NEW TRB PUBLICATION

The Highway Capacity Manual, 6th Edition

A Guide for Multimodal Mobility Analysis

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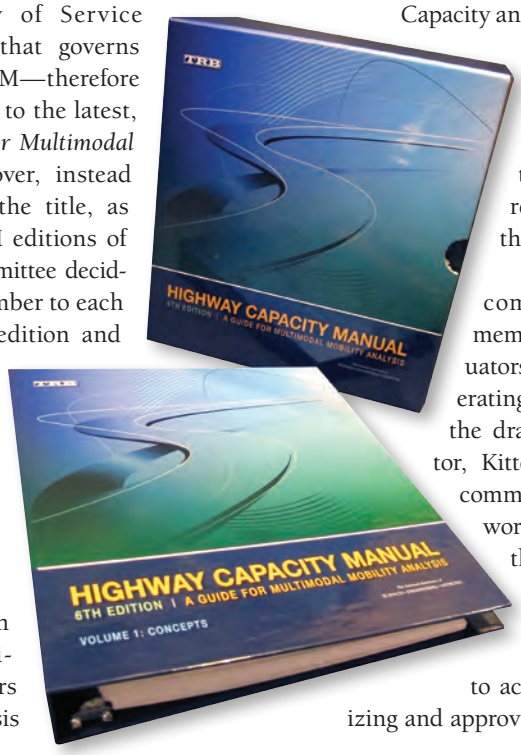
The first edition of the *Highway Capacity Manual* (HCM), published in 1950, aimed to provide "a practical guide by which the engineer, having determined the essential facts, can design a new highway or revamp an old one with assurance that the resulting actual capacity will be as calculated" (*1*). The 1965 edition introduced the concept of levels of service (LOS) based on a selected performance measure, such as traffic speed or density (*2*).

As highways became more and more congested, the understanding of traffic operations evolved, along with the needs of the practicing transportation professional. Evaluating congested operations, considering multiple modes and their interactions, and obtaining a variety of performance measures and tools, including simulation, became increasingly important.

PHOTO: ERIC ROBITAILLE, PEDBIKEIMAGES.ORG

Multiple transportation modes and their interactions were a major focus in updates and revisions to the *Highway Capacity Manual* (HCM).

As a result, the HCM has evolved. The Transportation Research Board's (TRB's) Highway Capacity and Quality of Service Committee—the body that governs the publication of the HCM—therefore decided to add a subtitle to the latest, sixth edition: *A Guide for Multimodal Mobility Analysis*. Moreover, instead of attaching a year to the title, as was done with the HCM editions of 2000 and 2010, the committee decided to attach a version number to each chapter, indicating the edition and revision, to allow for more frequent updates of individual chapters as new research becomes available.



A Collaboration of Experts

The HCM 6th Edition (HCM6) offers practitioners and researchers an extensive set of analysis tools (*3*) incorporating the most recent research findings on the operational analysis of traffic. Highway Capacity and Quality of Service Committee members, who reviewed the research and the tools, constitute a wide cross section of transportation professionals in the United States and abroad, representing the public sector, the private sector, and academia.

Approximately 200 experts—committee and subcommittee members, as well as external evaluators—reviewed the HCM6, generating a total of 3,331 comments on the drafts developed by the contractor, Kittelson & Associates, Inc. The committee vetted the comments and worked with the contractor over three years to revise and finalize the document. The appropriate subcommittees and the full committee formally voted to accept each chapter before finalizing and approving the HCM6 for publication.

The *Highway Capacity Manual, 6th Edition*, consists of a boxed set of three printed volumes in looseleaf binders, plus a fourth volume online. To order, contact the TRB Bookstore, http://www.trb.org/Finance/Bookstore.aspx, or go to https://www.mytrb.org/Store/Product.aspx?ID=8313.

