FINAL REPORT

CONTRACT N° : 2000-RD.10041

PROJECT N° : GRD1-1999-10041

ACRONYM : TRAVEL-GUIDE

TITLE :
TRAVELler and traffic information systems: **GUIDE**lines for the enhancement of integrated information provision services

PROJECT CO-ORDINATOR :
Aristotle University of Thessaloniki - Transport Systems Research Group

PARTNERS :

Aristotle University of Thessaloniki	(EL)
City of Thessaloniki	(EL)
Consorzio Intercomunale Area Fiorentina	(IT)
Institute for Human Factors and Technology Management	(D)
FIAT Research Centre	(IT)
MIZAR Automazione S.p.A.	(IT)
Rijksuniversiteit Groningen	(NL)
VTT	(FI)
Institut fuer Arbeitsphysiologie an der Universitaet Dortmund	(D)
Navigation Technologies	(NL)

REPORTING PERIOD : **FROM** April 2000 **TO** March 2002

PROJECT START DATE : 24 April 2000 **DURATION :** 24 months

Date of issue of this report : June 2002

Project funded by the European Commission under the 'Competitive and Sustainable Growth' Programme (1998-2002)

TRAVEL-GUIDE project
GRD1-1999-10041
TRAVELler and traffic information systems: **GUIDE**lines for the enhancement of integrated information provision services

Project co-ordinator:
Dr. A. Naniopoulos
Aristotle University of Thessaloniki
Laboratory of Transportation Engineering
Transport Systems Research Group
Ermou 61, GR-54623
Thessaloniki – Macedonia, GREECE
Tel:+302310256033,
Fax:+302310256037
e-mail: naniopou@spark.net.gr

Deliverable No: Final Report

Editor: A. Naniopoulos

Authors:	A. Naniopoulos	AUTh
	A. Bekiaris	AUTh
	P. Pavlakis	AUTh
	D. Nalmpantis	AUTh
	A. J. Roskam	RUG
	K. A. Brookhuis	RUG
	D. de Waard	RUG
	M. Dangelmaier	IAT
	C. Knoll	IAT
	P. Rämä	VTT
	J. Luoma	VTT
	L. Andreone	CRF
	F. Lilli	CRF
	S. Damiani	CRF
	M. Pasquero	MIZAR
	G. Ambrosino	ATAF
	N.D. Volo	ATAF
	W.Verwey	IfADo
	S. Brecker	IfADo
	C. Fokylides	CT
	P. Charalambides	CT
	S. Christotzoglou	CT
	T. Molenschot	Den Hague

Status: Final
Nature: Public
Submission date: June 2002

1 Table of contents

1 Table of contents 3
List of Abbreviations 5
2 Executive Publishable Summary 6
3 Objectives of the project 7
4 Scientific and technical description of the results 8
4.1 Introduction – why TRAVEL-GUIDE 8
4.2 A review of existing and prospective traffic information and traffic management systems, identification of gaps and priorities 9
4.2.1 Context / Introduction / Methodology 9
4.2.2 Review of existing and prospective Traffic Information Systems 9
4.2.3 Analysis of Human-Machine Interfaces concerning provision of information 12
4.2.4 Review of existing and prospective Traffic Management Systems 13
4.2.5 Cooperation between Traffic Management and Traffic Information Systems 15
4.2.6 Gaps and Priorities 17
4.3 Architecture of traffic information systems. 21
4.3.1 Introduction 21
4.3.2 Stakeholders of traffic information systems 22
4.3.3 Data collection modes and reliability 23
4.3.4 Towards an information provision feedback scheme 24
4.3.5 Towards a new service provision architecture 27
4.4 Development of scenarios for the evaluation of information provision 29
4.4.1 Introduction 29
4.4.2 Evaluation Scenarios 30
4.4.3 Evaluation Methodology 31
4.4.4 Evaluation Criteria 32
4.5 New schemes for integrated driver information provision services combining different information sources 33
4.5.1 Identification of areas of improvement 33
4.5.2 Optimisation of Information Presentation Modules, the matrix layout. 35
4.5.3 Development of integrated information provision aids and services 36
4.5.4 Implications for TMS (Traffic Management Systems). 37
4.6 Evaluation of pilots and testing 38
4.6.1 Introduction 38
4.6.2 Overview of the pilots and tests performed 38
4.6.3 Tests performed by AUTh 40
4.6.4 Tests performed by IFADO 42
4.6.5 Tests performed by CRF and MIZAR 42
4.6.6 Tests performed by RUG 43
4.6.7 Tests performed by VTT 43
4.6.8 Tests performed by ATAF 44
4.6.9 Tests performed by IAT 46

4.7 Design guidelines and best practices issues for driver information systems and services. ... 47
4.7.1 Introduction ... 47
4.7.2 Overview of pilot studies and focus of tests. ... 48
4.7.3 Contribution of TRAVEL-GUIDE to the improvement of transfer and integration of information ... 49
4.8 Cost Benefit Analysis, Dissemination activities and exploitation plan. ... 52
5 List of deliverables ... 54
5.1 Contractual Deliverables ... 54
5.2 Additional deliverables ... 54
6 Comparison of initially planned activities and work actually accomplished ... 55
7 Management and co-ordination aspects ... 56
8 Results and Conclusions ... 58
9 Acknowledgements. ... 65
10 References ... 81

List of Abbreviations

AVL	- Automated Vehicle Location
DRT	- Demand Responsive Transport
EI	- Environment-Independent (Guideline class)
FCIP	- Full Colour Information Panel
GPS	- Global Positioning System
GRIP	- Graphic Route Information Panel
GSM-SMS	- Global System for Mobile Communication - Short Message Service
ITS	- Intelligent Transport Systems
IV	- In-vehicle (Guideline class)
IVIS	- In-Vehicle Information System
OS	- On-site, roadside (Guideline class)
P&R	- Park and Ride
PT	- Public Transport (Guideline class)
RDS-TMC	- Radio Data System – Traffic Message Channel
SMS	- Short Message Service
TIS	- Traffic Information System
TMS	- Traffic Management System
VMS	- Variable Message Sign
VDS	- Variable Directional Sign
E&D	- Elderly and Disabled
GPRS	- General Package Radio Service
R&D	- Research and Development
WAP	- Wireless Application Protocol
WWW	- World Wide Web
PA	- Public Authorities
PT	- Public Transport
DVD	- Digital Versatile Disk
HTML	- Hypertext Mark up Language
PDA	- Personal Digital Assistant

2 Executive Publishable Summary

The main objectives of TRAVEL-GUIDE were, to:

- Develop guidelines for traffic related information provision by in car and infrastructure based systems.
- Assess the information needs of the end-users with respect to:
  - Content and presentation
  - Availability and reliability
  - Timing and priority
- Test new information provision methods.

Initially a review of existing and prospective: traffic information systems and services, traffic management systems, schemes of co-operation between the previous two families of systems and human – machine interfaces concerning the provision of information, has been performed.

Issues such as, foreign drivers and inter-border travel, the reliability of TI systems the integration of data exchange among traffic centers, safety related services, the financing problem of the investments have been also examined. Next an identification of gaps and priorities for future research and development was made for the above issues.

An evaluation methodology tailored to the TRAVEL-GUIDE pilots and not as a description of an evaluation framework applicable to the evaluation of TIS in general, has been produced, although some aspects can certainly be considered universal. The evaluation criteria outlined are useful for evaluation methodologies of other projects as long as the same impact area, is of interest.

Concerning the development of new methods for integrated driver information provision, as the number of gaps and inefficiencies identified is rather large, priorities for further research have been selected, and investigated in next steps of the project.

In TRAVEL-GUIDE eight tests and pilot studies have been performed. In summary these are:

Pilot 1 (IAT)	Comprehensible design of the output of in-vehicle information systems (Simulated: Computer mock-ups)
Pilot 2 (RUG)	Comprehensible design of Roadside information panels (Projected & driving simulator)
Pilot 3 (CRF)	IVIS (On-road: existing and new)
Pilot 4 (MIZAR)	In-vehicle, Roadside, External-to-internal
Pilot 5 (VTT)	Reinforcement of roadside information by means of integration with additional in-vehicle information.
Pilot 6 (AUTh)	VMS, GSM-SMS, RDS, Internet, Radio use (non-proffesional)
Pilot 7 (ATAF)	GSM, GPS, Radio use for professional drivers
Pilot 8 (IFADO)	TIS road tests on driver awarness (extra pilot study)

The review and assesment of the TRAVEL-GUIDE work, especially the part of tests and pilot studies has resulted in a set of guidelines and best practice examples. They are addressed to all actors involved in the “travel information chain” i.e. road operators, authorities, information providers and manufacturers.

Each guideline is presented in a format containing specific fields such as:

Code, category, target groups, short title, problem identified, example, documentation, references, testing verifications, suggestions for further research, remarks.

In total, have been produced 63 guidelines.

