

HCM2010

HIGHWAY CAPACITY MANUAL



CHAPTER 1 HCM USER'S GUIDE



TRANSPORTATION RESEARCH BOARD
OF THE NATIONAL ACADEMIES

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HCM2010

HIGHWAY CAPACITY MANUAL

The HCM 2010 significantly enhances how engineers and planners assess the traffic and environmental effects of highway projects by

- Providing an integrated multimodal approach to the analysis and evaluation of urban streets from the points of view of automobile drivers, transit passengers, bicyclists, and pedestrians;
- Addressing the proper application of microsimulation analysis and the evaluation of the results;
- Examining active traffic management in relation to demand and capacity; and
- Exploring specific tools and generalized service volume tables to assist planners in quickly sizing future facilities.



The HCM 2010 consists of four volumes:

Volume 1: Concepts;
Volume 2: Uninterrupted Flow;
Volume 3: Interrupted Flow; and
Volume 4: Applications Guide (electronic only).

The four-volume format provides information at several levels of detail, to help users more easily apply and understand the concepts, methodologies, and potential applications.

Volumes 1, 2, and 3 are issued as a boxed set. Volume 4 is electronic only, accessible to registered HCM users via the Internet, and includes four types of content: supplemental chapters on methodological details and emerging issues; interpretations, clarifications, and corrections; comprehensive case studies; and a technical reference library.

To order HCM 2010, go to <http://books.trbbookstore.org/hcm10.aspx>.

For more information about HCM 2010 and TRB publications, contact the Transportation Research Board Business Office, 500 Fifth Street, NW, Washington, DC 20001 (telephone 202-334-3213; fax 202-334-2519; e-mail TRBsales@nas.edu; or through the Internet, www.trb.org).

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1. INTRODUCTION

The *Highway Capacity Manual 2010* (HCM) is the fifth edition of this fundamental reference document. Like its predecessors, the HCM 2010 has been significantly revised to incorporate the latest research on highway capacity and quality of service. It has also been substantially reorganized. These changes continue the HCM's evolution, keeping the manual in step with its users' needs and present times.

The 1950 HCM (1) was the first document to quantify the concept of capacity for transportation facilities and focused almost entirely on that subject. This focus was in response to the rapid expansion of the U.S. roadway system after World War II and the need to determine lane requirements for the Interstate highway system and the roads that provided access to it. The manual was designed to be "a practical guide by which the engineer, having determined the essential facts, can design a new highway or revamp an old one with assurance that the resulting capacity will be as calculated."

The focus on design continued in the 1965 HCM (2), but the level-of-service (LOS) concept was also introduced with this edition, along with a chapter on bus transit. The HCM permitted the "determination of the capacity, service volume, or level of service which will be provided by either a new highway design, or an existing highway under specified conditions."

The 1985 HCM (3) was another significant step in the evolution of the HCM. It further refined the concept of LOS and incorporated the results of several major research projects performed since the publication of the 1965 HCM. The target audience was broadened through the addition of chapters on pedestrians and bicycles and an expansion of the transit chapter.

A substantial increase in the volume and breadth of material occurred with the publication of the HCM2000 (4). The intent of the manual was "to provide a systematic and consistent basis for assessing the capacity and level of service for elements of the surface transportation system and also for systems that involve a series or a combination of individual facilities."

The HCM 2010 has added much new material from research projects completed since the publication of HCM2000 and has been reorganized to make its contents more accessible and understandable. The reorganization is also intended to encourage analysts and decision makers to consider all roadway users, as well as a broader range of performance measures, when they assess transportation facility performance.

Chapter 1, HCM User's Guide, is the starting point for learning how to use this edition of the HCM. This chapter presents the purpose, objectives, intended use, and target users of the HCM 2010; describes the contents of each of the four volumes that make up the HCM; summarizes the major changes that have been made to HCM2000 methodologies; and mentions some of the important companion documents to the HCM. The remainder of Volume 1 presents the fundamental information with which users should be familiar before starting to apply the manual.

