Part A—Introduction, Human Factors, and Fundamentals

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.

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

- 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.

The CMFs in Part D—Crash Modification Factors can be used as a resource for methods and calculations presented in Chapter 6, "Select Countermeasures," Chapter 7, "Economic Appraisal," and chapters in Part C—Predictive Method. Some Part D CMFs are used in the Part C—Predictive Method. However, not all CMFs presented in Part D apply to the predictive models in Part C. CMFs in general can be used to test alternative design options.

The chapters in Part D are organized by site type as follows:

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

Each chapter includes exhibits summarizing the treatments and available CMFs. The appendix to each chapter contains the treatments for which CMFs are not available but general trends are known (e.g., increase or decrease in crash occurrence), and the treatments whose crash effects are unknown. Similar to Part C, it is envisioned that the material included in Part D will be expanded in future editions of the HSM.

1.4.1. Relationship Among Parts of the HSM

Figure 1-1 illustrates the relationship among the four parts of the HSM and how the associated chapters within each part relate to one another.

Part A is the foundation for the remaining information in the HSM. This part presents fundamental knowledge useful throughout the manual. Parts B, C, and D can be used in any order following Part A depending on the purpose of the project or analysis. The chapters within each part can also be used in an order most applicable to a specific project rather than working through each chapter in order. The dotted line connecting Part C with Chapters 4 and 7 denotes that the safety performance functions in Part C can be calibrated and applied in Chapters 4 and 7. The dashed line connecting Part D with Chapters 6 and 7 denotes that the crash modification factors in Part D are used for calculations in Chapters 6 and 7.

1.4.2. Activities Beyond the Scope of the HSM

The procedures in the HSM support engineering analysis and decision making to reduce crash frequency or severity, or both, on a roadway network. In general, crash reduction may also be achieved by considering the following:

- Enforcement
- Education for road users
- Improving incident response and emergency medical services (EMS)
- Improving vehicle safety performance

Enforcement of traffic laws, compliance with driving under the influence laws, the proper use of passenger restraints, driver education and other safety-related legislative efforts—along with infrastructure improvements—contribute to a roadway's safety performance. Although education, enforcement, and emergency medical services are not addressed in the HSM, these are also important factors in reducing crashes and crash severity.

1.5. RELATING THE HSM TO THE PROJECT DEVELOPMENT PROCESS

The following subsections define a generalized project development process for the purpose of explaining the connection between planning, design, construction, operations, and maintenance activities and the HSM. This section further provides example applications of the HSM within the generalized project development process, illustrating how to integrate the HSM into various types of projects and activities.

