

Highway Capacity Manual 2010

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The fifth edition of the *Highway Capacity Manual* (HCM 2010), recently released by the Transportation Research Board (TRB), incorporates results from more than \$5 million of research completed since the publication of the HCM 2000. This latest edition significantly updates the methodologies that engineers and planners use to assess the traffic and environmental effects of highway projects.

HCM 2010 introduces several firsts, including

- ◆ 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;
- ◆ Guidance on the proper **application of microsimulation analysis** and the evaluation of those results;
- ◆ The presentation of **active traffic management** in relation to demand and capacity; and
- ◆ **Generalized service volume tables** to assist planners in sizing roadway facilities.

Key Changes

Following are some of the key changes in the HCM 2010:

- ◆ The **signalized intersections** procedure models



HCM 2010 features findings on active traffic management, which strategically deploys an array of measures to relieve congestion.



Among the new features of HCM 2010 is updated material on the impact of weather and work zones on freeway capacity.

the operation of an actuated controller. A new incremental queue accumulation (IQA) method calculates the delay term d_i and the length term Q_i . Although equivalent to the HCM 2000 method for the idealized case, the IQA method is more flexible and can accommodate nonideal cases, such as coordinated arrivals and multiple green periods with differing saturation flow rates, which can occur with protected-plus-permitted left turns. A check procedure for left-turn lane overflow also has been added.

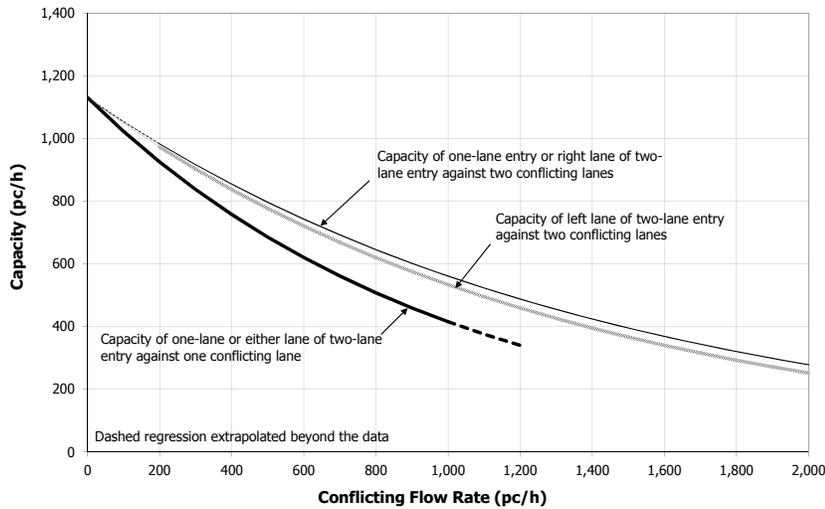
◆ **Unsignalized intersections**, previously a single chapter, now are described in three chapters, covering two-way STOP-controlled (TWSC) intersections, all-way STOP-controlled (AWSC) intersections, and roundabouts. The TWSC method in the HCM 2010 can analyze intersections along six-lane streets, and the AWSC method now includes a queue-estimation procedure. The roundabout material is completely updated, based on the work of National Cooperative Highway Research Program (NCHRP) Project 3-65,¹ which developed a comprehensive database of U.S. roundabout operations and established new methodologies for evaluating roundabout performance. The chapter adds a level-of-service (LOS) table for roundabouts.

- ◆ The **interchange ramp terminals** chapter has

¹ For titles of the NCHRP projects cited in this article, see the sidebar on page 48.