VOLUME 1: CONCEPTS

1. HCM User's Guide

2. Applications
3. Modal Characteristics
4. Traffic Flow and Capacity Concepts
5. Quality and Level-of-Service Concepts
6. HCM and Alternative Analysis Tools
7. Interpreting HCM and Alternative Tool Results
8. HCM Primer
9. Glossary and Symbols

2. HCM PURPOSE AND SCOPE

PURPOSE AND OBJECTIVES

The purpose of the HCM is to provide a set of methodologies, and associated application procedures, for evaluating the multimodal performance of highway and street facilities in terms of operational measures and one or more quality-of-service indicators.

The objectives of the HCM are to

1. Define performance measures and describe survey methods for key traffic characteristics,
2. Provide methodologies for estimating and predicting performance measures, and
3. Explain methodologies at a level of detail that allows readers to understand the factors affecting multimodal operation.

The HCM 2010 presents the best available techniques at the time of publishing for determining capacity and LOS. However, it does not establish a legal standard for highway design or construction.

INTENDED USE

The HCM is intended to be used primarily for the analysis areas listed below, to the extent that they are supported by the individual analysis methodologies.

- *Levels of analysis:* operations, design, preliminary engineering, and planning.
- *Travel modes:* automobile (and other motorized vehicles), pedestrian, and bicycle, plus transit when it is part of a multimodal urban street facility.
- *Spatial coverage:* points, segments, and facilities.
- *Temporal coverage:* undersaturated and oversaturated conditions.

TARGET USERS

The HCM is prepared for use by (a) engineers who work in the field of traffic operations or highway geometric design and (b) transportation planners who work in the field of transportation system management. To use the manual effectively and to apply its methodologies, some technical background is desirable—typically university-level training or technical work in a public agency or consulting firm.

The HCM is also useful to management personnel, educators, air quality specialists, noise specialists, elected officials, regional land use planners, and interest groups representing special users.

Quality of service describes how well a transportation facility or service operates from the traveler's perspective.

Level of service is the A-F stratification of quality of service.

3. STRUCTURE

OVERVIEW

Since 2000, more than \$5 million in funded National Cooperative Highway Research Program (NCHRP) research has partially or entirely focused on HCM methodologies. To keep the HCM at a manageable size and yet incorporate the results of this research, the HCM 2010 has been divided into four volumes:

1. Concepts,
2. Uninterrupted Flow,
3. Interrupted Flow, and
4. Applications Guide.

When the HCM2000 (4) was being developed, U.S. states were moving toward compliance with federal requirements to use metric units in the design of roadways. As a result, the HCM2000 was published in “U.S. customary” and “metric” versions. Because the federal metrication requirements were later dropped and most states returned to U.S. customary units, this edition only uses U.S. customary units. A metric conversion guide is provided later in this chapter.

The following sections describe the contents of each HCM 2010 volume.

VOLUME 1: CONCEPTS

Volume 1 covers the basic information that an analyst should be familiar with before performing capacity or quality-of-service analyses. Its chapters cover the organization of the HCM; the kinds of applications that can be performed with the HCM; modal characteristics; traffic flow, capacity, and quality-of-service concepts; the range of tools available to perform an analysis; guidance on interpreting and presenting analysis results; and the terms and symbols used in the HCM. Chapter 8, HCM Primer, provides an executive summary of the HCM for decision makers.

Users familiar with the HCM2000 will find that Volume 1 incorporates Part I of the HCM2000; conceptual material from HCM2000 Parts II, IV, and V; and new material developed for the 2010 edition. Volume 1 is provided in three-ring binder and electronic formats, to facilitate the addition of new conceptual material as new research is incorporated into the HCM between major updates.

VOLUME 2: UNINTERRUPTED FLOW

Volume 2 contains the methodological chapters relating to uninterrupted-flow system elements. All of the material necessary in performing an analysis of one of these elements appears here: a description of the process thorough enough to allow an analyst to understand the steps involved (although not necessarily replicate them by hand), the scope and limitations of the methodology, specific default values, LOS thresholds, and guidance on special cases and the use of alternative tools.