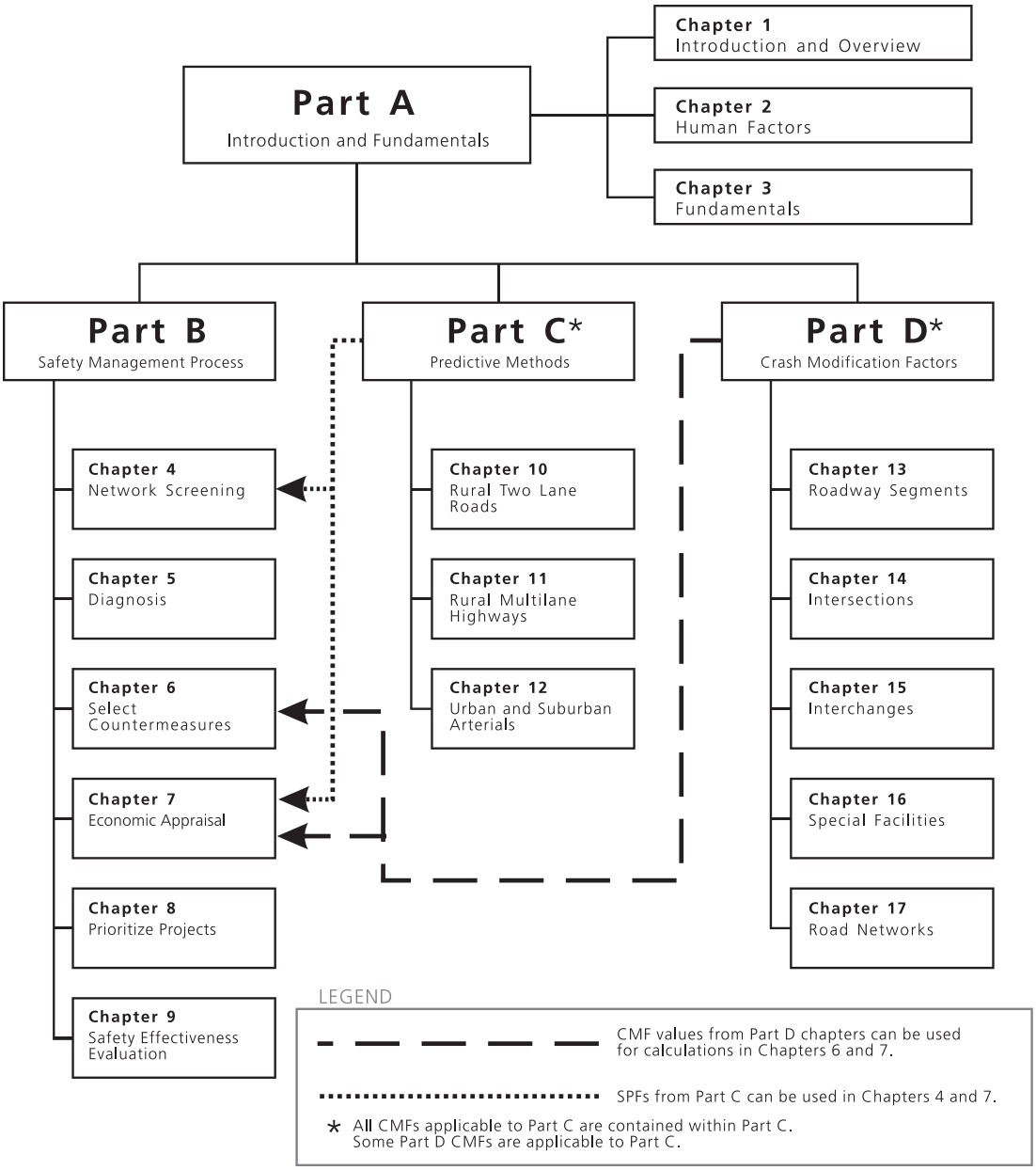

Figure 1-1. Organization of the Highway Safety Manual

1.5.1. Defining the Project Development Process

The phrase and concept of the "project development process" was framed and is documented by AASHTO in *A Guide for Achieving Flexibility in Highway Design* and the Federal Highway Administration's (FHWA) *Flexibility in Highway Design* (1,2). The process was developed as a means to discuss the typical stages of a project from planning to post-construction operations and maintenance activities. It is applicable to all projects including those influenced by other processes, policies, or legislation (e.g., National Environmental Policy Act (NEPA), Context Sensitive Solutions).

There are minor differences in how AASHTO and FHWA have documented the process; however, for the purpose of the HSM, a generalized project development process is as follows:

- System Planning
  - Assess the system needs and identify projects/studies that address these needs.
  - Program projects based on the system needs and available funding.
- Project Planning
  - Within a specific project, identify project issues and alternative solutions to address those issues.
  - Assess the alternatives based on safety, traffic operations, environmental impacts, right-of-way impacts, cost, and any other project specific performance measures.
  - Determine preferred alternative.
- Preliminary Design, Final Design, and Construction
  - Develop preliminary and final design plans for the preferred alternative.
  - Evaluate how the project-specific performance measures are impacted by design changes.
  - Construct final design.
- Operations and Maintenance
  - Monitor existing operations with the goal of maintaining acceptable conditions balancing safety, mobility, and access.
  - Modify the existing roadway network as necessary to maintain and improve operations.
  - Evaluate the effectiveness of improvements that have been implemented.

