

Registrar of Regulations	Date/Time filed with Registrar of Regulations
<i>AUTHORIZATION TO FILE DOCUMENTS INCORPORATED BY REFERENCE BY DESCRIPTION</i>	
① Agency: <u>Virginia Department of Transportation</u>	
② Regulation Numbers: <u>N/A</u> <u>24 VAC 30-72</u> Title of Regulation: <u>Access Management Regulations: Principal Arterials</u>	
③ Effective Date of Regulation: <u>December 2011</u>	
④ Name of Document Incorporated by Reference: <u>Highway Capacity Manual, 2010</u>	
⑤ Attach a summary of the document incorporated by reference, including publication date and a copy of the cover page. <u>See attachments</u>	
⑥ Document available for inspection at the following location: <u>Va. Dept. of Transportation</u> <u>Transportation and Mobility Planning Division</u> <u>1401 E. Broad St.</u> <u>Richmond, Va. 23219</u>	⑦ Copy of referenced document may be procured from: <u>Transportation Research Board. 500 Fifth St.</u> <u>NW, Washington, D.C. 20001</u> <u>http://books.trbbookstore.org/hcm10.aspx</u>
⑧ Exemptions Claimed (Specific Reference): Administrative Process Act <u>N/A</u> Virginia Register Act <u>N/A</u> Virginia Code Commission Regulations <u>§ 3.3 (B) (1) - exceeds 500 pages in length; generally available to the public and 3.3 (B)(5)- material is copyrighted or otherwise the property of an organization other than state government</u>	
Request submitted by: <u>Jo Anne P. Maxwell</u> <u>Agency Regulatory Coordinator</u> <u>11/28/11</u> Title Date	
Approved: <u>Jane D. Chaffin, Registrar of Regulations</u> <u>Date</u>	

SUMMARY OF DOCUMENT INCORPORATED BY REFERENCE

Highway Capacity Manual 2010

The Transportation Research Board publishes the *Highway Capacity Manual 2010* (HCM2010), which is the fifth edition of the volume. The *HCM2010* incorporates more than \$5 million of funded research that has occurred since publication of the *HCM2000*. This latest edition will significantly update how engineers and planners assess the traffic and environmental effects of highway projects:

- It is the first HCM to provide 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;
- It is the first to address the proper application of micro-simulation analysis and the evaluation of those results;
- It is the first to discuss active traffic management in relation to both demand and capacity; and
- It is the first to provide specific tools and generalized service volume tables, to assist planners in quickly sizing future facilities.

The 1,650-page HCM 2010 has been split into four volumes:

Volume 1 - Concepts;

Volume 2 - Uninterrupted Flow;

Volume 3 - Interrupted Flow; and

Volume 4 - Applications Guide (electronic only)

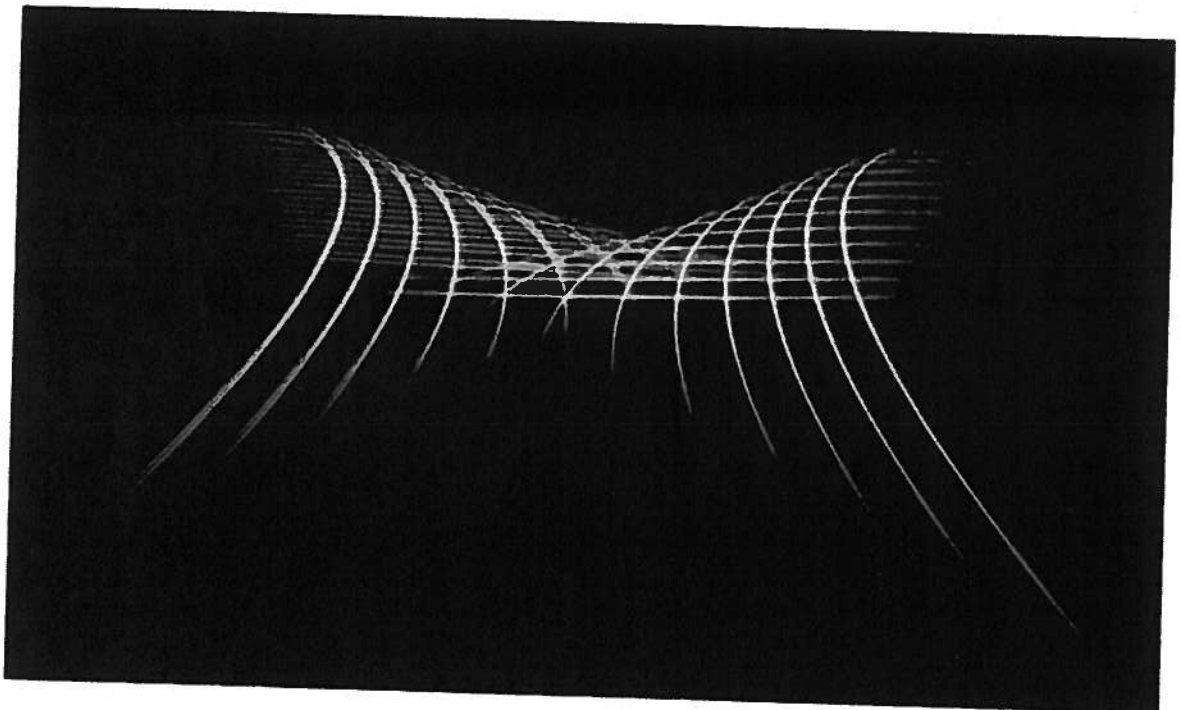
This four-volume format was developed to provide information at several levels of detail, to help HCM users more easily apply and understand the concepts, methodologies, and potential applications presented in the manual.