The freeway chapters are presented first, arranged from the facility level down to the segment level; the chapters for multilane and two-lane highways

VOLUME 1: CONCEPTS

1. HCM User's Guide
2. Applications
3. Modal Characteristics
4. Traffic Flow and Capacity Concepts
5. Quality and Level-of-Service Concepts
6. HCM and Alternative Analysis Tools
7. Interpreting HCM and Alternative Tool Results
8. HCM Primer
9. Glossary and Symbols

Chapter 8 serves as an executive summary of the HCM for decision makers.

VOLUME 2: UNINTERRUPTED FLOW

10. Freeway Facilities
11. Basic Freeway Segments
12. Freeway Weaving Segments
13. Freeway Merge and Diverge Segments
14. Multilane Highways
15. Two-Lane Highways

Uninterrupted-flow system elements, such as freeways, have no fixed causes of delay or interruption external to the traffic stream.

VOLUME 3: INTERRUPTED FLOW

- 16. Urban Street Facilities
- 17. Urban Street Segments
- 18. Signalized Intersections
- 19. TWSC Intersections
- 20. AWSC Intersections
- 21. Roundabouts
- 22. Interchange Ramp Terminals
- 23. Off-Street Pedestrian and Bicycle Facilities

Interrupted-flow system elements, such as urban streets, have traffic control devices such as traffic signals and stop signs that periodically interrupt the traffic stream.

VOLUME 4: APPLICATIONS GUIDE

- Methodological Details
- 24. Concepts: Supplemental
- 25. Freeway Facilities: Supplemental
- 26. Freeway and Highway Segments: Supplemental
- 27. Freeway Weaving: Supplemental
- 28. Freeway Merges and Diverges: Supplemental
- 29. Urban Street Facilities: Supplemental
- 30. Urban Street Segments: Supplemental
- 31. Signalized Intersections: Supplemental
- 32. STOP-Controlled Intersections: Supplemental
- 33. Roundabouts: Supplemental
- 34. Interchange Ramp Terminals: Supplemental
- 35. Active Traffic Management Interpretations
- Case Studies
- Technical Reference Library

follow. Users familiar with the HCM2000 will find that Volume 2 incorporates the Part III uninterrupted-flow chapters, along with the material from the corresponding Part II chapters (e.g., specific default values and LOS thresholds) used directly in an analysis. The Interchange Ramp Terminals chapter, which appeared with the uninterrupted-flow chapters in the HCM2000, appears with the interrupted-flow chapters (Volume 3) in the HCM 2010.

Volume 2 is provided in both three-ring-binder and electronic formats to facilitate interim HCM updates as new research is performed.

VOLUME 3: INTERRUPTED FLOW

Volume 3 contains all of the methodological chapters relating to interrupted-flow system elements. Its content is similar to that of the Volume 2 chapters. The facility chapter is presented first, followed by the segment chapter, the point chapters, and a chapter on off-street pedestrian and bicycle facilities.

Volume 3 incorporates the interrupted-flow chapters from the HCM2000's Part III, along with the corresponding detailed Part II material. Where applicable, pedestrian and bicycle material has been integrated throughout the Volume 3 chapters, along with public transit material specific to multimodal analyses. Users are referred to the *Transit Capacity and Quality of Service Manual (TCQSM)* (5) for transit-specific analysis procedures. The HCM2000 Unsignalized Intersections chapter has been split into three chapters in the 2010 edition, which individually cover two-way STOP-controlled intersections, all-way STOP-controlled intersections, and roundabouts. Finally, the Interchange Ramp Terminals chapter is now included with the interrupted-flow chapters.

Volume 3 is provided in both three-ring-binder and electronic formats to facilitate interim HCM updates as new research is performed.

VOLUME 4: APPLICATIONS GUIDE

Volume 4 is an electronic-only volume (www.HCM2010.org) that includes four types of content: supplemental chapters, methodological interpretations, comprehensive case studies, and a technical reference library.