Other processes, policies, or legislation that influence a project's form and scope often include activities that fall within this generalized process.

1.5.2. Connecting the HSM to the Project Development Process

Figure 1-2 illustrates how planning, design, construction, operations, and maintenance activities relate to the HSM. Specific information about how to apply individual chapters in the HSM is provided in the Parts B, C, and D, "Introduction and Applications Guidance." The left side of the figure depicts the overall project development process. The right side describes how the HSM is used within each stage of the project development process. The text following Figure 1-2 further explains the relationship between the project development process and the HSM.

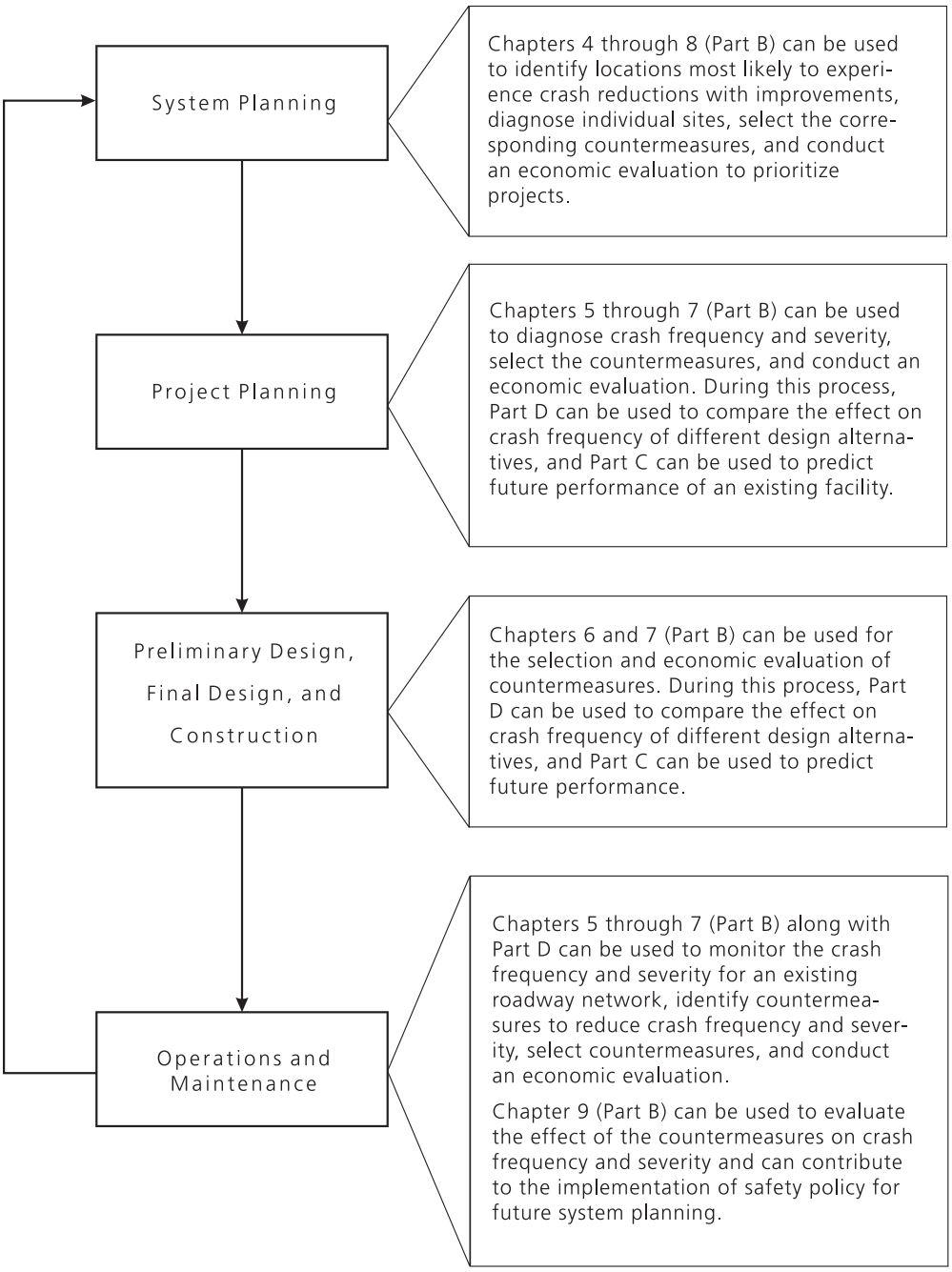

Figure 1-2. Relating the Project Development Process to the HSM

System planning is the first stage of the project development process and is the stage in which network infrastructure priorities are identified and assessed. 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," can be used to identify crash patterns to be targeted for improvement at each site. Chapter 6, "Select Countermeasures," can be used to identify the factors contributing to observed crash patterns and to select corresponding countermeasures. Chapter 7, "Economic Appraisal," and Chapter 8, "Prioritize Projects," are used to prioritize expenditures and ensure the largest crash reductions from improvements throughout the system.

During the project planning stage, project 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 at a particular site. Each alternative is evaluated across multiple performance measures, which can include weighing project costs versus project benefits. These projects can include extensive redesign or design of new facilities (e.g., introducing a couplet system, altering the base number of lanes on an existing roadway, and other changes that would substantially change the operational characteristics of the site). The result of this stage is a preferred design alternative carried forward into preliminary design Chapters 5, "Diagnosis," can be used to identify crash patterns to be targeted for improvement during project planning. Chapter 6, "Select Countermeasures," is used to identify the factors contributing to observed crash patterns and to evaluate