3 Objectives of the project

The main objectives of TRAVEL-GUIDE were to:

- Develop guidelines for traffic related information provision by in car and infrastructure based systems.
- Assess the information needs of the end-users with respect to:
  - Content and presentation
  - Availability and reliability
  - Timing and priority
- Test new information provision methods

Main innovative aspects of the project are the following:

- Assessment of the information needs of drivers, taking into account particular driver groups (especially travellers that are not familiar with the environment such as foreigners).
- Development of guidelines concerning the content, presentation, timing and priority of traffic information.
- Development and testing of new information provision methods that will attribute different interaction elements to different types of information to the driver, taking into account the overall processing capacities of the driver at any given time.
- Development of guidelines for road operators, authorities, information providers and system manufacturers on information provision to the driver for a wide range of driver aids.
- Improvement of the validity and reliability of traffic information and development of methods for the drivers/ users to provide feedback to the information provider.
- Investigation of measures of encouragement for the development of relevant market applications through the co-operation of road operators & authorities, information providers and system manufacturers.

4 Scientific and technical description of the results

4.1 Introduction – why TRAVEL-GUIDE

Traffic information systems, in conjunction with traffic management systems, can assist in reducing several negative aspects of road transport such as accidents, congestion and pollution by providing information and guidance for safer, more efficient and more environmental friendly use of the road transport infrastructure. In general, such applications permit a higher level of traffic intensity and decrease average travel times. Environmental impacts, in the form of emissions and fuel consumption are subsequently reduced by avoiding unnecessary driving. Moreover, the provision of accurate and timely information can significantly improve traffic safety, preventing drivers to be involved in hazardous situations.

An increasing number of information and communication technologies have provided the means for numerous applications of pre-trip and on-trip traveller and driver information, allowing a growing flow of information addressed at the driver and the traveller. However, the driver's exposition to increasing amounts of traffic information can often result in an information overload and, since not all information is necessarily useful, may distract the driver's attention and can even become a safety hazard. In addition, since most traffic information systems are planned taking into account almost exclusively local user requirements, the needs of other travellers, and especially foreigners, are not dealt with sufficiently (e.g. messages in local language). It is apparent that the design and implementation of traffic information systems should follow a more uniform process at a European level, especially in the context of the Trans-European Networks. Thus there is a need for an assesment of user needs at this level, aiming at the formulation of guidelines that will facilitate the development of efficient systems that will meet the needs of a wider range of users, including foreign, elderly & disabled and professional drivers. Such guidelines can only be developed at a European level, in order for European standards to be created and relevant EU policies in the context of the **Common Transport Policy** to be supported. **A stable European harmonised framework** within which service providers can provide cross-border services will help ensure the interoperability of the services on the Trans European Networks and facilitate deployment of the services across borders in a seamless way. Such a framework could also be used as a model for the extension of the value-added services into other parts of the road network.

TRAVEL-GUIDE is a project funded by E.U. / DG TREN in the FP5 GROWTH Programme. It is a shared cost project with a total cost of 2,281 K.EUROS and E.U. contribution of 1,550 KEUROS with a scheduled duration of 24 months starting from April 2000. The main issues addressed in TRAVEL-GUIDE were:

- Production of guidelines contributing to a common information concept of autonomous and infrastructure based systems (e.g. VMS and AICC info)
- In close co-operation with information system manufacturers and info service providers provision of advice to cover all 5 areas of concern:
    - Information usability and reliability (Why?)
    - Information content (What?)
    - Information timing (When?)
    - Information Priorities (Which first?)

- Suggestions for the extension and adaptation of the selected applications to all drivers, including professional drivers, foreign drivers, elderly and disabled drivers, etc.

4.2 A review of existing and prospective traffic information and traffic management systems, identification of gaps and priorities

4.2.1 Context / Introduction / Methodology

Technological developments of the last decade enabled a rapid increase of applications for traffic information provision to drivers and travellers. Advanced traffic information systems and services contribute to a safe, efficient and environmentally friendly traffic flow in the road network.
Only if traffic information is easily accessible, understandable and matched to user needs, information overload of drivers will be avoided. In a multinational and multilingual Europe it is a special problem that most traffic information systems currently consider only local and national user requirements. At the European level it is important to present traffic information in a form easily understandable by drivers and travellers even when they cross the borders of their home country.
The TRAVEL-GUIDE Consortium has conducted extensive literature reviews and information searches in the World Wide Web and also had direct contact with protagonists in the area of traffic information provision at an international level gaining insight into weak and strong points of the traffic information provision chain. Traffic information systems and traffic management systems have been reviewed and co-operation issues of the two families of systems were identified and discussed. Human-machine interfaces of different classes of in-vehicle as well as roadside traffic information systems were assessed.Results and recommendations are integrated in order to identify main gaps and priorities for future research and development.

4.2.2 Review of existing and prospective Traffic Information Systems

4.2.2.1 General review

Due to increasing demands on the capacity of the traffic network, optimised travel and traffic information is becoming more and more important. Traditional driver and traveller information provision methods do not match driver and traveller needs resulting from rapidly changing traffic environments. New methods of information provision allow a timely transmission of information selectively tailored to the needs of individual road-users. Pre-trip information systems provide essentially information related to the strategic planning of a trip. Information about temporary and long-term bottlenecks before starting a trip has major advantages. Traffic participants can choose between three different ways of travel change: Change of departure time, change of route, and change of transport mode. Advanced pre-trip information systems integrate data from several sources and present information to the driver and traveller through electronic communication devices. The source for trip planning support, with highest future potential, is the World Wide Web. Numerous Internet locations already offer their route planning and traffic information services free of charge. In addition to general cost-free services, subscribed users can call

sophisticated traffic information services and route recommendations based on their individual requirements on demand. Nevertheless, even advanced pre-trip planning services do not make use of all possibilities.
Advanced on-trip traffic information systems assist drivers en route, by providing continuously available and pre-selected traffic information and / or dynamic route guidance. Real-time traffic information allows re-routing in order to avoid ineffective traffic conditions. In contrast to traditional analogue broadcasting channels digital radio channels (Radio Data System – Traffic message Channel; RDS-MC / Digital Audio Broadcast; DAB) allow user-controlled presentation of pre-selected traffic messages. Traffic messages are stored in the memory of the system and can be retrieved on demand. In addition, information can be restricted to the areas or the driver is interested in. One promising aspect of digitised traffic messages for European transport is the easy translation of traffic messages into a driver's native language. Due to standardisation of digitally coded signals traffic information can be provided in a user-controlled language regardless of the country where the driver actually is. Dynamic in-vehicle navigation systems aim at computation of an optimal route based on user preferences as well as real-time traffic conditions. Dynamic route guidance generally integrates either information digitally transmitted via RDSTMC or information provided via mobile telecommunication (at present usually GSM/SMS). Although dynamic navigation is not employed very frequently yet, some applications are already available in lower market segments. Storage medium of road network infrastructures is generally CD-ROM. Navigation systems using DVD-ROMs with higher storage capacity are already on the market too. The problem due to the limited storage capacity of data carriers might be solved by 'off-board' navigation. Here the road network infrastructure is stored on an external central computer and the route recommendations are transmitted to the vehicle via telecommunication channels.
Mobile phone services are an alternative to radio traffic messages and dynamic navigation provided by fixed in-vehicle systems. On demand real-time traffic information and / or route guidance advice is displayed visually on the display of a mobile phone or is communicated via verbal instructions.
The objective of advanced collective roadside information systems is to optimise traffic flows in a limited traffic network according to selected network criteria. Messages displayed on Variable Message Signs (VMS) or Variable Direction Signs (VDS) are addressed at all drivers. Roadside information systems route and re-route traffic flows based on actual traffic or weather conditions and display road regulation information like warnings or speed limits. The purpose of infrastructure-based information systems is manipulation of traffic flows in order to reduce average travel costs for the traffic network as a whole. Therefore roadside information systems mark the border between traffic information systems providing information to road-users and traffic management systems influencing traffic flows.

4.2.2.2 Traffic information presentation

In general, all applications providing traffic information on-trip to road-users face the same difficulties. Perceiving and understanding system output may distract road-users from driving tasks with higher priority and draws away attention from the traffic environment. In-vehicle systems like navigation systems or mobile phones face similar problems regarding system input. Although most road-users are aware of safety risks due to the use of in-vehicle information devices some researchers propose to restrict all input interactions and provision of information not relevant for the actual driving task to situations when the vehicle is at zero speed.

4.2.2.3 Road user needs

The design of traffic information systems and services has to take into account a very heterogeneous road-user population. In order to stabilise and increase the benefits of new methods of traffic information provision technological solutions must be directed at human factors. Thus, design of traffic information provision methods should be human-centred. If traffic information is not matched to actual road-user traffic information needs, it will influence neither individual driving behaviour nor average traffic flows. Therefore understanding of requirements of different road-user subgroups is paramount.

