

CHAPTER 1

INTRODUCTION

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I. INTRODUCTION

PURPOSE OF THE MANUAL

The *Highway Capacity Manual* (HCM) provides transportation practitioners and researchers with a consistent system of techniques for the evaluation of the quality of service on highway and street facilities. The HCM does not set policies regarding a desirable or appropriate quality of service for various facilities, systems, regions, or circumstances. Its objectives include providing a logical set of methods for assessing transportation facilities, assuring that practitioners have access to the latest research results, and presenting sample problems. This fourth edition of the HCM is intended 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 manual is the primary source document embodying research findings on capacity and quality of service and presenting methods for analyzing the operations of streets and highways and pedestrian and bicycle facilities. A complementary volume, *Transit Capacity and Quality of Service Manual*—now in development by the Transportation Research Board (TRB)—presents methods for analyzing transit services from the perspectives of both the user and the operator.

SCOPE OF THE MANUAL

This manual is divided into five parts. Part I provides an overview of the traffic flow concepts inherent in capacity and level-of-service analyses, a discussion of their applications, and a description of policy decision making based on this fourth edition. It also includes a glossary of terms and a list of symbols. Part II describes the concepts and provides the estimated default values for use in the analytical work presented in Part III. Part III offers specific methods for assessing roadway, bicycle, pedestrian, and transit facilities in relation to their performance, capacity, and level of service.

For the analyst who must assess more than an individual facility, Part IV of this manual provides a framework for the analysis of corridors, areas, and multimodal operations. In some cases, it provides specific computational techniques, while in others it provides a more general analysis of the facility or facilities. Part V offers background and information on the type of models appropriate for systemwide or more complex capacity and level-of-service analyses.

Additional information beyond this manual is available on the World Wide Web at <http://nationalacademies.org/trb/hcm>.

USE OF THE MANUAL

In addition to the service measures necessary to determine quality of service, this manual identifies analytical procedures for other performance measures. These allow the analyst to assess different aspects of an existing or planned facility. Moreover, this document makes it possible to evaluate broader systems of facilities and to establish a link between operational and planning models.

This manual is intended for use by a range of practitioners, including traffic engineers, traffic operations personnel, design engineers, planners, management personnel, teachers, and university students. 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.

RESULTS FROM THE METRIC AND U.S. CUSTOMARY VERSIONS

This fourth edition of the manual is published in two versions, one in metric units and one in U.S. customary units. Although the methodologies in the metric and U.S. customary versions of the manual are identical, parameters, level-of-service thresholds, and other values will be hard-converted. This means that analysis results calculated using

Part I: Overview

1. Introduction
2. Capacity and Level-of-Service Concepts
3. Applications
4. Decision Making
5. Glossary
6. Symbols

Part II: Concepts

7. Traffic Flow Parameters
8. Traffic Characteristics
9. Analytical Procedures Overview
10. Urban Street Concepts
11. Pedestrian and Bicycle Concepts
12. Highway Concepts
13. Freeway Concepts
14. Transit Concepts

Part III: Methodologies

15. Urban Streets
16. Signalized Intersections
17. Unsignalized Intersections
18. Pedestrians
19. Bicycles
20. Two-Lane Highways
21. Multilane Highways
22. Freeway Facilities
23. Basic Freeway Segments
24. Freeway Weaving
25. Ramps and Ramp Junctions
26. Interchange Ramp Terminals
27. Transit

Part IV: Corridor and Areawide Analyses

28. Assessment of Multiple Facilities
29. Corridor Analysis
30. Areawide Analysis

Part V: Simulation and Other Models

31. Simulation and Other Models

the metric version may differ slightly from those calculated using the U.S. customary version. Transportation agencies may want to specify which system of units they and their consultants will use and discourage conversions between systems of units.

NORTH AMERICAN AND INTERNATIONAL APPLICATIONS

During the 1990s, capacity and level of service analysis generated interest on an international scale. Therefore, increased attention and effort has focused on incorporating into the HCM research results and proposed procedures from countries outside of North America. Also, by producing its first HCM with metric units, TRB has taken a step toward making these methods and procedures more applicable to international work. However, the user of the manual is cautioned 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.

