INFORMATION SOCIETY TECHNOLOGIES (IST) PROGRAMME

AIDE
IST-1-507674-IP

Integration of Nomadic Devices: The AIDE Use Case

Deliverable No.		**D3.4.3**	
SubProject No.	**SP3**	SubProject Title	**Design and Development of an Adaptive Integrated Driver-Vehicle Interface**
Workpackage No.	**WP3.4**	Workpackage Title	**Adaptive Interface Design and Development**
Activity No.	**A 3.4.3**	Activity Title	**Prototype Nomadic Integration and Validation Tests**
Authors (per company, if more than one company provide it together)		**Callum Stuart, Harry Zhang, Bob Leivian (Motorola), Kimmo Kauvo (VTT), Harald Berninger (Opel), Angvall Anders (VTEC), Angelos Amditis, Katia Pagle (ICCS), Andreas Engelsberg (Bosch)**	
Status (D: draft, in progress, S: Submitted to EC, F: Final accepted by EC)		**F**	
File Name:		**AIDE D3.4.3 V8.0**	
Project start date and duration		**01 March 2004, 48 Months**	

History Table

Version No.	Date (dd/mm/yy)	Details
0.1	24/10/2006	Initial document by Motorola
1.2	10/01/2007	Modified by Motorola
3.0	14/06/2007	Modified by Motorola
3.1	15/06/2007	Modified by Motorola
3.2	25/06/2007	Modified by VTT, congruent with VTEC contributions
3.3	06/07/2007	Modified by Motorola, BOSCH and ICCS
4.0	11/07/2007	Format modifications; draft version for peer review
5.0	24/07/2007	Modified by Motorola
6.0	25/07/2007	This version is submitted to EC
7.0	10/07/2008	Modified by Motorola
8.0	23/07/2008	This is the final version

List of Abbreviations and Definitions

List of Abbreviations

A	Auditory
ABS	Anti-lock Brake System
ACC	Adaptive Cruise Control
ADAS	Advanced Driver Assistance Systems
AIA	AIDE Interface Adapter
AIDE	Adaptive Integrated Driver-vehicle InterfacE
ARV	Application Request Vector
ASR	Automatic Speech Recognition
ATIS	Advanced Traveller Information
AVM	Automatic Vehicle Monitoring
BS	Blind Spot monitoring
CAA	Cockpit Activity Assessment
CAN	Controller Area Network bus
CC	Cruise Control
CD-ROM	Compact Disc – Read Only Memory
CIC	Configurable Instrument Cluster
CFT	Channel Flag Table
CS	Channel Selector
CSV	Channel Status Vector
CVO	Commercial Vehicle Operation
CW	Collision Warning
DAE	Driver Availability Estimation
DC	Driver Characteristics
DCM	Driver Characteristics Module
DI	Driver Impairment
DMS	Drowsiness Monitoring System
DM	Distraction Monitoring or Driver Monitoring
DRT	Demand Responsible Transport
DSD	Driver State Degradation
DSRU	Driver Status Recognition Unit
DVE	Driver-Vehicle-Environment
DVEM	Driver Vehicle Environment Monitor module
DWE	Driver Workload Evaluator
EI	Environment Information
ESoP	European Statement of Principles
EUCAR	The European Automotive manufacturer's association for Collaborative Research
FCW	Frontal Collision Warning
FM	Fleet Management
FP6	Sixth Framework Programme
GPS	Global Positioning System
GST	Global Systems of Telematics
GUI	Graphical User Interface
HBK	Haptic Barrel Key
HDD	Head-Down Display
HMI	Human-machine Interaction
HUD	Head-Up Display
IC	Instrument Cluster
ICA	Interaction and Communication Assistant
IM	Information Manager

IP	Integrated Project
ISO	International Standardization Organization
IVIS	In-Vehicle Information Systems
IVT	In-vehicle terminal
LCD	Liquid Crystal Display
LCW	Lane Change Warning
LDW	Lane Departure Warning
LED	Light Emission Diode
LSS	Lateral Support System
LW	Lane departure Warning
M	Multimodal
MP	Mobile Phone
NGO	Non-Governmental Organizations
NS	Navigation System
OEM	Original Equipment Manufacturer
PA	Parking Aid
PCF	Primary modality Channel Flag
PD	Pedestrian Detection System
PDA	Personal Digital Assistant
PDT	Peripheral Detection Task
PI	Panel Instrument
PM	Profile Management
PRM	Priority Management Module
POI	Point Of Interest
PTI	Push To Initiate
PTT	Push To Talk
PT	Public Transport
RDS	Radio Data System
RGI	Road Geometry Information
RNV	Request No more valid Vector
RP	Road pricing
RPM	Revolutions Pro Minute
RS	Road Status
RT	Reaction Time
RTD	Research and Technological Development
RV	Reply Vector
S&G	Stop and Go
SAE	the Society of Automotive Engineers
SCF	Secondary modality Channel Flag
SID	Secondary Info Display
SME	Small or Medium-size Enterprise
SMS	Short Messaging System
SP	Sub-project
SPM	Sub-project management
STREP	Specific Targeted Research Project
STW	Steering Wheel
SUS	System Usability Scale
T	Tactile
TC	Trip Computer
TERA	Traffic and Environmental Risk Assessment
TI	Traffic Information
TDC	Travel Dispatch Centre
TFT	Thin Film Transition
TLR	Total Level of Risk
TM	Text Messages

TMC	Traffic Message Channel
TTC	Time To Collision
TTS	Text To Speech
UML	Unified Modelling Language
V	Visual
VDM	Visual Demand Measurement
VMS	Variable Message Sign
VUD	Vulnerable road Users Detection
WOz	Wizard of Oz
WP	Workpackage

Relevant terms from the AIDE glossary

Term	Definition	Notes	Reference
Action	An event initiated by the driver or an application.	Some examples of actions are: route guidance message from the navigation application, a warning from the ACC or an SMS from the phone. An action could also be a continuous output presented to the driver (e.g. the speedometer or output from the radio). The driver actions of interest here are those directed towards systems.	Original definition.
ADAS (Advanced Driver Assistance Systems	Systems that interact with the driver with the main purpose of supporting the driving task on the tactical and operational levels.	This definition was discussed at the Soesterberg SP2 meeting 041122. Alternative definitions might be considered.	AIDE D2.2.1 [Johansson et al., 2004].
AIDE design scenario	A driving situation, specified by at least one action and one or more DVE state parameters, acted upon by the AIDE system.	AIDE design scenarios represent a problem scenario (conflict situation). A description of possible general solution is included. The scenario + solution represents a use case for AIDE meta-functions.	Original definition.
AIDE meta-function	The response of the AIDE system to an AIDE design scenario.	Examples of potential AIDE meta functions are HMI I/O management, prioritisation, scheduling and warning adaptation.	Original definition.
AIDE system	The Adaptive Integrated Driver-vehicle Interface targeted by the AIDE IP, implementing the AIDE meta-functions.	The AIDE system consists of a basic set of HMI management components, in particular the ICA and the DVE monitor. Thus, the AIDE system does not include a specific set of applications or HMI I/O devices. Rather, the AIDE system should support different number of applications, I/O devices and configurations in a modular way.	
Application	A program (as a word processor or a spreadsheet) that performs one of the important tasks for which a computer is used.	An application is a software component that fulfils a functional specification. Exchanges between application components are persistent or non-persistent information.	EAST-EAA (Webster).
Application Programming Interface (API)	A software interface that enables applications to communicate with each other.	API represents a way to get application independence from the lower SW layer (namely operating	EAST-EAA (http://www-3.ibm.com/ibm/ter

	An API is the set of programming language constructs or statements that can be coded in an application program to obtain the specific functions and services provided by an underlying operating system or service program.	system, drivers and other system service).	minology/).
Architecture	The fundamental organization of a system embodied in its components, their relationships to each other, and to the environment, and the principles guiding its design and evolution.	In EAST WP3, architectures denote system descriptions on different abstraction levels. For example, the same system has a sketchy architecture on a high level (the Functional Analysis A.) and a detailed architecture on a lower level (The Logical A.). The term "view" could be used, but does not catch the fact that the architectures are subject to design work on the respective level of abstraction.	EAST-EAA (IEEE Recommended Practice for Architectural Description of Software-Intensive Systems; IEEE Standard P1471, IEEE Architecture Working Group (AWG)).
CAN Frame	Information on the bus sent in fixed format frames of different but limited length.	A CAN Frame can have a wide range of lengths. A CAN Frame in Standard Format with zero data bytes has 47 bits. A CAN Frame in Extended Format with 8 data bytes can have up to 154 bits because of bit stuffing. Of course, the length is still defined – within a large range. The Data Link Layer adds more to the raw data than just some identification bits. In the case of CAN, it adds the Start-Of-Frame bit, the Arbitration Field, the Control Field, calculates the CRC and adds the CRC Field, the Acknowledge Field and the End-Of-Frame Field (see CAN Specification for details).	EAST-EAA (ISO 11898, section 4.1).
Channel	I/O channels are linked to the output devices or part of them used to exchange information with the user.	In AIDE an output channel can be associated to a single device like a display, a buzzer, a telltale or a portion of them like a display area or a single indicator in the instrument panel.	
Configuration	The arrangement of hardware and/or software elements in a system.		EAST-EAA (Functional safety: safety instrumented systems for the process industry section; Part 1: Framework, definitions, system, hardware and software requirements; IEC2002).
Class	A description of a set of objects that share the same attributes, operations, methods,		EAST-EAA (OMG)

	relationships, and semantics. A class may use a set of interfaces to specify collections of operations it provides to its environment.		
Configuration	The arrangement of hardware and/or software elements in a system.		EAST-EAA (Functional safety: safety instrumented systems for the process industry section; Part 1: Framework, definitions, system, hardware and software requirements; IEC2002).
Data	Data is the software implementation of an information. It can be exchanged between software components. A data is persistent. It is persistent in memory.		EAST-EAA (Webster).
Device	Functional unit of hardware or software, or both, capable of accomplishing a specified purpose.	Devices can implement a part of a function (more than one device could be necessary to fulfil a function – e.g. rear-view mirror inside and outside to provide for rear-viewing) or one device can implement more than one function (side rear-view mirror is a device that can include temperature captor, direction signalisation, etc).	EAST-EAA (Functional safety: safety instrumented systems for the process Industry section; Part 1: Framework, definitions, system, hardware and software requirements; IEC2002).
Driving demand	The demands of the driving task.	Demand is determined by the goal that has to be attained by means of task performance, and is, once the goal has been set, external and independent of the individual driver (c.f. mental workload). Used as a DVE state parameter in AIDE.	de Waard, D. (1996). The Measurement of Drivers' Mental Workload. ISBN 90-6807-308-7. Traffic Research Centre. University of Groningen.
Driver intent	The intention of the driver to perform an action.	Actions of interest here are mainly those related to the primary task, e.g. overtaking.	
Driver distraction	Attention given to a non-driving related activity.	Used as a DVE state parameter in AIDE.	ISO TC22/SC13 WG8 CD 16673 (Occlusion Committee Draft).
Driver drowsiness	The physiological state preceding sleep onset.	Used as a DVE state parameter in AIDE.	Original definition.
Driving task	All aspects involved in mastering a vehicle to obtain a certain goal (e.g. reach a destination). This corresponds	The driving task can be described on different levels of abstraction. Michon (1985), proposed a widely adopted scheme where the driving	Original definition.

	to the primary task in a driving situation.	task is considered on strategic, tactical and operational levels. The strategic level concerns behaviours directed towards more high-level goals, e.g. reaching a destination in time. The tactical level concerns behaviour on a shorter time frame, e.g. selecting headway and deciding when to change lane. Finally, the operational level concerns the moment-to-moment control of the vehicle. (Michon, J.A. (1985). A critical review of driver behaviour models: What do we know? What should we do? In L.A Evans and R.C. Schwing (Eds.) Human Behaviour AND Traffic Safety. (pp. 487-525). New York: Plenum Press).	
DVE (driver-vehicle-environment) state	A set of dynamic parameters representing certain aspects of the driver, the vehicle and the environment.	DVE state and DVE condition is used interchangeably in this deliverable. Personalization as a static characteristic is addressed separately (output of DC module).	Original definition.
Element	A component of a system; may include equipment, a computer program, or a human.		EAST-EAA (IEEE Guide for Developing System Requirements Specifications; IEEE Standard P1233a, 1998).
Embedded System	A small computer system that is generally hidden inside equipment (machine, electrical appliance, or electronic gadget) to increase the value of the equipment for better or more efficient functionality.	This kind of system always involves both the software and hardware co-development. Some embedded systems include an operating system, but many are so specialized that the entire logic can be implemented as a single program. Embedded systems in French are the „on-board" systems, i.e. systems that run on mobile mechanics (airplanes, trains, etc.), so they need not be small and hidden, but there are generally constraints of size and robustness. It is also a common acceptance that this term also designates systems, which are small and hidden and robust.	EAST-EAA.
Feature	(A) User-visible aspects or characteristics of a system. (B) A feature is a functionality that is specifically perceptable by the customer/stakeholder. (C) A feature is a prominent or distinctive user-visible aspect, quality, or characteristic of the system.	Whereas requirement expresses only a wish, feature goes a step further in the sense it is a requirement that I am sure to find in my system. In other words features set results from filtering the requirements set. Feature is a characteristic, quality, property, behaviour, capability, functionality, etc, proper (related to) of a system that enables the users to better qualify (measure) that system. A feature is a perceptible quality or	(A) EAST-EAA (P. Clements; L. Northrop; Software Product Lines – Practices and Patterns; SEI series in software engineering; Addison-Wesley, 2002.)

		characteristic of a system. What is an electronic feature (as used in WP3)? An electronic feature could be defined as a desired functionality or quality, implemented by means of an electrical system. Electronic features bring added value to the user of a system (e.g. vehicle) and justify the electrical system. Climate control and navigation system are examples of electronic features.	(B) EAST-EAA (P. Clements; L. Northrop; Software Product Lines – Practices and Patterns; SEI series in software engineering; Addison-Wesley, 2002).
Format	The detailed way in which the information is given to the user (voice, sound, text, icon, etc.). For each modality (Acoustic, Visual, Haptic, etc.) of presentation of an information it is possible to have different formats. (see: Modality)	Examples of modalities and formats: - Acoustic *(possible formats: Voice / Alarm tone / Sound / etc..)* - Visual *(possible formats: Pictogram / Text / Map / Icon / etc.)* - Haptic *(possible formats: Steering wheel vibration, seat vibration, pedal force, etc.)*	
Function	A task, action, or activity that is accomplished to achieve a desired outcome (EAST-EAA).	Examples of Functions are: turn by turn navigation, voice call, incoming warning from an ADAS.	EAST-EAA (IEEE Guide for Developing System Requirements Specifications; IEEE Standard P1233a, 1998).
Functionality	A synthesis of functions to provide a major functional entity of a unit.		EAST-EAA.
Human Machine Interface (HMI)	All the input and output devices which permit the interaction between the user and one or more vehicle systems.	The EAST definition considers only interaction with IVIS. The current definition comprise any device that mediates interaction with a vehicle system.	EAST-EAA (slightly modified).
HMI strategy	The HMI strategy determines the behaviour of the system towards the user. It contains rules defining which adaptation function is used in which condition.	The HMI strategy is implemented in the ICA module.	
Interaction and Communication Assistant (ICA)	The central component in the AIDE system responsible for managing the interaction between the driver and various applications.	The ICA has the main responsibility for implementing the AIDE metafunctions.	
IVIS (In-vehicle Information Systems)	Systems that interact with the driver and induce tasks that are not directly related to the driving task on the tactical and operational levels. Such additional tasks are called secondary tasks and may interfere with the primary task.	This definition was discussed at the Soesterberg SP2 meeting 041122. Alternative definitions might be considered.	AIDE D2.2.1 [Johansson et al., 2004].
Mental workload	The specification of the amount of information processing capacity that is used for task performance.	The effect that driving demand has on the operator in terms of stages that are used in information processing and their energetic (c.f. driving demand).	de Waard, D. (1996). The Measurement of Drivers' Mental Workload. ISBN

