

Contents

Part I Modeling Traffic: Vehicle – Driver – Driving Environment Interactions

1 Modeling the Motion of a Single Vehicle	3
Motion of a Single Vehicle	3
The Case of Constant Speed	6
The Case of Constant Acceleration	6
The Case of Varying Acceleration	8
Equations of Motion as a Function of Distance and Speed	14
Vehicle Trajectories and Traffic Performance	15
Effects of Vehicle Characteristics on the Motion of a Single Vehicle	15
Effects of Driver Characteristics and Behavior on the Motion of a Single Vehicle	20
Effects of the Driving Environment on the Motion of a Single Vehicle	24
Location and Surroundings	25
Facility Type	25
Highway Design	25
Control	27
Other Factors	28
References	28
2 Modeling Vehicle Interactions and the Movement of Groups of Vehicles	31
Car-Following	32
A Historical Overview of Car-Following Algorithms	36
Currently Used Models: The Gipps Model	40
Other Currently Used Models	43
Evaluations of Car-Following Algorithms Using Field Data	47
Concluding Remarks on Car-Following Models	48

Lane Changing	50
Gap Acceptance	53
References	56
Part II The Traffic Stream: Traffic Flow Performance Characteristics	
3 Flow, Speed, Density, and Their Relationships	61
Flow and Time Headway	61
Flow, Capacity, and Demand	61
Time Headway	65
Measurement Techniques for Flow and Time Headways	68
Speed	69
Measurement Techniques for Speed	74
Density and Space Headway	76
Traffic Stream Characteristics in Time and Space	76
Traffic Stream Models	78
The Greenshields Model	79
Overview of Other Traffic Stream Models	81
The HCM Models	83
Data Collection Location and the Speed–Flow Density Relationships	85
Relationship to Car-Following Models	86
Pedestrian Traffic Stream Models	88
References	89
4 Capacity	93
Capacity in the HCM: A Historical Perspective	94
The State of the Art in Defining and Measuring Capacity	95
Maximum Throughput Values	96
Maximum Throughput Distributions	97
Definitions of Breakdown	97
Breakdown Probability Models	99
Summary of the State of the Art in Defining and Measuring Capacity	104
Capacity of Uninterrupted Flow Facilities	106
Field Data Collection	106
Capacity Estimates in the HCM 2010	108
References	109
5 Traffic Operational Performance Measures	111
Travel Time	111
Travel Time During Non-congested and Congested Conditions	113
The Distribution of Travel Time and Travel Time Reliability	114
Travel Time for Traveler Information Purposes	117
Delay	118

Queue Length	118
Other Mobility-Related Performance Measures	121
Measures of Effectiveness and Level of Service	121
References	125

Part III Traffic Operational Analysis Techniques

6 Mathematical and Empirical Models	129
Shockwave Analysis	129
Cumulative Curves and Queuing Analysis	133
References	135
7 Simulation Modeling	137
Principles of Stochastic Microsimulation: An Example	139
Key Components of Traffic Microsimulators	142
Algorithms Used for Vehicle Traffic Movement	142
Network Representation	144
Infrastructure Elements	145
Drivers, Travelers, and Vehicles	145
Performance Measures	146
Other Elements	147
Using Microsimulation	147
Step 1: Project Scope	148
Step 2: Package Selection	149
Step 3: Data Assembly and Input	150
Step 4: Verification and Calibration	150
Step 5: Alternatives Analysis and Conclusions	152
Developing a Microsimulator	152
GPSS Concepts	153
Commercially Available Simulators	158
Is Simulation the Right Tool?	158
References	160

Part IV Highway Facilities and Principles for Their Analysis

8 Freeways	165
Freeway Segments and Systems: Configurations and Operations	166
Merge Junctions	168
Diverge Junctions	170
Weaving Sections	172
Lane Additions and Lane Drops	174
Basic Freeway Segments	174
Freeway Systems	175
Advanced Traffic Management Methods for Freeway Facilities	177

Ramp Metering	177
Variable Speed Limit Systems	180
HOV/HOT Lanes	183
Use of Shoulder	183
Incident Management	184
Freeway Analysis Methods	184
The HCM Analysis Methods for Freeways	185
Simulation for Freeway Systems	186
References	186
9 Signalized Intersections and Networks	189
Signalization Principles and Traffic Operations	189
Key Terms and Their Definitions	190
Capacity of a Signalized Intersection Movement	192
Delay at a Signalized Intersection Approach	196
The Operation of Signalized Intersections	199
Signalized Intersection Phasing Plans and Optimal Cycle Length	200
Pre-timed and Actuated Control for Isolated Intersections	205
Additional Elements of Interest in Signalized	
Intersection Operations	206
Signalized Arterials and Networks	207
Principles of Coordination for Signalized Arterials	207
A Special Case of Signalized Arterials:	
Two-Intersection Interchanges	210
Operational Analysis Methods for Signalized Intersections	
and Networks	212
Overview of the HCM 2010 Procedures	
for Signalized Intersections and Networks	212
Traffic Signal Optimization Software	214
Simulation of Signalized Intersections and Networks	215
Advanced Technologies in Signal Control	215
References	216
10 Unsignalized Intersections	219
Principles of Gap Acceptance	221
Operational Analysis Methods for Unsignalized Intersections	224
TWSC Intersections	224
AWSC Intersections	228
Roundabouts	230
References	231
11 Two-Lane Highways	233
Principles of Two-Lane Highways Operations	234
Capacity of Two-Lane Highways	237
Overview of the HCM Procedures	238
Microsimulators for Two-Lane Highways	239
References	240

Appendix A: Standard Normal Table	243
Appendix B: Chi-Square Table	245
References	247
Index	249