

# INFORMATION SOCIETY TECHNOLOGIES (IST) PROGRAMME



## AIDE IST-1-507674-IP

### Review and Taxonomy of IVIS/ADAS applications

Deliverable No. (use the number indicated on technical annex)		D2.1.2	
SubProject No.	SP2	SubProject Title	Evaluation and assessment methodology
Workpackage No.	WP2.1	Workpackage Title	Generic evaluation methodology
Activity No.	A2.1.2	Activity Title	Review and taxonomy of IVIS/ADAS applications
Authors (per company, if more than one company provide it together)		Nikolaos Floudas, Angelos Amditis (ICCS), Andreas Keinath, Klaus Bengler (BMW), Arnd Engeln (Bosch)	
Status (F: final; D: draft; RD: revised draft):		F	
File Name:		AIDE D2_1_2_v7.doc	
Project start date and duration		01 March 2004, 48 Months	

## List of abbreviations

<b>ABS</b>	Anti Blocking System
<b>ACC</b>	Adaptive Cruise Control
<b>ADA</b>	Advanced Driving Assistance
<b>ADAS</b>	Advanced Driving Assistance System
<b>AF</b>	Alternative Frequencies
<b>AHS</b>	Advanced cruise-assist Highway System
<b>AHSRA</b>	Advanced cruise-assist Highway System Research Association
<b>AICC</b>	Autonomous Intelligent Cruise Control
<b>AIDE</b>	Adaptive Integrated Driver-vehicle InterfacE
<b>APS</b>	Auto Pilot System
<b>ARIB</b>	Association of Radio Industries and Businesses
<b>ASL</b>	Application Sub-Layer
<b>ASR</b>	Acceleration Skid Control
<b>ASV</b>	Advanced Safety Vehicle
<b>ATIS</b>	Advanced Traveller Information Systems
<b>BUA</b>	Back Up Aid
<b>CA</b>	Collision Avoidance
<b>CAN</b>	Controller Area Network (bus)
<b>CCD</b>	Charge Coupled Device
<b>CD-ROM</b>	Compact Disc – Read Only Memory
<b>CEM</b>	Consumer Electronics Manufacturers
<b>CEMVOCAS</b>	Centralised Management of Vocal Interfaces aiming at a better Automotive Safety
<b>CEN</b>	Comité Européenne de Normalisation
<b>CMOS</b>	Complementary Metal Oxide Semiconductor
<b>CWA</b>	Collision Warning and Avoidance
<b>DAB</b>	Digital Audio Broadcasting
<b>DDS</b>	Drowsiness Detection System
<b>DGPS</b>	Differential GPS
<b>DSP</b>	Digital Signal Processor
<b>DSRC</b>	Dedicated Short Range Communication (technology)
<b>DSRU</b>	Driver Situation Recognition Unit
<b>DVB</b>	Digital Video Broadcasting
<b>EBU</b>	Electrical Business Unit
<b>EPS</b>	Electric Power Steering
<b>EPS</b>	Electric Power Steering
<b>ESP</b>	Electronic Stability Program
<b>ETC</b>	Electronic Toll Collection
<b>ETS</b>	Electronic Traction System
<b>FCW</b>	Forward Collision Warning
<b>FLR</b>	Forward Looking Radar
<b>FMCW</b>	Frequency Modulated Continuous Wave (radar)
<b>GPRS</b>	General Packet Radio Service
<b>GPS</b>	Global Positioning System
<b>GSM</b>	Global System for Mobile Communications
<b>GUI</b>	Graphics User Interface
<b>HDD</b>	Head Down Display
<b>HMI</b>	Human Machine Interface
<b>HRR</b>	High Resolution Radar
<b>HUD</b>	Head Up Display
<b>ICC</b>	Intelligent Cruise Control
<b>IDIS</b>	Integrated Driver Information System
<b>IDSS</b>	Intelligent Driver Support System