PHOTO: MINNESOTA DOT

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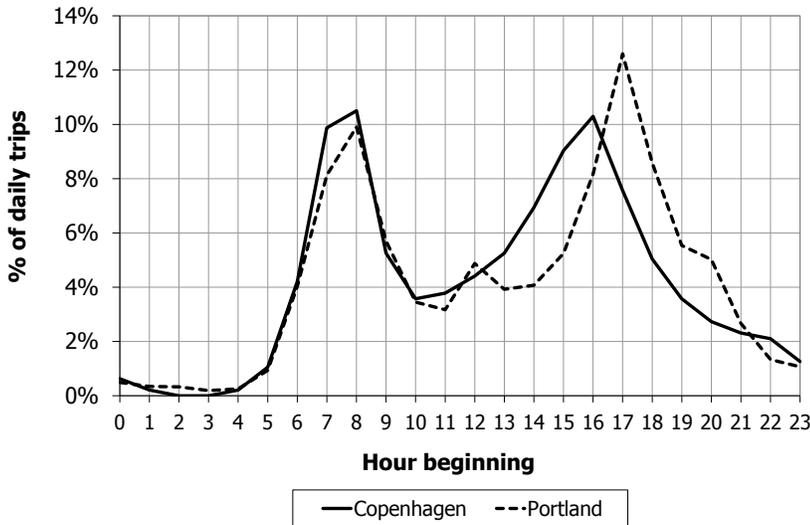
Capacity of roundabout entries, from Chapter 21; the roundabout material in HCM 2010 is completely updated and includes new methodologies for evaluating performance.

been completely updated with findings from the work of NCHRP Projects 3-60 and 3-60A. The chapter describes a new method for conducting operational analyses and obtaining the LOS for a full range of service interchange types—diamond, partial cloverleaf, and the single-point urban interchange. The chapter includes a methodology for assessing the operational performance of various types of interchanges and making an appropriate selection.

◆ The **urban street segments** chapter has been rewritten, incorporating the work of NCHRP Project 3-79. The chapter presents improved methods for estimating urban street free-flow speeds and running times, as well as a new method for estimating the stop rate along an urban street. In addition, NCHRP Project 3-70 has provided a methodology for evaluating tradeoffs in allocating urban street right-of-way among the modes.

◆ A new **urban street facilities** chapter traces out a methodology for aggregating results from the seg-

Hourly variations in bicycle volumes for two cities that have invested in infrastructure and programs: Copenhagen, Denmark, and Portland, Oregon; from HCM 2010, Chapter 3.



ment and point levels of analysis into a facility assessment. Information is provided on the impact of active traffic management measures on urban street performance.

◆ The **freeway facilities** chapter introduces a table for LOS based on density. Other updates include material on the impact of weather and work zones on freeway facility capacity, plus new information on the impact of active traffic management measures on freeway operations.

◆ The **freeway weaving** chapter has been completely updated with findings from NCHRP Project 3-75. Although the general process for analyzing weaving segments is similar to that given in HCM 2000, the HCM 2010 models derive from an up-to-date set of weaving data. The two major differences in applying the methodology are (a) a single algorithm for predicting weaving speeds and a single algorithm for predicting nonweaving speeds, regardless of the weaving configuration, and (b) the threshold for LOS F has changed.

New Approaches

A new chapter on **active traffic management**, based on research produced and compiled by the Federal Highway Administration (FHWA), describes various strategies to relieve highway congestion; the mechanisms affecting demand, capacity, and performance; and general guidance on evaluating active traffic management techniques. Strategies discussed include roadway metering, congestion pricing, traveler information systems, managed lanes, traffic signal control, and speed harmonization.

The HCM 2010 examines the use of **alternative tools** in conjunction with techniques presented, applying research conducted under NCHRP Project 3-85. Chapter 6 describes typical applications of HCM and alternative analysis tools, and Chapter 7 offers guidance on interpreting the results from alternative tools. In addition, each methodological chapter contains specific guidance on the application of the tools in analyzing a facility. Several examples illustrate the use of alternative tools in conjunction with the HCM 2010.

To encourage HCM users to consider all travelers, the HCM 2010 incorporates tools for **multimodal analysis** along highway facilities. This is the first edition of the HCM that takes into account the effects of cars on bicyclists and pedestrians. The stand-alone chapters for the bicycle, pedestrian, and transit modes have been eliminated—instead, the methods applicable to bicycles, pedestrians, and transit have been incorporated into the analyses of the various roadway facilities. For methodologies specific to the operation of transit vehicles on urban streets, readers can con-



PHOTO: DAN BIRNER, PEDESTRIAN AND BICYCLE INFORMATION CENTER

A shared pedestrian-bicycle path in San Luis Obispo, California. HCM 2010 updates off-street shared-use path procedures.

sult *TCRP Report 100: Transit Capacity and Quality of Service Manual*.