			90-6807-308-7. Traffic Research Centre. University of Groningen.
Modality	The way in which an information is given to the driver (Acoustic, Visual, Haptic, etc.). The detailed form in which the information is given is described as Format. (see: Format).	Examples of modalities and formats: - Acoustic *(possible formats: Voice / Alarm tone / Sound / etc..)* - Visual *(possible formats: Pictogram / Text / Map / Icon / etc.)* - Haptic *(possible formats: Steering wheel vibration, seat vibration, pedal force, etc.)*	
Primary task	All interaction tasks which are driving related.		AIDE Glossary.
Real time	System that has to finish the processing within a specific time interval (deadline) dedicated by its environment.		EAST-EAA.
Secondary Task	All interaction tasks which are not driving related, but refer to infotainment		AIDE Glossary.
Service	A type of operation that has a published specification of interface and behaviour, involving a contract between the provider of the capability and the potential clients.	First a service could be seen as a functional feature. For example the middleware transmits the request of a client to the corresponding server. Another possibility could be that services are solutions (but don't mean implementation!) to fulfil features. [1..n] to [1..n] relation that is one service can be a solution for one or more features but also n services may be needed to fulfil a feature. Services could be solutions (not implementations!) to fulfil features. Services can be used to realize a feature; a service can be a feature. A service is the mean to satisfy a need.	EAST-EAA.
Software Architecture	A software architecture is the structure or structures of a system, which comprise software components, the external visible properties of these components and the relationships among them.		EAST-EAA (L. Bass and P. Clements and R. Kazman; Software Architecture in Practice; Addison-Wesley, 1998).
Software component	A unit of composition with contractually specified interfaces and explicit context dependencies only. A software component can be deployed independently and is subject to composition by third parties.		EAST-EAA (Szyperski, Clements.; Component Software – Beyond Object- Oriented Programming; Addison-Wesley, 1997; P. Clements; L. Northrop; Software Product Lines – Practices and Patterns; SEI series in software

			engineering; Addison-Wesley, 2002).
Specification	Precise (formal if possible) description of an object within the scope of the task.		EAST-EAA (Safety terms for automation systems reliability and safety of complex systems; VDI/VDE 2000).
System	A collection of components organized to accomplish a specific function or set of functions.	Set of elements, which interact according to a design; an element of a system can be another system, called a subsystem, which may be controlling system or a controlled system and may include hardware, software and human interaction.	EAST-EAA (IEEE Recommended Practice for Architectural Description of Software-Intensive Systems; IEEE Standard P1471, IEEE Architecture Working Group (AWG), 2000).
Use case	An intended or desired flow of events or tasks that occur within the vehicle and are directed to or coming from the driver in order to accomplish a certain system-driver interaction.	Standard use case templates are mainly intended for individual IVIS/ADAS functions and include solutions. The “use cases” for AIDE meta-functions are called AIDE design scenarios.	Original definition (based on existing definitions).

Table of Contents

LIST OF ABBREVIATIONS AND DEFINITIONS III

LIST OF ABBREVIATIONS III
RELEVANT TERMS FROM THE AIDE GLOSSARY V

TABLE OF CONTENTS XII

LIST OF FIGURES XIII

LIST OF TABLES XIII

EXECUTIVE SUMMARY 1

1 INTRODUCTION 2

1.1 OVERVIEW OF THIS REPORT 2

2 PREREQUISITES FOR AN AIDE SOLUTION FOR NOMADIC DEVICE INTEGRATION 3

2.1 EUROPEAN STATEMENT OF PRINCIPLES (ESOP) 3
2.2 NOMADIC DEVICE FORUM 3
2.3 THE AIDE SYSTEM 5

3 NOMADIC DEVICES 8

3.1 MOBILE PHONES 8
3.2 PORTABLE MUSIC DEVICES 9
3.3 PERSONAL NAVIGATION DEVICES (PND) 9

4 INTEGRATION CONSIDERATIONS 11

5 THE AIDE SOLUTION FOR NOMADIC DEVICE INTEGRATION 12

5.1 REQUIREMENT SPECIFICATIONS 12
5.2 INTEGRATION AND IMPLEMENTATION STRATEGIES 14
5.3 NOMADIC DEVICE GATEWAY DESIGN 16
5.3.1 Communication: Between the Nomadic Device Gateway and the Nomadic Device 17
5.3.2 Communication: Between the Nomadic Device Gateway and the Vehicle System 18
5.3.3 Communication: Sequence Diagrams 18

6 AN IMPLEMENTED DEMONSTRATION OF NOMADIC DEVICE INTEGRATION 29

6.1 OUTGOING PHONE CALL REQUEST 29
6.2 INCOMING PHONE CALL REQUEST 30

7 POTENTIAL BENEFITS 32

7.1 SAFETY 32
7.2 USABILITY 32

8 COMPLIANCE WITH ESOP 33

9 INNOVATION 39

10 CONTRIBUTION OF THIS DELIVERABLE TO OVERALL AIDE OBJECTIVES 41

11 CONCLUSION 42

12 REFERENCES 43

List of Figures

FIGURE 1: AIDE FUNCTIONAL REFERENCE ARCHITECTURE. 6
FIGURE 2: AIDE NOMADIC DEVICE CONNECTION ARCHITECTURE. 17
FIGURE 3: AN AIDE COMMUNICATION SEQUENCE DIAGRAM FOR MAKING AN OUTGOING PHONE CALL THAT IS TERMINATED BY THE USER. 19
FIGURE 4: AN AIDE COMMUNICATION SEQUENCE DIAGRAM FOR MAKING AN OUTGOING PHONE CALL THAT IS TERMINATED BY THE RECEIVING END. 20
FIGURE 5: AN AIDE COMMUNICATION SEQUENCE DIAGRAM FOR RECEIVING AN INCOMING PHONE CALL ON A FREE-STANDING NOMADIC DEVICE. 21
FIGURE 6: AN AIDE COMMUNICATION SEQUENCE DIAGRAM FOR RECEIVING AN INCOMING PHONE CALL AT SAFE TIME. 22
FIGURE 7: AN AIDE COMMUNICATION SEQUENCE DIAGRAM FOR RECEIVING AN INCOMING PHONE CALL AT UNSAFE TIME (CALLS RE-ROUTED TO VOICEMAIL). 23
FIGURE 8: AN AIDE COMMUNICATION SEQUENCE DIAGRAM FOR RECEIVING AN INCOMING PHONE CALL WHILE CHANGING FROM UNSAFE TO SAFE STATE (STATE-BASED COMMUNICATION). 24
FIGURE 9: AN AIDE COMMUNICATION SEQUENCE DIAGRAM FOR RECEIVING AN INCOMING PHONE CALL WHILE CHANGING FROM UNSAFE TO SAFE STATE (TRANSACTION-BASED COMMUNICATION). 25
FIGURE 10: AN AIDE COMMUNICATION SEQUENCE DIAGRAM FOR GETTING SONG LIST FROM MUSIC DEVICE. 26
FIGURE 11: AN AIDE COMMUNICATION SEQUENCE DIAGRAM FOR UPDATING SENSOR DATA. 28
FIGURE 12: A SCREENSHOT OF PC DEVELOPMENT DESKTOP 31

List of Tables

TABLE 1: LEVELS OF NOMADIC DEVICE INTEGRATION 15
TABLE 2: NOMADIC DEVICE GATEWAY COMMUNICATION PROTOCOL MESSAGE DESCRIPTORS. 18
TABLE 3: DESCRIPTOR VARIABLES USED IN AIDE NDG PROPRIETARY PROTOCOL MESSAGE. 29
TABLE 4: AIDE COMPLIANCE WITH ESOP ON HMI PRINCIPLES. 33
TABLE 5: AIDE COMPLIANCE WITH ESOP ON HMI RSU. 37

Executive Summary

The aim of this Deliverable "Integration of Nomadic Devices: The AIDE Use Case" is to describe the specific AIDE solution for integrating nomadic devices in the vehicle environment, and explain how this solution complies with Commission Recommendation of 22 December 2006 on safe and efficient in-vehicle information and communications systems [3]. This document is based on the nomadic device integration project that is performed within the AIDE project.

The major objective of the nomadic device integration project is the integration of nomadic devices into the vehicle environment safely. The main requirements for the AIDE HMI include an improvement of driver-system interactions in terms of driver distraction and usability, an enhancement of driving safety, and an increase of users' comfort level. In order to reach this objective, the AIDE system, in contrast to other approaches, takes the following factors into account.

- It takes into account the effects of HMI interdependencies in order to prevent interference among different I/O events presented at the same time to the driver;
- It takes into account the driving situation, driver state and driver preferences in order to adapt the HMI depending on these conditions. In order to reduce a driver's distraction level and draw a driver's attention to the driving task, the driver-system interaction may be changed in critical conditions or modified according to driver preferences;
- It includes nomad devices in a common in-vehicle HMI in a way that they do not differ in terms of the HMI strategy from the integrated applications.

Nomadic devices cover a wide range of services, provided by systems that may be introduced into the vehicle environment by an occupant. These services may create driver distraction and divert a driver's attention from the primary task of driving. Because this distraction has obvious safety implications, it is important, within the AIDE project, to manage the introduction of nomad devices into the AIDE enabled environment and pass all nomadic device HMI communication through the managed AIDE HMI system without sacrificing functionality in either system. The managed integration of nomadic devices into the vehicle environment has to offer specific functionality and satisfy specific use cases outlined within this document. The managed HMI communication between the user and the nomadic device is controlled by the intelligent Interaction and Communication Assistant (ICA) that is present within the general AIDE system. The ICA ensures that specific nomadic device functions are available only when it is appropriate for the driver to gain access. The core functions available to the driver under the managed AIDE nomadic device integration are listed below:

- **Telephony:**
  - Incoming calls and outgoing calls
- **Music:**
  - Music Streaming from nomadic devices into vehicle systems
- **SMS Message:**
  - Sending SMS messages between nomadic devices and vehicle systems
- **Calendar Reminder:**
  - Outlook calendar synchronisation and reminders
- **Sensor Data**
  - Sending vehicle sensor data to nomadic devices

1 Introduction

The use of mobile devices such as mobile phones, personal navigation devices, and personal music devices has increased dramatically in the past five years. The significant rise in the use of mobile devices outside the home has inevitably led to an increase in the number of nomadic devices being introduced, unmanaged, into the vehicle environment.

The widespread use of mobile phones has led to a culture of expecting people to be "always available". This ability to contact anyone anytime regardless of their whereabouts consequently also extends into the vehicle environment, where people are expected to be contactable whilst driving. The similar mass widespread use of personal music devices has led to people expecting to be able to take their own choice of music, on one device, with them everywhere they go, as such this expectation also extends into the vehicle environment.

These unmanaged aftermarket nomadic devices offer the users valuable, productive and timesaving services from which the benefits are obvious and well received by drivers. However, the issue of driver distraction when using these devices requires research, development and subsequent the establishment of recommendations for the integration of these devices into the vehicle environment.

1.1 Overview of This Report

This report will document the findings that are gleaned from the process of integrating nomadic devices into the vehicle environment. First, because this report is based on previous research projects including preceding AIDE deliverables, previous research activities that are pertinent to the integration of nomadic devices within the vehicle environment are reviewed in Chapter 2. They include the European Statement of Principles (ESoP), Nomadic Device Forum, and general AIDE architecture. Second, a definition of nomadic devices is provided, and major categories of nomadic devices are described in Chapter 3. Major suppliers, communication capabilities, services and applications are spelled out for commonly used mobile device categories (e.g., mobile phones). Third, general issues that should be taken into account for the integration of nomadic devices in the vehicle environment are discussed in Chapter 4. Fourth, the AIDE solution for the integration of nomadic devices into the vehicle environment is explained in Chapter 5, including the requirement specification for the nomadic device gateway, the description of different levels of integration, location of I/O devices, data, and applications, and the design of the nomadic device gateway and its communication protocols. Typical use cases for the nomadic device gateway are also explained. They include making outgoing calls, answering incoming calls, accessing song lists, playing songs, and accessing vehicle sensor data.

Next, in Chapter 6 an implemented demonstration of nomadic device integration within the AIDE system is discussed. In Chapter 7, potential benefits for the integration of nomadic devices in the vehicle environment are described. In Chapter 8, the compliance with ESoP is discussed for the integration of nomadic devices in the vehicle environment. In Chapters 9 and 10, innovations from this project and major contributions of this project to the overall AIDE objectives are discussed. Finally, integration recommendations based on this research project are compiled in Chapter 11. These recommendations are useful for the safe integration of nomadic devices within the vehicle environment.

2 Prerequisites for an AIDE Solution for Nomadic Device Integration

In order to accomplish the work that is reported in this document, we have made heavy use of previous AIDE results. These include the AIDE use cases of WP3.1, the AIDE architecture from WP3.2, the ICA design and its logic flow from WP3.4. In addition, we have leveraged the European Statement of Principles and the Nomadic Device Forum. In this chapter, we will describe these previous results and activities that are pertinent to this report.

2.1 European Statement of Principles (ESoP)

The ESoP for HMI clearly covers any type of information and communication systems that are used in the vehicle environment, including nomadic devices and after-market systems [1, 3]. A nomadic device provides many services, some of which are more distracting to the driver than others (e.g., watching DVD movies is more distracting than playing a song). Because of the diversity of functions provided by nomadic devices, it is neither practical nor preferable to categorically declare the use of nomadic devices inside the vehicle environment unsafe. The level of criticality is directly related to the type of function that the driver decides to access and to the demand of the driving task (e.g., speed, road type, traffic situation). Therefore, a general ban on the use of nomadic devices inside a vehicle environment seems unjustified. On the other hand, suitable measures should be defined in order to address the use of nomadic devices by the driver while driving. Research is needed to determine the potential of driver distraction for various nomadic device functions in the driving context.

The development of nomadic devices involves many types of stakeholders who are not organised into easily identified networks and may not necessarily be aware about road safety issues. The advertisements of these products often indicate that safety aspects are not sufficiently taken into account. Furthermore, there are no regulations applicable to nomadic devices in terms of installations and services (compared with more than 200 European Directives applicable to vehicles and vehicle equipments). In some European countries, there are regulations on the use of nomadic devices, for example, on the use of hand-held phones while driving. Nomadic devices can also present a physical risk in case of crashes because they are often not securely installed in the vehicle.

2.2 Nomadic Device Forum

The aim of the Nomadic Devices Forum [4] is to constitute a cross-sector working group to deal with all aspects of safe, effective and user-friendly nomadic device integration and its use in the vehicle. Specific objectives of the Forum are as follows:

- Act as a European consensus platform to reach cross-sector agreements on issues relating to nomadic device safety, technical harmonisation, in-vehicle integration and deployment;
- Define the principles for managing nomadic device-vehicle information exchange via a “Smart Vehicle-Device Interface”;
- Address key issues for nomadic devices, including specifications for in-vehicle docking/integration and installation, standardisation of interfaces and recommendations for nomadic device HMI and safety;

- Identify requirements for new work items in the appropriate standardisation bodies;
- Act as a bridge between the eSafety research projects on nomadic device issues and also between Europe and the rest of the world;
- Provide advices to the EC and support AIDE and other projects' work on nomadic devices issues.

Within AIDE IP a number of issues related to the use of Nomadic Devices by drivers are explored. The following list is the most important issues that have been identified:

- Safety;
- Integration (concept of a gateway);
- Requirements both from OEMs but also from device manufacturers.

