect crash frequency and severity. This will be facilitated as agencies improve the processes used to collect and maintain data for crashes, roadway geometry, traffic volumes, land uses, and many other useful data to assess the roadway environment and context in which crashes are occurring. These or other potential enhancements in analysis techniques and knowledge will be reflected in future editions of the HSM.

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Part A—Introduction, Human Factors, and Fundamentals

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Chapter 1—Introduction and Overview

1.1. PURPOSE AND INTENDED AUDIENCE

The *Highway Safety Manual* (HSM) provides analytical tools and techniques for quantifying the potential effects on crashes as a result of decisions made in planning, design, operations, and maintenance. There is no such thing as absolute safety. There is risk in all highway transportation. A universal objective is to reduce the number and severity of crashes within the limits of available resources, science, and technology, while meeting legislatively mandated priorities. The information in the HSM is provided to assist agencies in their effort to integrate safety into their decision-making processes. Specifically, the HSM is written for practitioners at the state, county, metropolitan planning organization (MPO), or local level. The HSM's intended users have an understanding of the transportation safety field through experience, education, or both. This knowledge base includes

- Familiarity with the general principles and practice of transportation safety;
- Familiarity with basic statistical procedures and interpretation of results; and
- Suitable competence to exercise sound traffic safety and operational engineering judgment.

The users and professionals described above include, but are not limited to, transportation planners, highway designers, traffic engineers, and other transportation professionals who make discretionary road planning, design, and operational decisions. The HSM is intended to be a resource document that is used nationwide to help transportation professionals conduct safety analyses in a technically sound and consistent manner, thereby improving decisions made based on safety performance.

Documentation used, developed, compiled, or collected for analyses conducted in connection with the HSM may be protected under Federal law (23 USC 409). The HSM is neither intended to be, nor does it establish, a legal standard of care for users or professionals as to the information contained herein. No standard of conduct or any duty toward the public or any person shall be created or imposed by the publication and use or nonuse of the HSM.

The HSM does not supersede publications such as the U.S. DOT FHWA's *Manual on Uniform Traffic Control Devices* (MUTCD), Association of American State Highway Transportation Officials' (AASHTO's) "Green Book" titled *A Policy on Geometric Design of Highways and Streets*, or other AASHTO and agency guidelines, manuals, and policies. If conflicts arise between these publications and the HSM, the previously established publications should be given the weight they would otherwise be entitled if in accordance with sound engineering judgment. The HSM may provide needed justification for an exception from previously established publications.

1.2. ADVANCEMENT IN SAFETY KNOWLEDGE

The new techniques and knowledge in the HSM reflect the evolution in safety analysis from descriptive methods to quantitative, predictive analyses.

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Descriptive Analyses and Quantitative Predictive Analyses

What are descriptive analyses?
Traditional descriptive analyses include methods such as frequency, crash rate, and equivalent property damage only (EPDO), which summarize in different forms one or more of the following: the history of crash occurrence, type, or severity at a crash site.

What are quantitative predictive analyses?
Quantitative predictive analyses are used to calculate an expected number and severity of crashes at sites with similar geometric and operational characteristics for one or more of the following: existing conditions, future conditions, or roadway design alternatives.

What is the difference?
Descriptive analyses focus on summarizing and quantifying information about crashes that have occurred at a site (i.e., summarizing historic crash data in different forms). Predictive analyses focus on estimating the expected average number and severity of crashes at sites with similar geometric and operational characteristics. The expected and predicted number of crashes by severity can be used for comparisons among different design alternatives.

Information throughout the HSM highlights the strengths and limitations of the methods presented. While these predictive analyses are quantitatively and statistically valid, they do not exactly predict a certain outcome at a particular location. Moreover, they cannot be applied without the exercise of sound engineering judgment.

1.3. APPLICATIONS

The HSM can be used to

- Identify sites with the most potential for crash frequency or severity reduction;
- Identify factors contributing to crashes and associated potential countermeasures to address these issues;
- Conduct economic appraisals of improvements and prioritize projects;
- Evaluate the crash reduction benefits of implemented treatments;
- Calculate the effect of various design alternatives on crash frequency and severity;
- Estimate potential crash frequency and severity on highway networks; and
- Estimate potential effects on crash frequency and severity of planning, design, operations, and policy decisions.

These applications are used to consider projects and activities related not only to safety, but also those intended to improve other aspects of the roadway, such as capacity, pedestrian amenities, and transit service. The HSM provides an opportunity to consider safety quantitatively along with other typical transportation performance measures.

1.4. SCOPE AND ORGANIZATION

The emphasis of the HSM is on quantifying the safety effects of decisions in planning, design, operations, and maintenance through the use of analytical methods. The first edition does not address issues such as driver education, law enforcement, and vehicle safety, although it is recognized that these are important considerations within the broad topic of improving highway safety.

- The HSM is organized into the following four parts:
- Part A—Introduction, Human Factors, and Fundamentals

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- Part B—Roadway Safety Management Process
- Part C—Predictive Method
- Part D—Crash Modification Factors

Part A—Introduction, Human Factors, and Fundamentals
Part A describes the purpose and scope of the HSM and explains the relationship of the HSM to planning, design, operations, and maintenance activities. Part A also presents an overview of human factor principles for road safety and fundamentals of the processes and tools described in the HSM. Content in Chapter 3, "Fundamentals," provides background information needed prior to applying the predictive method, crash modification factors, or evaluation methods provided in the HSM. This content is the basis for the material in Parts B, C, and D. The chapters in Part A include

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

Part B—Roadway Safety Management Process
Part B presents the steps that can be used to monitor and reduce crash frequency and severity on existing roadway networks. This section includes methods useful for identifying improvement sites, diagnosis, countermeasure selection, economic appraisal, project prioritization, and effectiveness evaluation. The chapters in Part B include

- 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 Method
Part C of the HSM provides a predictive method for estimating expected average crash frequency of a network, facility, or individual site. The estimate can be made for existing conditions, alternative conditions, or proposed new roadways. The predictive method is applied to a given time period, traffic volume, and constant geometric design characteristics of the roadway. The Part C predictive method is most applicable when developing and assessing multiple solutions for a specific location. For example, a roadway project that considers various cross-section alternatives could use Part C to assess the expected average crash frequency of each alternative. Part C can also be used as a source for safety performance functions (SPFs).

The chapters in Part C provide the prediction method for the following facility types:

- Chapter 10, Rural Two-Lane Roads (Segments and Intersections)
- Chapter 11, Rural Multilane Highways (Segments and Intersections)
- Chapter 12, Urban and Suburban Arterials (Segments and Intersections)

Future editions of the HSM will expand the material included in Part C to include information applicable to additional types of roadway facilities.

Part D—Crash Modification Factors
Part D summarizes the effects of various treatments such as geometric and operational modifications at a site. Some of the effects are quantified as crash modification factors (CMFs). CMFs quantify the change in expected average crash frequency as a result of modifications to a site.

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