---

<b>IP</b>	Integrated Project
<b>IRDA</b>	Infrared Data Adapter
<b>ISA</b>	Intelligent Speed Adaptation
<b>ITS</b>	Intelligent Transportation System
<b>IVHS</b>	Intelligent Vehicle Highway System
<b>IVI</b>	In-Vehicle Information
<b>IVICS</b>	In-Vehicle Information and Communication System
<b>IVIS</b>	In-Vehicle Information System
<b>LANEX</b>	Lane Exceedences
<b>LCD</b>	Liquid Crystal Display
<b>LCT</b>	Lane Change Test
<b>LDW</b>	Lane Departure Warning
<b>LED</b>	Light Emitting Diode
<b>LK</b>	Lane Keeping
<b>LKAS</b>	Lane Keeping Assistance System
<b>MMIC</b>	Monolithic Microwave Integrated Circuits
<b>OBU</b>	On Board Unit
<b>OEM</b>	Original Equipment Manufacturer
<b>OIP</b>	Open Integrating Platform
<b>PB</b>	Pre-crash Brake
<b>PBA</b>	Pre-crash Brake Assist
<b>PCS</b>	Pre-Crash Safety (system)
<b>PDA</b>	Personal Digital Assistant
<b>PSB</b>	Pre-Crash Seat Belt
<b>PSN</b>	Programme Service Name
<b>RDS</b>	Radio Data System
<b>RESCU</b>	Remote Emergency Satellite Cellular Unit
<b>RF</b>	Radio Frequency
<b>RPA</b>	Reversing / Parking Aid
<b>SDK</b>	Smart Distance Keeping
<b>SDLP</b>	Standard Deviation of Lateral Position
<b>SMS</b>	Short Messaging System
<b>SP</b>	Sub-project
<b>SWT</b>	Sidewall Torsion Sensor
<b>TA</b>	Traffic Announcement
<b>TLC</b>	Time to Line Crossing
<b>TMC</b>	Traffic Message Channel
<b>TPEG</b>	Transport Protocol Expert Group
<b>TPMS</b>	Tire-Pressure Monitoring System
<b>TTC</b>	Time To Collision
<b>TTI</b>	Travel and Traffic Information
<b>UMTS</b>	Universal Mobile Telecommunication System
<b>VE</b>	Vision Enhancement
<b>VES</b>	Vision Enhancement Systems
<b>VODIS</b>	Voice Operated Driving Information System
<b>VRU</b>	Vulnerable Road Users
<b>VSC</b>	Vehicle Stability Control
<b>WAP</b>	Wireless Application Protocol
<b>WP</b>	Workpackage

## Table of contents

<b>LIST OF ABBREVIATIONS</b> .....	<b>2</b>
<b>LIST OF FIGURES</b> .....	<b>9</b>
<b>LIST OF TABLES</b> .....	<b>9</b>
<b>EXECUTIVE SUMMARY</b> .....	<b>10</b>
<b>REVISION CHART AND HISTORY LOG</b> .....	<b>11</b>
<b>1 INTRODUCTION</b> .....	<b>12</b>
1.1 DELIVERABLE OBJECTIVES AND STRUCTURE.....	12
1.2 METHODOLOGY.....	12
<b>2 IVIS CATEGORIES</b> .....	<b>14</b>
2.1 NAVIGATION SYSTEMS.....	14
2.1.1 <i>Integrated navigation</i> .....	14
2.1.2 <i>Route guidance system and route navigation systems</i> .....	15
2.1.3 <i>Junction management</i> .....	15
2.1.4 <i>Location database</i> .....	15
2.2 TRAVELING RELATED INFORMATION SYSTEMS.....	16
2.2.1 <i>Vehicle monitoring</i> .....	17
2.2.2 <i>Emergency related services</i> .....	18
2.3 AUDIO, RADIO, CD, MP3 DEVICES.....	18
2.4 TRAFFIC RELATED INFORMATION SYSTEMS.....	18
2.4.1 <i>Traffic Management in Transport and Logistics</i> .....	20
2.4.2 <i>Automated transactions – electronic toll collection</i> .....	20
2.4.3 <i>Traffic Message Channel</i> .....	21
2.4.4 <i>Traffic Network Equalization</i> .....	21
2.4.5 <i>Travel and Traffic Information</i> .....	21
2.5 VEHICLE COMMUNICATION SYSTEMS.....	21
2.5.1 <i>Vehicle-infrastructure communication</i> .....	21
2.5.2 <i>Vehicle-vehicle communication</i> .....	21
2.6 DRIVER CONVENIENCE SERVICES.....	22
2.6.1 <i>Phone related services</i> .....	22
2.6.2 <i>PDA</i> .....	22
2.6.3 <i>Driver convenience communication</i> .....	22
2.6.4 <i>On-board hands-free functions</i> .....	22
2.6.5 <i>Driver identification and automatic cockpit configuration</i> .....	23
2.7 CONCLUSIONS.....	23
<b>3 ADAS CATEGORIES</b> .....	<b>24</b>
3.1 LATERAL CONTROL.....	25
3.1.1 <i>Lane keeping and warning</i> .....	25
3.1.2 <i>Blind spot monitoring</i> .....	25
3.1.3 <i>Lane change and merge collision avoidance</i> .....	26
3.2 LONGITUDINAL CONTROL.....	26
3.2.1 <i>Intelligent Speed Adaptation (ISA)</i> .....	26
3.2.2 <i>Distance keeping – Adaptive Cruise Control</i> .....	27
3.2.3 <i>ACC + Curve Management</i> .....	27
3.2.4 <i>Curve Warning</i> .....	28
3.2.5 <i>Collision Warning and Avoidance Systems</i> .....	28
3.2.6 <i>Intersection collision avoidance</i> .....	29
3.2.7 <i>Rail-road crossing collision avoidance</i> .....	29
3.2.8 <i>Stop &amp; Go</i> .....	29