To address these issues, in addition to the work undertaken within the framework of AIDE, the AIDE Nomadic Devices Forum has organised several working groups. The first Working Group (WGA) deals with the definition of a smart Device-Car Gateway, while the other (WGC) explores the Commercial issues and business cases for vehicle-device integration (a Working Group B, on HMI and safety issues, was formed when the Forum was set up, but after one meeting its members agreed that there was not sufficient interest to maintain a separate WG). The working groups that are presently constituted are illustrated below.

Working Group A: Smart Device-Car Gateway:

The objectives of this working group are as follow:

- Compile and agree scenarios and use cases for nomadic device-vehicle cooperation (installation, interaction, and integration);
- Identify functional and system requirements;
- Define system architecture for a nomadic device-vehicle solution;
- Outline specifications for a “smart” vehicle-device gateway (including intermediate gateway for information management), including physical, data, functional and application interfaces.

Working Group C: Commercial Issues for Vehicle-Device Integration:

This working group is charged to address the following issues:

- Car industry view of ND issues;
- Positive business case options;
- Pre-conditions for cross-sector collaboration;
- Obstacles to a standardised gateway;
- Possible steps forward.

These working groups met once approximately every six months. In addition, the groups work off line using web tools and other means of communication. Within AIDE, a report (deliverable) is prepared describing the activities of the AIDE Nomadic Forum every year.

Additional Working Groups may be set up with the approval of the Organising Committee to address other issues as the need arises.

2.3 The AIDE System

In AIDE Deliverable 3.2.2, "System architecture, data flow protocol definition and design and AIDE specifications" [5], a functional reference architecture is developed. This AIDE reference architecture is presented in Figure 1. Since HMI strategies, I/O devices, and applications differ between different vehicle manufacturers and between different car segments, modularity and flexibility are most important requirements. This strongly affects the principle design decisions, the specification of the interfaces and the communication flow. Therefore, it is important to note that the AIDE architecture describes a functional structure and semantic communication independent from a concrete implementation, because the implementation varies widely between the OEM's.

This architecture focuses on the functional structure of the software components and their communication. The individual components are specified in terms of their tasks, responsibilities and dependencies that are necessary to provide adaptive functionalities for an integrated, in-vehicle HMI system. In order to realize the I/O management of interfering output events and adapt the driver system interaction to the driver status and preferences and as well to the driving situation, the following main components were identified:

- *Applications:* These are components offering a specific functionality to the user such as navigation, phone, lane departure warning, music player, radio, etc. The application should be as independent as possible and should, in principle, work independently of the HMI management functions. The application is designed with a model-view-control pattern and includes an AIDE interface adapter offering the AIDE specific functions such as communicating to the ICA and the DVE and performing a priority mechanism.
- *I/O Device Control:* This includes the specific I/O devices such as LCD displays, head-up displays (HUD), haptic input/outputs, loudspeakers or buzzers. It also includes pre- or post processing units such as speech recognition system and TTS-engine [8].
- *Interaction and Communication Assistant (ICA):* An intelligent assistant that performs the management and adaptation functionality. It contains the rules governing the system behaviour or HMI strategy that is perceived by the user. [4]
- *Driver Vehicle Environment (DVE) Module:* A module that monitors the driver and the driving situation and derives condition information about the driver, the vehicle and the environment that is used by ICA to adapt the driver-system-interaction. It is also used by the applications to adapt application-specific functionalities such as changing priorities and adapting warning strategies. [2]
- *Nomad Device Gateway:* The integration of nomad devices uses a Nomad Device Gateway to connect to the in-vehicle system. Thus the functionality of the nomad device in terms of data, applications and I/O devices can be used by the in-vehicle system and vice-versa. The in-vehicle system contains a virtual application software connected to the nomad device functionality via a gateway that provides the user interface software (views) that accesses the I/O devices.

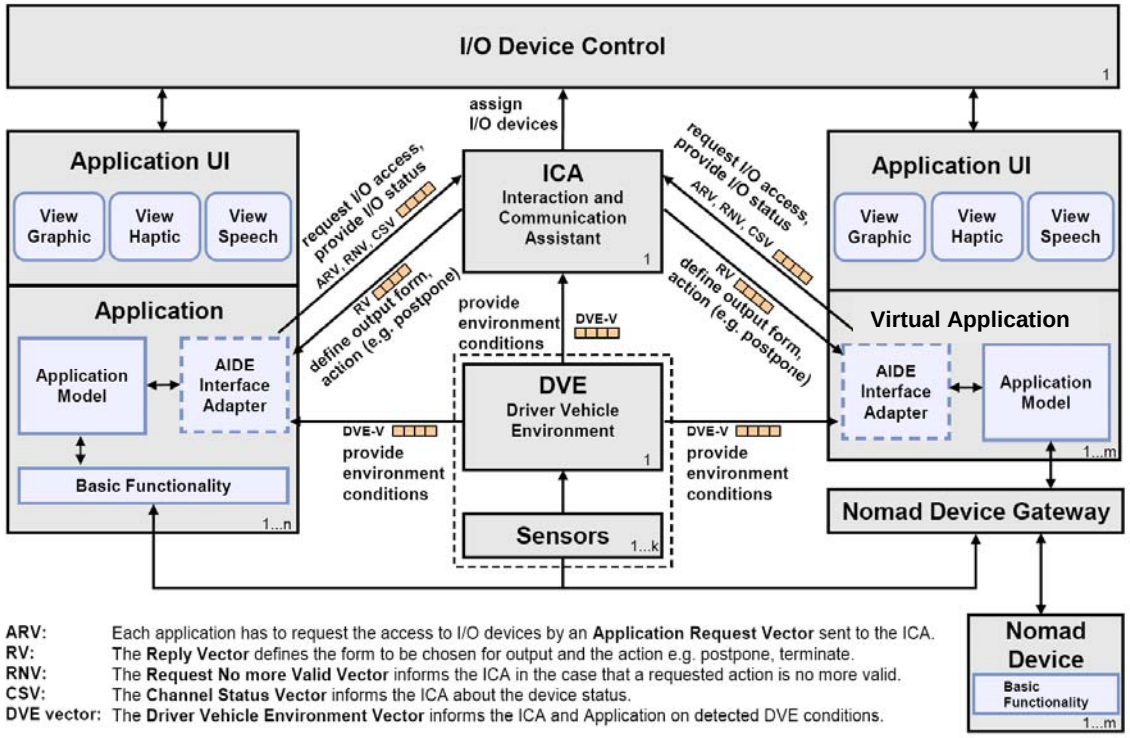

Figure 1: AIDE Functional Reference Architecture.

In order to fulfil the aforementioned requirements, the ICA and the applications components are independent of each other by design to ensure that ICA must not know the semantics of an application. Thus, an output message is not rendered or performed by ICA, but by the application itself. It only has to ask ICA in advance for permission and informs ICA about the output form and desired devices. This information is used by ICA together with the DVE data to determine the suited output strategy. After receiving the decision, the applications perform the output task. Due to timing reasons the ICA controls the final I/O device access determining which device is perceivable for the driver.

This mechanism also holds for the virtual applications connected to the nomad devices. A virtual application (for example, an MP3-player) equals ordinary installed in-vehicle applications. It is a software module installed in the vehicle accessing the in-vehicle I/O devices and differs from a normal application only because the basic functionality is located in the nomadic device. In the case of the MP3 player, the MP3 data and the MPEG decoder software player run on the nomadic device. The virtual application offers the HMI software to control the player and use the in-vehicle HMI. In addition, for the AIDE specific functionality the virtual applications do not differ from the normal applications because they communicate with ICA in a similar manner.

All interfaces are specified using generalized content to guarantee the modularity. For example, the ICA has to assign priorities to each output request from the applications. This is done using informing parameters sent by the application to the ICA. These parameters objectively characterize the output message which has to be done in terms of their importance for the driver like “driving relevance”, “safety criticality”, etc. All parameters are defined unambiguously and do not include application specific aspects. Thus, the communication flow

between the ICA and application components remains simple and uses the following four messages (see also Figure 1):

- The Application Request Vector (ARV) to ask for permission to perform an output;
- The Reply Vector (RV) to inform the application about if and how to perform the output;
- The Channel Status Vector (CSV) to inform ICA when devices are freed again;
- The Request No More Valid Vector (RNV) to inform ICA when a postponed output is no longer valid.

In addition, there is one DVE Vector and one PM Vector to provide condition information and driver preferences that are used by ICA for all general valid adaptive functions and by applications for the application specific functions.

The nomad device interface is clearly most complex but all necessary interface data are already described. The used mechanism is based on existing and standardized Bluetooth (BT) technology. But a new Bluetooth profile needs to be defined for AIDE. In this case AIDE recommends a specific implementation, because there is no established implementation available.

3 Nomadic Devices

As defined in the "Recommendations from the eSafety-HMI Working Group" document [9], "a nomadic device is a device for information, including entertainment, and/or communication that can be used outside of the vehicle and inside the vehicle by the driver while driving. It is not supplied or installed by the vehicle manufacturer". A nomadic device contains its own HMI and output/input capabilities. Using the aforementioned definition, nomadic devices include the following major categories:

- Mobile phones;
- Portable music players;
- Personal navigation devices (PND);
- Personal digital assistant (PDA);
- Portable multimedia devices (PMD);
- Portable gaming devices;
- Laptop computers.

Mobile phones are the most ubiquitous nomadic devices and therefore the devices of main interest to the AIDE project. Another focus is portable music players. Personal navigation devices (PND) and personal digital assistants (PDA) are also of interest to the AIDE project. Smart phones, some PND and other upcoming nomadic devices integrate more than one of the above mentioned categories and therefore can be treated as several ND. In the following sections, more details are provided for mobile phones, portable music players, and personal navigation devices.

3.1 Mobile Phones

New generation mobile phones are characterized by an ever increasing computing power. The computing power, coupled with their large bandwidth wireless communication capabilities, is making mobile phones very powerful tools for mobile communication, entertainment, business and multimedia interactions. On the other hand, mobile phones are limited in terms of screen size, input modalities, memory footprint, battery life, and expansion capabilities.

The communication capabilities of mobile phones include but are not restricted to the following protocols. Not all mobile phones will support all of the following protocols:

- GSM/CDMA
- GPRS (2.5G)
- UMTS (3G)
- Bluetooth
- Wi-Fi

"Standard" services provided by a mobile phone include making/receiving calls, sending/receiving SMS messages, address book (contact list), and clock (calendar, alarm clock). Most phones provide considerably more services as more features and applications are bundled into the device. Other common features that are typically bundled into mobile phones

include appointment calendar, calculator, games, camera, multimedia messaging, and WAP internet browsing.

The top suppliers for mobile phones (2004) are Nokia, Motorola, Samsung, Sony Ericsson, LG, Panasonic, Ningbo Bird, Mitsubishi, and NEC.

3.2 Portable Music Devices

Portable music devices have in the last few years changed from a niche product used by a small percentage of the population to becoming a must-have product in certain market segments. This has been typified (and some may argue caused) by the Apple iPod product, which has combined the ease of use with an effective product styling.

In general, a portable music device has a very simple, single communication port, usually via USB or Firewire to connect to a PC or Mac for download of music files to the device. It is typically a single-feature device, namely the selection and playing of songs. This is changing as competition increases, and the feature count is starting to affect this product group as well. Features that are sometimes bundled in portable music devices include calendar/PDA functions, games, photo backup and display, and data backup. The latest models have colour screens with video playback functions. This allows the user to playback music videos and movies which have been downloaded onto the device.

Suppliers of portable music devices include but are not restricted to the following: Apple, Sony, Creative, Philips, Toshiba, and Microsoft.

3.3 Personal Navigation Devices (PND)

PND devices come in a variety of styles. These can be categorised as follows:

- Non-Self Contained: These types of GPS receivers require a connection to another device such as a PDA or computer to enable the information to be presented. These are often used as part of telematics systems in which they are integrated into the telematics system and use the screen of the telematics system to present the map/direction information.
- Self Contained: These are self contained devices with an integrated screen. Within this type there are those that have mapping facilities (such as those targeted at the automotive market) and non-mapping devices (such as those targeted at recreational hill climbing).
- Professional: These are more accurate receivers for “professional” use (e.g., for surveyors). These devices are typically used in the same manner as the self-contained devices, but they have more accurate antennas to improve the reception quality.
- Dedicated: Dedicated GPS devices are used for a particular market, for example, the automotive industry. Particular devices include TomTom GO and AmeriGO GPS Nav. These systems can be shared between cars and come with maps and navigation instructions that are typically of a turn-by-turn nature.

In the context of nomadic device integration within the AIDE project, “non-self contained” (when connected with a PDA), “self contained”, and “dedicated” devices that provide personal navigation services such as routing information are of primary interest.

The communication capabilities of PNDs are typically limited to some form of wired communication (e.g., serial, USB). As expected, services provided by the PND are related to navigation features including (1) entering trip address/location, (2) reviewing map data, and (3) providing turn-by-turn route guidance. Other features are being added to higher-end models. For example, when integrated with a mobile phone, real time travel information (including traffic alerts, points of interest, and additional maps) can be provided and hands-free operation (using built-in speaker/microphone and display) can be enabled.

Suppliers of GPS/PND devices include but are not restricted to Skynav, Royal, TomTom, Garmin, Navman, and Magellan.

4 Integration Considerations

A successful integration of nomadic devices in the vehicle environment must consider the following aspects:

- Physical (e.g., mounting position, brackets, safety during a crash).
- Electrical (e.g., power supply, antennas, connectors or wireless communication).
- HMI logic (e.g., interface, ICA, nomadic device gateway).
- HMI I/O vehicle-side devices (e.g., displays, buttons, and voice recognition systems).

In this context different levels of integration will be possible. They are discussed in detail in Chapter 5.

Comparing HMIs between nomadic devices and existing in-vehicle information systems, there are some fundamental differences that need to be considered when integrating nomadic devices in the vehicle environment. These include but are not restricted to the following:

- Display resolution (number of pixels): The number of pixels is in general greater in nomadic devices than in the in-vehicle information systems.
- Number of (usable) control devices: The number of usable control devices is in general greater in nomadic devices than in the in-vehicle information systems.
- Viewing distance: The viewing distance for nomadic devices is generally shorter in nomadic devices than in the in-vehicle information systems.
- Product lifecycle: The product lifecycle is significantly shorter for nomadic devices than for in-vehicle information systems.
- Innovation level: More new and innovative technologies are implemented in nomadic devices than in the in-vehicle information systems. The implementation is also earlier in nomadic devices than in the in-vehicle information systems.
- Working temperature range and vibration: The working temperature range is considerably smaller for nomadic devices than for in-vehicle information systems. The tolerable vibration is less for nomadic devices than for in-vehicle information systems.

5 The AIDE Solution for Nomadic Device Integration

After a series of discussions at AIDE workshops and meetings, the AIDE team has identified the requirements for the integrated system, developed integration strategies with different levels of integration, proposed design requirements for the nomadic device gateway, spelled out the protocol for communicating between the nomadic device gateway and the vehicle or nomadic device, and implemented common use cases in the AIDE system. The requirements of the integrated system are driven by the demonstration needs. In order to demonstrate the integration of nomadic devices in the vehicle environment, common nomadic device services and functions must be implemented. The commonly used services include telephony, music, SMS messaging, and calendar applications. Other services such as playing DVD movies are used infrequently and very distracting to the driver, and therefore are not implemented in the demonstrations. For each of these applications, major functions are implemented. For example, for the telephony application, common functions such as receiving an incoming call and making an outgoing call are implemented. In the following sections, the AIDE solution for the integration effort is described.

5.1 Requirement Specifications

In this section, the requirements for the integration of nomadic devices in the vehicle environment are described. A brief reason is also provided for each requirement. These requirements are developed to enable a seamless connection of a nomadic device with a vehicle system and support four major nomadic device applications in the demonstrations (e.g., telephony, music, SMS messaging, and calendar applications).