To assist planners in sizing highway facilities, the HCM 2010 includes **generalized service volume tables** that show the maximum demand volumes for a given LOS under a specified set of conditions. The HCM 2010 also provides **computational engines** to assist users in applying some of the intensive methods.

Additional Changes

Smaller changes have been implemented throughout the manual. For example, the speed-flow curves in the chapter on **basic freeway segments** have been updated with an expanded database. Small changes in the ramps and ramp junctions material—now called **freeway merges and diverges**—check and correct for unreasonable lane distributions. The **two-lane highways** chapter now provides only a one-directional methodology, and several key tables and curves have been updated. Finally, the **off-street shared-use path** procedures have been updated with U.S. data.

Multivolume Format

The new manual has retained many of the stylistic elements introduced in the HCM 2000, such as the page layout formats. The HCM 2010 content, however, is organized into four volumes—Concepts, Uninterrupted Flow, Interrupted Flow, and Applications Guide. The first three volumes are issued as a slipcased set of three looseleaf volumes; Volume 4 is electronic only. The four-volume structure delivers information at several levels of detail, to help HCM users apply and understand the concepts, methodologies, and potential applications.

Volume 1: Concepts presents the basic information that an analyst should master before performing analyses of highway capacity or quality of service. The chapters cover the organization of the HCM 2010; the kinds of applications that can be performed; 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 2010. Chapter 8, HCM Primer, offers an executive summary for decision makers.

Volume 2: Uninterrupted Flow contains methodological chapters relating to system elements, as well as the materials and resources needed to analyze these elements. The description of the process thoroughly conveys the steps involved, including the scope and limitations of the methodology, the specific default values, the LOS thresholds, the handling of special cases, and the application of alternative tools.

The freeway chapters are presented first, arranged from the facility level to the segment level; the chapters on multilane and two-lane highways follow. Volume 2 incorporates the Part III uninterrupted-flow chapters of the HCM 2000, along with material from the corresponding Part II chapters—such as specific default values and LOS thresholds—used directly in an analysis. The chapter on interchange ramp terminals, which appeared with the uninterrupted-flow chapters in the HCM 2000, appears in Volume 3 of the HCM 2010 with the interrupted-flow chapters.

The methodological chapters of **Volume 3: Interrupted Flow** reflect an approach similar to that of Volume 2, starting with a chapter on urban street facilities, followed by urban street segments, the various intersections, and off-street pedestrian and bicycle facilities. The chapters on urban street facilities and segments provide the highest level of multimodal evaluation, presenting methods to determine LOS for motorists, pedestrians, bicyclists, and transit users.

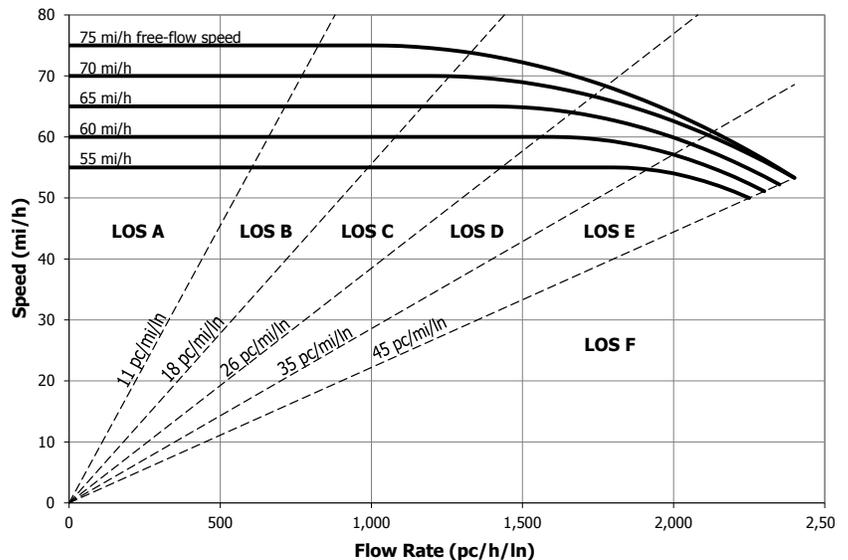
Web Volume

Volume 4: Applications Guide is an electronic-only volume accessible exclusively to registered HCM



HCM 2010 consists of four volumes—three looseleaf volumes in a slipcased set and one electronic-only volume. To order, visit the TRB online bookstore, <http://books.trbbookstore.org/hcm10.aspx>.