Naturally, a major part of traffic information needs are shared by all drivers and travellers. Road-users want traffic information at the lowest price possible. Nevertheless, they expect efficient traffic information, that is timely, reliable and easily understandable, information provided in a safe manner. Besides such general requirements there is great variation at a deeper level regarding specific aspects of traffic information provision. Instead of providing the same information to all drivers, content and format of traffic information should be customised to the needs and preferences of different user clusters. The problems arising from the variety of road-users may be solved through traffic information systems adapting to the requirements of different road-user populations. Based on subgroup-specific requirements and individual preferences a driver should be able to select between different presentation forms, message contents and / or different message timing options.

As long as effective customisation to different road-user-subgroups is not possible information should be provided considering abilities and requirements of the least capable users. The danger to overload elderly or disabled road-users with additional traffic information is quite high, as road-users with decreased resources are closer to the limits of information processing capacities. A ‘design for all’ ensures high effectiveness for people with reduced resources too. A special problem is, that the information requirements of elderly and disabled drivers and travellers often exceed the information needs of average road-users. Such additional information needs affect usually the strategic planning of a trip (e. g. wheelchair users need to know entrance widths, location of elevators etc.). As comparable information is classified as pre-trip, it should better be restricted to non-driving situations in order not to distract drivers during actual driving.

Foreign drivers constitute a road-user subgroup that shares key information needs with elderly and disabled drivers. The difficulties of foreign drivers to comprehend the meaning of particular messages is closely related to the problems of elderly and disabled drivers. If traffic messages were designed in a self explaining manner (e. g. visual pictograms) neither foreign nor elderly and disabled road-users would have serious difficulties to understand the message.Unfortunately, visual pictograms related to traffic information are hardly standardised at a European level. Nevertheless, at least the language problem might be solved for foreign drivers in the near future. Digital traffic channels offer possibilities to translate digitally coded messages immediately into a drivers’ native languages. Another difficulty for foreign road-users stems from their unfamiliarity with foreign road traffic networks. It is well established that a driver’s familiarity with a road network affects the ideal type of traffic information. While, for example, drivers familiar with a particular road traffic network prefer short and simple auditory information about location and duration of an incident, unfamiliar drivers want detailed information about an incident and additional route recommendations and location information simultaneously, in a visual and auditory format.

4.2.3 Analysis of Human-Machine Interfaces concerning provision of information

In parallel to the review of traffic information systems and services human-machine interfaces of traffic and traveller information systems and services have been analysed. Systems judged as prime examples for different system and services types have been selected focusing on the question how traffic relevant information can be presented best to the driver. Expert assessments based on practical experience in real life with the systems have been carried out. Based on a user-oriented task scheme systems and services were ranked according to ergonomic (e.g. consistency of system structure, controllability, feedback etc.) and behavioural (information content, mental strain, sensory strain) criteria. In addition, conclusions were drawn to what extent the interaction with a particular system affects traffic safety. The following categories of systems and services have been assessed: Pre-trip internet services, on-trip navigation systems (static and dynamic), one GSM/WAP mobile phone service and roadside information systems (VMS).

- **Internet pre-trip information services**
  As traffic information and route planning web-sites are still mainly used today in the pre-trip stage, the human-machine interface has little impact on traffic safety. Therefore the contribution to traffic safety of these systems is graded quite high. What has been criticised most is the missing language adaptation. The services assessed offer no or very few language selection options. Learning the necessary input and output interactions can be quite demanding. The main conclusion drawn from the assessment of web-based pre-trip information systems is that the user has rather an orientation problem than an information processing problem. As the user has not to focus attention on the driving task all resources can be devoted to the intake of pre-trip information. Nevertheless, the effort to learn to control these systems can be quite high and time-consuming.

- **On-trip systems (static and dynamic navigation)**
  On-trip navigation systems show a versatile profile of strong and weak points regarding the HMI issue. Above all, the systems assessed seem to form a traffic safety hazard rather, than a contribution to safety. Here, the negative side-effect of new information systems manifests: Due to the additional information system load on the driver increases. Although the sensory strain exerted on the drivers is assessed as low, the mental strain to operate the systems is judged as high. This shows, that ergonomic criteria regarding output modalities (content, presentation form etc.) are better solved than ergonomic aspects related to the operation of the systems (access to functions etc.). Good information presentation is possible with small visual displays too. Regarding input to the systems, the more functions an in-vehicle system offers, the more difficult it is to make them accessible to the users in an appropriate way. Those systems showing a high functionality offering many options exert the highest mental strain on the users at the same time.

- **On-trip mobile phone services**

The tested on-trip mobile phone services provided traffic information on the mobile phone LCD display. Due to the reduced display space the information provided needs necessarily be to reduced to a minimum. Still, the limited space seems sufficient to provide the essential information. The evaluators tested this specific mobile service concluded that a low mental and sensory strain is provided at a high information content provided. This confirms that the dimensions of information output can be significantly reduced to key information on the condition that the particular information need is satisfied.

- **Roadside information systems (VMS)**

In this category, obviously no input or other operational activities of the driver are necessary. Accordingly, sensory and mental strain induced by the tested systems was on average low. An assessed parking guidance system, especially designed for the world fair EXPO 2000 in Germany, showed several minor disadvantages. Surprisingly, even though expecting millions of international tourists, it used German wording only. In addition, at major decision points drivers were confronted with far too much information. Due to the high information complexity sensory strain was temporarily very high. Nevertheless, besides these punctual disadvantages route guidance was safe and effective. Even better was the performance of an assessed VMS system focusing on traffic management based on weather conditions. Here, no difficulties were reported. The system did not show contradictions with traffic messages provided by in-vehicle devices. Thus, in both cases the information was sufficient, the self-explanatory potential of the systems was high and the system structure conformed to user-expectations.

4.2.4 Review of existing and prospective Traffic Management Systems

4.2.4.1 The typical Traffic Management scheme

The data collection and data processing necessary for traffic and / or traveller information provided to road-users is done by traffic management systems. More specifically, traffic management aims at efficient use of the traffic network infrastructure, based on traffic network capacities. Traffic management systems can broadly be categorised into two classes: urban traffic control systems and inter-urban traffic control systems. Both system types share general objectives like incident detection, reduction of travel times, priority for selected vehicles, congestion alleviation etc. Inter-urban traffic control centres can again be divided into two major types: Systems managing recurrent congestion and systems managing non-recurrent congestion.
The operations of traffic management systems involve three different stages: The data collection stage (by inductive loops, video monitoring etc.), the data processing stage (usually done in a traffic information centre where data from different sources converge) and the decision stage, where suitable actions are either initiated automatically or by human operators. In addition to the data used for traffic control, traffic management systems identify the information which is provided to road-users by traffic information systems.

4.2.4.2 Data Collection

A key instrument for incident detection and highway surveillance are inductive loop detectors. The issues and problems associated with data collection can be described representatively using this data collection method as an example. When the induction frequency of the electromagnetic field changes significantly in relation to a predetermined threshold a passing vehicle is detected. Data collected by inductive loops are either processed in traffic control centres or remotely in the field. Centralised processing implies higher control over aspects like data reliability and information deployment by higher costs due to higher hardware requirements for processing larger amounts of raw data. Loop malfunctions can produce erroneous detector data. The robustness of the system is closely related to its installation and maintenance. Maintenance for one year operation is approximately 10% of the price for purchase and installation. Some surveys show a range of system failures between 10% and 15%, and so it is highly recommended to inspect the systems 10 to 25 times a year as data have to be highly reliable and accurate for effective traffic management strategies. Therefore many traffic control centres work with combinations of tests for data validation. Validation techniques include identification of impulses in invalid time-intervals, comparison of detector data against realistic thresholds in specific time periods or comparison of one detector against the average of all other detectors at one station. Such tests serve a double function: They find erroneous data and identify wrong detectors.

4.2.4.3 Data processing and direct actions

The information obtained by different kinds of information sources is mostly controlled by a network of computer and communication systems located in the traffic control centre. Here, the whole data processing needed to interpret the data for initialisation of necessary actions is done. The algorithms detecting incidents have to be highly sensitive. Variables determining the effectiveness of incident detection algorithms are the false alarm rate (relation of incorrect alarms to the total number of algorithm applications), the detection rate (detected incidents in relation to the number of actual incidents in the data set) and the detection time (time needed to run an algorithm). Different algorithms have different data requirements (occupancy and / or volume and / or speed) and vary generally along the three dimensions detection rate, false alarm rate and average detection time. Incident detection algorithms can be split up into five categories:

- Comparative algorithms
- Statistical algorithms
- Time series and smoothing / Filtering algorithms
- Traffic model and theoretical algorithms
- Advanced incident detection techniques

After processing data traffic management actions are to be carried out. Exemplary actions are ramp metering and prioritisation of high occupancy vehicles. Ramp metering is used in order to limit the number of vehicles entering the freeway in order to keep the mainline volumes at tolerable levels. In ideal conditions the wait on the entrance ramp will be compensated by increased speeds once on the freeway.

The objective of high occupancy vehicle systems is to improve the capacity of congested corridors to move more people in a given time frame. This is done by providing travel time savings to high occupancy vehicles carrying a number of travellers. Exclusive lanes are separated from the normal traffic flow by physical barriers or separated lanes. The best way of optimising vehicle occupancy is by setting a minimum number of people per vehicle and rising this minimum when traffic flow increases.