Volume 4 is an electronic-only volume that registered HCM users will be able to access over 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.

HCM 2010 is produced in U.S. customary units only. There is no CD-ROM or other electronic versions of the contents of Volumes 1 through 3.

HCM2010

HIGHWAY CAPACITY MANUAL



VOLUME 1: CONCEPTS



TRANSPORTATION RESEARCH BOARD
OF THE NATIONAL ACADEMIES

WASHINGTON, DC | [WWW.TRB.ORG](http://www.trb.org)

FOREWORD

This fifth edition of the *Highway Capacity Manual* breaks a great deal of new ground.

- It is the first *Highway Capacity Manual* to provide 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. This is the first manual to take into account the effects of cars on bicyclists and pedestrians.
- It is the first to address the proper **application of microsimulation analysis** and the evaluation of those results.
- It is the first to discuss **active traffic management** in relation to both demand and capacity.
- It is the first to include **example applications of its procedures implemented in software code and executables** to assist users and software developers in understanding the subtleties of the methodologies.
- It is also the first to provide tools, **generalized service volume tables**, to assist planners in quickly sizing future facilities.

While this edition of the *Highway Capacity Manual* has many firsts, it also builds on more than 60 years of work by many dedicated experts in the field.¹

The first *Highway Capacity Manual* was published in 1950 as a joint venture between the Highway Research Board's Committee on Highway Capacity and the Bureau of Public Roads. That effort was led by O. K. Normann, committee chair, and William Walker, committee secretary. The manual was the first international document on the broad subject of capacity and provided definitions of key terms, a compilation of maximum observed flows, and the initial fundamentals of capacity.

The second edition was published in 1965 by the Highway Research Board and authored by the Committee on Highway Capacity. O. K. Normann led much of this effort until his untimely death in 1964. Carl C. Saal continued the work as the new committee chair with Arthur A. Carter, Jr., as secretary. The Bureau of Public Roads was again a significant contributor to the project. The 1965 manual was a significant extension of the 1950 edition and introduced the concept of level of service.

The third edition of the manual was published in 1985 by the Transportation Research Board (TRB) and authored by the Committee on Highway Capacity and Quality of Service, chaired by Carlton C. Robinson, with Charles W. Dale as secretary. Credit is also due to Robert C. Blumenthal and James H. Kell, who served as committee chairs between the publication of the 1965 and 1985 editions. The 1985 edition extended capacity analysis to additional facility types,

¹ Thanks are extended to Adolf D. May for this short history of the *Highway Capacity Manual*, which was first provided in his Foreword to the 1994 edition.

incorporated driver perceptions into level of service, and was the first to have the analysis procedures implemented in computer software.

An update to the third edition of the manual was published in 1994 with Adolf D. May as chair of the committee and Wayne K. Kittelson as secretary. The 1994 edition of the manual is noted for new procedures for the analysis of freeway ramp junctions, all-way and two-way STOP-controlled intersections, and two-lane rural highways.

The fourth edition of the manual was published in 2000 with John D. Zegeer as chair of the committee and Richard G. Dowling as secretary. That manual was the first to go to a multivolume format (with one volume dedicated to concepts for policy makers) and was the first to test novel electronic formats for the manual using hyperlinked text and narrated self-guided tutorials for some of the example problems.

The *Highway Capacity Manual* has grown over the decades, and it has long since ceased to be the product of a few highly competent experts or even that of a single committee. This edition of the *Highway Capacity Manual* has benefited from the most extensive involvement of the professional community—far surpassing that of all the previous editions. More than 300 professionals, many of them entirely new to TRB, the Committee on Highway Capacity and Quality of Service, and the manual development process itself, contributed in the year-long chapter review process, which has culminated in the publication of this fifth edition.

This edition is the first to involve other TRB committees in its development. The following committees from the Operations Section (AHB00) of the Technical Activities Council of TRB provided reviewers or comments directly on the drafts of the manual:

- AHB20, Freeway Operations;
- AHB25, Traffic Signal Systems;
- AHB35, Committee on High-Occupancy Vehicle, High-Occupancy Toll, and Managed Lanes; and
- AHB45, Traffic Flow Theory and Characteristics.

The members of the Committee on Highway Capacity and Quality of Service thank these committees for their assistance and thank the chairs of the Operations Section, Daniel S. Turner and then Peter M. Briglia, Jr., for their support and encouragement of the multicommittee involvement in the development of the *Highway Capacity Manual*.

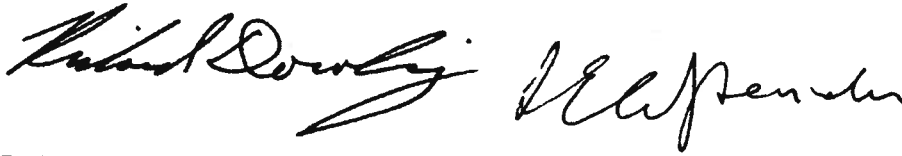
We are also grateful for the support we have received from the members and staff of the Institute of Transportation Engineers (ITE). Our joint summer meetings with local ITE sections throughout the manual development process were particularly informative and productive.

