

Contents

1	Principles and Megatrends Affecting Transportation	1
1.1	General Transportation Principles	4
1.1.1	Transportation Brings Freedom to Citizens	4
1.1.2	Transportation Enriches Society	5
1.1.3	Transportation Improves Quality of Life	6
1.1.4	Integration Is Key to Successful Transportation	6
1.1.5	Networks Must be Designed for Peak Hour Capacity	7
1.1.6	Transit Technologies are Competing with Each Other	8
1.1.7	People Prefer Private Over Public Transport	8
1.1.8	People Don't Want to Reduce Their Lifestyle	8
1.1.9	Not in My Backyard Syndrome	9
1.2	An Increasingly Environmentally Conscious Society	10
1.2.1	Greenhouse Gas Emission	10
1.2.2	Air Pollution	11
1.2.3	Investment in Clean Generation Technologies	12
1.2.4	Investment in Clean Combustion Technologies	12
1.2.5	Transport Modes Energy Comparison	13
1.2.6	Economic Impact of Going Electric for Transportation	14
1.3	Risk Adverse Society	15
1.3.1	Graying of Society	16
1.3.2	Litigation Society	16
1.3.3	Safety Systems	17
1.3.4	Mathematics and Algorithms	19
1.3.5	Security	21

- 1.4 Mega Cities 22
 - 1.4.1 Massive Urbanization of Developing and Poor Countries 22
 - 1.4.2 Mega Transportation Problems of Megacities 24
 - 1.4.3 Increased Vehicle Capacity 25
 - 1.4.4 Increased Network Capacity 25
 - 1.4.5 Road Capacity 27
 - 1.4.6 Bus Rapid Transit (BRT) Capacity 28
 - 1.4.7 Mass Transit Capacity 29
 - 1.4.8 System Price Comparison 30
- 1.5 Connected Cities 30
 - 1.5.1 Constant Network Connection 31
 - 1.5.2 The “Internet of Things” 33
 - 1.5.3 M2M Communication 34
 - 1.5.4 M2M Applied to Cars 35
- 1.6 New Business Models 35
 - 1.6.1 Privatization 36
 - 1.6.2 Financing Transportation Projects 38
 - 1.6.3 Financial Instruments and Incentives 39
 - 1.6.4 Capturing Future Wealth Increase 40
 - 1.6.5 Mobile Advertising 41
 - 1.6.6 Geo-localization Advertising 41
 - 1.6.7 Portal of Choice 42
- 1.7 Changing the Face of Transportation. 42
 - 1.7.1 Electrifying Transport 43
 - 1.7.2 Encouraging New Business Models. 43
 - 1.7.3 Creating the Legal Framework for Unmanned Vehicles 45
 - 1.7.4 Barriers to Adoption 45
- Companies and Brands Stated in the Chapter. 46
- 2 Risk Adverse Society 49**
 - 2.1 Introduction 50
 - 2.1.1 Graying of Society 51
 - 2.1.2 Society of Litigation 53
 - 2.1.3 Impact of These Trends on Transportation 53
 - 2.1.4 Safety Facts and Figures 54
 - 2.1.5 Security 60
 - 2.1.6 Homologation. 62
 - 2.2 Safety Concepts 63
 - 2.2.1 Railway Safety Concepts 64
 - 2.2.2 Safety Procedures 66
 - 2.2.3 Interoperability 67
 - 2.2.4 WaySide Safety Technologies 67