The supplemental chapters include the following:

- More detailed descriptions of certain computational methodologies, written for users who seek a greater depth of understanding or plan to develop HCM implementation software;
- Example applications of alternative tools to situations not addressed by the Volume 2 or 3 chapter's methodology;
- Additional example problems and calculation results; and
- A new chapter on the impact of active traffic management techniques on roadway operations.

The methodological interpretations section will develop over time, as users apply the HCM 2010 and pose questions about particular methodologies to the Transportation Research Board (TRB) Committee on Highway Capacity and Quality of Service (AHB40). Clarifications of, interpretations of, and corrections

to the HCM that have been officially approved by the committee will be posted in the interpretations section of Volume 4.

The comprehensive case studies illustrate how to use the HCM to perform common types of analyses. The case studies are focused on the process of applying the HCM, rather than on the details of performing calculations (which are addressed by the example problems). Case Studies 1 through 5 are derived from the web-based *HCM Applications Guidebook* (6) that was developed after the HCM2000 was published, while Case Study 6 was developed by the NCHRP 3-85 project (7).

The Technical Reference Library contains a selection of papers, technical reports, and companion documents that provide background information about the development of HCM methodologies.

COMPUTATIONAL ENGINES

Historically, all HCM methodologies have been fully documented within the manual through text, figures, and worksheets (the Freeway Facilities chapter in the HCM2000 represents the first departure from this pattern). However, in response to practitioner needs and identified HCM limitations, methodologies have continued to grow in complexity, and some have reached the point where they can no longer be feasibly documented in such a manner (for example, methodologies that require multiple iterations to reach a solution). In these cases, computational engines become an important means by which details of some of the more complex calculations can be fully described. For the most complex methodologies, the Volume 2 or 3 chapter, the Volume 4 supplemental chapter, and the computational engine together provide the most efficient and effective way of fully documenting the methodology.

The TRB Committee on Highway Capacity and Quality of Service maintains computational engines for most HCM methodologies for the purposes of evaluating methodologies as they are developed, developing new example problems, identifying needed improvements, and judging the impact of proposed changes. These engines are tools for developing and documenting HCM methodologies and do not have or need the sophisticated interfaces and input data manipulation techniques that would make them suitable for use in an engineering or planning office. The engines are not generally publicly distributed but are made available on request to researchers, practitioners, software developers, students, and others who are interested in understanding the inner workings of a particular HCM methodology.

COMMERCIAL SOFTWARE

To assist users in implementing the methodologies in the manual, commercial software is available (and has been since the publication of the 1985 HCM) to perform the numerical calculations for the more computationally intensive methods. A variety of commercial software products are available that implement HCM techniques and provide sophisticated user interfaces and data manipulation tools. It is the policy of TRB not to review or endorse commercial products.

Access Volume 4 at
www.HCM2010.org

HCM chapters describe, at a minimum, the process used by a given methodology. For simpler methodologies, the chapters fully describe the computational steps involved.

Supplemental chapters in Volume 4 provide calculation details for the more computationally complex methods.

Computational engines document all the calculation steps for the most complex methods, such as those involving iterative calculations.

4. INTERNATIONAL USE

APPLICATIONS

Capacity and quality-of-service analyses have generated interest on an international scale. The HCM has been translated into several languages, and research conducted in numerous countries outside of North America has contributed to the development of HCM methodologies. HCM users are cautioned, however, that the majority of the research base, the default values, and the typical applications are from North America, particularly from the United States. Although there is considerable value in the general methods presented, their use outside of North America requires additional emphasis on calibrating the equations and the procedures to local conditions, as well as recognizing major differences in the composition of traffic; in driver, pedestrian, and bicycle characteristics; and in typical geometrics and control measures.