Throughout this effort, the advice and support of Richard Cunard, Engineer of Traffic and Operations of TRB, was extremely valuable in helping the committee anticipate, address, and overcome the obstacles that arise every time a major new document is published.

The *Highway Capacity Manual 2010* would never have become a reality without the hard work of the National Cooperative Highway Research Program (NCHRP) 3-92 panel, chaired by Barbara Ostrom, with Ray Derr as Senior Program Officer for the project. The committee thanks the NCHRP 3-92 panel, its staff, and its contractor, Kittelson & Associates, Inc. for delivering a high-quality manual that will greatly improve transportation engineering and planning practice in the years to come.

The committee invites those interested in improving the profession's understanding of capacity and quality of service analysis to contact us at www.AHB40.org and become involved.

For the Committee on Highway Capacity and Quality of Service (AHB40),



Richard G. Dowling
Committee Chair
October 1, 2010

Lily Elefteriadou
Committee Secretary

CHAPTER 1

HCM USER'S GUIDE

CONTENTS

1. INTRODUCTION.....	1-1
2. HCM PURPOSE AND SCOPE	1-2
Purpose and Objectives	1-2
Intended Use	1-2
Target Users.....	1-2
3. STRUCTURE	1-3
Overview	1-3
Volume 1: Concepts.....	1-3
Volume 2: Uninterrupted Flow	1-3
Volume 3: Interrupted Flow.....	1-4
Volume 4: Applications Guide	1-4
Computational Engines	1-5
Commercial Software.....	1-5
4. INTERNATIONAL USE.....	1-6
Applications	1-6
Metric Conversion Guide	1-6
5. WHAT'S NEW IN THE HCM 2010.....	1-8
Overview	1-8
Methodological Changes by System Element	1-10
6. COMPANION DOCUMENTS.....	1-14
Highway Safety Manual.....	1-14
A Policy on Geometric Design of Highways and Streets.....	1-14
Manual on Uniform Traffic Control Devices.....	1-14
Transit Capacity and Quality of Service Manual	1-14
7. REFERENCES	1-15