2.2.5	Fixed, Semi-Fixed, and Moving Block Principles	69
2.2.6	WaySide Interoperability Technologies	73
2.2.7	Train Integrity Technologies.	76
2.2.8	Train Protection Technologies	77
2.2.9	Onboard Operational and Safety Procedures.	79
2.2.10	Positive Train Control (PTC)	80
2.2.11	System Interoperability Procedures	80
2.2.12	Grade Crossing.	81
2.2.13	Safety Integrity Level (SIL)	81
2.3	Communication-Based Train Control (CBTC)	82
2.3.1	CBTC and Moving Block	84
2.3.2	Metro Evolution Toward Unmanned Railway Systems.	85
2.4	Applying Railway Safety Principle to Cars	87
2.4.1	Automotive Block Interlocking Concept	88
2.4.2	Automotive Block Signaling Concept	89
2.4.3	Automotive Integrity Concept.	91
2.4.4	Automotive Protection Technologies	93
2.4.5	Automotive System Interoperability.	95
2.4.6	Other Relevant Automotive Safety Concept	95
2.5	Automation Level in the Automotive Environment	95
2.5.1	Reducing or Eliminating the Human Factor in Driving	96
2.5.2	Level of Car Automation	96
2.5.3	Similarities Between Level of Car and Train Automation	99
2.6	Personal Rapid Transit (PRT).	99
2.6.1	PRT References	100
2.6.2	Smart Infrastructure.	101
2.6.3	(Reasonably) Smart Cars	104
2.6.4	PRT Operational Characteristics	104
2.6.5	Cost Characteristics.	107
2.6.6	PRT Versus Unmanned Cab.	108
2.7	E-Mobility Technologies Reducing Fatalities	108
2.7.1	Black Box	108
2.7.2	Drink Driving: Alcohol Ignition Interlock	111
2.7.3	Seat Belt Wearing.	111
2.7.4	Real-Time Limitation on Over-Speeding	112
2.7.5	Real-Time Information on Over-Speeding	112
2.7.6	Automatic Car Parking	112
2.7.7	Fatigue	113
2.7.8	Wrong Perception or Judgment.	113

- 2.8 The Advent of Vehicle-to-Vehicle Communication
 - Technology 114
 - 2.8.1 VANET. 114
 - 2.8.2 Wave Technology. 115
 - 2.8.3 CALM Technology. 115
 - 2.8.4 LTE Technology in VANET 116
 - 2.8.5 Mesh Network Infrastructure 116
 - 2.8.6 Vehicular Application 118
 - 2.8.7 Anti-collision System 118
 - 2.8.8 Accurate Geo-Positioning. 119
 - 2.8.9 V2V Operational Mode 121
- 2.9 Intelligent Wayside Technologies 122
 - 2.9.1 Vehicle-to-Cloud (V2C). 122
 - 2.9.2 Intelligent Parking. 123
 - 2.9.3 Intelligent Traffic Systems 123
 - 2.9.4 Distributed Intelligence 124
- 2.10 Driverless Cars. 125
 - 2.10.1 Data Acquisition. 125
 - 2.10.2 Data Treatment. 126
 - 2.10.3 Financial Barrier to Adoption. 128
 - 2.10.4 Legal Barrier to Adoption 129
 - 2.10.5 Legal Responsibilities 130
 - 2.10.6 Vehicle Manufacturer Potential Liabilities 131
 - 2.10.7 Onboard Signaling System Provider Potential Liabilities. 131
 - 2.10.8 Telecom Provider Potential Liabilities 132
 - 2.10.9 V2C Hosting Centers 133
 - 2.10.10 Road Infrastructure Provider. 133
 - 2.10.11 Operator or Car Owner 133
 - 2.10.12 Suggestions to Minimize Legal Barrier to Adoption 134
 - 2.10.13 Technical Suggestions to Minimize Potential Litigation. 136
 - 2.10.14 When Will It Happened?. 137
 - 2.10.15 Self-driving Market. 139
 - 2.10.16 Testing the Driverless Application. 141
- 2.11 Security. 141
 - 2.11.1 E-Mobility Security Solution 142
 - 2.11.2 End-to-End Security Solutions 143
 - 2.11.3 Technological Trends in Security 143
 - 2.11.4 Limitations of Analog Security Systems. 145
 - 2.11.5 IP Cameras 145
 - 2.11.6 Integrated Audio. 146
 - 2.11.7 Compression Technology. 146