METRIC CONVERSION GUIDE

The HCM2000 (4) was produced as two editions, one using U.S. customary units and the other using metric units. Variables in the HCM2000 were subject to *hard conversion*, meaning that figures were rounded where this was reasonable. For example, a lane width of 12 ft was converted to a rounded value of 3.6 m. In comparison, a soft conversion would multiply 12 ft by a conversion factor of 0.305 m/ft, resulting in a value of 3.66 m.

As described in this chapter's Structure section, there is no metric edition of the HCM 2010. Therefore, a soft conversion is favored from U.S. customary units to metric units, so that computational engines produce the same result regardless of the measurement system used. However, in comparisons of the metric results of methodologies that have not changed from 2000 to 2010, such as multilane highways, small discrepancies may appear: the results produced by the HCM 2010 with soft conversion may be slightly different from those produced by the metric version of the HCM2000.

Exhibit 1-1 provides approximate conversion factors from U.S. customary to metric units.

Symbol	When You Know	Multiply By	To Find	Symbol
LENGTH				
in.	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
AREA				
in. ²	square inches	645.2	square millimeters	mm ²
ft ²	square feet	0.093	square meters	m ²
yd ²	square yards	0.836	square meters	m ²
ac	acres	0.405	hectares	ha
mi ²	square miles	2.59	square kilometers	km ²
VOLUME				
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft ³	cubic feet	0.028	cubic meters	m ³
yd ³	cubic yards	0.765	cubic meters	m ³
MASS				
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2,000 lb)	0.907	megagrams (or metric tons)	Mg (or t)
TEMPERATURE (exact conversion)				
°F	Fahrenheit	(F – 32)/1.8	Celsius	°C
ILLUMINATION				
fc	foot-candles	10.76	lux	lx
fl	foot-Lamberts	3.426	candela/square meter	cd/m ²
FORCE and PRESSURE or STRESS				
lbf	pound force	4.45	newtons	N
lbf/in. ²	pound force per square inch	6.89	kilopascals	kPa

Source: Federal Highway Administration (8).

Exhibit 1-1
Metric Conversion Table

5. WHAT'S NEW IN THE HCM 2010

OVERVIEW

Although the page layout of the HCM 2010 is similar to that of the HCM2000, a number of changes have been made to the manual—a result of both the extensive research that has been conducted since the HCM2000 and the feedback received from HCM2000 users.

Research Basis for the HCM 2010

Exhibit 1-2 lists the major research projects that have contributed to the HCM 2010. The impacts of these and other projects on individual HCM chapters are described later in this section.

Exhibit 1-2
Major Research Projects
Contributing to the
HCM 2010

Project	Project Title	Project Objective(s)
NCHRP 3-60	Capacity and Quality of Service of Interchange Ramp Terminals	Develop improved methods for capacity and quality-of-service analysis of interchange ramp terminals, for a full range of interchange types.
NCHRP 3-64	<i>Highway Capacity Manual</i> Applications Guide	Develop an HCM Applications Guide that shows how to apply HCM methodologies to real-world problems and indicate when other methods may be more appropriate.
NCHRP 3-65	Applying Roundabouts in the United States	Develop methods of estimating the safety and operational impacts of U.S. roundabouts and refine the design criteria used for them.
NCHRP 3-70	Multimodal Level of Service Analysis for Urban Streets	Develop a framework and enhanced methods for determining levels of service for automobile, transit, bicycle, and pedestrian modes on urban streets, in particular with respect to the interaction among the modes.
NCHRP 3-75	Analysis of Freeway Weaving Sections	Develop improved methods for capacity and LOS analysis of freeway weaving sections.
NCHRP 3-79	Measuring and Predicting the Performance of Automobile Traffic on Urban Streets	Develop techniques to measure the performance of automobile traffic on urban streets for real-time applications; develop procedures to predict the performance of automobile traffic on urban streets.
NCHRP 3-82	Default Values for Capacity and Quality of Service Analyses	Determine appropriate default values for inputs to HCM analyses; develop a guide to select default values for various applications.
NCHRP 3-85	Guidance for the Use of Alternative Traffic Analysis Tools in Highway Capacity Analyses	Enhance the guidance in the HCM for the selection and use of alternative traffic analysis tools.
NCHRP 3-92	Production of the Year 2010 <i>Highway Capacity Manual</i>	Develop the 2010 edition of the HCM.
Federal Highway Administration	Evaluation of Safety, Design, and Operation of Shared-Use Paths (DTFH61-00-R-00070)	Develop an LOS estimation method for shared-use paths to assist path designers and operators in determining how wide to make new or rebuilt paths and whether to separate the different types of users.
Federal Highway Administration	Active Traffic Management Measures for Increasing Capacity and Improving Performance (DTFH61-06-D-00004)	Describe active traffic management techniques and available information and analysis methods for evaluating their effectiveness in increasing highway facility capacity and improving operational performance.