Requirement 1.1	**The system will allow the connection of a nomadic device by Bluetooth wireless connection.**
Reason:	By allowing a nomadic device to pair with the system through the Bluetooth technology, all functions of the gateway can be utilised.
Requirement 1.2	**The system will offer a confirmation to the vehicle HMI of successful connection with a nomadic device.**
Reason:	Confirmation to the vehicle HMI of the successful connection of a Nomadic Device to the gateway will offer users a clear indication of the status of their nomadic device within the AIDE vehicle.
Requirement 1.3	**The system will offer a notification to the vehicle HMI of the disconnection of a nomadic device from the gateway.**
Reason:	Notification of the disconnection of a nomadic device will be offered to the vehicle HMI to keep the driver aware of the current status of any nomadic devices within the AIDE vehicle.
Requirement 1.4	**The system will take calls from a mobile phone nomadic device through the vehicle HMI.**
Reason:	To integrate the nomadic device into the vehicle the system must take any incoming calls, give notification to the vehicle HMI if it is safe to do so and then route the audio

	of the call through the in car audio system.
Requirement 1.5	**The system will take SMS messages from the nomadic device and pass them to the vehicle HMI.**
Reason:	To integrate the nomadic device into the vehicle, the system must allow the user to read any SMS messages in the nomadic device's memory using the safety mechanisms present in the vehicle HMI.
Requirement 1.6	**The system will allow calls to be made via a Mobile Phone nomadic device using the vehicle HMI.**
Reason:	To integrate the nomadic device into the vehicle, the system must allow the user to make outgoing calls from the nomadic device using the safety mechanisms present in the vehicle HMI.
Requirement 1.7	**The system will allow the synchronisation of address book contacts from the nomadic device to the vehicle HMI.**
Reason:	The synchronisation of the address book contacts from the nomadic device to the vehicle HMI will allow the user to call specific contacts within their address book in a controlled manner using the safety mechanisms present in the vehicle HMI.
Requirement 1.8	**The system may allow the streaming of music to the vehicle audio system.**
Reason:	The streaming of music to the vehicle audio system will demonstrate the support for PMDs within the nomadic device gateway.
Requirement 1.9	**The system may allow the synchronisation of music playlists to the vehicle HMI.**
Reason:	The synchronisation of the music playlist from a PMD to the vehicle HMI will allow the user to view the current audio tracks in safe and controlled manner using the safety mechanisms present in the vehicle HMI.
Requirement 1.10	**The system may allow the control of audio streaming functions using the vehicle HMI.**
Reason:	The control of audio streaming functions through the vehicle HMI allows the user to perform various control functions on the PMD to manage their listening experience in a controlled manner, using the safety mechanisms present in the vehicle HMI.
Requirement 1.11	**The system may allow the sending of SMS text messages using the vehicle HMI.**
Reason:	The creation and sending of SMS text messages using the vehicle HMI allows the user to operate this function in a

	controlled manner using the safety mechanisms present in the vehicle HMI. Because of potential visual distraction, drivers should exercise cautions when sending SMS text messages.
Requirement 1.12	**The system will be capable of controlling the nomadic device state.**
Reason:	The control of the phone state allows the system to vary the functions available to the user and vehicle HMI based on driving conditions at any given time.
Requirement 1.13	**The system will read the driver context information from the AIDE ICA to determine the state of functionality the nomadic device should be currently displaying.**
Reason:	The ability to read the context information from the AIDE ICA system allows the nomadic device gateway to accurately control the behaviour of the nomadic device within the AIDE system.
Hardware Requirement 2.1	**The phones to be used for full functionality with the nomadic device gateway will be Motorola MPx220 Mobile Handsets.**
Reason:	The Motorola MPx220 offers the greatest range of functions and software capabilities currently available for use with the AIDE system. Testing of compatibility with other mobile phones is beyond the scope of this project.
Hardware Requirement 2.2	**The phones for use with the nomadic device gateway will be pre-installed with all the required software for operation.**
Reason:	The phones supplied by Motorola for use with the nomadic device gateway will be pre-installed with all the required software for interfacing with the AIDE system through the nomadic device gateway.

5.2 Integration and Implementation Strategies

As a result of the analysis carried out during the AIDE Architecture workshops, a number of features was identified to have an impact on potential use cases. The high level categories of those identified were:

1. **Full Integration versus Installation**. This is the difference between the factory fit and aftermarket. In the “full integration” scenario, the ND is fully integrated into the vehicle system, and the I/O devices of the ND and in-vehicle system are fully shared. The integration of nomadic devices within the vehicle environment encompasses all aspects including physical, electrical, HMI logic, and HMI I/O vehicle-side devices. In the “installation” scenario, however, the integration of the ND with the vehicle system is limited, and separate I/O devices on the ND and the in-vehicle system are used. The

integration is restricted to physical, electrical, and some basic HMI logic aspects (ICA only) in the "installation" scenario.

2. **Location of I/O** – Because the input and output devices may reside in either the ND side or the vehicle system, there are four permutations of input and output locations. These permutations are as follows: (1) both input and output devices in the vehicle system, (2) both input and output devices on the ND, (3) the input device in the vehicle system and the output device on the ND, and (4) the output device in the vehicle system and the input device on the ND.
3. **Data** – The location of the "data" that is being used for the ND application can either be in the car (e.g., transferring of music files to the car) or remain in the device.
4. **Application** –The location of the "application" can also reside either in the car, or in the ND (e.g., the for a music device, the device could either process and play the audio itself, or just be a dumb device, and give the car application access to the data).

Different levels of integration can be seen between those nomadic devices and the vehicles. As shown in Table 1, at least five levels can be identified: basic installation, full integration, partial integration of I/O, partial integration of O/I, and streaming integration.

Table 1: Levels of nomadic device integration.

Integration level	Example of Nomadic Device	
Full integration	mobile phone, smartphone	integrity level increases →
Streaming integration	smartphone, mp3 player	
Partial integration O/I	mobile phone, smartphone, mp3 player	
Partial integration I/O	mobile phone, smartphone	
Basic installation	portable navigation device	

At the lowest level of integration, there is the "**basic installation"**. In this case, application and data runs on the nomadic device. A nomadic device should be securely fitted in the vehicle by an installation kit that has been designed by the nomadic device system manufacturer in accordance with the latest ESoP recommendations [3]. It may have a physical interface for power - the integration at this level thus means in most cases only use of a power outlet connection. A typical device at that level is a portable navigation device.

In the "**Full integration"** level, all control of the nomadic device is via the vehicle I/O. For mobile phones, the vehicle interface (e.g., steering wheel buttons) accepts phone calls, and the integrated hands-free devices (car audio and microphone) are utilised. The "**Partial integration I/O"** level assumes that there is some integration into the vehicle I/O. In the case of a mobile phone that is mounted in the vehicle, and the input (e.g., answering a phone call) would be done via the mobile phone, but the audio output and voice input is via the vehicle (e.g., using the Bluetooth hands-free profile). The "**Partial integration O/I"** level is similar to the **Partial integration I/O** level but with the input/output reversed. For example, vehicle steering wheel buttons are used for input, and output is directed via the nomadic device.

At the "**streaming integration"** level, a nomadic device is just a storage device with data streaming and an application in the car is using that storage device. An example of this integration level is an MP3 player, where music is in a nomadic device and the user interface is in the built-in car stereo with possible steering wheel buttons that are used to browse playlists and select tracks and the music is delivered by the in-car loudspeakers. It must also

be noted that there is no digital rights management infringement seen in this case, because no files are copied to the vehicle, only music is streamed when needed. [6]

The derivation of the AIDE strategy (i.e., which integration level will be developed in WP3.4.3) was based on how adaptive control of application (ICA module) could be implemented:

- Basic installation as described above will **not** incorporate adaptive control by ICA.
- Streaming integration leaves the **application in the car**, so ICA is in the vehicle.
- Partial I/O and O/I are subsets to full integration and as well require a ND gateway

Consequently the AIDE strategy decision was to develop full integration level.

5.3 Nomadic Device Gateway Design

The Nomadic Device Gateway (NDG) interface is designed to allow nomadic devices (ND) to interface with a vehicle running the Adaptive Integrated Driver Vehicle Interface (AIDE) system. The gateway will allow such a nomadic device to be introduced into the vehicle, the control of the nomadic device can be passed to the vehicle's HMI system and functionality of the device can be altered depending on the driving state.

The gateway will receive information from the AIDE ICA module to determine the driving state and control the information and functionality displayed by the nomadic device. The gateway will also allow the synchronisation of information between the vehicle HMI and the nomadic device. The gateway will also allow the streaming of audio content from the nomadic device into the vehicle sound system with control via the vehicle HMI.

The nomadic device gateway is designed to accommodate many different connection options and variables. The use of the Gadget Bluetooth profile created by Motorola for the passing of context allows the gateway its inherent flexibility. The gateway is also designed with standard input and output protocols. This design methodology offers the ability to connect the gateway with many different vehicles and many different hardware types as required.

The Gadget Bluetooth profile is compatible with and works in tandem with other standard Bluetooth profiles (e.g., A2DP, HFP). The standard Bluetooth profiles will function normally, but the Gadget Bluetooth profile will moderate some functions. For example, an incoming phone call will still be handled with the standard HFP profile. The Gadget Bluetooth profile will moderate this process by rerouting an incoming call to voicemail or delaying the ringing for a few seconds if the ICA within the AIDE system determines that it is unsafe to allow the call at the current time.

The AIDE implementation of the gateway has been written in Java using open standards and designed to use the Bluetooth technology to access the L2CAP level in a standard Bluetooth stack for connecting with nomadic devices. In order to operate the gateway, this Java code would have to be added as an application to a supported mobile device, and the L2CAP level must be accessible in the Bluetooth stack. The gateway utilises the gadget Bluetooth protocol for the passing of messages between the NDG and the ND. Figure 2 shows the AIDE Nomadic Device Connection architecture.

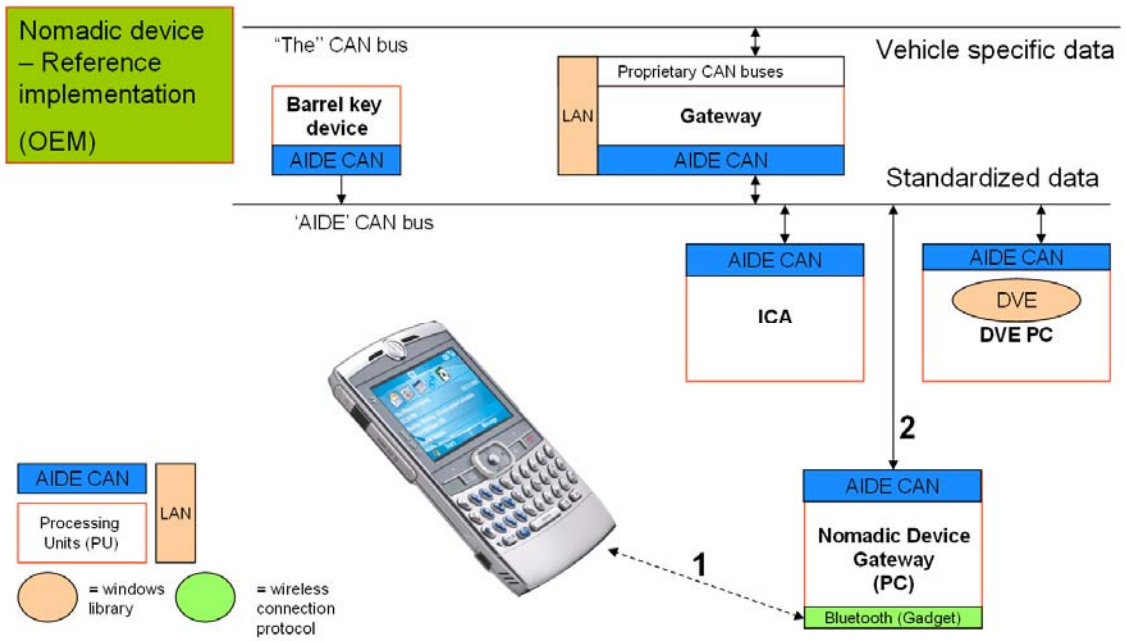

Figure 2: AIDE Nomadic Device Connection Architecture.

In the AIDE project, the Nomadic Device Gateway runs as a "Gadget Node" in order to allow a direct interfacing with the Bluetooth Gadget profile to the nomadic devices. The Nomadic Device Gateway implements the "InteractionManager" gadget service by acting as a bridge for the ICA application vectors and gadget messages. This in turn allows the ICA, through the "InteractionManager" interface, to control the nomadic devices and allow the AIDE internal voice recognition system to control the cell phone and music player. The Nomadic Device Gateway also provides the "Moderator" gadget service for recruiting and maintaining the gadget network. Finally the Nomadic Device Gateway provides the "ConditionServer" gadget service by receiving the DVE vectors via UDP socket or direct java method calls. It uses these vectors to maintain the current values of all sensors and derived conditions for subscription based updates in any associated gadgets.

The nomadic device gateway has the following two logical components:

- The addressing component: This component is responsible for receiving information from one component and transmitting the information to another component. For example, it receives information from a nomadic device and transmits the information to the ICA, or vice versa.
- The formatting component: This component is responsible for converting the information format that is appropriate for the receiving end, if it is not in a standard format. For the demonstrations, four major nomadic device services will be supported: telephony, music, SMS message, and calendar. For each of these services, several functions supported, for example, the music service provides functions such as play, stop, and pause, and the SMS service provides functions such as send, receive, and reminder. Depending on the specific service and function, the gateway will convert the information to an appropriate format that is appropriate for the function.

5.3.1 Communication: Between the Nomadic Device Gateway and the Nomadic Device

The communication between the NDG and the ND (link number 1 in Figure 2) is serviced by a standard 802.15.1 Bluetooth wireless communication standard. This uses a custom Bluetooth profile created by Motorola known as Gadget. This profile enables the communication and passing of context between Bluetooth devices.

5.3.2 Communication: Between the Nomadic Device Gateway and the Vehicle System

The communication between the NDG and the vehicle AIDE system (link number 2 in Figure 2) is carried out by a network connection to the AIDE CAN bus which uses a specifically designed AIDE proprietary protocol. Table 2 shows the nomadic device gateway communication protocol message descriptors. These descriptors are constructed and passed in messages between the NDG and AIDE HMI to inform either system of an event or request.

Table 2: Nomadic Device Gateway Communication Protocol Message Descriptors.

Acronym	Full name	Meaning
Phone		
NDP	Nomadic device present	A nomadic device is/has connected
NDA	Nomadic device absent	A nomadic device is/has disconnected
RNDS	Request Nomadic device status	Request nomadic status -- reply with a NDP or NDA
IPCR	Incoming phone call request	There is an incoming phone call on a connected phone
PCNV	Phone call no longer valid	The other part in the phone call has hung up, or the user has hung up using the "No" button on the handheld device.
RPCS	Request phone call status	query phone for current call status -- reply with PCS
PCS	Phone call status	possible values:inACall[:<number>[:< caller_id>]], onHold, ringing, dialing, none -- this is sent on each state change or in response to a RPCS
RPB	Request phone book	Request of phone book entry(s) -- reply with PBE (if exact match) or PBL is more than one match
PBL	Phone book name list	Phone book list of names that match the RPB pattern
PBE	Phone book entry	A Vcard with detail contact information
PCY	Phone call yes	The user has accepted an incoming phone call using the vehicle HMI.
PCN	Phone call no	The user has denied or ended a phone call using the vehicle HMI.
OPCR	Outgoing phone call request	The user has initiated a phone call using the in-vehicle HMI.
SMS	Short Message Service	Display an incoming SMS text
PCH	Phone Call Hold	put the phone call on hold (or take off hold)
Music Player		
MP_RSL	Request song list	Request of song list -- reply with many MP_SI
MP_CS	Choose song	User choice of song
MP_C	Command	play/Pause/stop/FF/REW
MP_SI	Song Information	Includes: ID, artist, album, song, length
MP_PIS	Position in song	Sent about twice a second (note from Bob, not sure this is avail inA2DP to be sent)
Calender		
CR_DR	Display request	Nomadic device wants to display a calendar reminder
CR_C	Command	Reply to reminder, E.g. dismiss/snooze, possibly including time of snooze. Incl ID.
Context Server		
USV	Update Sensor Value	update the published value of a named sensor with this value
RSV	Request Sensor value	request the current value of a named sensor - reply with a USV
OSV	Override Sensor value	request overriding current sensor value for x milli-seconds
RNS	Request Sensor Names	request the names of all sensors in the current system - reply with 1 or more SI
SI	Sensor Information	return sensor name and optional precision, range and unit info

5.3.3 Communication: Sequence Diagrams

In this section, use cases upon which the AIDE nomadic device integration is based will be described. These use cases are depicted from the end user perspective. Many of the use cases are from AIDE WP3.1.