**CHAPTER 2
APPLICATIONS**

CONTENTS

1. INTRODUCTION.....2-1

2. LEVELS OF ANALYSIS.....2-2

 Overview 2-2

 Operational Analysis..... 2-2

 Design Analysis 2-2

 Planning and Preliminary Engineering Analysis..... 2-3

 Relationship Between Analysis Levels and Objectives 2-3

3. ROADWAY SYSTEM ELEMENTS.....2-4

 Types of Roadway System Elements 2-4

 Analysis of Individual System Elements..... 2-6

 Assessment of Multiple Facilities 2-7

 System Performance Measurement..... 2-7

4. TRAVEL MODES2-9

 Automobile..... 2-9

 Pedestrian 2-9

 Bicycle 2-9

 Transit 2-9

5. OPERATING CONDITIONS.....2-10

 Uninterrupted Flow 2-10

 Interrupted Flow..... 2-10

 Undersaturated Flow 2-11

 Oversaturated Flow..... 2-11

 Queue Discharge Flow..... 2-12

6. HCM ANALYSIS AS PART OF A BROADER PROCESS2-13

 Noise Analysis 2-13

 Air Quality Analysis 2-13

 Economic Analysis 2-13

 Multimodal Planning Analysis..... 2-14

 System Performance Measurement..... 2-14

 Summary..... 2-14

7. REFERENCES2-16

**CHAPTER 3
MODAL CHARACTERISTICS**

CONTENTS

1. INTRODUCTION.....3-1

2. AUTOMOBILE MODE.....3-2

 Vehicle and Human Factors 3-2

 Variations in Demand 3-3

 Travel Time Variability 3-12

 Automobile Facility Types 3-13

 Measured and Observed Volumes and Flow Rates..... 3-14

 Interactions with Other Modes..... 3-15

3. PEDESTRIAN MODE.....3-17

 Overview 3-17

 Human Factors..... 3-17

 Variations in Demand 3-18

 Pedestrian Facility Types..... 3-18

 Interactions with Other Modes..... 3-20

4. BICYCLE MODE.....3-22

 Overview 3-22

 Human Factors..... 3-22

 Variations in Demand 3-23

 Bicycle Facility Types..... 3-24

 Measured and Observed Volumes..... 3-25

 Interactions with Other Modes..... 3-25

5. TRANSIT MODE.....3-26

 Overview 3-26

 Human Factors..... 3-26

 On-Street Transit Characteristics..... 3-27

 Travel Time Variability 3-28

 On-Street Transit Facility Types 3-28

 Measured and Observed Volumes..... 3-29

 Interactions with Other Modes..... 3-29

6. REFERENCES3-31

**CHAPTER 4
TRAFFIC FLOW AND CAPACITY CONCEPTS**

CONTENTS

1. INTRODUCTION.....4-1

2. AUTOMOBILE MODE.....4-2

 Basic Automobile Flow Parameters 4-2

 Additional Uninterrupted-Flow Parameters 4-9

 Additional Interrupted-Flow Parameters 4-10

 Capacity Concepts..... 4-17

 Estimation of Traffic Flow Parameters 4-21

3. PEDESTRIAN MODE.....4-24

 Pedestrian Characteristics 4-24

 Pedestrian Flow Parameters..... 4-25

 Capacity Concepts..... 4-32

4. BICYCLE MODE.....4-33

 Bicycle Flow Parameters..... 4-33

 Capacity Concepts..... 4-34

 Delay 4-34

5. TRANSIT MODE.....4-35

 Bus Speed Parameters..... 4-35

 Capacity Concepts..... 4-38

6. REFERENCES4-42

**CHAPTER 5
QUALITY AND LEVEL-OF-SERVICE CONCEPTS**

CONTENTS

1. INTRODUCTION.....5-1

2. QUALITY OF SERVICE5-2

3. LEVEL OF SERVICE5-3

 Definition..... 5-3

 Usage..... 5-3

4. SERVICE MEASURES5-7

 Definition and Characteristics 5-7

 Service Measure Selection 5-7

 Determination of LOS F..... 5-9

 Service Measures for Specific System Elements..... 5-9

5. REFERENCES5-16

CHAPTER 6 HCM AND ALTERNATIVE ANALYSIS TOOLS

CONTENTS

1. INTRODUCTION.....	6-1
2. HCM-BASED TOOLS.....	6-2
Generalized Service Volume Tables.....	6-2
Application of Default Values to HCM Methodologies.....	6-3
Operations-Level HCM Analysis.....	6-3
3. ALTERNATIVE TOOLS.....	6-4
Overview.....	6-4
Traffic Modeling Concepts and Terminology.....	6-5
Conceptual Differences Between Deterministic and Simulation Tools.....	6-9
Appropriate Use of Alternative Tools.....	6-9
Application Framework for Alternative Tools.....	6-13
Performance Measures from Alternative Tools.....	6-16
Traffic Analysis Tool Selection Criteria.....	6-17
Application Guidelines for Simulation Tools.....	6-25
4. REFERENCES.....	6-29
APPENDIX A: DEVELOPING LOCAL DEFAULT VALUES.....	6-31
Reference.....	6-31
APPENDIX B: DEVELOPING LOCAL SERVICE VOLUME TABLES.....	6-32
Introduction.....	6-32
Table Construction Process.....	6-32
Reference.....	6-34

CHAPTER 7

INTERPRETING HCM AND ALTERNATIVE TOOL RESULTS

CONTENTS

1. INTRODUCTION.....	7-1
2. UNCERTAINTY AND VARIABILITY	7-2
Uncertainty and Variability Concepts	7-2
Sources of Uncertainty.....	7-3
Sensitivity Analysis.....	7-4
Accuracy and Precision	7-7
Average Values.....	7-8
3. DEFINING AND COMPUTING UNIFORM PERFORMANCE	
MEASURES.....	7-9
Performance Measures Reported by HCM Procedures	7-9
Use of Vehicle Trajectory Analysis in Comparing Performance	
Measures.....	7-13
Requirements for Computing Performance Measures by Vehicle	
Trajectory Analysis.....	7-17
Stochastic Aspects of Simulation Analysis.....	7-26
Comparing HCM Analysis Results with Alternative Tools	7-29
4. PRESENTATION OF RESULTS	7-37
Guidance on the Display of HCM Results	7-37
Presenting Results to Facilitate Interpretation.....	7-38
Graphic Representation of Results.....	7-39
5. REFERENCES	7-42

CHAPTER 8 HCM PRIMER

CONTENTS

1. INTRODUCTION.....	8-1
2. HIGHWAY CAPACITY CONCEPTS.....	8-2
Definition of Capacity.....	8-2
Uninterrupted-Flow Roadways.....	8-3
Interrupted-Flow Roadways.....	8-4
Modal Interactions.....	8-6
3. QUALITY AND LEVEL-OF-SERVICE CONCEPTS	8-8
Overview	8-8
Quality of Service	8-8
Level of Service	8-9
Service Measures	8-11
4. ANALYSIS PROCESS.....	8-13
Levels of HCM Analysis.....	8-13
Analysis Tool Selection.....	8-15
Interpreting Results.....	8-16
Presenting Results	8-17
5. DECISION-MAKING CONSIDERATIONS.....	8-18
Role of HCM Companion Documents.....	8-18
Tools Versus Standards	8-19
6. REFERENCES	8-21