ONLINE MANUAL

HCM 2000 is available in electronic format on CD-ROM. The online edition offers several multimedia, user-interactive components that allow for viewing of simulated and real-world traffic conditions, explanations of capacity and level of service concepts, and a step-by-step graphic presentation of the solutions to sample problems. The online manual faithfully presents the material and procedures described in this book.

CALCULATION SOFTWARE

As a companion tool to this manual, commercial software is available to perform the numerical calculations for the chapters in Part III. The CD-ROM online manual has a feature to incorporate the user's preferred software as required. Although there are several calculation software packages available, TRB does not produce, review, or endorse any.

CD-ROM version

Software for
implementing HCM
methodologies

II. HISTORY OF THE MANUAL

The first edition of the HCM was published in 1950 by the U.S. Bureau of Public Roads as a guide to the design and operational analysis of highway facilities. In 1965, TRB—then known as the Highway Research Board—published the second edition under the guidance of its Highway Capacity Committee. The third edition, published by TRB in 1985, reflected more than two decades of comprehensive research conducted by a variety of agencies under the sponsorship of several organizations, primarily the National Cooperative Highway Research Program and the Federal Highway Administration. Its development was guided by the TRB Committee on Highway Capacity and Quality of Service. As a result of continuing research in capacity, the third edition of the HCM was updated in 1994 and 1997. Exhibit 1-1 lists the 1985 HCM chapters along with their most recent updates.

The 1997 update included extensive revisions to Chapters 3, 9, 10, and 11. In addition, Chapters 1, 4, 5, 6, and 7 were modified to make them consistent with other revised chapters.

The basic freeway sections chapter (Chapter 3) revised the procedure for determining capacity based on density. It also proposed that capacity values under ideal flow conditions varied by free-flow speed.

EXHIBIT 1-1. HCM 1985 EDITION: ORGANIZATION AND UPDATES

Chapter	Description/Facility Type	Final Update
1	Introduction, Concepts, and Applications	1997
2	Traffic Characteristics	1994
Uninterrupted-Flow Facilities		
3	Basic Freeway Sections	1997
4	Weaving Areas	1997
5	Ramps and Ramp Junctions	1997
6	Freeway Systems	1997
7	Multilane Rural and Suburban Highways	1997
8	Two-Lane Highways	1985
Interrupted-Flow Facilities		
9	Signalized Intersections	1997
10	Unsignalized Intersections	1997
11	Arterial Streets	1997
12	Transit Capacity	1985
13	Pedestrians	1985
14	Bicycles	1985

The signalized intersections chapter included findings from research on actuated traffic signals. The delay equation was modified to account for signal coordination, oversaturation, variable length analysis periods, and the presence of initial queues at the beginning of an analysis period. The level-of-service measure was changed from stopped delay to control delay. Adjustments were made to the permitted left-turn movement model and to the left-turn equivalency table.

The chapter on unsignalized intersections was completely revised to incorporate the results of a nationwide research project in the United States examining two-way and four-way stop-controlled intersections. In addition, it addressed the impact of an upstream traffic signal on capacity at a two-way stop-controlled intersection. Procedures were provided to account for flared approaches, upstream signals, pedestrian crossings, and two-stage gap acceptance (when vehicles seek refuge in a median before crossing a second stream of traffic).

The arterial streets chapter in the 1997 HCM incorporated the relevant changes from the signalized intersections chapter. It also established a new arterial classification for high-speed facilities. The delay equation was modified to account for the effect of platoons from upstream signalized intersections.

III. WHAT'S NEW IN HCM 2000

This fourth edition of the HCM is published in two versions: metric and U.S. customary units. The chapter organization also has changed—HCM 2000 consists of five parts with a total of 31 chapters. Exhibit 1-2 lists the parts and chapters. The changes to these are summarized in the next sections.

