

# Contents

Preface and Acknowledgments	xv
Forward	xvii
<b>CHAPTER 1</b>	
Introduction	1
1.1 Machine Intelligence on the Road	1
1.2 Definition of Intelligent Vehicles	3
1.3 Overview of Chapters	3
References	6
<b>CHAPTER 2</b>	
Goals and Visions for the Future	7
2.1 Government Safety Goals	8
2.1.1 Asia-Pacific Region	8
2.1.2 Europe	10
2.1.3 North America	10
2.2 Visions for the Future	11
2.2.1 Europe's eSafety Vision	12
2.2.2 Sweden's Vision Zero	13
2.2.3 ITS America's Zero Fatalities Vision	13
2.2.4 ITS Evolution in Japan	14
2.2.5 The Netherlands Organization for Scientific Research (TNO)	15
2.2.6 France	18
2.2.7 The Cybercar Approach	21
2.2.8 Vision 2030	21
2.3 Summary	22
References	23
<b>CHAPTER 3</b>	
IV Application Areas	25
3.1 Convenience Systems	25
3.1.1 Parking Assist	26
3.1.2 Adaptive Cruise Control (ACC)	26
3.1.3 Low-Speed ACC	27
3.1.4 Lane-Keeping Assistance (LKA)	27
3.1.5 Automated Vehicle Control	28

3.2	Safety Systems	28
3.2.1	Assisting Driver Perception	29
3.2.2	Crash Prevention	30
3.2.3	Degraded Driving	32
3.2.4	Precrash	33
3.2.5	External Vehicle Speed Control (EVSC)	33
3.3	Productivity Systems	34
3.3.1	Truck Applications	34
3.3.2	Transit Bus Applications	34
3.4	Traffic-Assist Systems	35
3.4.1	Vehicle Flow Management (VFM)	36
3.4.2	Traffic-Responsive Adaptation	36
3.4.3	Traffic Jam Dissipation	36
3.4.4	Start-Up Assist	37
3.4.5	Cooperative ACC (C-ACC)	37
3.4.6	Platooning	37
	References	37

## CHAPTER 4

	Government-Industry R&D Programs and Strategies	39
4.1	Asia-Pacific	39
4.1.1	Australia	39
4.1.2	China	40
4.1.3	Japan	42
4.1.4	South Korea	44
4.2	European Programs	45
4.2.1	Pan-European Activities Conducted Through the EC	45
4.2.2	The DeuFrako Program	51
4.2.3	French Programs	52
4.2.4	IV Research in Germany	53
4.2.5	Activities in the Netherlands	55
4.2.6	IVSS in Sweden	57
4.2.7	United Kingdom	58
4.3	United States	59
4.3.1	U.S. DOT	59
4.3.2	IV R&D at the State Level	63
4.3.3	IV R&D Under Way by the U.S. Department of Defense	65
4.4	Contrasts Across IV Programs Worldwide	65
	References	66

## CHAPTER 5

	IV Priorities and Strategies for the Vehicle Industry	69
5.1	Automobile Manufacturers	70
5.1.1	BMW	70
5.1.2	DaimlerChrysler	70
5.1.3	Fiat	73
5.1.4	Ford	73

5.1.5	General Motors	74
5.1.6	Honda	76
5.1.7	Mitsubishi	77
5.1.8	Nissan	77
5.1.9	PSA Peugeot Citroën	78
5.1.10	Renault	78
5.1.11	Subaru	79
5.1.12	Toyota	79
5.1.13	Volkswagen (VW)	81
5.1.14	Volvo Global Trucks	81
5.2	Automotive Industry Suppliers	81
5.2.1	Aisin Group	82
5.2.2	Bosch	82
5.2.3	Continental	83
5.2.4	Delphi	83
5.2.5	Denso	86
5.2.6	Hella	87
5.2.7	IBEO Automobile Sensor	87
5.2.8	MobilEye	88
5.2.9	Siemens VDO Automotive	89
5.2.10	TRW's Three-Phase Roadmap	89
5.2.11	Valeo: Seeing and Being Seen	90
5.2.12	Visteon	91
5.3	Automotive Industry Summary	92
	References	93