**CHAPTER 9
GLOSSARY AND SYMBOLS**

CONTENTS

1. GLOSSARY.....9-1

A 9-1

B 9-2

C 9-3

D 9-5

E 9-7

F 9-7

G 9-8

H 9-9

I 9-9

J 9-10

K 9-10

L 9-10

M 9-11

N 9-12

O 9-13

P 9-13

Q 9-15

R 9-15

S 9-16

T 9-19

U 9-21

V 9-21

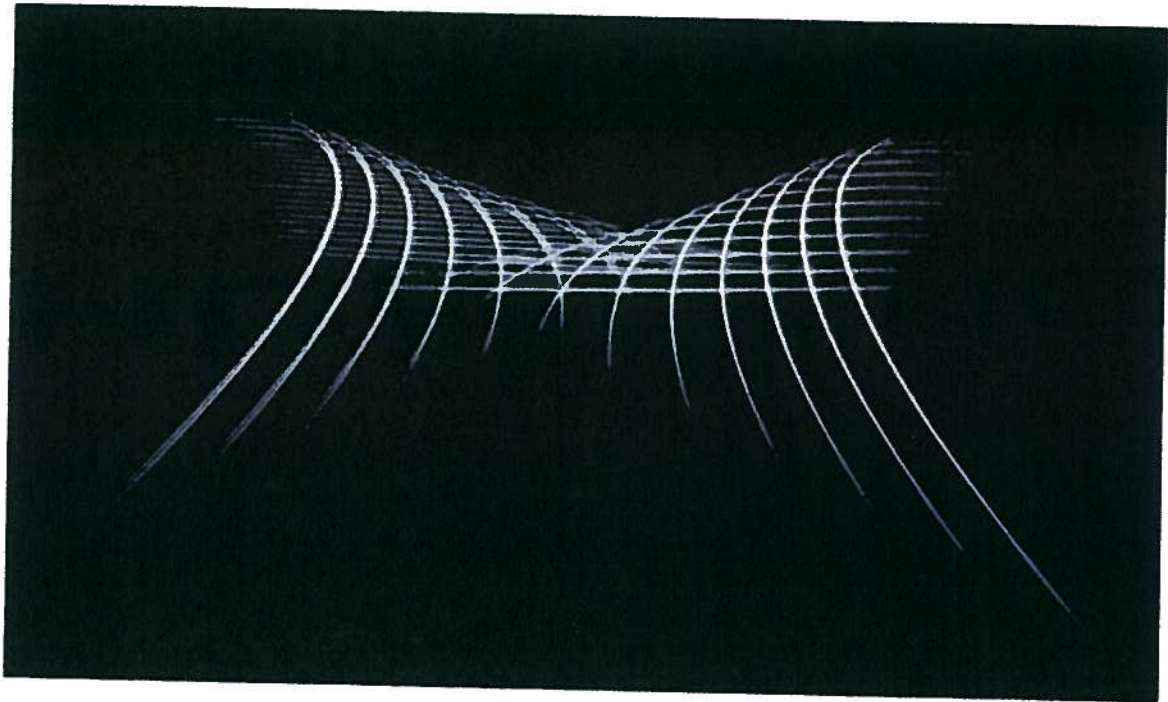
W 9-21

Y 9-22

2. LIST OF SYMBOLS.....9-23

HCM2010

HIGHWAY CAPACITY MANUAL



VOLUME 2: UNINTERRUPTED FLOW



TRANSPORTATION RESEARCH BOARD
OF THE NATIONAL ACADEMIES

WASHINGTON, DC | [WWW.TRB.ORG](http://www.trb.org)

CHAPTER 10 FREEWAY FACILITIES

CONTENTS

1. INTRODUCTION.....	10-1
Segments and Influence Areas.....	10-2
Free-Flow Speed	10-3
Capacity of Freeway Facilities	10-4
LOS: Component Segments and the Freeway Facility	10-8
Service Flow Rates, Service Volumes, and Daily Service Volumes for a Freeway Facility.....	10-10
Generalized Daily Service Volumes for Freeway Facilities	10-11
Active Traffic Management and Other Measures to Improve Performance	10-14
2. METHODOLOGY	10-16
Scope of the Methodology.....	10-16
Limitations of the Methodology.....	10-17
Overview	10-18
Computational Steps.....	10-19
3. APPLICATIONS	10-40
Operational Analysis.....	10-40
Planning, Preliminary Engineering, and Design Analysis	10-41
Traffic Management Strategies	10-41
Use of Alternative Tools	10-42
4. EXAMPLE PROBLEMS.....	10-48
Example Problem 1: Evaluation of an Undersaturated Facility.....	10-48
Example Problem 2: Evaluation of an Oversaturated Facility	10-54
Example Problem 3: Capacity Improvements to an Oversaturated Facility.....	10-58
5. REFERENCES	10-63

CHAPTER 11 BASIC FREEWAY SEGMENTS

CONTENTS

1. INTRODUCTION.....	11-1
Base Conditions	11-1
Flow Characteristics Under Base Conditions	11-2
Capacity Under Base Conditions	11-4
LOS for Basic Freeway Segments	11-5
Required Input Data.....	11-8
2. METHODOLOGY	11-9
Limitations of Methodology	11-9
Overview of Methodology	11-9
Computational Steps.....	11-10
Sensitivity of Results	11-19
3. APPLICATIONS	11-21
Default Values.....	11-21
Establish Analysis Boundaries.....	11-22
Types of Analysis	11-22
Use of Alternative Tools	11-25
4. EXAMPLE PROBLEMS.....	11-29
Example Problem 1: Four-Lane Freeway LOS.....	11-29
Example Problem 2: Number of Lanes Required for Target LOS.....	11-31
Example Problem 3: Six-Lane Freeway LOS and Capacity	11-33
Example Problem 4: LOS on Upgrades and Downgrades.....	11-36
Example Problem 5: Design-Hour Volume and Number of Lanes	11-39
Example Problem 6: Service Flow Rates and Service Volumes.....	11-41
5. REFERENCES	11-44
APPENDIX A: COMPOSITE GRADES.....	11-45
Example Problem.....	11-45
Procedural Steps	11-47
Discussion.....	11-47