Scope of the HCM6

Improving mobility is an essential aspect of transportation engineering. The HCM6 identifies four general dimensions of mobility (Figure 1, right):

- Capacity: the amount of traffic that can be processed—for example, the capacity of a freeway in vehicles per hour per lane;
- Quality of travel: the performance of a facility as a function of the demand and of the facility's design—for example, the expected operating speed under prevailing conditions;
- Quantity of travel: the magnitude of traffic—for example, vehicle miles traveled (VMT) or vehicle hours traveled (VHT) within a region and a specified time period, including measures of demand, an input to the HCM6 methods; and
- Accessibility: the availability of access—for example, the availability of transit within a region.

HCM6 focuses on evaluating the capacity and quality of service of various facilities and modes and uses quantity-related data—namely, demand—as an input. LOS is one of the best-known measures of the quality of service; nevertheless, HCM6 provides tools for estimating additional performance measures for a variety of modes and facilities. The user also can apply a performance measure estimate by itself, without assigning a LOS letter to the result—LOS is intended primarily for communicating about operations to nontechnical audiences.

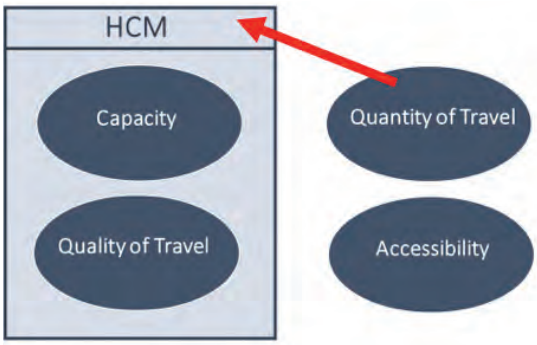


FIGURE 1 The four dimensions of mobility and the HCM.

Performance Measures

Transportation professionals often need multiple performance measures to evaluate a particular facility's operational performance. Performance measures that represent a single dimension of mobility may not provide a full picture; often two or more dimensions are necessary for a more complete evaluation of operational performance for a particular study. For example, a study of the mobility provided by a bikeway facility may require data on the level of utilization, the expected LOS, the expected LOS of

PHOTO: ARBYREED, FLICKR

Harbor Boulevard in Orange County, California, in the mid-1960s. The 1965 edition of the HCM introduced the concept of levels of service, and HCM6 offers tools for additional performance measures.

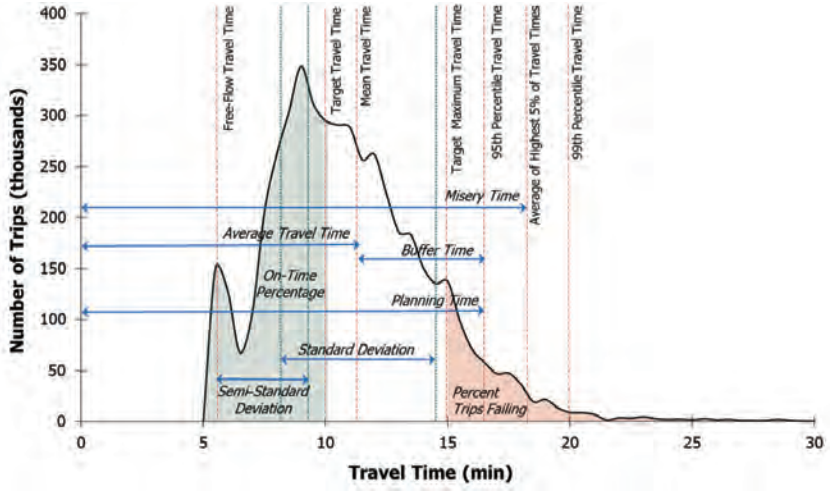


FIGURE 2 Illustration of a travel time distribution obtained with the HCM6, along with pertinent performance measures. (Source: HCM6, Chapter 11, Exhibit 11-3.)