5.3.3.1 Outgoing Call: Call Terminated by the User

This use case demonstrates that a user places an outgoing call and then terminates the phone call while a mobile phone is connected to the AIDE system. The user dials a sequence of numbers (e.g., 123-4567). When the caller hears a ring tone, the receiver answers the phone call and commences a phone conversation. The phone call is terminated by the initiating user.

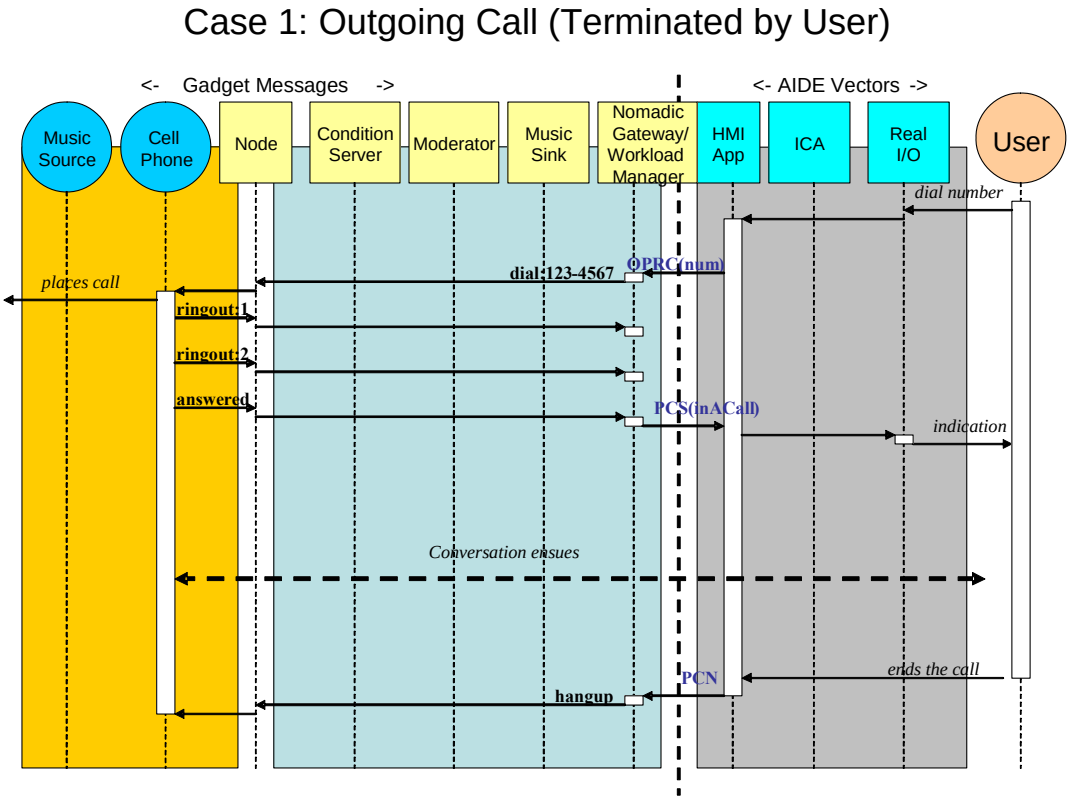

Figure 3: An AIDE Communication Sequence Diagram for Making an Outgoing Phone Call that is Terminated by the User.

5.3.3.2 Outgoing Call: Call Terminated by the Receiving End

This use case is similar to the previous use case except that the phone call is terminated by the receiver rather than the initiator. The chart depicts that a user initiates an outgoing call and the call is terminated by the receiver while a mobile phone is connected to the AIDE system. The user dials a sequence of numbers (e.g., 123-4567). When the caller hears a ring tone, the receiver answers the phone call and commences a phone conversation. The phone call is terminated by the receiving end.

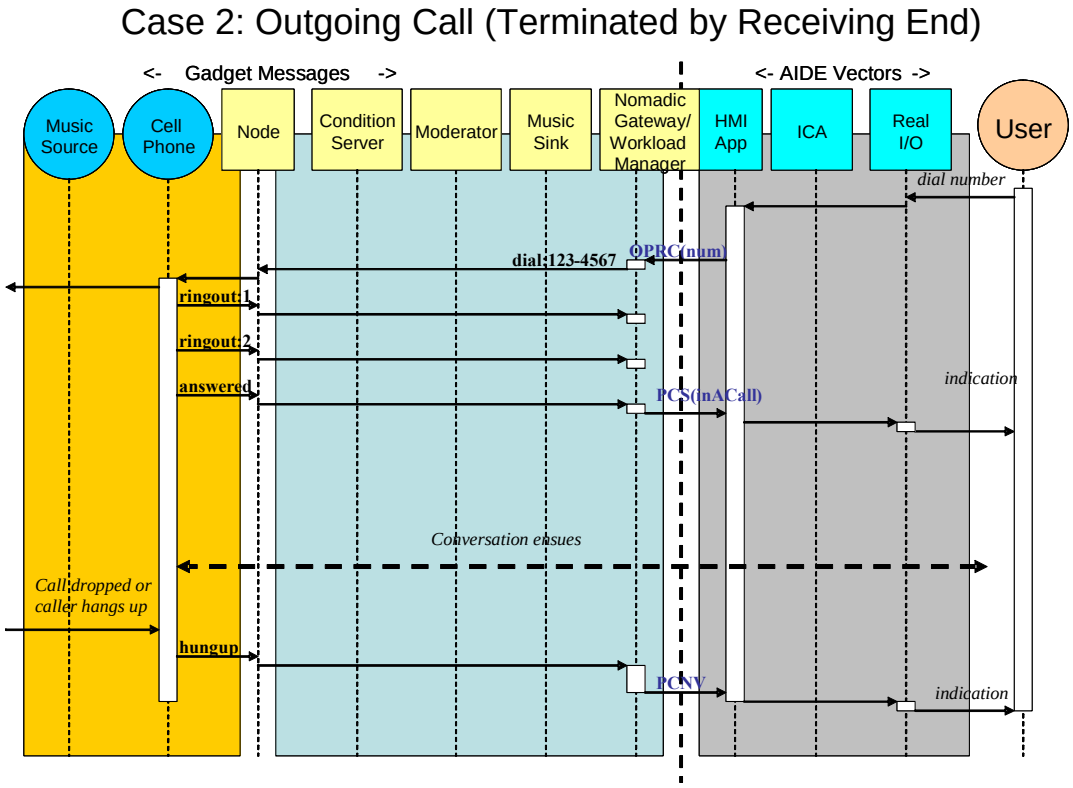

Figure 4: An AIDE Communication Sequence Diagram for Making an Outgoing Phone Call that is Terminated by the Receiving End.

5.3.3.3 Incoming Call: Free-Standing Nomadic Device

This use case demonstrates that a user answers an incoming phone call on the Nomadic Device that is not connected to the AIDE system. When the incoming call arrives, a ring tone is played on the nomadic device. The user presses a button to commence a conversation, and presses another button to terminate the conversation.

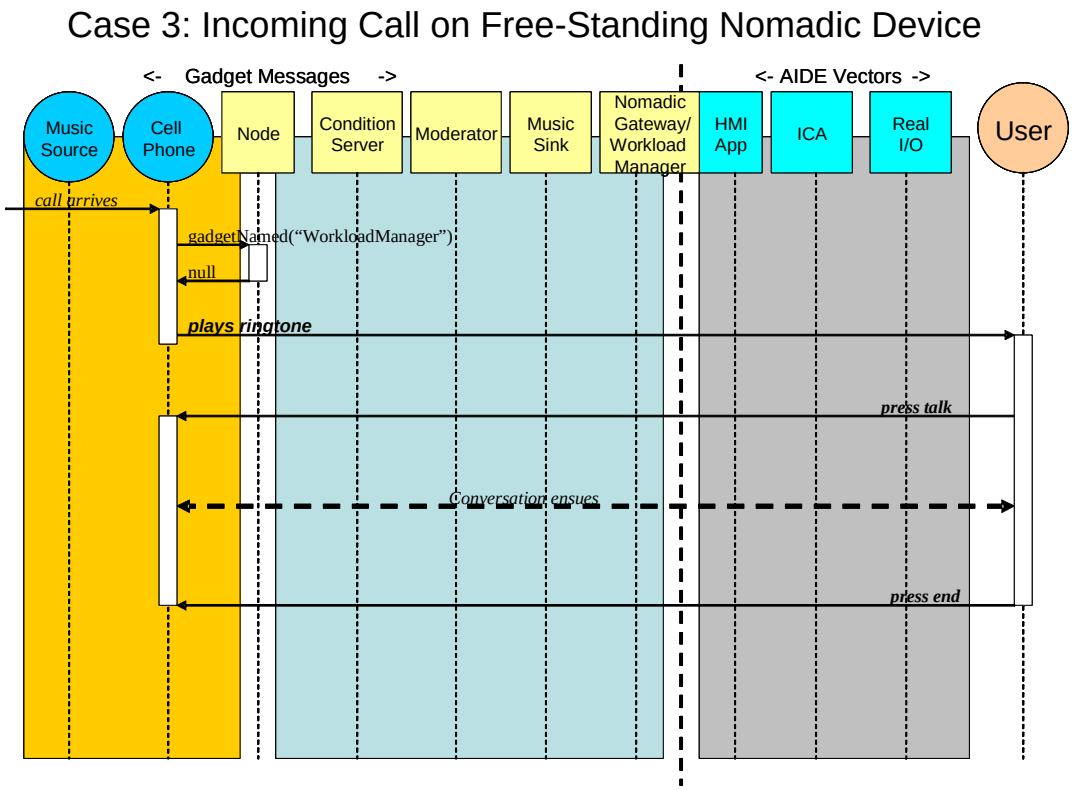

Figure 5: An AIDE Communication Sequence Diagram for Receiving an Incoming Phone Call on a Free-Standing Nomadic Device.

5.3.3.4 Incoming Call: Safe State

This use case demonstrates that an incoming call arrives at the nomadic device that is connected to the AIDE system and the ICA within the AIDE system determines that it is currently safe for the user to accept the call. Therefore, the phone rings and the call is answered by the user. Some moments later, the user ends the phone conversation and hangs up the phone.

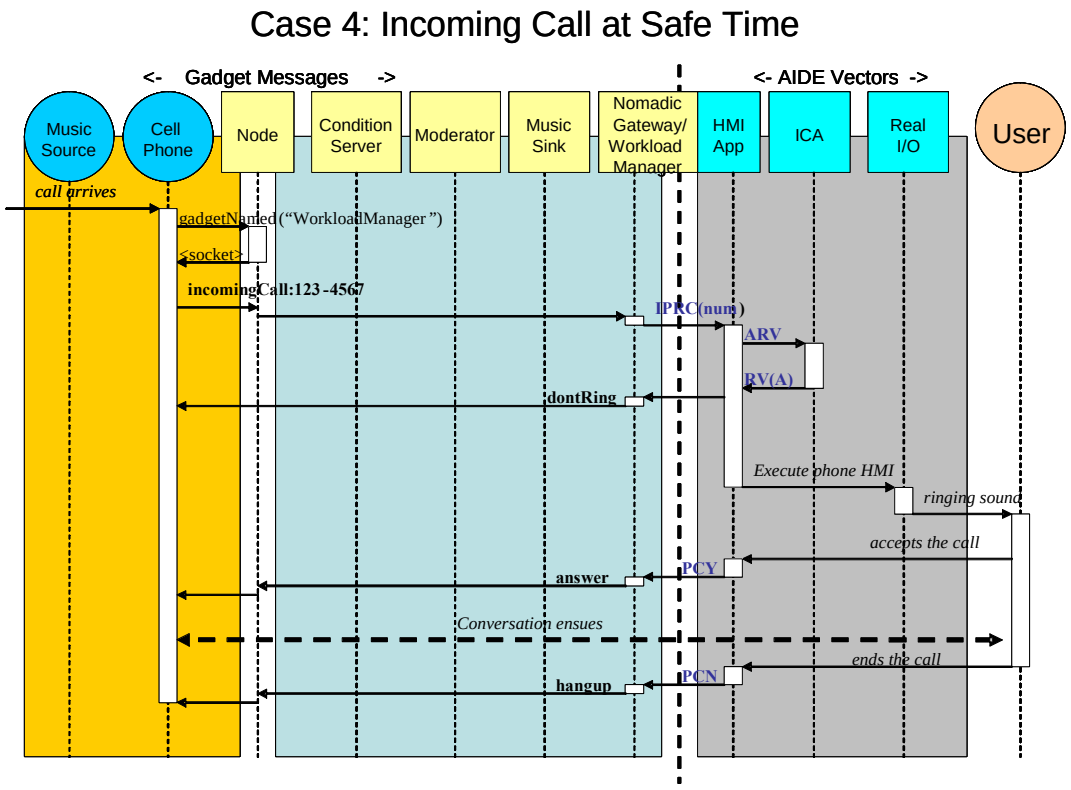

Figure 6: An AIDE Communication Sequence Diagram for Receiving an Incoming Phone Call at Safe Time.

5.3.3.5 Incoming Call: Unsafe State (Phone Calls Re-Routed to Voicemail)

This use case demonstrates that an incoming phone call arrives while the nomadic device is connected to the AIDE system and the ICA within the AIDE system determines that it is an unsafe time for the user to accept the phone call. The phone call is therefore routed to a voicemail message system. When a new voicemail message arrives at a safe time, a light voicemail icon is displayed on the nomadic device.

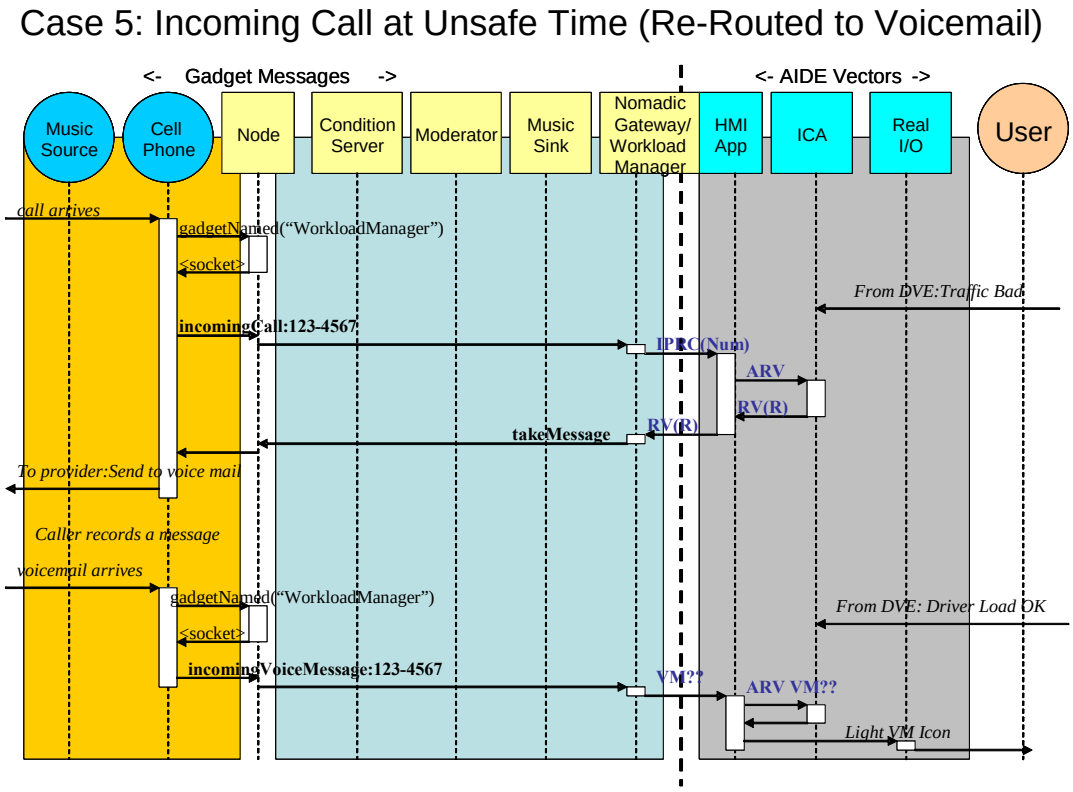

Figure 7: An AIDE Communication Sequence Diagram for Receiving an Incoming Phone Call at Unsafe Time (Calls Re-Routed to Voicemail).