CHAPTER 12 FREEWAY WEAVING SEGMENTS

CONTENTS

1. INTRODUCTION.....	12-1
2. WEAVING SEGMENT CHARACTERISTICS.....	12-2
Overview	12-2
Length of a Weaving Segment.....	12-2
Width of a Weaving Segment	12-3
Configuration of a Weaving Segment.....	12-4
3. METHODOLOGY	12-9
Limitations of the Methodology	12-9
Overview of the Methodology.....	12-9
Parameters Describing a Weaving Segment.....	12-10
Computational Procedures	12-12
Special Cases	12-23
4. APPLICATIONS	12-25
Default Values.....	12-25
Types of Analysis	12-25
Use of Alternative Tools	12-27
5. EXAMPLE PROBLEMS.....	12-31
Example Problem 1: LOS of a Major Weaving Segment	12-31
Example Problem 2: LOS of a Ramp-Weaving Segment.....	12-36
Example Problem 3: LOS of a Two-Sided Weaving Segment	12-40
Example Problem 4: Design of a Major Weaving Segment for a Desired LOS.....	12-44
Example Problem 5: Constructing a Service Volume Table for a Weaving Segment.....	12-50
6. REFERENCES	12-55

**CHAPTER 13
FREEWAY MERGE AND DIVERGE SEGMENTS**

CONTENTS

1. INTRODUCTION.....13-1

 Ramp Components..... 13-1

 Classification of Ramps..... 13-2

 Ramp and Ramp Junction Analysis Boundaries 13-2

 Ramp-Freeway Junction Operational Conditions 13-3

 Base Conditions 13-3

 LOS Criteria for Merge and Diverge Segments..... 13-4

 Required Input Data..... 13-5

2. METHODOLOGY13-7

 Scope of the Methodology 13-7

 Limitations of the Methodology 13-7

 Overview 13-7

 Computational Steps..... 13-10

 Special Cases 13-22

 Overlapping Ramp Influence Areas 13-27

3. APPLICATIONS13-28

 Default Values..... 13-28

 Establish Analysis Boundaries..... 13-28

 Types of Analysis 13-29

 Use of Alternative Tools 13-31

4. EXAMPLE PROBLEMS.....13-36

 Example Problem 1: Isolated One-Lane, Right-Hand On-Ramp to a
 Four-Lane Freeway 13-36

 Example Problem 2: Two Adjacent Single-Lane, Right-Hand Off-Ramps
 on a Six-Lane Freeway 13-38

 Example Problem 3: One-Lane On-Ramp Followed by a One-Lane
 Off-Ramp on an Eight-Lane Freeway 13-43

 Example Problem 4: Single-Lane, Left-Hand On-Ramp on a Six-Lane
 Freeway..... 13-48

 Example Problem 5: Service Flow Rates and Service Volumes for an
 Isolated On-Ramp on a Six-Lane Freeway 13-51

5. REFERENCES13-56

CHAPTER 14 MULTILANE HIGHWAYS

CONTENTS

1. INTRODUCTION.....	14-1
Types of Multilane Highways	14-1
Base Conditions	14-1
Flow Characteristics Under Base Conditions	14-2
Capacity of Multilane Highway Segments	14-4
LOS for Multilane Highway Segments.....	14-4
Required Input Data.....	14-6
2. METHODOLOGY	14-8
Limitations of Methodology	14-8
Automobile Mode.....	14-9
Bicycle Mode	14-19
3. APPLICATIONS	14-20
Default Values.....	14-20
Establishing Analysis Boundaries.....	14-21
Types of Analysis	14-21
Generalized Daily Service Volumes.....	14-23
Use of Alternative Tools	14-26
4. EXAMPLE PROBLEMS.....	14-27
Example Problem 1: LOS on Undivided Four-Lane Highway.....	14-27
Example Problem 2: LOS on Five-Lane Highway with TWLTL.....	14-29
Example Problem 3: Design Cross Section Required to Provide Target LOS	14-32
Example Problem 4: Multilane Highway Modernization.....	14-34
Example Problem 5: Future Cross Section Required to Provide Target LOS	14-35
5. REFERENCES	14-38