## CHAPTER 6

	Lateral/Side Sensing and Control Systems	97
6.1	Lane Departure Warning System (LDWS)	98
6.1.1	LDWS Approaches	98
6.1.2	LDWS on the Market	101
6.1.3	LDWS Evaluations	104
6.2	Road Departure Warning Systems (RDWS)	106
6.2.1	Curve Speed Warning	106
6.2.2	U.S. DOT Road Departure Warning Field Operational Testing	107
6.3	Lane Keeping Assist Systems (LKA)	109
6.3.1	System Approaches	109
6.3.2	LKA Systems on the Market	111
6.4	Parallel Parking Assist	112
6.5	Side Sensing: Blind Spot Monitoring and Lane Change Assistance (LCA)	113
6.5.1	Radar-Based Systems	113
6.5.2	Vision-Based Systems	114
6.5.3	Ultrasonic-Based Side Object Sensing For Transit Buses	115
6.6	Comprehensive Lateral Control Assistance (LCA)	115
6.6.1	INVENT: LCA	115

6.6.2	PReVENT	116
6.7	Rollover Collision Avoidance (RCA) for Heavy Trucks	116
6.8	Summary	118
	References	119

## CHAPTER 7

	Longitudinal Sensing and Control Systems	121
7.1	Rear Sensing for Parking	122
7.1.1	System Description	122
7.1.2	Market Aspects	123
7.2	Night Vision	123
7.2.1	System Description	123
7.2.2	Night Vision Systems	124
7.2.3	Market Aspects	125
7.3	Adaptive Front Lighting (AFS)	125
7.3.1	System Description	125
7.3.2	System Descriptions	126
7.3.3	Market Aspects	126
7.4	Adaptive Cruise Control (ACC)	127
7.4.1	ACC Sensor Technologies and Trade-offs	127
7.4.2	High-Speed ACC	129
7.4.3	Low-Speed ACC	132
7.4.4	Full-Speed Range ACC	134
7.5	Safe Gap Advisory	134
7.5.1	System Description	134
7.5.2	Research and Evaluation	134
7.6	Forward Collision Warning	135
7.6.1	System Description	135
7.6.2	Market Aspects	136
7.6.3	Evaluation of FCW: The ACAS Field Operational Test	137
7.7	Rear Impact Countermeasures	140
7.8	Precrash Brake Assist	140
7.8.1	System Description	140
7.8.2	Market Aspects	141
7.9	Forward Crash Mitigation (FCM) and Avoidance—Active Braking	141
7.9.1	System Description	141
7.9.2	Market Aspects	141
7.9.3	FCM Research	143
7.9.4	Forward Collision Avoidance	143
7.10	Pedestrian Detection and Avoidance	144
7.10.1	System Description	144
7.10.2	Market Aspects	144
7.10.3	Ongoing R&D	145
7.11	Next Generation Sensors	151
7.11.1	Next Generation Sensors—Radar	151
7.11.2	Next Generation Sensors—Laser Scanners	153
7.12	Summary and Observations	155