3.2.9	<i>Pedestrian or obstacle detection</i> .....	30
3.2.10	<i>IVHS - platooning</i> .....	30
3.3	REVERSING AIDS / PARKING AIDS .....	30
3.4	VISION ENHANCEMENT SYSTEMS .....	31
3.5	DRIVER MONITORING .....	32
3.5.1	<i>Driver vigilance monitoring</i> .....	32
3.5.2	<i>Driver health monitoring</i> .....	32
3.6	PRE-CRASH SYSTEMS .....	33
3.6.1	<i>Smart Restraints</i> .....	33
3.6.2	<i>Rear End Collision avoidance - Pre-crash sensing</i> .....	33
3.7	ROAD SURFACE / LOW FRICTION WARNING .....	33
3.8	CONCLUSIONS .....	34
<b>4</b>	<b>GENERIC TAXONOMY OF IVIS/ADAS BY AIDE USE CASES</b> .....	<b>37</b>
4.1	INFORMATION SYSTEMS .....	39
4.2	COMFORT AND INFOTAINMENT SYSTEMS .....	40
4.3	SAFETY SYSTEMS .....	42
<b>5</b>	<b>FUNCTIONAL TAXONOMY OF IVIS/ADAS APPLICATIONS</b> .....	<b>50</b>
5.1	NAVIGATION SYSTEMS (IVIS) .....	52
5.2	TRAVELING/TRAFFIC RELATED INFORMATION SYSTEMS (IVIS) .....	53
5.3	VEHICLE COMMUNICATION SYSTEMS (IVIS) .....	53
5.4	DRIVER CONVENIENCE SERVICES (IVIS) .....	53
5.5	LATERAL CONTROL (ADAS) .....	53
5.6	LONGITUDINAL CONTROL (ADAS) .....	54
5.7	REVERSING / PARKING AID (ADAS) .....	55
5.8	VISION ENHANCEMENT SYSTEMS (ADAS) .....	55
5.9	DRIVER MONITORING (ADAS) .....	55
5.10	PRE-CRASH SYSTEMS (ADAS) .....	55
5.11	VULNERABLE ROAD USERS PROTECTION SYSTEMS (ADAS) .....	55
5.12	ROAD LOW FRICTION WARNING SYSTEMS (ADAS) .....	55
<b>6</b>	<b>STATE OF THE ART OF IVIS/ADAS HMI COMPONENTS</b> .....	<b>57</b>
6.1	DEFINITION OF HMI COMPONENTS .....	57
6.2	IVIS/ADAS HMI COMPONENTS TO NOTICE TECHNICAL EVENTS .....	57
6.3	IVIS/ADAS HMI COMPONENTS TO INTERVENE TECHNICAL EVENTS .....	57
6.4	IVIS/ADAS HMI COMPONENTS NOTICE PEOPLE .....	58
6.5	IVIS/ADAS HMI COMPONENTS INTERVENE PEOPLE .....	58
<b>7</b>	<b>METHODOLOGIES FOR ASSESSING USABILITY OF IVIS/ADAS</b> .....	<b>59</b>
7.1	INSPECTION METHODS .....	59
7.1.1	<i>Heuristic evaluation</i> .....	59
7.1.2	<i>Cognitive walkthrough</i> .....	60
7.2	EXPERIMENTAL METHODS .....	60
7.2.1	<i>Laboratory methods</i> .....	61
7.2.2	<i>Driving simulator experiments and experiments in real traffic</i> .....	62
7.3	DRIVING PERFORMANCE MEASURES .....	62
7.3.1	<i>Michons model</i> .....	62
7.3.2	<i>GADGET model</i> .....	63
7.3.3	<i>DRIVABILITY model</i> .....	63
7.3.4	<i>INVENT FVM AP3000 method</i> .....	65
7.4	CONCLUSION .....	65
7.5	REFERENCES FOR METHODOLOGIES OF IVIS/ADAS USABILITY .....	66
<b>8</b>	<b>CONCLUSIONS</b> .....	<b>68</b>