2.11.8	Wayside IP CCTV Solutions	147
2.11.9	Integrated Security Event Management Systems	148
2.11.10	Total Integrated Public Transport System	149
2.11.11	Video Analytics	149
2.11.12	Distributed Intelligence	150
2.11.13	Video Analytics Limitations	151
2.11.14	Video Analytics Technologies	152
2.11.15	Security for Cars	154
	Company or Brand Names Stated in the Chapter	155
3	Environmentally Conscious Society	157
3.1	Governmental Environmentally Friendly Initiatives	159
3.1.1	Tax on Combustible	160
3.1.2	Carbon Tax	162
3.1.3	New Clean Air Regulation: California Clean Car Law	162
3.1.4	Internalization of External Costs	163
3.1.5	Incentive Measures: Tax Credit or Penalties	163
3.1.6	Congestion Charges	164
3.1.7	Public Transport Subsidies	164
3.2	Energy Consumption Comparison Between Car Technologies	165
3.2.1	Diesel, Gasoline, or Electric Cars	165
3.2.2	Comparable Measuring Units	165
3.2.3	Comparison at the Point of Energy Consumption	166
3.2.4	Electrical Car Consumption Study	167
3.2.5	Engine Efficiency	169
3.2.6	Braking Energy Recuperation	170
3.2.7	A Comparison Done at the Point of Energy Generation	174
3.2.8	Electric Power Generation and Distribution Efficiency	174
3.2.9	Petroleum-Equivalency Factor (PEF)	176
3.2.10	Well-to-Wheel Energy Comparison	176
3.2.11	Energy Efficiency According to the Energy Matrix	178
3.2.12	National Energy Savings Resulting from an All Electric Fleet	181
3.3	Evolution of the Electric Vehicle Market	181
3.3.1	Difference in Price at the Pump	182
3.3.2	Total Cost of Ownership	183
3.3.3	Battery Capacity	184
3.3.4	Battery Efficiency	185
3.3.5	Energy Charging Time	186
3.3.6	Charging Infrastructure	188

3.3.7	Trolleybus	189
3.3.8	Catenary-Free Buses	190
3.4	Energy Consumption Comparison Between Private and Public Transport Means.	191
3.4.1	Weight Comparison	193
3.4.2	Acceleration Force Comparison	194
3.4.3	Rolling Friction Force Comparison	194
3.4.4	Air Drag Force Comparison	196
3.4.5	Energy Consumption Comparison at Vehicle Level. . .	199
3.4.6	Power Comparison at Maximum Capacity	200
3.4.7	Energy Consumption Comparison with Real Occupancy Rate	201
3.4.8	Train Energy Losses and Recuperation	205
3.5	Greener Technology	205
3.5.1	Silicon Carbide Inverter	205
3.5.2	Permanent Magnet (PM) Motor	207
3.5.3	Direct Drive Mechanism	208
3.5.4	Direct Drive with PM Motors Controlled by SiC Inverters	208
3.5.5	Energy Recuperation and Wayside or Onboard Storage.	209
3.6	Final Energy Consumption Comparison.	213
3.7	Pollution Comparison Between Car Technology.	214
3.7.1	Air Pollution	216
3.7.2	Carbon Dioxide (CO ₂).	217
3.7.3	Nitrogen Oxide: NO _x	219
3.7.4	Nitrous Oxide: N ₂ O	219
3.7.5	Particulate Matter: PM ₁₀ and PM _{2.5}	219
3.7.6	Volatile Organic Compound (VOC)	219
3.7.7	Health Impact of Pollution.	220
3.7.8	Greenhouse Gas Effect	221
3.7.9	Wheel-to-Wheel Pollution of Different Transport Modes.	222
3.7.10	Well-to-Wheel Pollution of Different Transport Modes.	222
3.7.11	Electric Generation Matrix	226
3.7.12	Emission of CO ₂ Per kWh.	227
3.7.13	Emission of CO ₂ Per Transportation Means	229
3.7.14	Conclusion About Pollutant Emission	229
3.8	Other Environmental Considerations	231
3.8.1	Battery Recycling	231
3.8.2	Enabling Renewable Energy Storage.	232
3.8.3	Reduced Land Intake.	233
3.8.4	City Integration	234