PART I: OVERVIEW

Part I presents the basic concept of level of service and capacity as applied throughout the manual. In addition, specific discussions cover different types of applications, decision making, and guidelines for using results from the methodologies in this manual. A glossary of terms and a list of symbols—previously at the end of the manual—now appear in the first part and are significantly expanded.

Part I: Chapters 1–6

EXHIBIT 1-2. HCM 2000 ORGANIZATION

Chapter	Description/Facility Type
Part I: Overview	
1	Introduction
2	Capacity and Level-of-Service Concepts
3	Applications
4	Decision Making
5	Glossary
6	Symbols
Part II: Concepts	
7	Traffic Flow Parameters
8	Traffic Characteristics
9	Analytical Procedures Overview
10	Urban Street Concepts
11	Pedestrian and Bicycle Concepts
12	Highway Concepts
13	Freeway Concepts
14	Transit Concepts
Part III: Methodologies	
15	Urban Streets
16	Signalized Intersections
17	Unsignalized Intersections
18	Pedestrians
19	Bicycles
20	Two-Lane Highways
21	Multilane Highways
22	Freeway Facilities
23	Basic Freeway Segments
24	Freeway Weaving
25	Ramps and Ramp Junctions
26	Interchange Ramp Terminals
27	Transit
Part IV: Corridor and Areawide Analyses	
28	Assessment of Multiple Facilities
29	Corridor Analysis
30	Areawide Analysis
Part V: Simulation and Other Models	
31	Simulation and Other Models

PART II: CONCEPTS

Part II presents the concepts of the facility types with methodologies described in the manual and includes discussions of typical capacity parameters. In the past, these materials were presented together with the methodology for each facility. New discussion reviews the precision and accuracy of variables in the HCM. Default values are offered to aid the analyst in obtaining input values for the methodologies that are presented in Part III. In addition, the second part includes several sample service volume tables and, in Chapter 10, a modified quick-estimation method for evaluating signalized intersections.

Part II: Chapters 7–14

PART III: METHODOLOGIES

Part III: Chapters 15–27

Part III contains the analytical methodologies, which generally correspond to the 12 facility chapters in the 1997 version of the HCM.

Urban Streets

Titled “Arterial Streets” in the 1997 HCM, this chapter does not change the methodology significantly, but includes new worksheets.

Signalized Intersections

A methodology for the estimation of back of queue is added, along with new saturation flow rate adjustment factors for pedestrian and bicycle effects. New consolidated worksheets are provided.

Unsignalized Intersections

Additions to this chapter include a new 95th percentile queue estimation equation and newly designed worksheets.

Pedestrians

This chapter expands the 1985 HCM methodology, enabling the evaluation of several pedestrian facility types previously not addressed.

Bicycles

A new methodology for evaluating bicycle facilities, based on the concept of events and hindrance, has replaced the previous version in its entirety.

Two-Lane Highways

A new methodology for evaluating two-lane highways by direction of travel or by both directions combined has replaced the previous version in its entirety.

Multilane Highways

New truck equivalency values are introduced.

Freeway Facilities

A new methodology is presented.

Basic Freeway Segments

Again, new truck equivalency values are introduced.

Freeway Weaving

The 1997 HCM methodology has been slightly revised.

Ramps and Ramp Junctions

A new speed prediction model is presented.

Interchange Ramp Terminals

Although this new chapter does not describe a methodology, it presents concepts for analyzing interchange areas.

Transit

A new methodology is presented, based on research conducted for TRB’s *Transit Capacity and Quality of Service Manual (I)*.

Part V: Chapter 31

PART IV: CORRIDOR AND AREAWIDE ANALYSES

Part IV: Chapters 28–30

The methodologies for corridor and areawide analyses are new additions to the HCM. The chapters show how to aggregate results from the Part III chapters to analyze the combined effects of different facility types.