<b>REFERENCES.....</b>	<b>69</b>
<b>A IVIS ANNEX OF APPLICATIONS.....</b>	<b>71</b>
A.1 EXISTING AND STATE OF THE ART APPLICATIONS .....	71
A.1.1 <i>General Motors' OnStar service (telematics)</i> .....	71
A.1.2 <i>Mercedes Benz's TeleAid service (telematics)</i> .....	72
A.1.3 <i>Ford's telematics</i> .....	73
A.1.4 <i>Renault's telematics</i> .....	74
A.1.5 <i>Simac's LOGIC</i> .....	74
A.1.6 <i>Rockwell Automotive's ADT</i> .....	74
A.1.7 <i>Blaupunkt RCO5</i> .....	75
A.1.8 <i>Ford's RESCU</i> .....	75
A.1.9 <i>DaimlerChrysler's ARTUR</i> .....	75
A.1.10 <i>France Telecom's Cellway</i> .....	75
A.1.11 <i>SKYNET service</i> .....	76
A.1.12 <i>Qualcomm's OMNI TRACS</i> .....	76
A.1.13 <i>CALSPAN system</i> .....	76
A.1.14 <i>Electronic Toll Collection system of Japan</i> .....	76
A.1.15 <i>Advanced Cruise-assist Highway System of Japan</i> .....	76
A.1.16 <i>Cadillac's Imaj concept car</i> .....	78
A.1.17 <i>Cadillac's navigation system</i> .....	79
A.1.18 <i>Mercedes Benz's navigation system</i> .....	79
A.1.19 <i>ACTIVE project</i> .....	80
A.1.20 <i>AutoGraL library of graphics</i> .....	80
A.1.21 <i>Andreas' array of microphones for automotive</i> .....	81
A.1.22 <i>VODIS and CEMVOCAS projects</i> .....	81
A.1.23 <i>The Visteon's Voice recognizer (Jaguar cars)</i> .....	81
A.1.24 <i>Delphi's voice recognition</i> .....	82
A.1.25 <i>HW acceleration for automotive speech interfaces</i> .....	82
A.2 FUTURE APPLICATIONS.....	83
A.2.1 <i>Nokia towards internet enabled cars</i> .....	83
A.2.2 <i>Delphi and Ericsson's: plug and play telematics systems</i> .....	84
A.2.3 <i>General Motors' telematics strategy</i> .....	84
A.2.4 <i>SmartMove: a Java-based intelligent vehicle</i> .....	85
<b>B ADAS ANNEX OF APPLICATIONS .....</b>	<b>86</b>
B.1 EXISTING AND STATE OF THE ART APPLICATIONS .....	86
B.1.1 <i>BMW's lane warning and keeping</i> .....	86
B.1.2 <i>Mitsubishi's lane warning and keeping</i> .....	86
B.1.3 <i>MAN's ACC</i> .....	86
B.1.4 <i>BMW's ACC</i> .....	86
B.1.5 <i>Celsius Tech Electronics, Bosch, Mercedes Benz and Porsche ACCs</i> .....	87
B.1.6 <i>Mazda, Mitsubishi, Nissan and Toyota collision avoidance systems</i> .....	87
B.1.7 <i>Mercedes Benz's collision avoidance system</i> .....	87
B.1.8 <i>Delphi' forewarn back up aid (BUA)</i> .....	87
B.1.9 <i>Bosch's Park Pilot</i> .....	88
B.1.10 <i>Denso's corner clearance warning system</i> .....	88
B.1.11 <i>Bosch's reversing / parking aid</i> .....	88
B.1.12 <i>Mercedes Benz's reversing / parking aid</i> .....	88
B.1.13 <i>Yazaki's reversing / parking aid</i> .....	88
B.1.14 <i>GEC Marconi Avionics' reversing / parking aid</i> .....	88
B.1.15 <i>Cadillac's reversing / parking aid</i> .....	89
B.1.16 <i>IMRA's 3D parking assistant system</i> .....	89
B.1.17 <i>DARWIN vision enhancement system</i> .....	89
B.1.18 <i>Cadillac's vision enhancement system</i> .....	90