5.3.3.6 Incoming Call: Changing from Unsafe to Safe State

This use case demonstrates a phone call arrives while the nomadic device is connected to the AIDE system. Because the ICA within the AIDE system determines that it is unsafe to allow the call at the current time, the Nomadic Device Gateway will wait x seconds and retry to advertise the call to the user. After x seconds elapsed, the ICA within the AIDE system determines that the user is safe to take the phone call and therefore the incoming phone call is allowed to go through.

The nomadic device gateway is designed to accommodate two methods of communication with the ICA within the AIDE system: Transaction-based communication and state-based communication. The selection of communication method will be based on the design and implementation of the vehicle's HMI system.

In the following figure, the state-based communication is implemented. This design involves the HMI remembering the current state which is updated periodically by the ICA.

Case 6A: Incoming Call: Changing from Unsafe to Safe State
(State-Based Communication)

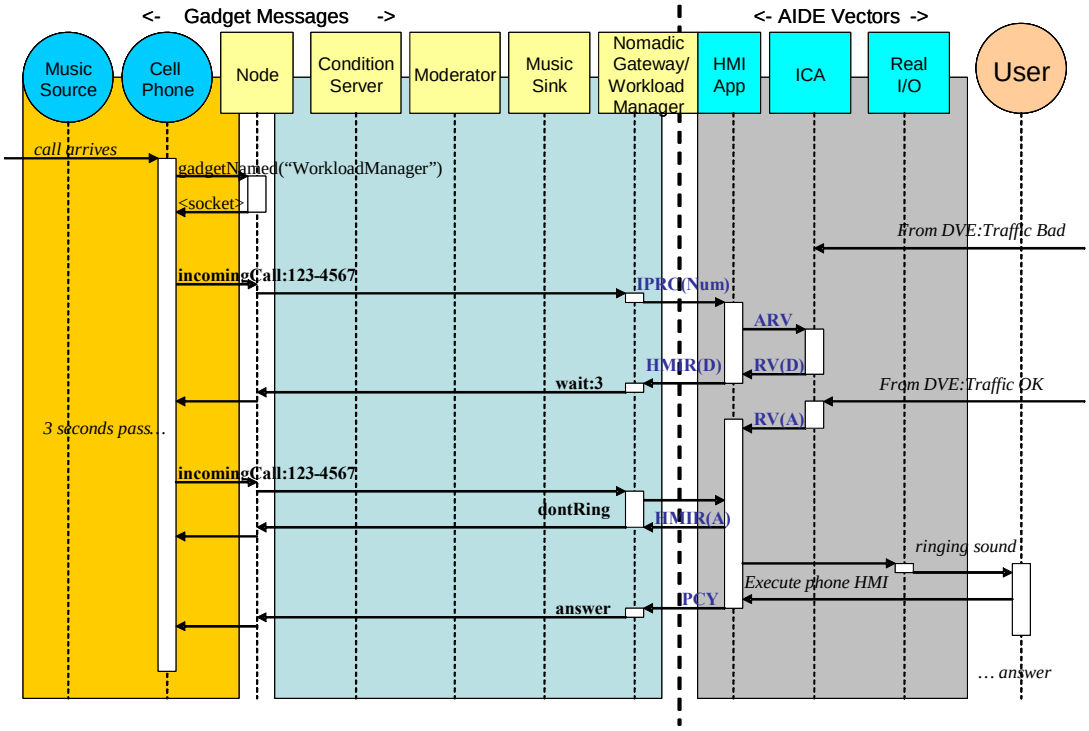

Figure 8: An AIDE Communication Sequence Diagram for Receiving an Incoming Phone Call While Changing from Unsafe to Safe State (State-Based Communication).

It is also possible for a transaction based system to be implemented and used with the Nomadic Device gateway. This involves the system requesting the current state from the ICA every time the information is required. This is in contrast with the State based system which remembers the previous state until it is updated by the ICA.

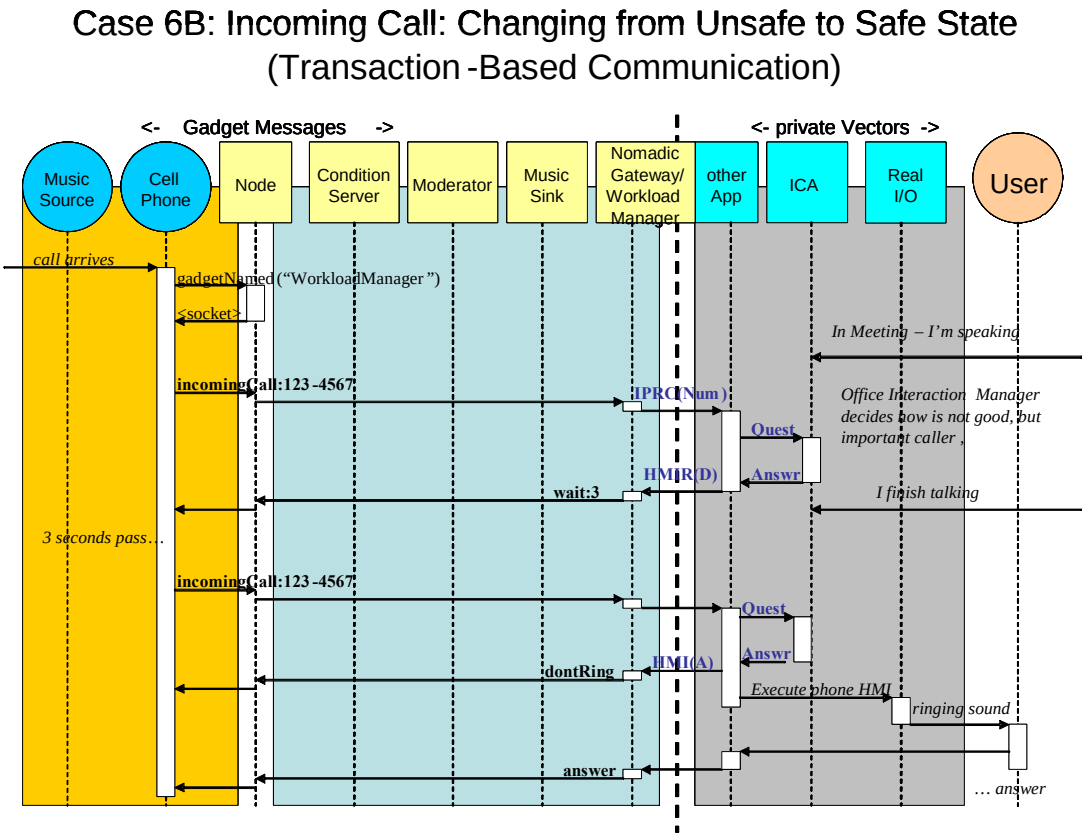

Figure 9: An AIDE Communication Sequence Diagram for Receiving an Incoming Phone Call While Changing from Unsafe to Safe State (Transaction-Based Communication).

5.3.3.7 Music Device: Get Song List

This use case demonstrates the process by which the HMI application retrieves the song list from the Nomadic Music Device. The user makes a request and receives a local copy of the song list for use when selecting songs.

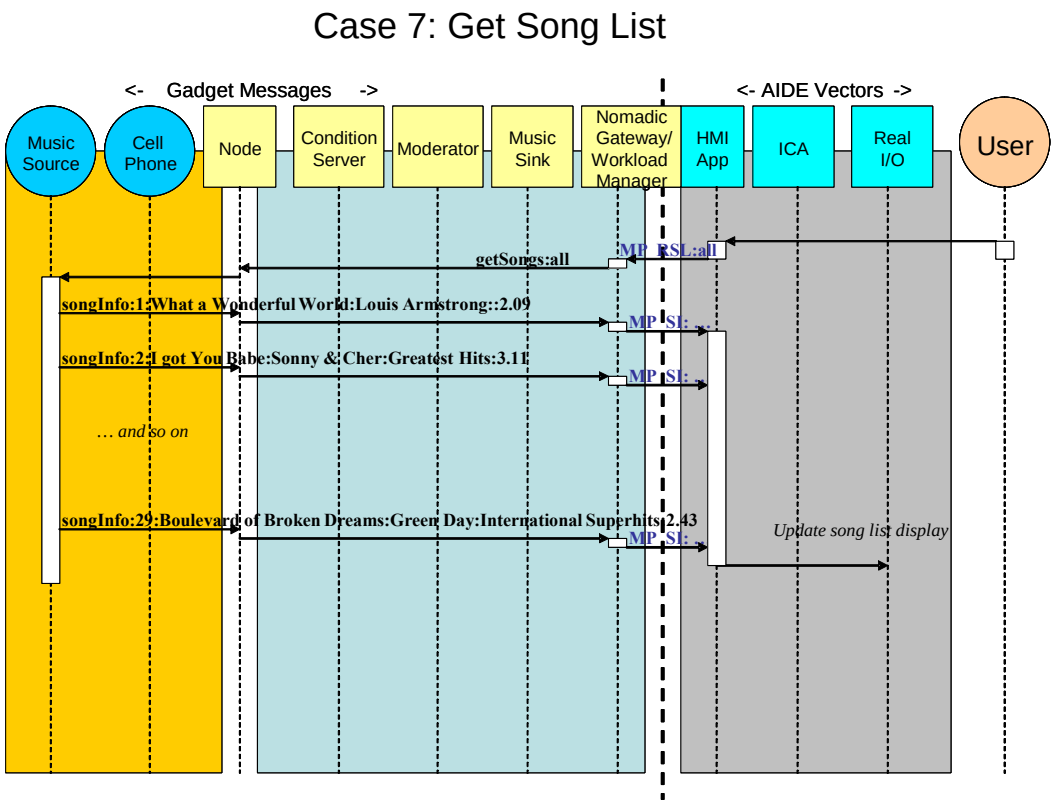

Figure 10: An AIDE Communication Sequence Diagram for Getting Song List from Music Device.

5.3.3.8 Music Device: Play a Song

This use case shows the process by which a user can select a song from the Nomadic Music Device. The user picks the song from the local HMI list. The HMI application creates the appropriate request which is sent to and interpreted by the NDG. The user can play or pause the song.

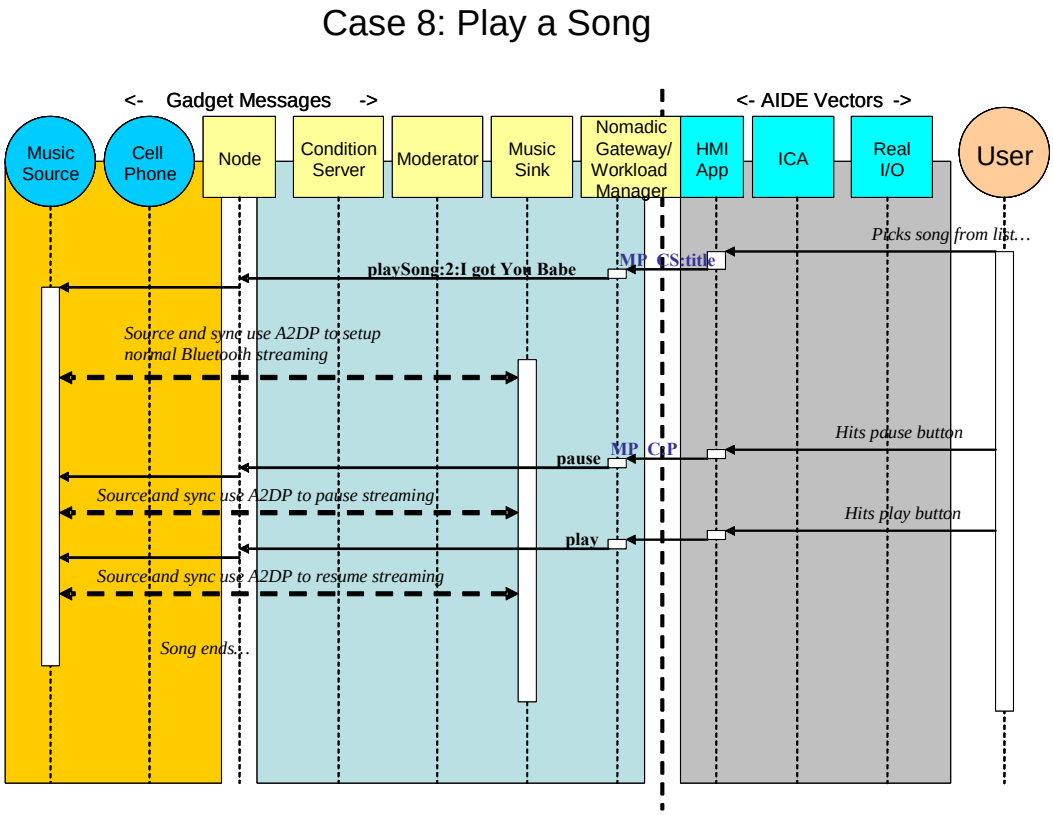

Figure 10: An AIDE Communication Sequence Diagram for Playing a Song on Music device.

5.3.3.9 Sensor Data Update

This case shows the process by which vehicle sensor information is updated through the NDG to the Nomadic Device. The vehicle sensor information (e.g., axle weight) is then shown on the display that is native to the nomadic device.