Focus Groups

After the publication of the HCM2000, the TRB Committee on Highway Capacity and Quality of Service sponsored a series of focus groups at various locations around the United States to obtain feedback and to identify desired improvements for the next edition. Committee and subcommittee members also prepared an audit of the HCM in the areas of planning, design and operations, and educational needs (9). After the HCM 2010 was funded, the Institute of Transportation Engineers sponsored a web-based survey on HCM usage and desired improvements, and the NCHRP 3-92 project organized several focus groups on those topics. The feedback from these and other sources was considered when decisions were made on the format, content, and organization of the HCM 2010.

Reorganization from the HCM2000

As described in detail in this chapter's Structure section, the HCM 2010 consists of four volumes: (a) Volume 1: Concepts, (b) Volume 2: Uninterrupted Flow, (c) Volume 3: Interrupted Flow, and (d) Volume 4: Applications Guide. Material from Parts I to V of the HCM2000 has been distributed to Volumes 1 to 4 of the HCM 2010 as follows:

- *Part I: Overview* material appears in Volume 1.
- *Part II: Concepts* material appears in Volumes 2 and 3 if used directly in an analysis (e.g., default values and LOS tables) and in Volume 1 otherwise.
- *Part III: Methodologies* material appears in Volume 2 for uninterrupted-flow chapters and Volume 3 for interrupted-flow chapters. Worksheets and highly detailed descriptions of methodological steps appear in the Volume 4 chapters.
- *Part IV: Corridor and Area-wide* material that is conceptual in nature appears in Volume 1. More detailed analytical material has been removed in favor of guidance in the use of alternative tools for corridor and area-wide analyses.
- *Part V: Simulation and Other Models* material has been distributed throughout the HCM 2010. Volume 1 contains an overview of alternative tools (Chapter 6) and general guidance on comparing HCM and alternative results (Chapter 7). Specific guidance on when to consider alternative tools is presented in each chapter in Volumes 2 and 3. Selected Volume 4 chapters provide examples of applying alternative tools to situations that cannot be addressed by HCM methodologies.

Multimodal Approach

To encourage HCM users to consider all travelers on a facility when they perform analyses and make decisions, the HCM 2010 integrates material on nonautomobile and automobile modes. Thus, there are no stand-alone Pedestrian, Bicycle, and Transit chapters in this edition. Instead, users should refer to the Urban Streets chapter for analysis procedures for pedestrians, bicyclists, and transit users on urban streets, to the Signalized Intersections chapter for procedures relating to signalized intersections, and so on.

In recognition of the companion TCQSM (5) and of the difficulty in keeping the two manuals in synch, users are referred to the TCQSM for transit-specific capacity and quality-of-service procedures. However, transit quality of service in a multimodal context continues to be addressed in the HCM.

Traveler-Perception Models

Since the 1985 HCM, LOS has been defined in terms of measures of operational conditions within a traffic stream (3, 4). HCM methodologies have generally presented a single LOS measure per system element that can be (a) directly measured in the field, (b) perceived by travelers, and (c) affected by facility owners. However, since the publication of the HCM2000, a number of research projects have studied whether a single operational factor is sufficient to describe LOS, as well as whether nonoperational factors should also be used (10). These projects have proposed models that (a) incorporate multiple factors of traveler satisfaction and (b) set LOS thresholds based on traveler perceptions of service quality. Traveler-perception models from two of these studies (11, 12) have been incorporated into the Multilane Highways, Two-Lane Highways, Urban Street Facilities, Urban Street Segments, and Off-Street Pedestrian and Bicycle Facilities chapters.