- 3.8.5 Noise Pollution 235
- 3.8.6 Vibration 236
- Companies and Brands Stated in the Chapter. 236
- 4 Avoiding Megacities’ Standstill 237**
 - 4.1 Private Transport Restriction Measures 238
 - 4.1.1 Congestion Charges 238
 - 4.1.2 Private Car Restriction. 239
 - 4.1.3 Promoting Car Pooling and Financial Restrictions. 240
 - 4.2 System Capacity. 240
 - 4.2.1 Holistic Approach to System Capacity. 240
 - 4.2.2 Increasing Capacity of Existing Infrastructure. 241
 - 4.2.3 Vehicle Capacity 241
 - 4.2.4 Maximum Number of Vehicles. 242
 - 4.2.5 Average Speed 242
 - 4.2.6 Headway 243
 - 4.3 Road Capacity with Drived Cars 243
 - 4.3.1 One-Lane Highway Intensity 244
 - 4.3.2 Level of Service (LOS) 245
 - 4.3.3 Highway Intensity. 247
 - 4.3.4 Road Crossing and Intersection Lights Impact on Intensity 248
 - 4.3.5 Intelligent Lighting Systems. 249
 - 4.3.6 Maximum and Real Road Capacity. 250
 - 4.4 Road Capacity with Unmanned Cars. 250
 - 4.4.1 Highway Intensity with Uniform Spacing. 251
 - 4.4.2 Highway Intensity with Nonuniform Spacing Design 252
 - 4.4.3 Platooning Policy 252
 - 4.5 Car Pooling 254
 - 4.6 Bus Capacity 254
 - 4.6.1 Loading Areas 255
 - 4.6.2 Bus Stops 257
 - 4.6.3 Bus Facilities 258
 - 4.6.4 Traffic Signal Timing 258
 - 4.6.5 Bus Capacity for One Loading Area 258
 - 4.6.6 Bus Capacity for Several Loading Areas 259
 - 4.6.7 Real Bus Capacity at Average Speed. 260
 - 4.7 Unmanned Bus Operation 261
 - 4.8 Mass Transit Capacity. 263
 - 4.8.1 Increasing Capacity of Existing Infrastructure. 263
 - 4.8.2 Vehicle Capacity 263
 - 4.8.3 Mass Transit Network Capacity 266
 - 4.8.4 Railway System Capacity. 266

- 4.9 Transport Mode Capacity Comparison. 267
 - 4.9.1 Highway and Road Capacity 267
 - 4.9.2 Bus and BRT Capacity 268
 - 4.9.3 Metro and Train Capacity 269
 - 4.9.4 Comparing Apples with Apples 270
 - 4.9.5 Considering Lost Capacity 271
- 4.10 System Price Comparison 272
 - 4.10.1 CAPEX Comparison 273
 - 4.10.2 OPEX Comparison 274
 - 4.10.3 Social and Environmental Costs 275
 - 4.10.4 Appropriation Costs 275
 - 4.10.5 Expropriation Costs 276
 - 4.10.6 Congestion Costs 276
 - 4.10.7 Environmental Costs 278
 - 4.10.8 Social Benefits 278
 - 4.10.9 Health Cost Linked to Air Pollution 279
- 4.11 Quality of Ride 279
 - 4.11.1 Average Speed 279
 - 4.11.2 Comfort 280
 - 4.11.3 Quality of Service 280
 - 4.11.4 Access to Information 280
 - 4.11.5 Transportation Modes’ Integration 281
- Companies and Brands Stated in the Chapter. 282