Freeway speed-flow curves, from HCM 2010, Chapter 11 (LOS = level of service; pc = passenger car; ln = lane).



HCM 2010 Research Resources

The following research projects contributed to the development of the HCM 2010:

- ◆ NCHRP Project 3-60, Capacity and Quality of Service of Interchange Ramp Terminals;
- ◆ NCHRP 3-60A, Validation and Enhancement of the *Highway Capacity Manual's* Interchange Ramp Terminal Methodology;
- ◆ NCHRP Project 3-64, *Highway Capacity Manual Applications Guide*;
- ◆ NCHRP Project 3-65, Applying Roundabouts in the United States;
- ◆ NCHRP Project 3-70, Multimodal Level of Service Analysis for Urban Streets;
- ◆ NCHRP Project 3-75, Analysis of Freeway Weaving Sections;
- ◆ NCHRP Project 3-79, Measuring and Predicting the Performance of Automobile Traffic on Urban Streets;
- ◆ NCHRP Project 3-82, Default Values for Capacity and Quality of Service Analyses;
- ◆ NCHRP Project 3-85, Guidance for the Use of Alternative Traffic Analysis Tools in Highway Capacity Analyses;
- ◆ NCHRP Project 3-92, Production of the 2010 *Highway Capacity Manual*; and
- ◆ Two FHWA projects: Evaluation of Safety, Design, and Operation of Shared-Use Paths; and Active Traffic Management Measures for Increasing Capacity and Improving Performance.

users via the Internet. This volume 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.

Chapters 24 through 34 in Volume 4 supplement chapters in Volumes 1, 2, and 3 with

- ◆ More detailed descriptions of selected computational methodologies, written for users who seek a greater depth of understanding or who plan to develop HCM implementation software;
- ◆ Example applications of alternative tools to situations not addressed by the methodologies in the chapters of Volumes 2 and 3;
- ◆ Descriptions of the computational engines for selected methodologies; and
- ◆ Additional example problems and calculation results.

In addition, Chapter 35 in Volume 4 provides a first-generation chapter on the impact of active traffic management techniques on roadway operations. As new research is completed, this chapter will be updated, and chapters may be added to address other emerging issues, such as travel time reliability.

The methodological interpretations section also will continue to develop, as users apply the HCM 2010 and pose questions about particular methodologies to the TRB Highway Capacity and Quality of Service (HCQS) Committee. Clarifications and interpretations of the HCM, as well as corrections, 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 focus on the analysis process in applying the HCM and alternative tools, not on the step-by-step details of performing calculations—calculations are addressed in the example problems in each methodological chapter and in selected supplemental chapters. Case Studies 1 through 5 derive from the web-based *HCM Applications Guidebook* developed after publication of the HCM 2000, and Case Study 6 was developed in conjunction with NCHRP Project 3-85.

Finally, the Technical Reference Library contains a selection of papers, technical reports, and companion documents cited in the HCM.

Community Collaboration

As the HCM has grown in the decades since its debut in 1951, the content has long since ceased to be the product of a few highly competent experts or of a single technical committee. The HCM 2010 has benefited from the extensive involvement of the professional community to an extent that far surpasses that of previous editions.

A series of practitioner focus groups conducted through NCHRP Project 3-92 and the HCQS Committee supplied valuable insights on the HCM content and organization. More than 300 professionals—many new to TRB—along with members of the HCQS Committee and participants in the manual development process contributed to the year-long review of the chapters.

Four committees from the TRB Technical Activities Operations Section provided reviews and comments on drafts of the manual. Finally, the HCQS Committee's joint summer meetings with local Institute of Transportation Engineers (ITE) sections during the development of the manual, along with focus groups sponsored by ITE, were informative and productive.

The HCQS Committee has invited users of the manual who are interested in improving the profession's understanding of highway capacity and quality of service analysis to participate in the committee deliberations and to provide feedback about the HCM 2010 methods. The committee website, www.AHB40.org, will be available for these interactions.