Generalized Service Volume Tables

The HCM2000 provided “example service volume tables” for 10 system elements. The service volume tables were developed by using a single set of default values and were accompanied by cautionary notes that they were illustrative only. The HCM 2010 provides “generalized service volume tables” for facilities that incorporate a range of national default values. These tables can be considered for such applications as statewide performance reporting, areawide (i.e., regional) modeling, and future-year analyses as part of a long-range transportation planning process.

METHODOLOGICAL CHANGES BY SYSTEM ELEMENT

Freeway Facilities

The basic methodology is similar to the one given in the HCM2000 but incorporates the new weaving-segment analysis procedure. A significant change is the addition of LOS thresholds for freeway facilities based on density. Other changes include updates to the material on the impact of weather and work zones on freeway facility capacity, along with new information on the impact of active traffic management measures on freeway operations.

Basic Freeway Segments

The basic methodology is similar to the one given in the HCM2000. The free-flow speed prediction model has been improved, and a speed-flow curve for segments with 75-mi/h free-flow speeds has been added.

Freeway Weaving Segments

This chapter has been completely updated and incorporates the methodology developed by the NCHRP 3-75 project. Although the general process for analyzing weaving segments is similar to that given in the HCM2000, the HCM 2010 models are based on an up-to-date set of weaving data. The following are the two major differences in how the methodology is applied: (a) there is now a single algorithm for predicting weaving speeds and a single algorithm for predicting nonweaving speeds, regardless of the weaving configuration, and (b) the LOS F threshold has changed.

Ramps and Ramp Junctions

The following revisions have been made to the HCM2000 methodology:

- Procedures have been added to check for unreasonable lane distributions that overload the left or right lane(s) (or both) of the freeway.
- A revision has been made to correct an illogical trend involving on-ramps on eight-lane freeways in which density increases as the length of the acceleration lane increases.

Multilane Highways

The multilane highways automobile methodology is essentially the same as that given in the HCM2000. A methodology for calculating bicycle LOS for multilane highways has been added.

Two-Lane Highways

The following revisions have been made to the HCM2000 automobile methodology:

- The two-direction analysis has been dropped: the one-direction methodology is the only one used, with two-direction results obtained by appropriate weighted averaging of the one-direction results.
- Several key curves and tables used in one-direction analyses have been adjusted and incorporated into the chapter.

A bicycle LOS methodology for two-lane highways has been added.

Urban Street Facilities

This is a new chapter that contains guidance to help analysts determine the scope of their analysis (i.e., isolated intersection versus coordinated signal system) and the relevant travel modes (i.e., automobile, pedestrian, bicycle, transit, or a combination). The methodology section describes how to aggregate results from the segment and point levels of analysis into an overall facility assessment. Information on the impact of active traffic management measures on urban street performance has been added.

Urban Street Segments

This chapter has been completely rewritten. The work of the NCHRP 3-79 project has been incorporated into the chapter, providing improved methods for estimating urban street free-flow speeds and running times, along with a new method for estimating the stop rate along an urban street. In addition, the work of the NCHRP 3-70 project has been incorporated, providing a multimodal LOS methodology that can be used to evaluate trade-offs in how urban street right-of-way is allocated among the modes using the street.

Signalized Intersections

The following revisions have been made to the HCM2000 methodology:

- A new incremental queue accumulation method has been added to calculate the d_1 delay term and the Q_1 length term. It is equivalent to the HCM2000 method for the idealized case but is more flexible to accommodate nonideal cases, including coordinated arrivals and multiple green periods with differing saturation flow rates (i.e., protected-plus-permitted left turns and sneakers).
- An actuated controller operation modeling procedure has been added.
- A left-turn lane overflow check procedure has been added.
- Pedestrian and bicycle LOS methodologies relating to signalized intersections have been moved into this chapter.