References	156
<b>CHAPTER 8</b>	
Integrated Lateral and Longitudinal Control and Sensing Systems	159
8.1 Sensor Fusion	160
8.1.1 CARSENSE for Urban Environments	160
8.1.2 Data Fusion Approach in INVENT	163
8.1.3 ProFusion	165
8.2 Applications	167
8.2.1 Autonomous Intersection Collision Avoidance (ICA)	168
8.2.2 Bus Transit Integrated Collision Warning System	169
8.2.3 Integrated Vehicle-Based Safety System (IVBSS) Program	170
8.2.4 PReVENT Integrated Systems	172
8.3 User and Societal Assessments of Integrated Systems	173
8.4 Summary	174
References	174
<b>CHAPTER 9</b>	
Cooperative Vehicle-Highway Systems (CVHS)	177
9.1 Wireless Communications as a Foundation for Cooperative Systems	178
9.1.1 Dedicated Short Range Communications (DSRC)	180
9.1.2 Transceiver Development for North American DSRC	185
9.1.3 Wireless Access Vehicular Environment (WAVE)	186
9.1.4 Continuous Air-Interface for Long and Medium (CALM) Distance Communications	186
9.1.5 Intervehicle Communications Using Ad Hoc Network Techniques	186
9.1.6 Radar-Based Intervehicle Communications	189
9.1.7 Millimeter-Wave (MMW)-Based Intervehicle Communications	190
9.2 Digital Maps and Satellite Positioning in Support of CVHS	191
9.2.1 Map-Enabled Safety Applications	192
9.2.2 ActMAP: Real-Time Map Updating	193
9.3 Cooperative Applications: Longitudinal Advisories	194
9.3.1 Japanese Operational Testing	194
9.3.2 Wireless Local Danger Warnings	195
9.4 Intelligent Speed Adaptation (ISA)	195
9.4.1 ISA in Sweden	196
9.4.2 LAVIA: The French Project of Adaptive Speed Limiter	196
9.4.3 ISA-UK	197
9.4.4 PROSPER	198
9.4.5 Australian ISA Research	199
9.5 Cooperative Intersection Collision Avoidance (ICA)	199
9.5.1 ICA Research in Japan	199
9.5.2 ICA Work in the United States	200
9.5.3 Cooperative ICA R&D in Europe	202
9.6 Cooperative Approaches for Vulnerable Road Users	203
9.7 CVHS as an Enabler for Traffic Flow Improvement	204

9.7.1	Traffic Assistance Strategies for Improving Stable Flow	205
9.7.2	Traffic Assistance Strategies To Prevent Flow Breakdown	208
9.7.3	Traffic Assistance Strategies Within Congestion	209
9.7.4	STARDUST Analyses	211
9.8	Business Case and Deployment Projects	212
9.8.1	Automotive Deployment for Cooperative Systems	212
9.8.2	Commercial Telematics CVHS Activities	213
9.8.3	Public-Sector CVHS Deployment Initiatives	214
9.8.4	U.K. CVHS Study	217
9.8.5	CVHS Deployment Research Initiatives	218
9.9	Summary	220
	References	220

## **CHAPTER 10**

Fully Automated Vehicles	225	
10.1	Passenger Car Automation	226
10.1.1	Highway Automation	226
10.1.2	Low-Speed Automation	230
10.1.3	Ongoing Work in Vehicle-Highway Automation	231
10.1.4	User Attitudes Toward Automated Vehicle Operations	232
10.2	Truck Automation	233
10.2.1	Electronic Tow-Bar Operations and Driver Assistance	233
10.2.2	Truck Automation for Long-Haul Application: Deployment Studies	235
10.2.3	Automation in Short-Haul Drayage Operations	238
10.2.4	Insertion of Automated Truck Lanes in Urban Areas	239
10.3	Automated Public Transport	240
10.3.1	ParkShuttle	240
10.3.2	Intelligent Multimode Transit System (IMTS)	241
10.3.3	Phileas	242
10.3.4	Bus Platooning R&D at PATH	243
10.4	CyberCars	244
10.5	Automated Vehicle for Military Operations	248
10.6	Deployment Options	249
	References	251

## **CHAPTER 11**

Extending the Information Horizon Through Floating Car Data Systems	253	
11.1	FCD Applications	254
11.2	Policy Issues Relating to FCD Techniques	254
11.3	Technical Issues	256
11.3.1	Data Reporting	256
11.3.2	Data Dissemination	257
11.3.3	Data Cleansing	257
11.4	FCD Activity in Japan	257
11.4.1	Road Performance Assessments	257
11.4.2	Taxi-Based Probe Experiments	257