4.2.5 Cooperation between Traffic Management and Traffic Information Systems

A wide range of actors is involved in the process of providing traffic information to road-users: Content providers, added value service providers, telecommunication operators, user organisations, equipment manufacturers etc. The roles of key actors vary across countries depending on national preferences and practices. In order to establish successful co-operation it is necessary to identify and clarify roles and rules of all actors involved.

4.2.5.1 The role of the public sector

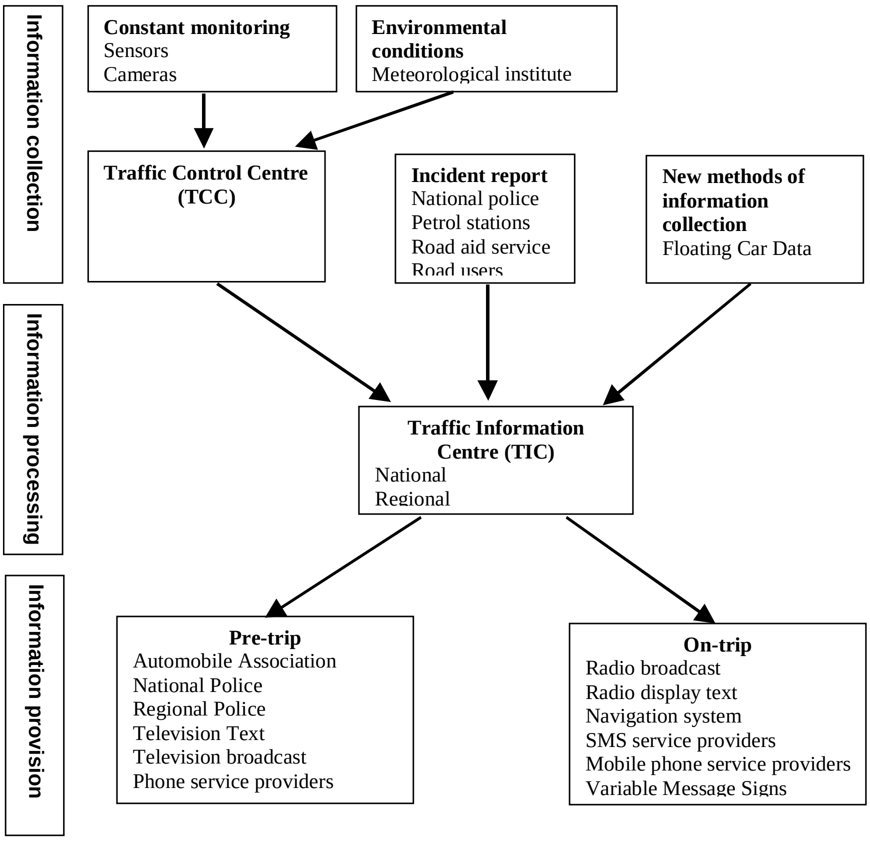
The deployment of traffic information and / or traffic management generally concerns a variety of authorities at different levels, e.g. the European Union, national and regional ministries, municipalities etc. As the public sector has a supervisory role to safeguard the general transportation interests of the public, it cannot overlook the implementation of traffic information and / or traffic management systems. Today, both system families are still regarded as technical solutions at the service of transport policy. The necessity to develop a policy context for these applications is not completely realised. A common approach defining the roles of the public sector is necessary in order to create confidence for commercial traffic information services to develop in the transport sector. The public sector can adopt one or more of the following roles:

- monitor (monitoring emerging technologies and analysing their effects)
- R&D agent (initiating and participating in strategic research programmes)
- innovation agent (initiating pilot and demonstration agents)
- operator (operating traffic information and / or management systems)
- user (of services provided by another party)
- regulator (regulating private sector operations)
- sponsor (starting up services serving a public interest).

In order to tackle present and future traffic problems traffic management and traffic information services have to be integrated, at best into a European context.
The collection, processing and dissemination of traffic information and traffic management data has to be organised in order to avoid confusion between the actors involved. The traffic data processing level has proved to be a suitable basis for this organisation procedure (see example of Fig.1), as all main actors have to communicate about issues like content and reliability of the data at this level. If the data processing level is well organised, successful conditions for all partners will be achieved. For the public sector it will not be necessary to co-ordinate all stages of the traffic information provision chain. In particular, co-ordination will not be necessary at the data collection and dissemination levels.
Removing barriers towards traffic information and traffic management services as well as setting the rules and guidelines, is one of the key responsibilities of the public sector. Each level of the traffic information provision chain can be performed by

collaboration between the public and the private sector. The definition of a general policy framework for public – private collaboration has to provide an overall structure for the provision of traffic information and traffic management services. Key questions that have to be considered include, the provision of public information to private sector service providers, the obligations placed on private service providers and the monitoring and regulation of service quality as well as user charges. Supported by initiatives of the public sector various actors may develop solutions adapted to the market and user needs.

Figure 1: Data integration at the processing level: The Dutch example



Typically, the private sector is seeking the following from the public sector in the area of commercial traffic and travel information services:

- Permission to install and maintain traffic monitoring equipment
- Guaranteed access to traffic data collected by public authorities
- Agreed rights to operate dynamic information services and broadcast information to subscribers without multiple permissions from different authorities
- Clear guidance on the authorities stance regarding road safety, HMI, traffic management etc.

4.2.5.2 Co-operation between actors in different European countries

The models of co-operation of existing across Europe can be classified into five groups:

- The state takes the full operational risk and imposes tasks on the private sector

- The state participates in the capital of the operator and is jointly responsible for the management of the company
- Initial or permanent public support to the private operator
- Financing of public services imposed by law or negotiations with the private sector
- The state puts the public or private service in a regulated framework (monopoly or competition)

The actual situation is naturally different in different European countries. In Finland, and comparably in Sweden and Norway, authorities are responsible for the whole traffic information provision chain. Only the distribution is partially taken over by a private company. There seems to be a lack of interest from the private sector, probably due to a perceived lack of customers. In Germany, systems and services are offered both by private companies and by pubic authorities. Basic services are provided by public authorities, while charged sophisticated services are offered by private companies. Public and private sector are active in both information collection and information provision. In general, collaboration between the local and the private sector has to be intensified, because at the moment traffic information provided by private actors and traffic management by local authorities, are not sufficiently related to each other. The situation in Austria is characterised by a nearly complete absence of private actors and slow and unreliable traffic data collection. The Netherlands try to co-ordinate traffic information provision at the data processing level. A good point in the Netherlands is the strong interrelation of traffic information and traffic management systems. The delay between the occurrence of an incident and its communication is minimised, so that traffic information is provided fast and precise. In Italy, the situation is marked by many different service providers owning or managing transport infrastructures. Therefore, lots of motorways, cities or public transport providers have their own traffic information or traffic management systems, as a consequence, the problem of integrating data from several sources is quite big. The first aspect of this problem is technical: Data from different sources are not always compatible. The second aspect is bureaucratic: There are a lot of private companies involved and they are obviously not always interested in publishing their data for other actors, possibly concurring to their own services. In Greece, traffic information and traffic management services are mainly provided by the public sector or by private companies working for the public sector. While the benefits of traffic information and traffic management systems are clearly recognised, public – private partnerships are however difficult to establish. Private companies hesitate to co-operate with authorities, partly due to the rigid organisation of the public sector. Nevertheless, most actors involved have concrete future plans for their systems expansion or for the development of new systems. Several ambitious developments are stimulated in Greece by the Athens Olympic Games 2004 Committee and the experience gained, will probably affect future systems and services and development, in this country.

4.2.6 Gaps and Priorities

A complete traffic information system or service supporting drivers and travellers during all relevant trip stages (pre-trip, motorised trip, public transport trip etc.) is still not available on the market. Most systems and services are restricted in that they provide only very particular support. In order to plan a trip in detail separate systems have to be used for different transport modes and / or trip stages. Whenever an individual system or service is used personal data like origin, destination, route type etc. have to be entered anew. As system and service interfaces are generally not standardised road-users have to learn interactions necessary for each system and service anew. Even advanced systems and services do not allow customisation of information provision to individual needs and preferences at a deeper level. For international transport, cross-border drivers and travellers face great difficulties when they try to plan their trip without much knowledge about international traffic situations. Therefore, integration of separated travel and traffic information systems and services to a European traffic information network, is a pressing issue for Transeuropean road transport.