B.1.19	<i>DaimlerChrysler's vision enhancement system</i> .....	91
B.1.20	<i>LACOS project</i> .....	92
B.1.21	<i>AWARE project</i> .....	93
B.1.22	<i>IN-ARTE project</i> .....	93
B.1.23	<i>EUCLIDE project</i> .....	94
B.1.24	<i>PROTECTOR project</i> .....	94
B.1.25	<i>SAVE-U project</i> .....	94
B.1.26	<i>PAROTO project</i> .....	95
B.1.27	<i>ARCOS project</i> .....	95
B.1.28	<i>APOLLO project</i> .....	96
B.1.29	<i>CARSENSE project</i> .....	97
B.1.30	<i>RADARNET project</i> .....	98
B.1.31	<i>PEIT project</i> .....	98
B.1.32	<i>SPARC project</i> .....	98
B.1.33	<i>Autoliv's night vision system</i> .....	99
B.1.34	<i>General Motor's night vision system</i> .....	100
B.1.35	<i>Bendix Xvision</i> .....	101
B.1.36	<i>Visteon's night vision system</i> .....	101
B.1.37	<i>AutoVue system</i> .....	102
B.1.38	<i>SafeTRAC system</i> .....	102
B.1.39	<i>Nissan's lane keeping assistance system</i> .....	103
B.1.40	<i>Toyota's lane monitoring system</i> .....	103
B.1.41	<i>SUBARU's System</i> .....	103
B.1.42	<i>Mitsubishi's System</i> .....	103
B.1.43	<i>Honda's Intelligent Driver Support System</i> .....	103
B.1.44	<i>Toyota's pre-crash safety system</i> .....	107
B.1.45	<i>BMW's PDS system</i> .....	108
B.1.46	<i>Siemens' IROPS</i> .....	108
B.1.47	<i>Sensor suite selection principle proposed by Delphi</i> .....	108
B.1.48	<i>Crash sensing by multiple sensor integration technology by Bosch</i> .....	108
B.1.49	<i>Anticipatory sensing technology by Bosch</i> .....	108
B.1.50	<i>CHAUFFEUR II project</i> .....	108
B.1.51	<i>Toyota's drowsiness detection and warning system</i> .....	109
B.1.52	<i>Nissan's drowsy/ inattentive driving warning system</i> .....	110
B.1.53	<i>DaimlerChrysler's drowsiness detection system</i> .....	110
B.1.54	<i>DaimlerChrysler's eye-gaze detection system</i> .....	111
B.1.55	<i>S.A.M. (Steering Attention Monitor) system</i> .....	112
B.1.56	<i>PERCLOS Monitor system</i> .....	112
B.1.57	<i>Johns Hopkins University drowsy driver detection system</i> .....	113
B.1.58	<i>MicroNod Detection System (MINDS)</i> .....	113
B.1.59	<i>Smart Eye system</i> .....	114
B.1.60	<i>TravAlert system</i> .....	114
B.1.61	<i>DAS 2000 road alert system</i> .....	115
B.1.62	<i>AlertDriver system</i> .....	115
B.1.63	<i>Eye-gaze system (LC technologies Inc.)</i> .....	116
B.1.64	<i>Volvo Trucks' ACC</i> .....	117
B.1.65	<i>Volvo Trucks' ESP</i> .....	117
B.1.66	<i>Volvo Trucks' reversing camera</i> .....	117
B.2	<b>FUTURE APPLICATIONS</b> .....	118
B.2.1	<i>Volvo Trucks' lane departure warning system</i> .....	118
B.2.2	<i>Stop &amp; Go and ACC system (research)</i> .....	118
B.2.3	<i>Hella KG Hueck &amp; Co. lane change assistant</i> .....	118
B.2.4	<i>Volkswagen's ACC and follow to stop system</i> .....	119
B.2.5	<i>CRF's safe speed and distance system</i> .....	119
B.2.6	<i>CRF's ACC and MAPPE system</i> .....	119