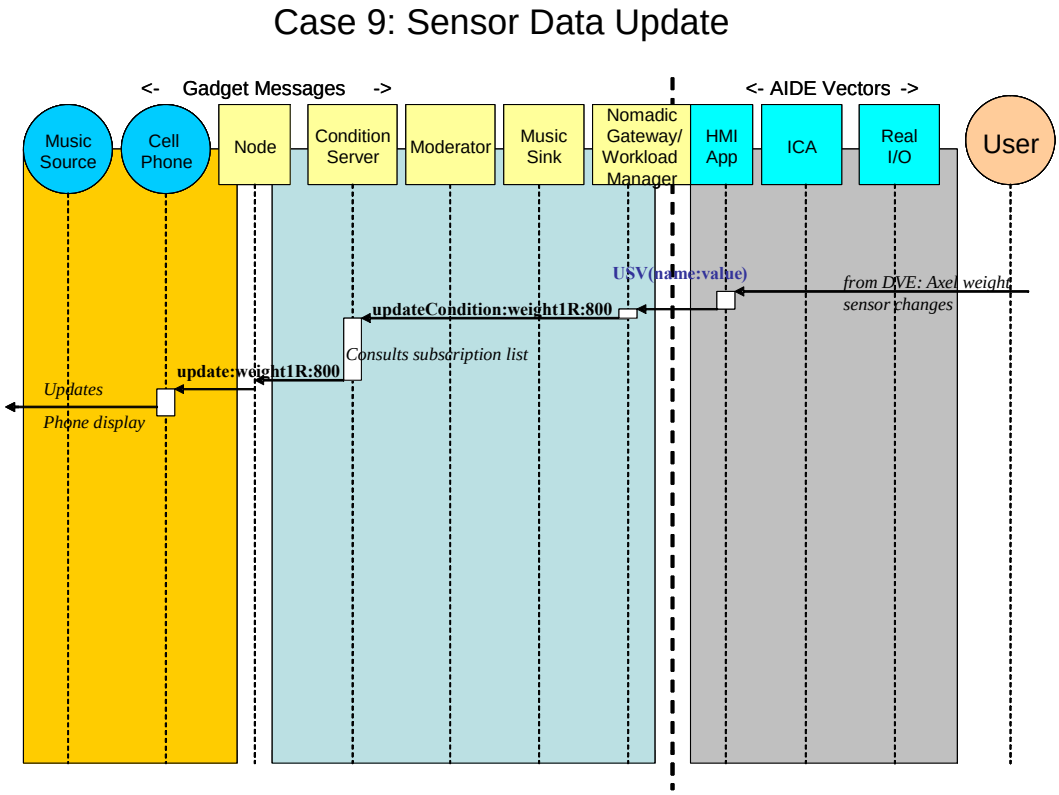

Figure 11: An AIDE Communication Sequence Diagram for Updating Sensor Data.

6 An Implemented Demonstration of Nomadic Device Integration

Table 3 presents a list of descriptor variables that is used in the nomadic device gateway communication protocol messages. These variables offer additional information which is required when a message is processed. Figure 12 is a screenshot of the PC development desktop that includes the nomadic device gateway, the cell phone simulator, and the ICA simulator. With this PC development desktop, messages can be sent between the nomadic device gateway and the cell phone or ICA to simulate the driver-system interaction. This simulation environment is useful for developing, testing, and demonstrating the integration of nomadic devices in the vehicle environment.

Table 3: Descriptor Variables Used in AIDE NDG Proprietary Protocol Message.

Message	Message type	Device_ID	Argument(s) chars colon separated...
NDP	0	x	
NDA	1	x	
IPCR	2	x	<number>[:<callerID>]
PCNV	3	x	{optional reasons why its not valid}
PCS	4	x	<status>
PBL	5	x	<name1>:…<nameN> (limited to 1400 total chars)
MP_PIS	6	x	<seconds>
MP_SI	7	x	<song#>:<title>:<artist>:<album>:<song length>
CR_DR	8	x	
RSV	9	x	<sensorName>
OSV	10	x	<sensorName>:<value>:<durationSec>
RSN	11	x	<all> | <starts with>
NDG_OK	12	x	< version info>
HMI_PING	13	x	
PBE	14	x	Vcard (for the single name phone book entry) (limited to 1400 total chars)
SMS	15	x	<from>:<text of the message>

vectorType 1	**Veh. HMI -> ND gateway**		
Message	Message type	Device_ID	Argument(s) ASCII chars colon separated...
USV	0	x	sensorName:newValue
RPB	1	x	<name template>{:Home|Cell|Work}
PCY	2	x	
PCN	3	x	
OPCR	4	x	<number OR name>
MP_RSL	5	x	all | num | fromNum-toNum>
MP_CS	6	x	
MP_C	7	x	p=play, P=pause/resume, s=stop, F=FFWD, R=RWD
CR_C	8	x	Snooze = 0 Dismiss = 1
RPCS	9	x	
RNDS	10	x	
HMIR	11	x	<reply status>
SI	12	x	<sensorName>:N|C:<state1>:…:<stateN>{:<unit>:<minval>:<maxval>}
HMI_OK	13	x	<version info>
NDG_PING	14	x	
PCH	15	x	

Below are some example communications between AIDE HMI and NDG for incoming and outgoing phone call requests.

6.1 Outgoing Phone Call Request

The AIDE HMI for the user to place a phone call gathers the necessary information (who or what number to call) by using a combination of input methods (such as buttons or voice recognition systems). In principle, when the system determines that it is a good time to actually place the call, it sends a request to the nomadic device to initiate the call. In the

current demonstration, making a phone call by the user falls into the highly prioritized "dialogue" category of the ICA and therefore an outgoing call is initiated without delay. The normal stand-alone interface of the phone is not used, the information is sent via a command from the gateway. The AIDE HMI sends a message to the NDG with a descriptor: "OPCR,<Device_ID>,<number OR name>"

- CarContext@9943 > HMI->NDG OPCR,0,0152361464

The NDG processes the request and replies to HMI. The nomadic device responds to "place call requests" with one or more "phone call status" messages. These messages are generated by the phone at its discretion, or in response to a query sent directly by the gateway. For example, the first reply of status that is sent from the NDG to the AIDE HMI may be a descriptor with "PCS, <Device_ID>, <status>"

- WorkloadManagerProc@10364 > NDG->HMI PCS,0,dialing:Joe Bloggs [work]

6.2 Incoming Phone Call Request

When an incoming call is detected, the nomadic device sends a message to the ICA system via the HMI/gateway, and waits for a response. The ICA system uses its sensor information to determine what to do with an incoming call at this time. It then responds to the IPCR message with A (accept) or R (reject). If it is accepted, the incoming call is indicated by the HMI to the user (via a ringtone sound, visual, or tactile feedback). A typical process would be as follows.

Step 1: The ND sends a message to the AIDE HMI with a descriptor: "IPCR,<Device_ID>, <number>[:<callerID>]"

- WorkloadManagerProc@22695 > NDG->HMI IPCR,0, 0152361464:Joe Bloggs [work]

Step 2: The AIDE HMI sends a reply to the NDG with a descriptor: " RV ,<Device_ID>, <decision>

- WorkloadManagerProc@22695 > HMI-> NDG RV ,0, A

Step 3: The ND sends a status message to the AIDE HMI with a descriptor: "PCS, <Device_ID>,<status>"

- WorkloadManagerProc@22705 > NDG->HMI PCS,0,incomingCall

Step 4: When the user decides and uses the HMI to answer or reject the call, the a message is sent to the phone PCY to accept the call or PCN to reject the call. The AIDE HMI sends a reply to the NDG with a descriptor: " PCY | PCN ,<Device_ID>

- WorkloadManagerProc@22695 > HMI-> NDG PCY ,0,

At this point the phone either initiates a voice conversation or sends the caller to the voice mail.

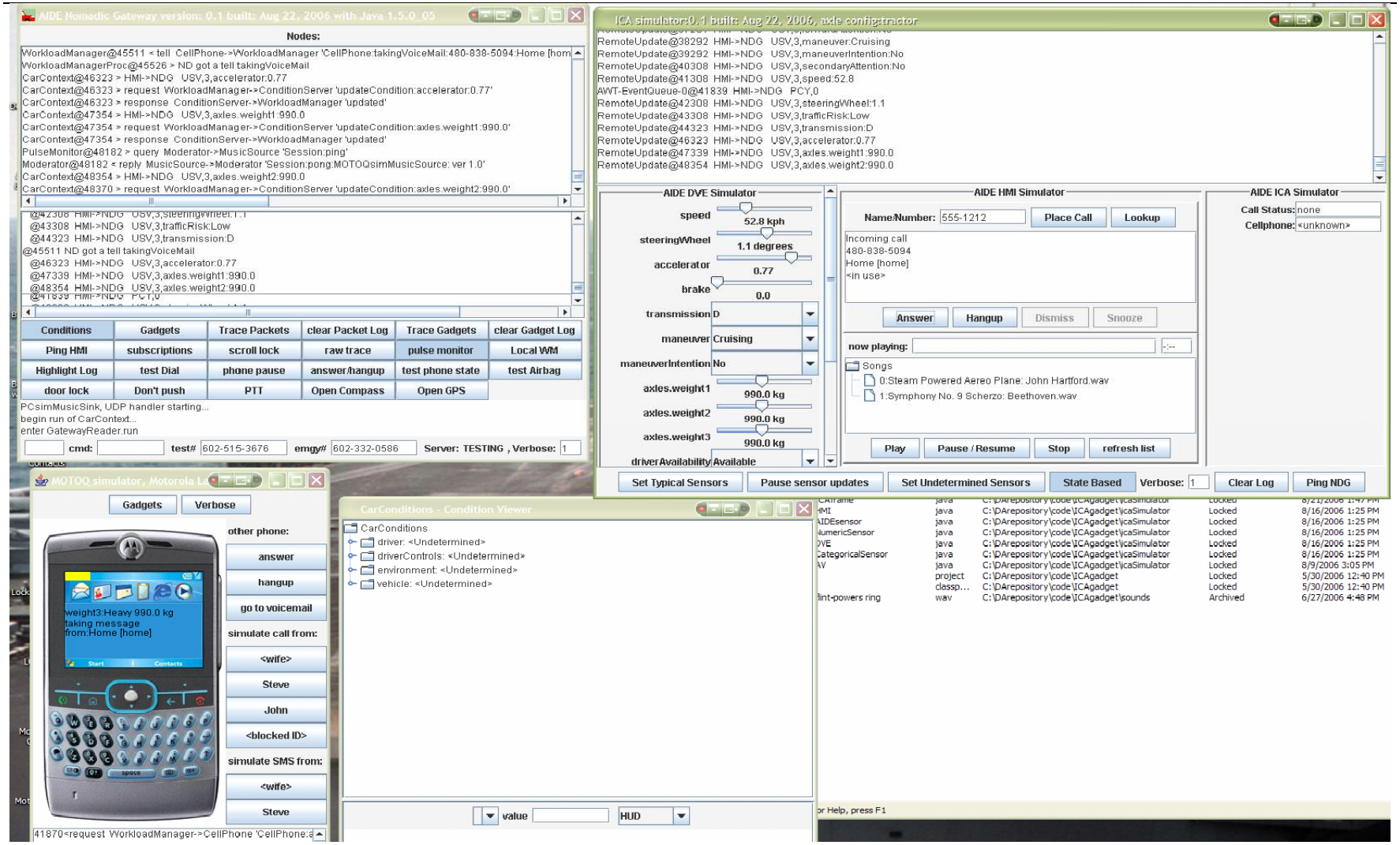

Figure 12: A Screenshot of PC Development Desktop
(Top Left - Nomadic Device Gateway; Bottom Left - Cell Phone Simulator; Top Right - ICA Simulator).

7 Potential Benefits

7.1 Safety

With the integration of nomadic devices in the vehicle environment within the AIDE framework, safety will be enhanced through extending the AIDE DVE adaptation to the nomad devices. The ND functionality will be included in the ICA control strategies regarding the driving task demand while driving in critical situations. For example, when the driving situation is demanding, incoming phone calls may be re-routed to a voice mail message system. The safety benefit should be valid for all levels of installation/integration.

Because vehicle information can be displayed on nomadic devices, the driver can perform a safety-related vehicle diagnostic using the nomadic devices. For example, the axle loading on a commercial vehicle may be presented on a nomadic device to detect any abnormal loading pattern and prevent vehicle crashes. Other diagnostics may include engine conditions and fuel levels.

7.2 Usability

Because the vehicle I/O devices are optimized for in-vehicle use while driving, the integration of nomadic devices within the vehicle system can potentially enhance the usability of nomadic devices. In the case of mobile phones, the integration can make it considerably easier to carry out a conversation, answer a phone call, and make a phone call. Using the in-vehicle microphone and speaker, the driver will no longer need to hold the phone while talking on the phone, and therefore the phone conversation can be made hands-free. Answering a phone call can also be simplified. The driver can simply push a button located at a convenient location (e.g., on the steering wheel or the center stack) rather than locate the phone and push a button on the phone. In addition, information from the nomadic device can also be presented on an in-vehicle display that is typically located at the center stack area. Similar improvements may be observed for other nomadic devices such as portable music players and personal navigation system.

8 Compliance with ESoP

The updated version of the European Statement of Principles on Human Machine Interface (HMI) for in–vehicle information and communication systems of 22 December 2006, summarises essential safety aspects to be considered for the Human Machine Interface (HMI) for in-vehicle information and communication systems [3, 9]. This updated version replaces the previous Commission Recommendation of 21 December 1999 on human machine interface. It states,

> ***"The principles are not a substitute for any current regulations and standards, which should always be taken into consideration. These principles can be reinforced by national legislation or by individual companies. These principles constitute the minimum set of requirements to be applied." [3, 9]***

AIDE IP complies with the updated ESoP on HMI for in–vehicle information and communication systems, which consists of Principles and Recommendations on Safe Use. The ESoP Principles are divided into:

(1) Design goals.
(2) Installation Principles.
(3) Information Presentation Principles.
(4) Interaction with Display Principles.
(5) Interface with Display Principles.

The way that AIDE meets the Principles reported in the updated ESoP for HMI are reported in Table 4 below. It should be noted that the compliance of some of the principles rests on the device manufacturers and service providers rather than the AIDE IP.

Table 4: AIDE compliance with ESoP on HMI Principles.

ESoP on HMI Principles			**Is the ESoP Principle Complied by AIDE IP? How?**
1. DESIGN	Design goal I	*The system supports the driver and does not give rise to potentially hazardous behaviour by the driver or other road users.*	Yes. The ICA within the AIDE system will schedule tasks based on driving conditions.
	Design goal II	*The allocation of driver attention while interacting with system displays and controls remains compatible with the attentional demand of the driving situation.*	Yes. The ICA within the AIDE system will assess the attentional demand and set interaction policy accordingly.
	Design goal III	*The system does not distract or visually entertain the driver.*	Yes. Prevention of driver distraction is a major objective of the AIDE program.
	Design goal IV	*The system does not present information to the driver which results in potentially hazardous behaviour by the driver or other road users.*	Yes. The ICA within the AIDE system will schedule the presentation of information based on driving conditions.
	Design goal V	*Interfaces and interface with systems intended to be used in combination*	Yes, if vehicle I/O units will be used for controlling and presenting

ESoP on HMI Principles			Is the ESoP Principle Complied by AIDE IP? How?
		by the driver while the vehicle is in motion are consistent and compatible.	nomadic device information when possible.
2. INSTALLATION PRINCIPLES	Installation principle I	*The system should be located and securely fitted in accordance with relevant regulations, standards and manufacturers instructions for installing the system in vehicles.*	It depends on the installation. Installation of nomadic device in the vehicle may vary with device types and service providers.
	Installation principle II	*No part of the system should obstruct the driver's view of the road scene.*	It depends on the installation. Nomadic devices are usually installed near the centre stack area.
	Installation principle III	*The system should not obstruct vehicle controls and displays required for the primary driving task.*	It depends. Installation of nomadic device in the vehicle may vary with device types and service providers. Nomadic devices are usually installed near the centre stack area.
	Installation principle IV	*Visual displays should be positioned as close as practicable to the driver's normal line of sight*	It depends. Nomadic devices are usually installed near the centre stack area, and in-vehicle displays (close to the driver's normal line of sight) will be used for presenting nomadic device information when possible.
	Installation principle V	*Visual displays should be designed and installed to avoid glare and reflections.*	Yes. When fully integrated, information from nomadic device will be presented on in-vehicle display that is designed to avoid glare and reflections.
3. INFORMATION PRESENTATION	Information presentation principle I	*Visually displayed information presented at any one time by the system should be designed such that the driver is able to assimilate the relevant information with a few glances which are brief enough not to adversely affect driving.*	Yes. The degree of compliance may vary with device type and service providers. When fully integrated, nomadic device information may be controlled by the ICA within the AIDE system.
	Information presentation principle II	*Internationally and/or nationally agreed standards relating to legibility, audibility, icons, symbols, words, acronyms and/or abbreviations should be used.*	It depends. Nomadic Device manufacturers typically follow human factors guidelines to optimize usability.
	Information presentation principle III	*Information relevant to the driving task should be accurate and provided in a timely manner.*	It depends. When integrated with the AIDE system, driving information will be gathered and shared.