4.2.6.1 Pre-trip information systems - gaps and priorities

Most web-based route recommendations are still static. Integration of real-time traffic information for web-based dynamic pre-trip information provision has to be extended. The on-line route builder services offered in the US (where the user provides his/her travel data and gets on-line route recommendations and time estimations) provide a good example of available technology for the task. In addition, pre-trip services can effectively support personalised information needs, by providing access through the Internet to local TI/TM sensors, such as real-time screen shots or even real-time video from particular TI/TM cameras, displaying to the user the current traffic situation at a given traffic node. This would serve people that wish to just cross traffic arterias or travel on highways for short distances at specific times. Furthermore, regional and national traffic information services should be connected to a traffic information service for the whole Paneuropean road network. Although advanced Internet sites provide information already in several languages a user-selected output language choice should be standard. Demand spreading by intermodal information provision has to be intensified. Obviously, pre-trip information should be provided adapted to the needs of different road-user subgroups. Succeeding steps have to deal with customisation of internet-based pre-trip information services to individual travel criteria. Alternative pre-trip information modalities, such as the Traveller Advisory Free Telephone Service or the Highway Advisory Radio, being standardised in USA, should also be promoted as alternative modalities to the Internet or fixed info points.

4.2.6.2 On-trip in-vehicle information systems - gaps and priorities

In-vehicle dynamic navigation systems, digital radio channels and mobile phone services face overlapping difficulties: In order to decrease negative impacts of in-vehicle information provision complexity of system input activities and output should be kept to a minimum. Where possible, voice-controlled input and output seems desirable, in order to keep additional loads on the visual channel low. A pressing issue regarding traffic safety is the timing of information provision. Where on-trip support is not called self-paced but provided regularly message timing is usually system - or service - controlled. Ill-timed messages may distract the driver or lead to intolerable driver workload increases during demanding driving manoeuvres. Message scheduling adapted to current driving conditions is urgently required. Although it is well established today that information processing resources and processing strategies of different driver subgroups are not the same, in-vehicle systems do not offer sufficient customisation options for different driver clusters. Likewise, individual needs and preferences are not considered at a deeper level. This might be a problem due to the relative youth of the in-vehicle driver information market. If the market were already well established system and service developers would have to direct their product development at specific consumer clusters. Regarding European transnational road transport, current systems and services do not support cross-border drivers efficiently. At this point, the potential of digitised traffic messages for foreign drivers has to be emphasised. Further development of in-vehicle systems capable to translate coded messages into a driver's native language should have priority for Transeuropean road transport. In addition, the standardisation of a single and common European Traffic Radio (in accordance to the US "Highway Advisory Radio") would help European citizens to have easy access to such info wherever in the EU.

4.2.6.3 On-trip roadside information systems - gaps and priorities

Infrastructure-based information systems like VMS or VDS have to present highly reliable information. Effective routing strategies depend on road-user trust into the information provided, because road-users balance the benefits of diversion against the risk of acting on inaccurate information. In order to facilitate message comprehension for foreign drivers, self-explaining pictograms harmonised across boundaries should be used for roadside information provision. Text-based VMS should not present too much information to avoid intolerable distractions of the drivers. As for all other systems and services, the guiding principle for traffic information provision to road-users should be maximum driver information value by minimum driver efforts to perceive, understand and use the provided information.

The analysis of human-machine interfaces concerning traffic information provision confirmed most of these observations. The less a driver is involved in interactions with a system, the higher a system's contribution to traffic safety is graded. It seems to be reasonable to restrict provision of information not directly related to car control and manoeuvring to non-driving situations and to reduce the amount of information of all on-trip messages to a minimum. This is the case for in-vehicle and roadside information systems as well. The lack of multilingual services was confirmed, too. In addition to the points already raised stronger feedback to the drivers from the systems seems to be necessary. For example, during dynamic navigation the message 'due to new information the system re-calculates your route' appears to be insufficient. The system should also provide background information like type of incident, benefit of the new route etc. in order to reduce the mental strain of the drivers. Stronger involvement of voice input and examination of haptic output possibilities are required. Furthermore, contradictions between in-vehicle and roadside information systems have to be avoided. Otherwise drivers have to solve difficult and distracting cognitive

conflicts resulting in drastic decreases of traffic safety. Finally, balancing a high system functionality offering many user options with an increased mental strain caused by higher system complexity is certainly an important issue for further development, especially regarding the required adaptation of traffic information provision to road-user subgroups and individual preferences, as all adaptation options will necessarily result in higher system complexity.
The goal for the future of traffic management systems is to reach the motorist before a congested area is entered. For the maximisation of the benefits of traffic management response plans for specific incidents are required. These response plans need to minimise the response time to an incident. Therefore it is necessary to include as many aspects into these plans as possible (emergency actions, signing implementation etc.). Co-ordination of response plans should be done by a response work team bringing together as many key actors (police, traffic management operators etc.) as possible. The US experience has proven that timely and reliable recognition of incident / congestion can not be performed if based only upon on site detectors and calculation algorithms and that data collection and confirmation by key actors should be maintained, and in fact intensified. Nevertheless, detecting incidents and congestion and responding quickly is not enough. Prevention is the key factor for future success. Therefore prediction of congestion and other incidents is essential. Another issue is the integration between traffic management at different levels (i.e. urban, inter-urban etc.) in order to provide drivers with homogeneous support and advice when they enter different levels of the traffic network. Finally, funding of generally cost-intensive traffic management systems is a crucial issue. For making investments feasible partnerships and alternative ways of funding are important. Alliances between private and public operators have to bring alternative financial resources for the implementation and maintenance of traffic management systems to the traffic sector. As a consequence there is a need for a general policy framework facilitating co-operation between traffic information and traffic management systems as well as the co-operation between all actors involved. As the preconditions in different countries and areas vary they should be taken into consideration. Guidelines and practices defined at a European level can be of great help at lower levels. The public sector has the possibility to determine the role of each actor, including its own. Minimum obligations and types of services to be provided should be identified. A common policy should be developed defining what kind of information can be given to the private sector on what conditions and also how quality of information can be assured. To establish the full advantage of new traffic information and traffic management methods the co-operation between traffic management operators (usually public sector) and traffic information operators (possibly private sector) should be defined. Integrated networks co-ordinating data from different sources have to minimise conflicts between the actors involved. In a multilingual European traffic environment, the presentation of information to foreign drivers is an important problem. A common set of obligations should be defined amongst the E.U. members so that this issue is not left to the free will of each country's operators. The definition of a common framework should help reducing risks of investment for both the public and the private sector. The very effective TI/TM standardisation scheme of Japan (where specific technical characteristics lead to three systems clusters) should be carefuly considered. Valuable private funds will

only be attracted to the traffic information and traffic management area if there is a secure and clearly defined investment environment.

An important related issue is the development of cross-border, multinational TI/TM networks, where one TM Centre can cover adjacent areas of more than one EU countries alone or in cooperation with TM Centres of other countries. The relevant cross-border, inter-state TI/TM in USA can be used as a good model to follow.

4.3 Architecture of traffic information systems.

4.3.1 Introduction

Stakeholders of traffic information systems cover a variety of roles. Part of them are public institutes, others are private companies. Traffic management is mainly a public sector affair. Management of a national road network is the responsibility of the national government, province or municipality. In general the focus is on the realization of the following three objectives:

- Ensure traffic flow
- Ensure traffic safety
- Traffic information provision to the public

In order to achieve these objectives the public sector has to adopt a variety of roles. Funds have to be allocated, policies have to be formulated and implemented, the network has to be constantly monitored and research on possible improvements has to be done. Not all of these roles are suitable for private sector interference, but for some private sector participation can be desirable.

From the country reports in task T1.1 of TRAVEL-GUIDE, it is clear that the private sector can adopt the role of information provider, host and service operator and equipment supplier in Traffic Information Systems. In Traffic Management Systems the role of the private sector is restricted to equipment supply. The actual management is the responsibility of the public sector.

The analysis of the flow of traffic information identifies three classes of actors:

- detection sources
- information service providers
- travellers, the end users

TRAVEL-GUIDE examined existing and prospective systems, including the information flow among actors, strong and weak points. Road coverage and information delay are the main classes of criteria.

A new kind of actor is emerging, who performs data collection but sometimes neither detection nor final service provision.

Three actual traffic information systems are analyzed in detail with the architecture scheme of KAREN, which is used as the European reference model. This document provides an overview of traffic information schemes, with the accent on the comparison of possibilities and limits.

TRAVEL-GUIDE investigated possible effects of the feedback from users, on the accuracy of the information provision in the reference architecture, in order to evaluate how such feedback can be beneficial for the information handling and provision processes. In more detail:

- Identification of the users
- Analysis of the information
- Investigation of the feedback provision schemes and associated issues (e.g. technical aspects related to data provision, time frame for the feedback, validation of feedback, co-ordination of alternative sources, institutional aspects, costs...)

Information technology provides the possibility of new channels and instruments to observe the use of broadcast services, along with traditional means, like market surveys, sale statistics and customer's complaints. Services with access upon connection – like telephone, Internet – allow monitoring the number of accesses. Sensors and networks gather automatically information on traffic, which can be useful for the evaluation of effects of a new service. It is also possible to monitor the journey of a vehicle – with the agreement of the traveller – with GSM or GPS technology.
The survey conducted by TRAVEL-GUIDE on existing traffic information systems showed that the systematic treatment of user feedback is unusual, at the moment, except for traffic advice, usually made with telephone calls. We can try to understand the potentials of information and what is going to be realized.