- 5 Connected Cities 283**
 - 5.1 Introduction 283
 - 5.1.1 The Mobile Environment 285
 - 5.1.2 Acquisition of Intelligent Thermostat Manufacturer 285
 - 5.2 The “Internet of Things” Technologies 286
 - 5.2.1 Internet Protocol Definition 287
 - 5.2.2 TCP/IP Layers 287
 - 5.2.3 Network Topology Description 290
 - 5.2.4 Service-Oriented Architecture (SOA) 292
 - 5.2.5 Service Delivery Platform (SDP) and Access
Networking 294
 - 5.2.6 Next Generation Networks (NGN) 295
 - 5.2.7 Event-Driven Architecture (EDA) 296
 - 5.2.8 EDA and SOA Together 297
 - 5.2.9 Plug and Play Technology (PnP) 298
 - 5.3 M2M Communication 298
 - 5.3.1 Sensing Devices 299
 - 5.3.2 RFID 299
 - 5.3.3 Algorithms 299

- 5.3.4 Communication Links and Networks 300
- 5.3.5 Transportation Within the M2M Market 300
- 5.4 M2M Applied to Public Transport 301
 - 5.4.1 Railway Onboard Networks 301
 - 5.4.2 New IT Technologies that Affect Transportation. 302
 - 5.4.3 Benefits of IP Networks Onboard Trains 303
 - 5.4.4 SOA Applied to the Railway Environment. 304
 - 5.4.5 InteGRail. 305
- 5.5 Predictive Maintenance 305
 - 5.5.1 Constant Monitoring 306
 - 5.5.2 Data Crunching 309
 - 5.5.3 Event-Driven Information 309
 - 5.5.4 Useful Algorithms. 310
 - 5.5.5 Failure Criticality 310
 - 5.5.6 M2M Public Transport Market Estimation 310
- 5.6 M2M Applied to Cars. 311
 - 5.6.1 Re-programmable SIM Cards 311
 - 5.6.2 Existing Onboard Car Networks 312
 - 5.6.3 Onboard Car IP Networks 312
 - 5.6.4 New M2M Added Value Services. 313
 - 5.6.5 M2M Versus V2V or V2I 316
 - 5.6.6 M2M Private Transport Market Estimation. 316
- 5.7 E-Mobility Technology Limitations. 317
- Companies and Brands Stated in the Chapter. 318
- 6 New Transportation Business Models 319**
 - 6.1 Project Finance 320
 - 6.1.1 Corporate Versus Project Finance 321
 - 6.1.2 Private Financial Players 322
 - 6.1.3 Private Participation in Transport Infrastructure. 325
 - 6.2 Transport Infrastructure Privatizations 326
 - 6.2.1 Concession Agreement of Existing Transport Facilities 326
 - 6.2.2 New Project Concession 326
 - 6.2.3 Management Contract 327
 - 6.2.4 Private Public Partnerships (PPP) 328
 - 6.3 New Potential Financial Instruments and Incentives 328
 - 6.3.1 Green Bonds 328
 - 6.3.2 Carbon Credits 329
 - 6.3.3 Voluntary Carbon Market 330
 - 6.3.4 Corporate Donation and Tax Exemption 331
 - 6.3.5 Certificate of Potential Increase in Construction (CEPAC). 332

