# Contents

1 Introduction ................................................... 1  
References ..................................................... 5  

Part I Three-Phase Traffic Theory  

2 Definitions of The Three Traffic Phases ...................... 9  
  2.1 Traffic Variables, Parameters, and Patterns ............. 9  
  2.2 Free Flow (F) and Congested Traffic .................. 13  
  2.3 Methodology of Three-Phase Traffic Theory ............ 18  
  2.4 Two Traffic Phases in Congested Traffic:  
      Wide Moving Jam (J) and Synchronized Flow (S) ....... 20  
  2.5 Characteristic Parameters of Wide Moving Jam Propagation ... 26  
  2.6 Microscopic Criterion for Traffic Phases in Congested Traffic ... 30  
  2.7 Motivation for Traffic Phase Definitions .............. 38  
References ..................................................... 39  

3 Nature of Traffic Breakdown at Bottleneck .................. 41  
  3.1 Induced Traffic Breakdown  
References ..................................................... 41  
  3.2 Explanation of Nature of Traffic Breakdown at Bottleneck through  
      Fundamental Hypothesis of Three-Phase Traffic Theory .... 45  
  3.3 Nucleation Features of Traffic Breakdown at Bottleneck .... 57  
  3.4 Dual Role of Lane Changing in Free Flow:  
      Maintenance of Free Flow or Traffic Breakdown ......... 69  
References ..................................................... 72  

4 Infinite Number of Highway Capacities of Free Flow at Bottleneck ... 73  
  4.1 Definition of Highway Capacity of Free Flow at Bottleneck ... 74  
  4.2 Characteristics of Highway Capacities .................. 75  
References ..................................................... 79
5  Nature of Moving Jam Emergence ........................................... 81
  5.1 Pinch Effect in Synchronized Flow ......................................... 81
  5.2 Nucleation Features of Wide Moving Jam Emergence in
      Synchronized Flow .................................................. 83
  5.3 Dual Role of Lane Changing in Synchronized Flow:
      Maintenance of Synchronized Flow or Wide Moving Jam
      Emergence ................................................................. 90
  5.4 Comparison of $F \rightarrow S$ and $S \rightarrow JT$ Transitions .................. 93
  5.5 Empirical Double Z-Characteristic for Phase Transitions in Traffic
      Flow ........................................................................... 95
References ........................................................................... 98

6  Origin of Hypotheses and Terms of
   Three-Phase Traffic Theory .................................................. 99
  6.1 Hypotheses of Three-Phase Traffic Theory as
      The Result of Empirical Criteria for Traffic Phases .................... 99
  6.2 Are Terms of Natural Science used in Three-Phase Traffic Theory
      Needed for Transportation Engineering? .................................. 100
References ........................................................................... 105

7  Spatiotemporal Traffic Congested Patterns .................................... 107
  7.1 Simplified Diagram of Congested Patterns at Isolated Bottleneck .... 107
  7.2 Variety of Congested Patterns at Isolated Bottleneck .................... 109
  7.3 Complex Congested Patterns at Adjacent Bottlenecks .................. 126
References ........................................................................... 135

Part II  Impact of Three-Phase Traffic Theory on
         Transportation Engineering

8  Introduction to Part II:
    Compendium of Three-Phase Traffic Theory .............................. 139
References ........................................................................... 142

9  Freeway Traffic Control based on
    Three-Phase Traffic Theory .................................................. 143
  9.1 Reconstruction and Tracking of Congested Patterns .................... 143
  9.2 Feedback On-Ramp Metering .................................................. 150
  9.3 Speed Limit Control ............................................................... 155
  9.4 Cooperative Driving for Improving of Traffic Flow and Safety ....... 159
  9.5 Traffic Control based on Wireless Car Communication ................. 162
  9.6 Adaptive Cruise Control ........................................................ 168
References ........................................................................... 170
# Contents

10 **Earlier Theoretical Basis of Transportation Engineering:**
   **Fundamental Diagram Approach** ........................................ 173
   10.1 Traffic Description and Control based on 
       Fundamental Diagram of Traffic Flow ................................. 173
   10.2 Congested Traffic Description in the 
       Framework of Lighthill-Whitham-Richards (LWR) 
       Traffic Flow Theory .................................................... 177
   10.3 Traffic Breakdown Description through Free Flow Instability in 
       General Motors (GM) Model Class ...................................... 182
   10.4 Common Features of earlier Traffic Flow Models .................. 200
   10.5 Empirical Tests of earlier Traffic Flow Models .................... 203
   10.6 Applications of Highway Capacity Definitions in Transportation 
       Engineering ...................................................................... 205
   10.7 Comparison of Feedback On-Ramp Metering Methods .............. 214
   References ........................................................................... 216

11 **Three-Phase Traffic Flow Models** ...................................... 221
   11.1 Overview of Three-Phase Traffic Flow Models .................... 221
   11.2 Deterministic Acceleration Time Delay Three-Phase Traffic Flow 
       Model .............................................................................. 222
   11.3 Stochastic Three-Phase Traffic Flow Model ....................... 229
   11.4 Cellular Automata Three-Phase Traffic Flow Model ............... 237
   11.5 Methodology of Empirical Test ......................................... 238
   11.6 What Three-Phase Traffic Flow Model is better to Use? ....... 239
   References ........................................................................... 242

12 **Linking of Three-Phase Traffic Theory and**
   **Fundamental Diagram Approach to Traffic Flow Modeling** ........ 245
   12.1 Three-Phase Traffic Models in the Framework of 
       Fundamental Diagram Approach .......................................... 245
   12.2 What Features of Three-Phase Traffic Theory are Missing 
       in Earlier Traffic Flow Theories and Models? ....................... 249
   References ........................................................................... 252

13 **Conclusions and Outlook** ................................................. 253

**Glossary** ............................................................................. 255

**Index** .................................................................................. 263
Introduction to Modern Traffic Flow Theory and Control
The Long Road to Three-Phase Traffic Theory
Kerner, B.S.
2009, XIII, 265 p., Hardcover
ISBN: 978-3-642-02604-1