Information exchange among information centres is not widely developed at the moment. Problems are related to the ownership of data and to the lack of standard instruments and protocols. TRAVEL-GUIDE identifies the technical requirements of traffic information exchange.

4.3.2 Stakeholders of traffic information systems

For Traffic Information Systems actors are categorised on the basis of the communication channel used for the traffic information provision service. Evaluated channels are respectively: television, radio, Internet, phone, info kiosk and Roadside Information Systems.
Traffic management is mainly a public sector affair. The role of the private sector is restricted to equipment supplier. Traffic information provision services on the other hand are mainly a private sector affair. The role of the public sector is mostly restricted to that of data provider, although public sector actors are known to operate information provision services.
The beneficial effect of inclusion of private sector actors in either Traffic Management Systems or Traffic Information Systems is fourfold. Firstly the private sector can be imagined to be willing to invest a significant amount of capital, i.e. money and hardware. Secondly the private sector has to offer specific expertise and know-how. Thirdly the private sector has adopted a different management style compared to the public sector which can be valuable for instance with respect to working effectively in a low cost manner. Fourthly in general the private sector has to concentrate on fewer objectives, which also facilitates operating effectively and in a low cost manner.
The objectives both sectors hold are quite different. Whereas the public sector focuses mainly on accomplishing societal relevant objectives, the private sector is less societal oriented and focuses mainly on continuation of business. This difference in objectives the two sectors hold implies a different approach. Private sector actors will aim at providing a service for which the public is willing to pay and public sector actors will aim at providing a service, that serves the public and therefore must be available to all. Striking a balance between these two extremes by engaging in public-private

partnerships will most likely be beneficial. On the other hand the difference in objectives, poses specific demands on the specific roles that actors from each sector are to fulfil.
The choice whether or not to engage in public-private partnerships is dependent on the following three issues: Is the public sector capable of realising the formulated objectives for a service on its own, will the involvement of the private sector amount to added value and will the general interest still be safeguarded when engaging in these partnerships.

4.3.3 Data collection modes and reliability

Stakeholders of TIS can be divided into three classes, depending on their ideal function in the flow of traffic information. The first stage is the continuous monitoring of traffic conditions done by sources of information. Then the raw information serves as input for information provision systems, which process it and provide it to users. Travellers are the final actors in the information chain. In some case they need dedicated devices that receive and display the information.
The main sources of traffic information are the transport operators, both road administrators and public transport companies. Other important sources are the police, meteo institutes and also users.
According to the studies made in TRAVEL-GUIDE Work-package 1, the channels for the service provision to users identify four groups: pre-trip services, mobile phone based, in-vehicle devices, roadside.
Collected information passes several stages form the source to the provision service. In detail the first stage is the gathering from the sources. Different sources, with different protocols, observed parameters and aggregation rules, can be stored in a single homogeneous database. This function is usually operated by a source operator, or by the information provider or also by a third party. In the information chain the collection step sometimes is performed by a party that is neither the source nor the service provider.
The main information exchanges identified in the traffic information chain concern data flows among the four steps source, collection, provision, use. Four different actors can be involved, however not all traffic information chains include four steps.
The reference for traffic information communication at the moment is Datex. It offers a topological identification of roads and is event oriented. Looking at prospective traffic information systems and at new communication channels, Datex seems rather old and limited. It can not manage all the interesting data.
Considering the survey on existing and prospective TIS, the variables that should be sent out by a complete service provider are identified, in four groups: road traffic monitoring, parking availability, public transport arrival times, user interactions for special services.
The coverage of the transport network by existing TIS is usually at one of the two levels: national, with low detail, or local (metropolitan) with higher detail. For a more user friendly service, a single provider should cover the entire transportation network, with all the available information, both at the higher level of detail and with the maximum width, which should ideally be Europe wide.
The reliability of the service depends on parameters like information delay, since the event to the provision to the user, and like the detection rate of events. It has been

observed that reliability depends both on the technology used, and on the organizational structure. Structures that separate the functions and assign the roles to different operators, have some theoretical advantage, but at the moment they seem to pay for a lower reliability.

Three examples of TIS were analysed in TRAVEL-GUIDE as case studies. Two of them manage the traffic information of metropolitan areas, in Rotterdam and Torino. Fileplan Regio Rotterdam is a project born in 1996 with the explicit target to reduce the traffic congestion. It has some control function, like lane use and speed enforcement, and several user information channels. Fileplan Regio collects by its own detectors the traffic measures. It is interesting to see analogies and differences respect to Titos in Torino. This system is an extension to the urban traffic control system of Torino, called 5T, with the task of providing information both to final users and to other providers. 5T controls the traffic lights and VMS. In both the systems PT information is collected by the specific management systems.
The Automatic Vehicle Monitoring of Firenze is another kind of application. It performs bus location detection, service regularity control, and information to travellers at kiosks. It is very important the internal information exchange between bus drivers and the control room.
All the case studies have three important functions, described by Karen. Even if one of them manages a bus fleet, while the others work on road traffic, the theoretic architectural functions are similar:

- data collection: flow measurements on roads, parking availability and bus location;
- control actions: traffic lights, lane use, speed enforcement for private traffic and regularity control for public transport;
- traveller assistance: real time information provision.

Another function is emerging and is well identified in the current analysis. As the number of telematic application is growing, they often can have mutual benefits in exchanging information. Also the chain from data collection to the final provision, in some new situation is not performed under one only system, but different independent institutes or companies play a role. Data exchange with external systems can be recognized in all the three case studies and is even the main innovative task of Titos.

4.3.4 Towards an information provision feedback scheme

TRAVEL-GUIDE investigated the possible feedback from users on the accuracy of the information provided by the reference architecture, and to evaluate how such feedback can be beneficial for the information handling and provision processes. This work involved the identification of the users actually or potentially involved in the process and the potential benefits of providing the information, the analysis of the information subject to feedback in terms of main characteristics and in relation to the involved users, and the subsequent investigation of the feedback provision schemes and of the main associated issues. The work has been based on two types of inputs:

- the general concepts identified and defined for TRAVEL-GUIDE architecture.
- the specific case study architectures defined and investigated in the case studies of Torino, Firenze and Rotterdam.

With user feedback we mean what providers of information and traffic observers can know about users, their use of information and the induced effects.

The survey made by TRAVEL-GUIDE on existing traffic information systems showed that the systematic treatment of user feedback is unusual, at the moment, except for traffic advises, usually made with telephone calls. We can try to understand the potentials of this information and what is going to be realised.
Public Transport (PT) services include both regular (fixed route and fixed time table - based) bus services as well as more advanced, flexible services (like demand-responsive bus services, shared taxis and other door-to-door collective transport services); we can identify two relevant end (direct) – user categories: the passengers and the driver: PT users are interested in timely, accurate and rich information about available services, both pre-trip and on-trip (e.g. at stops, in vehicle); PT vehicles drivers are part of the service provision loop and are mainly interested in information related to service operations (e.g. delays, service regularity, events and service modifications, etc.). We can also identify another category in the information provision, that includes all the people with some interest in the system but not directly involved, like the maintenance staff, the operators of the TDC/Control Room, the PT company and Local Authorities stakeholders and the Mobility Agency for the overall mobility planning and the management of information in the metropolitan area.
The dynamic information which could be provided to the end-users at a general level includes arrival times of vehicles at bus stops, departure times of vehicles from terminal stops and indications of the line/platforms, delays, service modifications and disruptions mobility related events (e.g. road closures, strikes, etc.), route information for DRT services, etc.; this information is mainly provided at bus stops, at information kiosks located in key places, through in-vehicle displays and, quite recently, on the internet (dedicated web-sites).
The information provided to the drivers of PT vehicles includes bus location information, delay with respect to the scheduled service, mobility related events, service modifications, route information (i.e. origin, destination, stops, passenger related information…) in DRT services; the information is mainly provided through the in-vehicle terminal used in the normal AVM system operation.
In today’s PT service operation systems and schemes very little is done in terms of feedback from users on information provision; in principle, in the current AVM systems, the technical infrastructures required to implement some form of feedback on information is available, even if this is actually done only occasionally and not with a predefined scheme, and most often directly by voice. Feedback on information from end users are currently obtained only in indirect ways, as a part of customers’ surveys; such feedback, however, is provided only off-line and thus it can only be used to improve the long term planning and management.