- 6.4 Reducing Infrastructure Construction Needs 336
 - 6.4.1 Encourage Working from Home 336
 - 6.4.2 Encourage People to Stay in Their Neighborhood 337
 - 6.4.3 Higher Occupancy Rate 337
 - 6.4.4 Higher Transportation Means Density 337
 - 6.4.5 Car and Parking Space Reduction 337
- 6.5 Electrifying Transport 337
- 6.6 Changing Public Transport Business Model 338
 - 6.6.1 Total Cost of Ownership (TCO) 339
- 6.7 Private to Public Transport Cross-Subsidizing 340
 - 6.7.1 Fast Lane Cross-Subsidizing 342
 - 6.7.2 Localized Congestion Charges 342
- 6.8 Internet Connectivity 343
 - 6.8.1 Pay-Per-Click Model (PPC) 344
 - 6.8.2 Time Spent Online 344
 - 6.8.3 Mobile Shopping 345
 - 6.8.4 Mobile Activities 345
 - 6.8.5 Generation Gap 346
 - 6.8.6 Mobile Advertising Market Estimation 346
- 6.9 Transport Information Supplier of Choice 347
 - 6.9.1 Public Transport Information System 348
 - 6.9.2 Battle for Passenger Information Access 349
 - 6.9.3 Social Public Transport Apps 350
 - 6.9.4 GPS Location-Based Information 351
 - 6.9.5 Beacon Location Based Information 352
 - 6.9.6 Legal Use of Geo-tagging Space 353
 - 6.9.7 Cross-Subsidies of Mobile Advertising Revenues 353
 - 6.9.8 Road Transport Information System 354
- 6.10 E-mobility Software Applications 354
 - 6.10.1 Social Car Apps 354
 - 6.10.2 Car Pooling Apps 355
 - 6.10.3 Car Sharing Initiatives and Apps 355
 - 6.10.4 Mobile Taxi Hailing Apps 356
- 6.11 Change of Car Ownership Business Model 356
 - 6.11.1 Car’s Negative Image 357
 - 6.11.2 Commoditization of Cars 358
 - 6.11.3 Blurring Differences Between Private and Public Transport 358
 - 6.11.4 Car Ownership Models 359
- 6.12 Change of “Public Service Car” Business Models 361
 - 6.12.1 Conventional Taxi Business Model 361
 - 6.12.2 New Taxi Hailing Business Model 362
 - 6.12.3 The End of Taxi Drivers 364
- Companies and Brands Stated in the Chapter 365

- 7 E-Mobility Likely Winners and Losers 367**
- 7.1 Who Can Ignore the E-Mobility Revolution? 367
 - 7.1.1 Flying Cars 368
 - 7.1.2 Trains and Hyperloops 369
 - 7.1.3 Can the E-Mobility Not Happen? 370
- 7.2 E-Mobility Technology Adoption 371
 - 7.2.1 Railway Industry 371
 - 7.2.2 Automotive and Bus Industries 371
 - 7.2.3 Lack of Industry Standard 372
 - 7.2.4 Lack of Infrastructure 372
 - 7.2.5 Unmanned Car Technology Adoption Barriers 373
 - 7.2.6 Sensor Technology 373
 - 7.2.7 V2V and V2I Connectivity Solution 373
 - 7.2.8 Putting All Pieces Together 374
 - 7.2.9 Growing or Shrinking Market? 375
 - 7.2.10 Railway Signaling Business Model 377
 - 7.2.11 Smartphone Revolution 377
 - 7.2.12 Designer Model 378
 - 7.2.13 Licensing Model 379
 - 7.2.14 Service Model 379
- 7.3 E-Mobility Likely Losers 380
 - 7.3.1 Parking Owners and Municipalities 380
 - 7.3.2 Car Manufacturers 381
 - 7.3.3 Body Shops 383
 - 7.3.4 Current PRT Manufacturers 383
 - 7.3.5 Steel Companies 383
 - 7.3.6 Light Rail Vehicle 383
 - 7.3.7 Conventional Bus Operation 383
 - 7.3.8 Conventional Car Rental Industry 384
 - 7.3.9 Fossil Fuel Industry 384
 - 7.3.10 Health Sector 384
 - 7.3.11 Personal-Injury Lawyers 385
- 7.4 E-Mobility Likely Winners 385
 - 7.4.1 Electric Car Manufacturers 385
 - 7.4.2 Environment 385
 - 7.4.3 Insurers 386
 - 7.4.4 Government Authorities 387
 - 7.4.5 Software Providers 387
 - 7.4.6 System Integration Providers 389
 - 7.4.7 Road Infrastructure Providers 389
 - 7.4.8 Electrical Infrastructure Providers 390
 - 7.4.9 Society 390
- Companies and Brands Stated in the Chapter 391



<http://www.springer.com/978-3-319-20665-3>

The Advent of Unmanned Electric Vehicles
The Choices between E-mobility and Immobility
Van Themsche, S.
2016, XIX, 392 p., Hardcover
ISBN: 978-3-319-20665-3