Elementary school students and Virginia Department of Transportation engineers tour a new pedestrian bridge over I-264 in Portsmouth. HCM6 includes tools to assess pedestrian facilities and other designs for nonautomobile modes.

the urban street parallel to the facility, and the connectivity of bicycle paths within the study area.

Transportation professionals may need to evaluate other aspects of a system, such as the financial or environmental; these are outside the scope of the HCM6. Nonetheless, the HCM6 may include performance measures—for example, capacity or travel time estimates—that can serve as inputs to these other types of analysis. Default values that the HCM6 provides for various analysis inputs also may be useful for analyses that do not require a high level of detail.

Chapter 1 provides additional information on the purpose, scope, and intended uses of the HCM6. Each methodological chapter—Chapters 10 through 15 on uninterrupted flow and Chapters 16 through 24 on interrupted flow—provides methods for estimating various performance measures for the type of facility and the modes of travel addressed.

PHOTO: TOM SAUNDERS, VIRGINIA DOT

Tools, Methods, and Resources

In one of its most significant enhancements, the HCM6 provides estimates of travel time reliability for freeway systems and for urban street facilities. Travel time reliability relates to the distribution of travel times over an extended period—for example, one year, instead of evaluating a single analysis period, such as the design hour.

This approach allows for a more comprehensive evaluation of system utilization and performance by considering multiple scenarios that could occur throughout the year, involving incident management, snow clearance, ramp metering and other advanced traffic management, congestion pricing, and work zone lane closures.

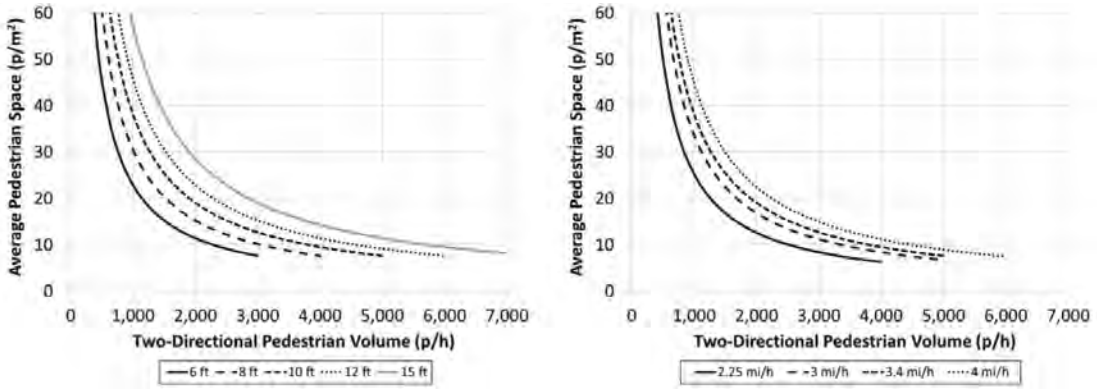
Operational Effects

The HCM6 presents tools for evaluating the operational effects of various policies and strategies and for conducting a detailed scenario analysis to identify the most effective strategies. Two new chapters relate to travel time reliability: Chapter 11, Freeway Reliability Analysis, and Chapter 17, Urban Street Reliability and Active Traffic and Demand Management (ATDM). These chapters describe the methods and tools for obtaining various metrics related to travel time reliability for freeways and urban streets. Figure 2 (above, left) illustrates a travel time distribution from an HCM6 analysis, along with several measures obtained.

ATDM is the dynamic management and control of traffic along transportation facilities. Chapter 37, ATDM: Supplemental, provides an overview of ATDM strategies and guidance on analyzing the operational effects. Chapters 11, Freeway Reliability Analysis, and 17, Urban Street Reliability and ATDM, provide methodologies for evaluating the effects of various strategies—notably ramp metering, managed lanes, and incident management.