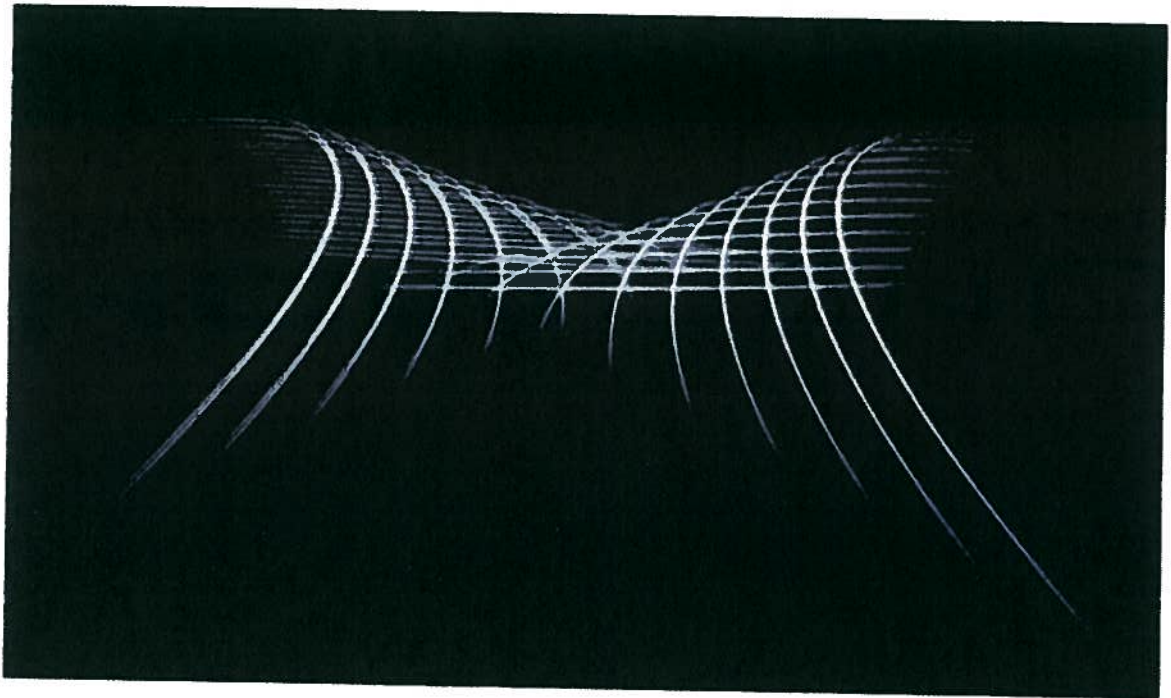
CHAPTER 15 TWO-LANE HIGHWAYS

CONTENTS

1. INTRODUCTION.....	15-1
Characteristics of Two-Lane Highways	15-1
Capacity and LOS.....	15-5
Required Input Data and Default Values.....	15-9
Demand Volumes and Flow Rates.....	15-10
2. METHODOLOGY	15-11
Scope of the Methodology.....	15-11
Limitations of the Methodology.....	15-11
Automobile Mode.....	15-12
Bicycle Mode	15-36
3. APPLICATIONS	15-39
Default Values.....	15-39
Types of Analysis	15-39
Service Flow Rates, Service Volumes, and Daily Service Volumes	15-40
Generalized Daily Service Volumes.....	15-41
Use of Alternative Tools	15-42
4. EXAMPLE PROBLEMS.....	15-44
Example Problem 1: Class I Highway LOS.....	15-44
Example Problem 2: Class II Highway LOS.....	15-48
Example Problem 3: Class III Highway LOS	15-51
Example Problem 4: Class I Highway LOS with a Passing Lane.....	15-53
Example Problem 5: Two-Lane Highway Bicycle LOS	15-55
5. REFERENCES	15-58
APPENDIX A: DESIGN AND OPERATIONAL TREATMENTS	15-59
Turnouts.....	15-59
Shoulder Use	15-60
Wide Cross Sections	15-60
Intersection Turn Lanes	15-61
Two-Way Left-Turn Lanes	15-62
References.....	15-64

HCM2010

HIGHWAY CAPACITY MANUAL



VOLUME 3: INTERRUPTED FLOW



TRANSPORTATION RESEARCH BOARD
OF THE NATIONAL ACADEMIES

WASHINGTON, DC | WWW.TRB.ORG

**CHAPTER 16
URBAN STREET FACILITIES**

CONTENTS

1. INTRODUCTION.....16-1

 Overview of the Methodology..... 16-1

 Urban Street Facility Defined..... 16-5

 LOS Criteria..... 16-7

 Required Input Data..... 16-9

 Scope of the Methodology..... 16-13

 Limitations of the Methodology..... 16-15

2. METHODOLOGY16-16

 Overview 16-16

 Automobile Mode..... 16-16

 Pedestrian Mode..... 16-18

 Bicycle Mode 16-21

 Transit Mode 16-23

3. APPLICATIONS16-25

 Types of Analysis 16-25

 Use of Alternative Tools 16-25

 Generalized Daily Service Volumes for Urban Street Facilities 16-26

 Active Traffic Management Strategies..... 16-27

4. EXAMPLE PROBLEMS.....16-29

 Example Problem 1: Auto-Oriented Urban Street 16-29

 Example Problem 2: Pedestrian and Bicycle Improvements 16-36

 Example Problem 3: Pedestrian and Parking Improvements..... 16-41

5. REFERENCES16-47

CHAPTER 17 URBAN STREET SEGMENTS

CONTENTS

1. INTRODUCTION.....	17-1
Overview of the Methodology.....	17-1
Urban Street Segment Defined	17-4
LOS Criteria.....	17-6
Required Input Data.....	17-8
Scope of the Methodology.....	17-24
Limitations of the Methodology.....	17-25
2. METHODOLOGY	17-27
Overview	17-27
Automobile Mode.....	17-27
Pedestrian Mode.....	17-44
Bicycle Mode	17-55
Transit Mode.....	17-59
3. APPLICATIONS	17-67
Default Values.....	17-67
Types of Analysis	17-70
Use of Alternative Tools.....	17-72
4. EXAMPLE PROBLEMS.....	17-76
Example Problem 1: Automobile LOS.....	17-76
Example Problem 2: Pedestrian LOS	17-84
Example Problem 3: Bicycle LOS.....	17-90
Example Problem 4: Transit LOS.....	17-95
5. REFERENCES	17-100