PART V: SIMULATION AND OTHER MODELS

Part V is a new addition, presenting concepts and numerical exercises using traffic simulation models. In addition, it demonstrates typical applications of simulation models to complement HCM methodologies. An extensive reference list points to more information on simulation and other models.

IV. RESEARCH BASIS FOR HCM 2000

Exhibit 1-3 lists the major research projects performed since 1990 that have contributed significantly to the contents of HCM 2000.

V. REFERENCE

1. *Transit Capacity and Quality of Service Manual*. Transit Cooperative Research Program Web Document No. 6. TRB, National Research Council, Washington, D.C., 1999. Online. Available: <http://www4.nationalacademies.org/trb/crp.nsf/all+projects/tcrp+a15>.

EXHIBIT 1-3. RELATED RESEARCH PROJECTS

Research	Research Title	Objective
NCHRP 3-33	Capacity and Level-of-Service Procedures for Multilane Rural and Suburban Highways	Develop procedures to determine capacity and level of service of multilane highways
NCHRP 3-37	Capacity and Level of Service at Ramp-Freeway Junctions	Develop methodology to determine capacity and level of service at ramp-freeway junctions
NCHRP 3-37(2)	Capacity and Level of Service at Ramp-Freeway Junctions (Phase II)	Validate methodology produced by NCHRP 3-37
NCHRP 3-45	Speed-Flow Relationships for Basic Freeway Segments	Revise material on speed-flow relationships to update HCM 1994 analysis of Basic Freeway Sections
NCHRP 3-46	Capacity and Level of Service at Unsignalized Intersections	Develop capacity analysis procedure for stop-controlled intersections and correlate with the warrants for installation of traffic signals in the <i>Manual on Uniform Traffic Control Devices</i>
NCHRP 3-47	Capacity Analysis of Interchange Ramp Terminals	Develop methodology to determine capacity and level of service at signalized ramp terminals
NCHRP 3-48	Capacity Analysis for Actuated Intersections	Develop capacity and level of service analysis at intersections with actuated control
NCHRP 3-49	Capacity and Operational Effects of Midblock Left-Turn Lanes	Develop qualitative methodology for evaluating alternative midblock left-turn treatments on urban streets
NCHRP 3-55	<i>Highway Capacity Manual</i> for the Year 2000	Recommend user-preferred format and delivery system for HCM 2000
NCHRP 3-55(2)	Techniques to Estimate Speeds and Service Volumes for Planning Applications	Develop extended planning techniques for estimating measures of effectiveness (MOEs)
NCHRP 3-55(2)A	Planning Applications for the Year 2000 <i>Highway Capacity Manual</i>	Develop draft chapters related to planning for HCM 2000
NCHRP 3-55(3)	Capacity and Quality of Service for Two-Lane Highways	Improve methods to determine capacity and quality of service of two-lane highways
NCHRP 3-55(4)	Performance Measures and Levels of Service in the Year 2000 <i>Highway Capacity Manual</i>	Recommend MOEs and additional performance measures
NCHRP 3-55(5)	Capacity and Quality of Service of Weaving Areas	Improved methods for capacity and quality of service analyses of weaving areas
NCHRP 3-55(6)	Production of the Year 2000 <i>Highway Capacity Manual</i>	Complete HCM 2000 document
TCRP A-07	Operational Analysis of Bus Lanes on Arterials	Develop procedures to determine capacity and level of service of bus flow on arterials
TCRP A-07A	Operational Analysis of Bus Lanes on Arterials: Extended Field Investigations	Expand field testing and validation of procedures developed in TCRP A-07
TCRP A-15	Development of Transit Capacity and Quality of Service Principles, Practices and Procedures	Provide transit input to HCM 2000
FHWA	Capacity Analysis of Pedestrian and Bicycle Facilities Project (DTFH61-92-R-00138)	Update method for analyzing effects of pedestrians and bicycles at signalized intersections; recommend improvements
FHWA	Capacity and Level of Service Analysis for Freeway Systems Project (DTFH61-95-Y-00086)	Develop procedure to determine capacity and level of service of a freeway facility