Unsignalized Intersections

The HCM2000's Unsignalized Intersections chapter has been split into three chapters: two-way STOP-controlled intersections, all-way STOP-controlled intersections, and roundabouts.

Two-Way STOP-Controlled Intersections

The two-way STOP-controlled intersection methodology for the automobile mode is essentially the same as the one given in the HCM2000, except gap-acceptance parameters for six-lane streets have been added. In addition, pedestrian and bicycle LOS methodologies relating to two-way STOP-controlled intersections have been moved into this chapter.

All-Way STOP-Controlled Intersections

The all-way STOP-controlled intersection methodology is essentially the same as the one given in the HCM2000. A queue-estimation model has been added.

Roundabouts

This chapter replaces the HCM2000 roundabout content. It is based on the work of the NCHRP 3-65 project, which developed a comprehensive database of U.S. roundabout operations and new methodologies for evaluating roundabout performance. A LOS table for roundabouts has been added.

Interchange Ramp Terminals

This chapter is completely updated on the basis of the NCHRP 3-60 project.

Off-Street Pedestrian and Bicycle Facilities

The pedestrian path procedures are essentially the same as those of the HCM2000, but guidance is provided on how to apply the procedures to a wider variety of facility types. The bicycle path procedures, which were based on Dutch research in the HCM2000, have been updated on the basis of results of a Federal Highway Administration (FHWA) study to calibrate the Dutch model for U.S. conditions and increase the number of path user groups (e.g., inline skaters and runners) addressed by the procedures.

6. COMPANION DOCUMENTS

Throughout its 60-year history, the HCM has been one of the fundamental reference works used by transportation engineers and planners. However, it is but one of a number of documents that play a role in the planning, design, and operation of transportation facilities and services. The HCM's scope is to provide tools to evaluate the performance of highway and street facilities in terms of operational and quality-of-service measures. This section describes companion documents to the HCM that cover important topics outside the HCM's scope.

HIGHWAY SAFETY MANUAL

The *Highway Safety Manual* (HSM) (13) provides analytical tools and techniques for quantifying the safety effects of decisions related to planning, design, operations, and maintenance. The information in the HSM is provided to assist agencies as they integrate safety into their decision-making processes. It is a nationally used resource document intended to help transportation professionals conduct safety analyses in a technically sound and consistent manner, thereby improving decisions made on the basis of safety performance.

A POLICY ON GEOMETRIC DESIGN OF HIGHWAYS AND STREETS

The American Association of State Highway and Transportation Officials' *A Policy on Geometric Design of Highways and Streets* ("Green Book") (14) provides design guidelines for roadways ranging from local streets to freeways, in both urban and rural locations. The guidelines "are intended to provide operational efficiency, comfort, safety, and convenience for the motorist" and to emphasize the need to consider other modal users of roadway facilities.

MANUAL ON UNIFORM TRAFFIC CONTROL DEVICES

FHWA's *Manual on Uniform Traffic Control Devices for Streets and Highways* (MUTCD) (15) is the national standard for traffic control devices for any street, highway, or bicycle trail open to public travel. Of particular interest to HCM users are the sections of the MUTCD pertaining to warrants for all-way STOP control and traffic signal control, signing and markings to designate lanes at intersections, and associated considerations of adequate roadway capacity and less restrictive intersection treatments.

TRANSIT CAPACITY AND QUALITY OF SERVICE MANUAL

The TCQSM (5) is the transit counterpart to the HCM. The manual contains background, statistics, and graphics on the various types of public transportation, and it provides a framework for measuring transit availability, comfort, and convenience from the passenger point of view. The manual contains quantitative techniques for calculating the capacity of bus, rail, and ferry transit services and transit stops, stations, and terminals.

7. REFERENCES

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Some of these references can be found in the Technical Reference Library in Volume 4.

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