countermeasures. Chapter 7, "Economic Appraisal," can be used to conduct an economic appraisal of countermeasures as part of the overall project costs. The chapters within Part D are a resource to compare the safety implications of different design alternatives, and the chapters in Part C can be used to predict future safety performance of the alternatives.

The preliminary design, final design, and construction stage of the project development process includes design iterations and reviews at 30 percent complete, 60 percent complete, 90 percent complete, and 100 percent complete design plans. Through the design reviews and iterations, there is a potential for modifications to the preferred design. As modifications to the preferred design are made, the potential crash effects of those changes can be assessed to confirm that the changes are consistent with the ultimate project goal and intent. Chapter 6, "Select Countermeasures," and Chapter 7, "Economic Appraisal," can be used during preliminary design to select countermeasures and conduct an economic appraisal of the design options. The chapters in Parts C and D are a resource to estimate crash frequencies for different design alternatives.

Activities related to operations and maintenance focus on evaluating existing roadway network performance, identifying opportunities for near-term improvements to the system, implementing improvements to the existing network, and evaluating the effectiveness of past projects. These activities can be conducted from a safety perspective using Chapters 5, "Diagnosis," to identify crash patterns at an existing location, and Chapter 6, "Select Countermeasures," and Chapter 7, "Economic Appraisal," to select and appraise countermeasures. Throughout this process Part D serves as a resource for CMFs. Chapter 9, "Safety Effectiveness Evaluation," provides methods to conduct a safety effectiveness evaluation of countermeasures. This can contribute to the implementation or modification of safety policy, and to the development of design criteria to be used in future transportation system planning.

1.6. RELATING ACTIVITIES AND PROJECTS TO THE HSM

Examples of how to integrate the HSM into typical project types or activities required by state or federal legislation (e.g., Highway Safety Improvement Program—HSIP, Strategic Highway Safety Plan—SHSP) are summarized in Table 1-1.