The infrastructures required to implement feedback schemes from PT drivers are basically available (long-range radio/telecom networks, in-vehicle terminals, control centre…) and simple solutions may be realised with today’s equipment and operational conditions. For instance, it could be possible to use specially pre-coded message types to transmit drivers feedback with on-board terminals, taking also advantage from automated location information (via GPS). Using these methods, PT vehicle drivers can provide feedback on the information received and advise about it regularly and in more systematic ways than currently done in normal operations. This could be most beneficial when the information is provided by a TMS interchanging information with the PT management centre, so that PT vehicles can operate as additional floating car data sources for the TMS providing, at the same time, feedback on the information distributed by the TMS. This is probably more relevant and

effective when considering DRT services, where PT vehicles are not constrained to operate along fixed routes.
Implementing viable ways to get feedback on information from PT passengers seems instead more difficult and anyway limited to the information that users receive about PT services. Recently, some PT service operators started to provide dynamic service information through the users' mobile phones (for instance, providing information about arrival times of buses at stops); even if these kind of services are mainly still at an experimental level, these new developments offer a possibility of implementing feedback to the PT control centre about the accuracy of this information using the same means. In order for this to be practically realised and to get effective co-operation by the users over time, it is probably necessary that the users themselves are paid for their feedback. This could be done by appropriate subscription schemes where feedback provision allows the user to get reductions on PT service fares. These new systems really seem promising, and much more reliable than the traditional feedback collection systems such as the collection of complaints or market surveys.

Road travellers are one of the sources for congestion detection, just by calling the information centre using a dedicated toll-free number. Usually they are volunteer users, members of some associations or categories of professional travellers, like taxi drivers and lorry drivers. The information centre can be managed by private and public operators such as automobile clubs, private radio stations, etc..
This kind of source can cover a very wide network, without specific devices. As the source is human, usually without specific instruction, the reliability is low. It is generally useful to look for a confirmation of the advice. The reliability of each traveller can be estimated separately.
The instruments of GPS (positioning based on different satellite transmission) or GSM (mobile phone network with antennas on ground) allow to know the position of a GPS navigator or a mobile phone. The spatial and temporal resolution are sufficient for traffic monitoring purpose. Of course, in order for it to be monitored, the agreement of the traveller is the minimum requirement. If the traveller is a private user, he could be paid, with money or services on trade. In case of transport companies the position monitoring can be a component of the fleet management system, as mentioned before.
This kind of source is subjected to the user's behaviour about the kind of journey and the driving style. Short stops can be due both to traffic situation and to traveller decision for personal reasons. Then a statistical processing is necessary, or the confirmation from another kind of source.
Road operators and police usually gather complaints and advises, in case of service or infrastructure faults at light signals, toll devices, bad traffic control, public transport delay. Other advises regard safety problems, like vehicles stopped on the way, dirty pavement, or structural limits of transport systems.
All these advises need confirmation. The statistical behaviour of complaints can not be considered as an indicator of the system quality, since it depends on several parameters, for example the expectation of users to be really listened.
Market surveys are a traditional way to analyse users preferences. They are used occasionally in the field of traffic information systems.
The complete system of the transport network, traffic management, traffic information to drivers and travellers includes a feedback effect. Information influences the traveller – for example route, speed, departure time, transport mode – with consequences on traffic and transportation condition. This effect is one of the main

targets of many TIS, when the system is financed by road operators or public administration. As a consequence the comparison of traffic with and without the service is a matter of efficiency evaluation.
Sometimes the information service is considered a real control instrument in the hands of road operators.
The utility of collecting users feedback has to be underlined under different aspects: it is a source for traffic monitoring and a market indicator of sales and satisfaction, giving the opportunity to observe important variables on the users degree of confidence and satisfaction with the information provision, and in particular on its understandability, efficiency, credibility/reliability and utility.

4.3.5 Towards a new service provision architecture

In TRAVEL – GUIDE deliverables D1 and I1 the state of the art situation of TI and TM Systems has been examined. Main gaps of the existing systems were identified as well as points where the existing systems do not meet the users' needs. Each separate system or model examined presents advantages and disadvantages, weak points or problems that have to be solved but also strong points that could form a good example for the other systems. Above all a major problem seems to exist, more or less obvious, the fact that there are a lot of different systems, models and architectures used across Europe, in many cases incompatible, not utilising each others' strengths. Thus it seems that there is a need for a common architecture all over Europe, that will combine all the TI and TM systems available and will subsume them in a new service provision architecture.

The interoperability issue of Traffic Information and Traffic Management systems is a crucial one and is examined across different systems used, across different service models, across different countries. Most of the different TI systems currently used (or planned to be used) are operating separately, usually ignoring each other and as a result the information given is usually limited and sometimes in contradiction with information given from other TI systems, as a result their cost is multiplied. Some of the problems may be solved when there exists a Traffic Management Centre, or another form of an organized Traffic Management System. The integration of the different systems requires changes in the content and timing of the messages used in each one. Each different system should be used to cover a different aspect of the service. The two major categories of TI systems that need a different confrontation in general are the in- vehicle and the roadside TI systems. The roadside systems as a general, usually public paid system, should contain information of interest to every driver. In vehicle TI systems are by default more personal, user-oriented, can provide more timely and accurate information but have more safety restraints. A lot of work has been done on improving each separate TI system. The challenge today seems to be finding the most appropriate ways to keep the best of each TI system and make them work all together.

Different service models are unavoidable, as there are different stakeholders, different philosophies and different degrees of technological development. But whatever the model used there can and should be a common framework where all different service models should fit in, giving and taking as much as possible from each other. Issues that should be characterised as crucial should be named. Then information related to those issues should be named public and ways should be established to ensure that all TI systems possessing such information, no matter the kind of service model, will exchange it with the other TI systems.

As, a significant proportion of users are foreigners and as inter-border travel is a living reality in many interborder areas, the need for an interoperable architecture across different countries is more than obvious. A common way of presenting information must be adopted across all European countries. A form of presenting information that seems to be understandable for all is pictograms. RDS/TMC that is provided in nine different European Languages is another step towards the direction of interoperability although there are still official European languages that are not included. Another important aspect is the continuity of information across different countries.

The reliability of the TI systems is a crucial factor in order to gain the driver's acceptance. Reliability of the TI systems can be increased with the use of better, newer, more technologically sophisticated traffic data collection methods. Another important aspect when trying to ensure better reliability of the TI systems is the verification of the transmitted information. It is also important to ensure that different TI systems will not provide conflicting information.

Providing information for foreign drivers will soon become required all over Europe. So ways should be found that will provide information to road users no matter of the country in which they travel. Because choosing a language commonly accepted may be difficult and even if one is adopted it is not sure that every driver will understand it, at least for some basic messages that should be understood by all drivers, other ways of presenting the information should be examined. Apart from the problem of understanding a message, the content of the message should not be the same for someone not familiar with the network. Being a foreign driver does not have to do only with the language. The familiarity with the local network is another important issue. Even a person from the same country that travels to another city may be characterised as foreigner. So another important aspect is to provide to these drivers messages with easily understandable content.

Together with the information services to final users, also transport system management and traffic control ask for data exchange among management centres.
A clear strategy of integration and data exchange among traffic centres is a need. The tools of exchange are:

1. **Location referencing**, how to say where the information is about
2. **Data dictionary**, how to express the information content
3. **Interface approach** between centres, how to ask for information and when to send the requested data.

Safety related services, such as incident detection, incident verification, incident response and management, on-scene actions, traffic management, post-clearance actions are executed by various actors and control centres such as the police, the fire department, the ambulance service, the roadway assistance, the traffic management. However, the tendency and unanimous actors' opinion is that all functions should be managed by one (master) Authority. Most likely this Authority would be the Traffic Management Centre.

A problem that is not easy to be solved is the financial problem of the investments for the introduction of TI systems and the funding of the related operational management which assumes a relevant role especially at a local level. A first analysis of the problem underlines that the development policies should be based, as much as possible, on the structures of free market, even if the realisation should remain however under the regulatory environment established by the Public Authorities. This implies a new role for the Public Authorities (P.A.). It is generally agreed that in the future the P.A. should become responsible for the traffic and safety management, giving the strategic guidelines for each different ITS systems and services and the criteria for integrating these systems on the network, while the direct investments and management costs will be financed by private operators.

4.4 Development of scenarios for the evaluation of information provision

4.4.1 Introduction

In order for existing methods of information provision to be evaluated and new methods to be tested by TRAVEL-GUIDE with respect to suitability, an evaluation framework based on adequate scenarios has been developed, aiming:

- To develop a framework for the evaluation of the human-machine framework within the total framework of TRAVEL-GUIDE
- To develop scenarios for the evaluation of existing and suggested methods of information provision

The evaluation methodology developed in TRAVEL-GUIDE is tailored to the requirements of the pilots and is not a description of an evaluation framework applicable to the evaluation of TIS in general, although some aspects can certainly be considered universal. The evaluation criteria outlined in this Deliverable are useful for evaluation methodologies of other projects, as long as the same impact area is of interest.

The nature of information (complexity, on-demand services, internal or external information processing and generation) will enhance but also significantly extend (multiply) the evaluation scenarios. In addition, the integration of information of in-vehicle and infrastructure based systems requires the definition of services, the development of simulated services and their integration into an Auto-PC (or simulation).

A number of alternative configurations for systems and infrastructure that are included in each subsequent scenario, are chosen according to the priorities set by the TRAVEL-GUIDE participants. Scenarios are distinguished with respect to the type of road the information systems apply to, i.e. highway, rural and urban. In addition, the specific requirements of the various driver groups (foreign, professional, elderly and disabled) have been considered in respective sub-scenarios to be tested in the pilots.