**CHAPTER 18
SIGNALIZED INTERSECTIONS**

CONTENTS

1. INTRODUCTION.....18-1

 Overview of the Methodology..... 18-1

 LOS Criteria..... 18-5

 Required Input Data..... 18-7

 Scope of the Methodology..... 18-28

 Limitations of the Methodology..... 18-29

2. METHODOLOGY18-31

 Overview 18-31

 Automobile Mode..... 18-31

 Pedestrian Mode..... 18-59

 Bicycle Mode 18-70

3. APPLICATIONS18-74

 Default Values..... 18-74

 Types of Analysis 18-79

 Use of Alternative Tools 18-81

4. EXAMPLE PROBLEMS.....18-85

 Introduction..... 18-85

 Example Problem 1: Automobile LOS..... 18-85

 Example Problem 2: Pedestrian LOS 18-95

 Example Problem 3: Bicycle LOS..... 18-102

5. REFERENCES18-105

CHAPTER 19

TWO-WAY STOP-CONTROLLED INTERSECTIONS

CONTENTS

1. INTRODUCTION.....	19-1
Intersection Analysis Boundaries and Travel Modes	19-1
Level-of-Service Criteria	19-1
Required Input Data.....	19-2
Scope of the Methodology	19-3
Limitations of the Methodology	19-3
2. METHODOLOGY	19-5
Overview	19-5
Theoretical Basis	19-5
Automobile Mode.....	19-7
Pedestrian Mode	19-30
Bicycle Mode	19-36
3. APPLICATIONS	19-38
Default Values.....	19-38
Establish Intersection Boundaries	19-38
Types of Analysis	19-38
Performance Measures.....	19-40
Use of Alternative Tools	19-40
4. EXAMPLE PROBLEMS.....	19-43
Example Problem 1: TWSC T-Intersection.....	19-43
Example Problem 2: TWSC Pedestrian Crossing	19-49
5. REFERENCES	19-53

**CHAPTER 20
ALL-WAY STOP-CONTROLLED INTERSECTIONS**

CONTENTS

1. INTRODUCTION.....20-1

 Intersection Analysis Boundaries and Travel Modes..... 20-2

 Level-of-Service Criteria..... 20-2

 Required Input Data..... 20-3

 Scope of the Methodology..... 20-3

 Limitations of the Methodology..... 20-3

2. METHODOLOGY20-4

 Overview 20-4

 Automobile Mode..... 20-9

 Pedestrian Mode..... 20-17

 Bicycle Mode 20-19

3. APPLICATIONS20-20

 Default Values..... 20-20

 Establish Intersection Analysis Boundaries..... 20-20

 Types of Analysis 20-20

 Use of Alternative Tools 20-21

4. EXAMPLE PROBLEM.....20-22

 Example Problem 1: Single-Lane, T-Intersection 20-22

5. REFERENCES20-28

CHAPTER 21 ROUNDBABOUTS

CONTENTS

1. INTRODUCTION.....	21-1
Intersection Analysis Boundaries and Travel Modes	21-1
Level of Service Criteria.....	21-1
Required Input Data.....	21-2
Scope of the Methodology.....	21-2
Limitations of the Methodology	21-2
2. METHODOLOGY	21-4
Overview	21-4
Capacity Concepts.....	21-4
Automobile Mode.....	21-11
Pedestrian Mode.....	21-21
Bicycle Mode	21-21
3. APPLICATIONS	21-22
Default Values.....	21-22
Types of Analysis	21-22
Calibration of Capacity Model.....	21-23
Use of Alternative Tools	21-23
4. EXAMPLE PROBLEMS.....	21-28
Example Problem 1: Single-Lane Roundabout with Bypass Lanes	21-28
Example Problem 2: Multilane Roundabout.....	21-33
5. REFERENCES	21-39

**CHAPTER 22
INTERCHANGE RAMP TERMINALS**

CONTENTS

1. INTRODUCTION.....22-1

 Scope of the Chapter 22-1

 Limitations of the Methodology 22-1

 Types of Interchanges 22-2

 Unique Operational Characteristics of Interchanges..... 22-7

 LOS Framework..... 22-11

2. METHODOLOGIES.....22-14

 Final Design and Operational Analysis for Signalized Interchanges..... 22-14

 Final Design and Operational Analysis for Interchanges with
 Roundabouts..... 22-34

 Interchanges with Unsignalized Intersections..... 22-36

 Operational Analysis for Interchange Type Selection..... 22-36

3. APPLICATIONS22-46

 Default Values..... 22-46

 Types of Analysis 22-46

 Use of Alternative Tools 22-53

4. EXAMPLE PROBLEMS.....22-57

 Introduction..... 22-57

 Example Problem 1: Diamond Interchange 22-57

 Example Problem 2: Parclo A-2Q Interchange 22-63

 Example Problem 3: Operational Analysis for Interchange Type
 Selection..... 22-67

5. REFERENCES22-73

CHAPTER 23 OFF-STREET PEDESTRIAN AND BICYCLE FACILITIES

CONTENTS

1. INTRODUCTION.....	23-1
Overview	23-1
Analysis Boundaries.....	23-2
LOS Criteria	23-2
Required Input Data.....	23-4
Scope of the Methodology.....	23-4
Limitations of the Methodology.....	23-5
2. METHODOLOGY	23-7
Overview	23-7
Exclusive Off-Street Pedestrian Facilities.....	23-9
Shared-Use Paths.....	23-13
Off-Street Bicycle Facilities.....	23-15
3. APPLICATIONS	23-24
Default Values.....	23-24
Analysis Boundaries.....	23-24
Types of Analysis	23-25
Special Cases	23-25
Use of Alternative Tools	23-27
4. EXAMPLE PROBLEMS.....	23-28
Example Problem 1: Pedestrian LOS on Shared-Use and Exclusive Paths.....	23-28
Example Problem 2: Bicycle LOS on a Shared-Use Path.....	23-30
5. REFERENCES	23-34