ESoP on HMI Principles			Is the ESoP Principle Complied by AIDE IP? How?
	Information presentation principle IV	*Information with higher safety relevance should be given higher priority.*	Yes. The ICA within the AIDE system will prioritize tasks based on factors such as safety relevance.
	Information presentation principle V	*System generated sounds, with sound levels that can not be controlled by the driver, should not mask audible warnings from within the vehicle or the outside.*	It depends. Manufacturers should follow human factors guidelines for sound optimization for in-vehicle or nomadic devices and warning systems.
4. INTERFACE WITH DISPLAYS AND CONTROLS	Interaction with displays and controls principle I	*The driver should always be able to keep at least one hand on the steering wheel while interacting with the system.*	Yes. Integrating nomadic devices within the vehicle environment will enable a hands-free operation.
	Interaction with displays and controls principle II	*The system should not require long and uninterruptible sequences of manual-visual interfaces. If the sequence is short, it may be uninterruptible.*	It depends. The degree of compliance may vary with device types, service providers, and nomadic device functions that are allowed while driving.
	Interaction with displays and controls principle III	*The driver should be able to resume an interrupted sequence of interfaces with the system at the point of interruption or at another logical point.*	It depends. The degree of compliance may vary with device types and service providers.
	Interaction with displays and controls principle IV	*The driver should be able to control the pace of interface with the system. In particular the system should not require the driver to make time-critical responses when providing inputs to the system.*	It depends. The degree of compliance may vary with device types and service providers.
	Interaction with displays and controls principle V	*System controls should be designed such that they can be operated without adverse impact on the primary driving controls.*	It depends. When integrated, in-vehicle controls may be used to access nomadic device information.
	Interaction with displays and controls principle VI	*The driver should have control of the loudness of auditory information where there is likelihood of distraction.*	Yes. Volume control is available on an in-vehicle unit and/or nomadic device.
	Interaction with displays and controls principle VII	*The system's response (e.g. feedback, confirmation) following driver input should be timely and clearly perceptible.*	It depends. The degree of compliance may vary with device types and service providers.

ESoP on HMI Principles			Is the ESoP Principle Complied by AIDE IP? How?
	Interface with displays and controls principle VIII	*Systems providing non-safety related dynamic visual information should be capable of being switched into a mode where that information is not provided to the driver.*	Yes. The ICA within the AIDE system will be able to defer or switch off visual information.
5. SYSTEM BEHAVIOUR	System behaviour principle I	*While the vehicle is in motion, visual information not related to driving that is likely to distract the driver significantly should be automatically disabled, or presented in such a way that the driver cannot see it.*	Yes. The ICA within the AIDE system is designed to comply with this principle in order to minimize driver distraction.
	System behaviour principle II	*The behaviour of the system should not adversely interfere with displays or controls required for the primary driving task and for road safety.*	Yes. Information presentation and access is coordinated in the AIDE system so that conflicts are minimized.
	System behaviour principle III	*System functions not intended to be used by the driver while driving should be made impossible to interact with while the vehicle is in motion, or, as a less preferred option, clear warnings should be provided against the unintended use.*	Yes. The adaptive interaction based on driving conditions is the key objective of the AIDE program.
	System behaviour principle IV	*Information should be presented to the driver about current status, and any malfunction within the system that is likely to have an impact on safety.*	It depends. Device manufacturers should follow this important human factors guideline.
6. INFORMATION ABOUT THE SYSTEM	Information about the system principle I	*The system should have adequate instructions for the driver covering use and relevant aspects of installation and maintenance.*	It depends. User manuals will be used for this compliance.
	Information about the system principle II	*System instructions should be correct and simple.*	It depends. This is the responsibility of ND manufacturers and service providers.
	Information about the system principle III	*System instructions should be in languages or forms designed to be understood by the intended group of drivers.*	It depends. Localized instructions will be used for this compliance.
	Information about the system principle IV	*The instructions should clearly state which functions of the system are intended to be used by the driver while driving and those which are not.*	It depends. Device manufacturers and service providers will provide instructions and warnings for device use.

ESoP on HMI Principles			Is the ESoP Principle Complied by AIDE IP? How?
	Information about the system principle V	*Product information should be designed to accurately convey the system functionality*.	It depends. This is the responsibility of device manufacturers.
	Information about the system principle VI	*Product information should make it clear if special skills are required to use the system as intended by the manufacturer or if the product is unsuitable for particular users.*	It depends. This is the responsibility of device manufacturers and service providers.
	Information about the system principle VII	*Representations of system use (e.g. descriptions, photographs and sketches) should neither create unrealistic expectations on the part of potential users nor encourage unsafe use*	It depends. User manuals should be carefully prepared by device manufacturers to comply with this principle.

The Recommendations on Safe Use (RSU) are divided into:

- Recommendations on influencing use.
- Recommendations for drivers.

The way that AIDE meets the Recommendations on Influencing Use is presented in Table 5:

Table 5: AIDE compliance with ESoP on HMI RSU.

Recommendations on Safe Use			Is ESoP RSU Complied by AIDE IP? How?
1. RECOMMENDATIONS ON INFLUENCING USE	Recommendation on influencing use I	*Employers should ensure that all in-vehicle information systems are maintained in accordance with the manufacturer's instructions.*	It depends. This is the responsibility of fleet owners and employers.
	Recommendation on influencing use II	*Employer's procedures and incentive schemes should not cause or encourage system misuse. There should be a clear distinction between systems or functions that are intended (by the employer) to be used while driving and those that are not.*	It depends. This is the responsibility of fleet owners and employers. The ICA within the AIDE system will facilitate the compliance.
	Recommendation on influencing use III	*Adequate training should be given on all in-vehicle systems that drivers are required to use by employers while driving. Employers should ensure that employees can use the systems without endangering themselves or other road users.*	It depends. This is the responsibility of fleet owners and employers. Typically training is a condition for employment.
	Recommendation on influencing	*Employers should ensure that a copy of the manufacturer's instructions for use is available in every*	It depends. This is the responsibility of fleet owners and employers.

Recommendations on Safe Use			Is ESoP RSU Complied by AIDE IP? How?
	use IV	*equipped vehicle.*	
	Recommendation on influencing use V	*Point of sale promotion (e.g. advertising) should not encourage unsafe use.*	It depends. This is the responsibility of device manufacturers.
	Recommendation on influencing use VI	*Point of sale information should inform vehicle purchasers of the safety issues associated with in-vehicle information systems.*	It depends. This is the responsibility of device manufacturers.
	Recommendation on influencing use VII	*Vehicle hire companies should ensure that all information and communication systems are maintained in accordance with the manufacturer's instructions.*	It depends. This is the responsibility of fleet owners and employers.
	Recommendation on influencing use VIII	*Vehicle hire companies should ensure that a copy of the manufacture's instructions for use is available in every equipped vehicle.*	It depends. This is the responsibility of fleet owners and employers.
	Recommendation on influencing use IX	*Vehicle hire personnel should have adequate knowledge concerning in-vehicle information systems within the vehicles they make available and should offer instructions in their safe use.*	It depends. This is the responsibility of fleet owners and employers.

In addition to the above, the AIDE IP consortium confirms that the AIDE system complies with the current EC directives with their subsequent amendments, including:

- On the field of vision of motor vehicle drivers: Commission Directive 90/630/EEC of 30 October 1990;
- The interior fittings of motor vehicles (interior parts of the passenger compartment other than the interior rear-view mirrors, layout of controls, the roof or sliding roof, the backrest and rear part of seats): Council Directive 74/60/EEC of 17 December 1973;
- Council Directive 78/316/EEC of 21 December 1977;
- Council Resolution of 17 December 1998[5] (4) on operating instructions for technical consumer goods;
- Council Directive 92/59/EEC of 29 June 1992 on general product safety.

9 Innovation

Several vehicle manufacturers have solutions on the market for in-vehicle HMI integration of nomadic devices. However, these are in many cases OEM specific and limited to specific applications. The Nomadic Device Forum, as the only existing cross-sectional discussion forum on ND integration, has taken the first step towards a common solution, in the WG-A specification of use cases and requirements [6].

Concerning the AIDE nomadic device gateway developed for use in the three AIDE demonstrator vehicles, its innovation is not in the specific nomadic device functions that it enables, as most of the AIDE demonstrator nomadic device integration features are already available in existing solutions on the market. An important result of this work is however the definition of the AIDE Bluetooth profile, the device profile capable of communicating with an in-vehicle ICA and coordinating output generated by other Bluetooth profiles (telephony, MP3, etc) with an entire AIDE HMI, as presented in Section 2.3. Thus, the AIDE nomadic device gateway, as it has been implemented in the demonstrators, has the potential to enable a better integration of already existing nomadic device features. Also, the integration in the demonstrator HMIs of a range of nomadic device functions, will allow for a thorough assessment of the real benefits of such integration solutions, potentially an important output from the AIDE project.

Following the aforementioned consideration, the major innovation of this Deliverable is a demonstration of integrating a nomadic device within the vehicle environment via a nomadic device gateway that communicates with both the vehicle system and the nomadic device. The AIDE nomadic device gateway is a key enabler for the safe integration of nomadic devices in the vehicle environment. Standard communication protocol has been defined to facilitate the integration process. Because the Bluetooth wireless technique is used for communications between the nomadic device gateway and the nomadic device, in principle, the integration can be performed for any nomadic devices that contain a compatible Bluetooth chip and gadget profile. This nomadic device gateway could therefore become a standard method for the integration of any nomadic devices.

In AIDE, the Nomadic Device Gateway runs as a “Gadget Node” and implements the “InteractionManager” gadget service (i.e., acting as a bridge for the ICA). This in turn allows the ICA, through the “InteractionManager” interface, to control the nomadic devices and allow the AIDE internal voice recognition system to control the cell phone and music player. The Nomadic Device Gateway also provides the “Moderator” gadget service for recruiting and maintaining the gadget network and the “ConditionServer” gadget service for receiving the DVE vectors. It uses these vectors to maintain the current values of all sensors and derives conditions for subscription based updates in any associated gadgets.

Following the preceding approach, when a nomadic device is integrated within the vehicle environment, via the AIDE Nomadic Device Gateway, information can also be passed from the vehicle system to the nomadic device. Therefore, vehicle system information (e.g., low fuel warning, uneven axle loading) may be displayed on the nomadic device. This should enhance driver productivity. The integration also enables information to be passed from the nomadic device to the vehicle system. Therefore, nomadic device information (e.g., caller ID, song title) may be presented on the vehicle display (e.g., HUD or dashboard display). This should enhance the usability of the nomadic devices. The integration also enables a seamless collaboration between the vehicle system and the nomadic device. For example, the driving state as assessed from vehicle variables (e.g., speed) may be used to determine whether it is

appropriate to receive an incoming phone call. When the driving situation is demanding, phone calls may be rerouted to a voice mail message system. This will enhance driving safety.

10 Contribution of this Deliverable to Overall AIDE Objectives

This Deliverable is closely linked with other AIDE deliverables. A deliberate architectural alignment is made between this Deliverable and the general AIDE architecture. This Deliverable is based on the AIDE functional reference architecture that is developed in WP3.2 and adopts the ICA design and its logic that is developed in WP3.4. It implements many of AIDE use cases that have been proposed by WP3.1. Because of these commonalities, the findings documented in this deliverable can be readily adopted by other AIDE tasks. In addition, we have made a conscientious effort to comply with the European Statement of Principles (ESoP).

Unlike other AIDE Deliverables, this Deliverable is focused exclusively on the integration of nomadic devices in the vehicle environment so that a common HMI can be applied to nomadic devices as well as to original equipments that are installed by the vehicle manufacturers. In particular, a nomadic device gateway has been developed that enables the easy sharing of information between the vehicle system and the nomadic device. This also enables the transfer of the user I/O from the nomadic device to the AIDE vehicle adaptive HMI, which gives the system control over user interaction with the device. This control allows the adaptive HMI to enhance the user experience while maintaining an obvious safety benefit by limiting use at inappropriate times and offering emergency functionality appropriately.

11 Conclusion

In this Deliverable, the AIDE approach to the integration of nomadic devices in the vehicle environment has been described. A nomadic device gateway has been developed to enable a seamless communication between the vehicle system and the nomadic device. With this integration, information about driving conditions can be used to determine whether a particular nomadic device service should be permitted or not at a given moment. When the driving situation is demanding, some nomadic device functions (e.g., incoming phone calls) may be postponed until the driving situation changes. In addition, information may be shared between the vehicle system and the nomadic device so that vehicle I/O units may be used to control nomadic device services and display nomadic device information conveniently. Furthermore, vehicle system information (e.g., uneven axle loading) may be presented on the nomadic device. Therefore the integration should enhance driving safety and device usability.

One objective of this Deliverable is to propose recommendations for safe nomadic device integration within the vehicle environment. Based on the research and development detailed within this document and throughout the nomadic device integration effort within AIDE project, the following recommendations are made:

- A nomadic device gateway should be used to facilitate context passing between the vehicle system and the nomadic device.
- The standard protocol developed in conjunction with nomadic device forum partners for nomadic device gateway communication with vehicle systems should be adopted.
- Standardised communication protocol for communication between nomadic device and nomadic device gateway should be used. Protocol should be platform independent and connection independent. The protocol should function on any nomadic device, over any type of wireless or wired connection, and it should be robust enough to cope with the dynamic environment within the vehicle.

Key task of this WP is to enable the ICA functionality to ND applications. This could successfully be demonstrated by implementing the Nomad Device Gateway and a wireless interface with the ND using the Bluetooth technology.

12 References

[1] AIDE Nomadic Devices Forum, available online, cited 18.6.2007. http://www.aide-eu.org/for_nomadic.php

[2] Boverie, S. ; Bolovinou, A. ; Polychronopoulos, A. ; Amditis, A. ; Bellet, T. ; Tattegrain-Veste, H. ; Manzano, J. ; Bekiaris, E. ; Panou, M. ; Portouli, E. ; Kutila, M. ; Markkula, G. ; Agnvall A. ; 2006. DVE monitoring modules design and development – first release. AIDE Deliverable 3.3.1.

[3] Commission Recommendation of 22 December 2006 on safe and efficient in-vehicle information and communications systems: update of the European Statement of Principles on human machine interface. (2006).

[4] Deregibus, E.; Bianco, E.; Andreone, L.; Amditis, A.; Polychronopoulos, A.; Kussmann, H.; La Tendresse, I.; Van den Beukel, A.; Pringle, A.; Markkula, G.; Marberger, C.; Romera, M.; Bellotti, F.; Couvreur, C.; 2006. Driver-vehicle interaction and communication management. AIDE Deliverable 3.4.1.

[5] Kussmann, H.; Modler, H.; Engelsberg, A.; Amditis, A.; Andreone, L.; Bolovinou, A.; Couvreur, C.; Deregibus, E.; Engström, J.; Feron, S.; Kompfner, P.; Piamonte, P.; Pringle, A.; Robertson, P.; Scholliers. J. 2006. System architecture, data flow protocol definition and design and AIDE specifications. AIDE Deliverable 3.2.2.

[6] Kauvo, K.; Tarkiainen, M.; Koskinen, H.; Kompfner, P.; Amditis, A. 2006. In-vehicle integration of nomadic devices. Intelligent Transport Systems and Services World Congress 2006. ExCeL London, 8 - 12 Oct. 2006.

[7] Kompfner, P.; Vermassen, E., 2007. AIDE Nomadic Forum activities report. AIDE Deliverable 3.0.1.

[8] Piamonte, P.; Deregibus, E.; Romera, M.; 2007. HMI Components (Prototypes: displays, HUDs, speech I/O, sound etc). AIDE Deliverable 3.4.2.

[9] Recommendations from the eSafety-HMI Working Group (2005), Paris, France.