B.2.7 PREVENT / SASPENCE subproject..... 120  
B.2.8 PREVENT/ LATERAL SAFE subproject..... 121  
B.2.9 PREVENT/ SAFELANE subproject ..... 122  
B.2.10 AWAKE project..... 123



## List of Figures

Figure 1: ADASE 2 Roadmap .....	24
Figure 2: ADAS roadmap (Response [31]).....	35
Figure 3: ADAS overview; sensors and functions (Response [31]).....	35
Figure 4: Characteristics of different forms of experiments.....	61
Figure 5: Contributors to DRIVABILITY.....	65
Figure 6: Cadillac's navigation system.....	79
Figure 7: Mercedes Benz's navigation system.....	80
Figure 8: AutoArray DA300 .....	81
Figure 9: Cadillac's VES.....	90
Figure 10: A scenario of Cadillac's VES use.....	91
Figure 11: The DC's VES function .....	92
Figure 12: The DC's VES .....	92
Figure 14: General Motors' night vision system .....	101
Figure 15: Bendix Xvision system .....	101
Figure 16: Visteon's night vision system .....	102
Figure 17: Toyota's drowsiness detection system.....	110
Figure 18: MINDS.....	114
Figure 19: AlertDriver system.....	116
Figure 20: The PREVENT project functions of safety ADAS .....	122
Figure 21: AWAKE driver warning devices .....	125

## List of Tables

Table 1: Taxonomy of IVIS/ADAS of annexes according to use cases.....	37
Table 2: Description of information systems from annexes.....	39
Table 3: Description of comfort and infotainment systems from annexes.....	41
Table 4: Description of safety systems from annexes.....	42
Table 5: Functional taxonomy of IVIS/ADAS applications from annexes.....	50
Table 6: Taxonomy of lateral control ADAS .....	54
Table 7: Correspondence between GADGET and Michon hierarchical levels.....	63

## EXECUTIVE SUMMARY

This deliverable aims to perform a review and taxonomy of IVIS/ADAS applications under the AIDE SP2. The survey and taxonomy includes applications available in the market, prototypes, state of the art or under development. In addition reviews of HMI components and methods for evaluation tests are also included in the taxonomy performed. This work will form a basis for future tasks of AIDE SP2, including WPs 3.1 and tasks 2.1.3, 2.1.4.

The structure of this report includes an introduction presenting the general objectives and the methodology used to achieve this work. Then it continues with the definition of the categories of IVIS and ADAS applications, based on relevant work on this subject and on the experience obtained with the survey of applications that was carried out during this task. An extended database of existing and coming applications gathered from various sources is presented in the annexes. The report goes further with the taxonomy of IVIS and ADAS applications with respect to use cases and their functionalities. The applications of the annexes are used as references and examples for the taxonomies. A significant part of this report concerns the presentation of the HMI components used in state of the art applications. A link with the coming tasks of this subproject is achieved with the chapter of the review of methodologies of usability and evaluation tests. Finally, the report ends with the conclusion and the references.

The main findings of this work are: an extended database of existing and coming IVIS and ADAS applications, a functional taxonomy of these applications, a classification of IVIS/ADAS according to AIDE use cases, an overview of HMI components used for this kind of applications and a survey on evaluation methodologies for testing IVIS and ADAS. As a general conclusion: the categories identified in this work together with the evaluation survey and the relative work of Task 2.1.1 on "Review of existing tools and methods" provide a well basis for the progress of the coming tasks (3 and 4) of scenarios development and implementation.