Nonautomobile Modes

In response to the increasing need to estimate the performance measures for pedestrian, bicycle, and transit facilities, as well as the interactions with vehicles, the HCM6 provides tools and methods for the assessments. Chapters 16 through 23 include methods for assessing nonautomobile modes and their interactions with vehicular traffic, and Chapter 24 supplies methods for analyzing off-street pedestrian and transit facilities. Figure 3 (page 19) offers an illustrative example of the relationship between pedestrian volume, effective path width, and average



(*a*) Effective Path Width

(*b*) Average Pedestrian Speed

FIGURE 3 Illustrative example relating pedestrian volume with (*a*) effective path width and (*b*) average pedestrian speed in average pedestrian space.

pedestrian speed on the average space for off-street pedestrian facilities.

Chapter 15 describes a methodology for evaluating bicycle operations on multilane and two-lane highways; a recent article on multimodal analysis in the HCM6 presents additional information on this topic (*4*). TRB's Transit Cooperative Research Program Report 100, *Transit Capacity and Quality of Service Manual*, 2nd Edition,[1] focuses on the evaluation of transit facilities (*5*); the HCM6 considers the effects of transit along urban streets within a multimodal analysis framework.

Intersections and Interchanges

Methods for the analysis of interchange ramp terminals and alternative intersections are included in Chapter 23. In addition to the operational and planning-level tools for diamond, partial cloverleaf, and single-point urban interchanges—included in the previous edition of the HCM—this chapter covers methods for the analysis of diverging diamond interchanges (Figure 4, right), which are gaining in use, as well as analysis methods for evaluating restricted crossing U-turn intersections, median U-turn intersections, and displaced left-turn intersections.

Alternative Tools

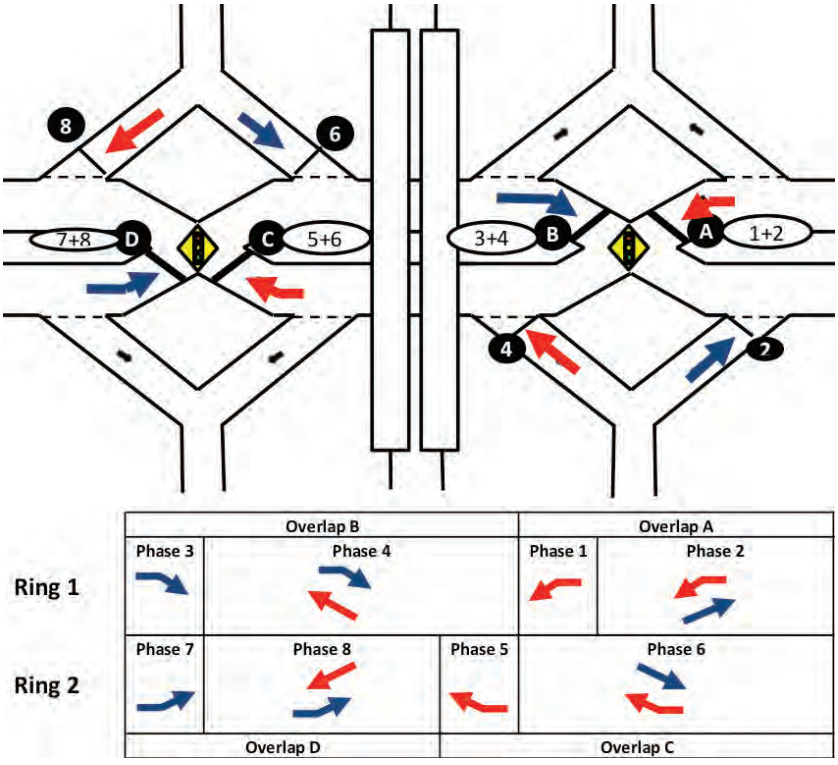
HCM6 recognizes the need to work with alternative tools on an operational analysis, describes the limitations of each methodology, and offers guidance on the use of simulation and other tools in conjunction with an HCM analysis. In addition, Chapter 6, HCM and Alternative Analysis Tools, explores cases for using alternative tools and simulation to supply additional performance measures not available from HCM6 methods or to analyze highway designs not addressed within the HCM performance measurement framework.