Table 1-1. General Project Types and Activities and the HSM

Project Development Process Stage	Activity or Project Type	Opportunity to Apply the HSM
System Planning	Long-Range Transportation Plans	Part B, Chapters 4–8—Identify sites most likely to benefit from a safety improvement. This information could be used to identify projects for safety funding and opportunities to incorporate safety into previously funded projects or studies.
System Planning/Project Planning	Highway Safety Improvement Program (HSIP)	Part B, Chapters 4–8—Identify a state's top locations most likely to benefit from safety improvements. Identify crash patterns, contributing factors, and countermeasures most likely to reduce crashes. Evaluate the economic validity of individual projects and prioritize projects across a system.
System Planning/Project Planning	Corridor Study	Part B, Chapters 4–8—Identify sites most likely to benefit from a safety improvement, diagnose crash patterns, evaluate countermeasures and economic implications, and identify project priorities. Parts C and D—Assess the safety performance of design alternatives related to change in roadway cross-section, alignment, and intersection configuration or operations.
Project Planning/Preliminary Design	Context Sensitive Design/ Solutions Projects (Includes Developing and Assessing Multiple Design Alternatives)	Parts C and D—Assess the safety performance of design alternatives based on their geometric and operational characteristics. The results of these methods can be used to help reach a preferred alternative that balances multiple performance measures.
Project Planning/Preliminary Design	Designing a New Network Connection or Facility	Part B, Chapters 5–7—Diagnose expected average crash frequency for similar locations, consider countermeasures, and conduct an economic evaluation of design alternatives. Parts C and D—Assess the safety performance of design alternatives related to change in roadway cross-section, alignment, and intersection configuration or operations. This information can be used to select a preferred alternative that balances multiple performance measures.
Preliminary Design, Final Design/ Operations and Maintenance	Widening an Existing Roadway	Part C—Assess the change in crashes that may be attributed to different design alternatives for widening an existing roadway. Part D, Chapter 13—Assess the change in crashes from changing roadway cross section.
Operations and Maintenance	Signal Timing or Phase Modifications	Part D, Chapter 14—Assess the effects that signal timing adjustments can have at individual intersections.
Operations and Maintenance	Adding Lanes to an Existing Intersection	Part D, Chapter 14—Assess the effects that modifying lane configurations can have on safety.
Operations and Maintenance	Developing an On-Street Parking Management Plan	Part D, Chapter 13—Assess the effects that the presence or absence of on-street parking has on the expected number of crashes for a roadway segment. It can also be used to assess the safety effects of different types of on-street parking.
System Planning/Operations and Maintenance	Traffic Impact Study	Part B—Identify sites most likely to benefit from a safety improvement, and identify ways to improve safety as part of other mitigations. Part D, Chapters 13 and 14—Identify the effects that mitigations to roadway segments (Chapter 13) and intersections (Chapter 14) may have on safety.

1.7. SUMMARY

The HSM contains specific analysis procedures that facilitate integrating safety into roadway planning, design, operations, and maintenance decisions based on crash frequency. The following parts and chapters of the HSM present information, processes, and procedures that are tools to help improve safety decision making and knowledge. The HSM consists of the following four parts:

- Part A provides an introduction to the HSM along with fundamental knowledge;
- Part B discusses the roadway safety improvement and evaluation process;
- Part C contains the predictive method for rural two-lane highways, rural multilane highways, and urban and suburban arterials; and
- Part D summarizes crash modification factors for planning, geometric, and operational elements.

Future editions of the HSM will continue to reflect the evolution in highway safety knowledge and analysis techniques being developed.

1.8 REFERENCES

(1) AASHTO. *Achieving Flexibility in Highway Design.* American Association of State Highway and Transportation Officials, Washington, DC, 2004.

(2) FHWA. *Flexibility in Highway Design*. FHWA-PD-97-062. Federal Highway Administration, U.S. Department of Transportation, Washington, DC, 1997.