[1] www.trb.org/Main/Blurbs/153590.aspx.

The HCM6 tools generally can be used for quick evaluations and comparisons of multiple scenarios. The analyst can screen the scenarios and select a reasonable number before applying more costly approaches, such as simulation.

Chapter 7 provides guidance for interpreting the results from HCM6 and alternative tools, including sources of uncertainty, the importance of precise definitions in computing performance measures with alternative tools, and comparing the HCM6 results with those from alternative methods. Figure 5 (page 20) illustrates the relationship between the HCM6 analyses and alternative tools for corridor and areawide studies.

FIGURE 4 Standard phasing scheme at a signalized diverging diamond interchange.



Tools to evaluate alternative intersections, such as median intersections, are provided in Chapter 23 of HCM6.

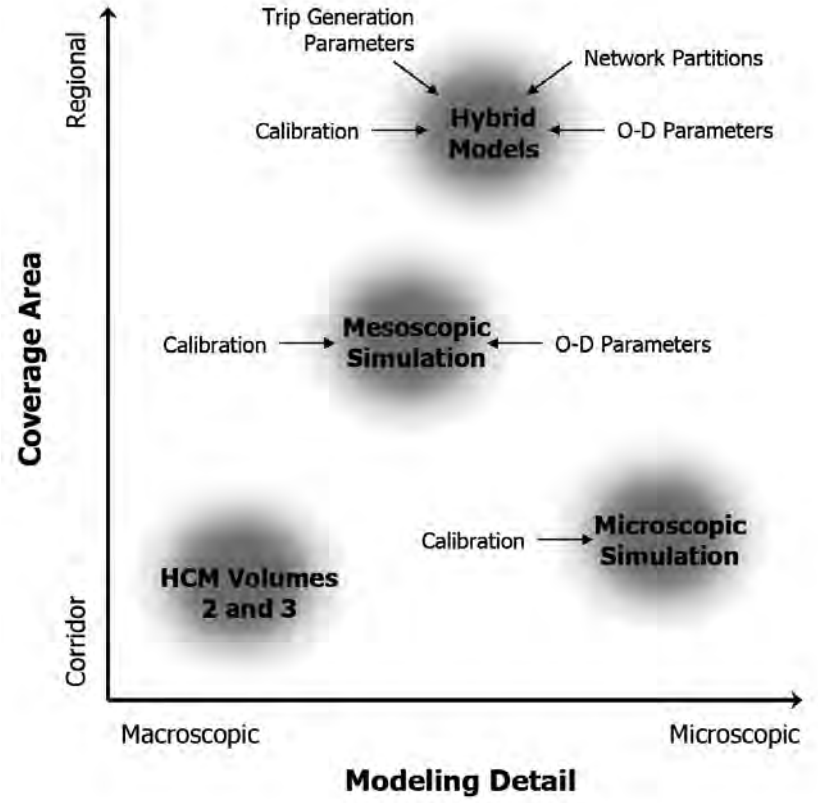
PHOTO: DANIEL ONES, FLICKR

Planning Analyses

For users interested in planning and preliminary analysis, the companion *Planning and Preliminary Engineering Applications Guide to the HCM* (6) provides tools for high- and medium-level analyses when the available data are limited. Typical applications include studies of large areas, studies with horizon years well into the future, and statewide performance monitoring. These types of analyses require simpler methods because of the large number of facilities and can tolerate results that are less precise because of uncertainties in future traffic forecasts or in facility design, or because large-scale data collection is not feasible.

HCM6 still provides methods for the more traditional analysis of uninterrupted facilities, such as freeways, multilane highways, and two-lane highways, and for interrupted facilities, such as urban streets, interchanges, signalized intersections, unsignalized intersections, and roundabouts.

FIGURE 5 HCM6 analyses and alternative tools. (O-D = origin–destination.)



HCM6 Applications

In addition to the LOS and capacity analysis tools, the HCM6 offers resources for a variety of studies. Because the methods are based on data from across the United States, analysts can apply the HCM6 values as default values in many other tools. For example, travel demand models can use the capacity and speed estimates; designs can apply the queue length estimates; evaluations of the operational effects of policy decisions can use the travel time reliability estimates; and evaluations of the impacts of urban street modifications on a bicycle facility can employ the bicycle LOS estimates.

In general, HCM6 provides tools for operational analysis, design analysis, and planning and preliminary engineering analysis.

◆ **Operational analysis** requires the most accurate input information—as well as the greatest amount. This type of analysis often evaluates alternative designs, such as the spacing and location of bus stops, changes in signal timing or lane channelization, or the addition or drop of a freeway lane. The HCM6 tools for operational analysis often can be the most cost-effective and practical for evaluating a series of alternatives without resorting to more data-intensive approaches.

◆ **Design analysis** focuses on the physical characteristics required for a facility to achieve a desired operational performance. The level of detail for the input data is similar to that for an opera-

tional analysis. A design analysis typically focuses on the required number of lanes, the lane widths, the grades, and the sidewalk.

◆ A **planning and preliminary engineering analysis** does not require the detailed information of an operational analysis. The HCM6 provides a variety of default values to approximate operational performance or design characteristics. The results may not be as accurate, but this type of analysis stands as a practical solution when data are unavailable and data collection is not feasible. HCM6 also includes generalized service-volume tables, which provide the maximum number of units of traffic that a facility can carry at a given LOS, under a set of assumed conditions. Planning and preliminary engineering analysis tools often are used to evaluate initial conceptual designs and alternatives.

How to Get Involved

As noted, the TRB Highway Capacity and Quality of Service Committee guided development of the HCM6. The committee and its subcommittees include representatives from state departments of transportation, local agencies, consulting firms, universities, and the Federal Highway Administration (FHWA). The committee meets twice a year to review ongoing research and make decisions about changes to the HCM: in January during the TRB Annual Meeting in Washington, D.C., and in the summer at various locations around the country or internationally.

The summer meeting often invites the local chapter of the Institute of Transportation Engineers to discuss topics of mutual interest. All transportation professionals are welcome to participate in committee activities, to provide feedback on HCM methods, and to suggest modifications and additions. The committee also addresses questions about HCM6 applications, clarifications, and errata.

More information on committee activities and upcoming events is available on the committee website.[2] The website contains links for joining the contact list.[3] The committee relies on the expertise of professionals around the country for feedback, to ensure that HCM6 remains relevant and addresses the needs of stakeholders.

Methods and Tools

The *Highway Capacity Manual, 6th Edition: A Guide for Multimodal Mobility Analysis* provides a wealth of methods and tools for estimating performance measures in assessing the quality of traffic operations for passenger cars, trucks, pedestrians, bicyclists, and transit passengers. The methods address a range of analyst needs related to the availability and accuracy of input data, including operational analysis, design, planning, and preliminary engineering analysis.

The HCM6 provides new tools to estimate travel time reliability, evaluate the impacts of ATDM, assess alternative designs for intersections and interchanges, and estimate multimodal LOS, among others. The Highway Capacity and Quality of Service Committee welcomes participation and input from all transportation professionals, because broad involvement is essential for the continued success of the HCM.

PHOTO: SOUNDERBRUCE, FLICKR

HCM6 resources can be applied to estimates of queue length, travel time reliability, and other operational, design, and planning analyses.

Acknowledgments

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[2] http://sites.kittelson.com/HCQS.

[3] Select Rosters/Email Groups, and click on "Become a Friend."