A detailed evaluation methodology is developed in order for the demonstrator and pilot evaluations to be prepared. In the evaluation methodology three areas are covered; driver behaviour, user acceptance and system reliability. With regard to driver behaviour, the evaluation will be based on scenario analysis and will use a suitable model to describe decision processes, information identification, interpretation and evaluation.

A number of specific routes and information provision sequences has been chosen for the pilots, based on which existing and suggested methods of information provision will be tested. The number of combinations of specific routes and sequences was selected based on the results of Task 3.1 'EVALUATION SCENARIOS'. The evaluation methodology has been tailored to each specific test, allowed also for comparable results for all test types, i.e. simulator, in-vehicle and on-site.

The criteria for the evaluation of human-machine interfaces are developed in accordance with relevant human factors engineering methods. Measurable indicators of driver behaviour and reaction are defined and assessed to safety criticality, in order for the influence of alternative methods and HMIs to be determined. Special emphasis is given to driver behaviour and reaction parameters that are related to safety, workload, reaction speed, etc. The acceptable value ranges for the selected criteria are defined through an extensive literature survey and tests in the fourth framework project SAVE (TR 1047).

The criteria for the evaluation of the systems’ efficiency are developed in accordance with the guidelines of the Ministry of Transport and Communications of Finland. Suitable indicators are developed in order for TRAVEL-GUIDE’s contribution to be evaluated, taking into account the early results of the project.

4.4.2 Evaluation Scenarios

The objective of this part of the work was to construct scenarios describing a set of circumstances under which the pilots of WP 5 are to be performed. This should be done in order to guarantee that all aspects of interest to TRAVEL-GUIDE are covered and evaluated in the pilots. The pilots are designed to evaluate effects of Traffic Information Systems as proposed by TRAVEL-GUIDE on user acceptance, driver behaviour and system reliability. The matter has been approached as to provide a framework for evaluation, detailed descriptions of the evaluation scenarios are therefore not provided.

Based on the work done in TRAVEL-GUIDE's WP 1 'TRAFFIC INFORMATION AND MANAGEMENT SYSTEMS, USER NEEDS AND TECHNOLOGICAL GAPS' and WP 2 'ARCHITECTURE OF TRAFFIC INFORMATION SYSTEMS' and Task 4.1 'IDENTIFICATION OF AREAS OF IMPROVEMENT', five aspects are defined along which evaluation scenarios for the pilots of WP 5 are constructed. The scenarios serve as a framework for the evaluation of the pilots of WP 5 and define the overall layout of those pilots.

The following five aspects can be considered to be important contributors to the variation of the evaluation scenarios. Firstly, a classification has been made of the type of road user to be evaluated in the pilots. Four types of road users are defined: standard, foreign, elderly and professional. Secondly, three types of road environment are defined: urban, rural and highway. Thirdly, seven information categories are defined and rated by experts on their importance given the type of road user and the type of road environment. These categories include traffic, incident, weather, regulatory, infrastructure, navigation, and additional information. Fourthly, three categories of information provision systems are defined that have been evaluated subsequently in the pilots of WP 5. These are in-vehicle systems, roadside information systems and integrated in-vehicle and roadside information systems. Finally the areas in which the information provision systems can be improved, as defined in Task 4.1 'IDENTIFICATION OF AREAS OF IMPROVEMENT', contribute to the variation of the evaluation scenarios. The areas susceptible to improvement are: message content, message presentation, message reliability, message timing and priority, HMI, feedback quality and the location of information provision.

On the basis of the above mentioned aspects the framework for evaluation is outlined. Scenarios can be constructed by systematically varying the levels of the aspects. The framework provides an overview of the content of the TRAVEL-GUIDE pilots as a whole. It makes apparent what aspects will be covered and what aspects are left outside the evaluation process. Furthermore the framework can serve the researcher as a guide for the formulation of the pilot plan.

4.4.3 Evaluation Methodology

The aim here was to provide a general idea and practical tools for the evaluation of those Traffic Information System (TIS) and Traffic Management System (TMS) which will be demonstrated and tested in the TRAVEL-GUIDE project. Evaluation methodology includes tools to systematically describe driver reactions and to measure the impacts of the applied TIS/TMS. The evaluation focuses on the expected impacts but takes into consideration possible other impacts as well. Some measurements are tailored to the specific context of the pilot, others are suggestions for common measurements. The common measurements described will be further developed in an interactive process during final definitions of the pilots. This will enhance a harmonised approach in pilots and, to some degree, to enable site independent evaluation by combining the results.

The evaluation methodology includes the following three parts: (1) the measurements of driver behaviour, (2) user acceptance measurements and (3) reliability analysis of the systems in tests. Additional background information is given in the form of examples of evaluation procedures applied in earlier studies.

For the evaluation of driver behaviour three categories of measures can be used, namely performance measures, physiological measures and subjective (self-report) measures. Performance measures can be further sub-divided to in-vehicle measures and behaviour measures. For the analyses of behavioural effects dependent and independent variables in the pilots are defined first. Measurements are defined for the task performance, responses to output or information provided by system, for driver behaviour and for driver workload. Where possible the description is tailored to the specific pilots.

The suggested user acceptance measurements include forms focusing on satisfaction with the information/service, evaluating the human machine interface of the receiver, the willingness to pay and the user's profile.

The reliability measurements guarantee that the system will technically function as intended during the tests. The timetable for the evaluation phase of the system is considered to ensure that the reliability data are utilised as feedback information during the system development. For each pilot the list of parameters will be reported, which are considered fundamental for the system reliability. Furthermore, the methods for the measurement of these parameters, based on the architecture of the TIS/TMS will be developed. Hardware and software components and other interesting parameters (the correctness and time transfer of the data to the vehicle, for example), will be tested and evaluated in order to provide feedback to the development phase for improving the system and to avoid incorrect functions during pilots. It is highlighted that each pilot has a different architecture and some of them are only simulator based and do not require all aspects suggested.

4.4.4 Evaluation Criteria

The aim here was to define criteria indicative of effects of the utilisation of TIS on the user. A user can be defined either as a person, i.e. a driver or as a company implementing TIS. When regarding the driver, the utilisation of TIS will primarily have an effect on his or her performance as a driver and thus indirectly on traffic safety. With respect to companies as a whole, it can be reasoned that implementing TIS will have effect on fleet efficiency, network operation, commercial aspects, and organisational aspects. In this task suitable measures for these areas are provided as well as corresponding criteria.

In this task a method is proposed and discussed, to index to what extent the driver performance can be considered impaired (in the following referred to as driver impairment). The approach described presents a decomposition of driver errors into operationalised measures of driver behaviour with the aim to monitor its safety. This analysis represents the first step towards the development of realistic criteria for determining impaired driving. The crucial aspect of criteria development concerns how to define the magnitude of change and those boundaries of driver impairment, which separate safety-critical changes from nonsafety-critical changes.

In order to be able to measure driver errors, driver behaviour must be decomposed and operationalised into quantitative data. This translation shifts the definition of impaired driving from a behavioural level to a sensor level. The first step in this process is to substitute vehicle measures for the appropriate category of vehicle control.

The utilisation of a multidimensional approach (i.e. using psychophysiology, observation and direct measurement of driver performance for the assessment of impaired driving behaviour) has a number of advantages in terms of improved sensitivity and validity.

Both absolute criteria and relative criteria are necessary in order to fulfil the paradoxical goal of providing a definition of impaired driving which is consistent, yet adaptable to inter-individual differences. However, within the current context, it is essential that driver performance itself functions as an anchor point for all other measures. The development of criteria to define driver impairment is necessary in order to:

a) define the validity of other indicators from different domains of measurement;
b) identify the magnitude of performance decrement to provide contextual information to a warning device.

The second step in the process is therefore to translate the categories of driver impairment into both relative and absolute criteria with respect to the selected measures of driver behaviour. It is proposed that absolute criteria be defined by those instances of driver behaviour which are deemed to be unsafe in general. These criteria may be defined in a qualitative fashion, e.g. driver starting to run off-road, or in a quantitative manner, e.g. SDLP of the vehicle surpassing a trigger level of 26 cm as in the alcohol case.

Furthermore the aim of this part of the work was to specify criteria for evaluation of effects of the implementation and utilisation of TIS in businesses. The defined areas of measurement are fleet efficiency, network operation, commercial aspects and organisational aspects. The selection of useful criteria for these areas follows rather closely the work done by the Finnish Ministry of Transport and Communications as publicised in the report "Guidelines for the evaluation of ITS projects".

4.5 New schemes for integrated driver information provision services combining different information sources.

4.5.1 Identification of areas of improvement

The results of the TRAVEL-GUIDE research about existing and prospective Traffic Information and Traffic Management Systems indicate that a system that supports a driver in all stages of the trip does not exist. Using separate systems and services for trip segments requires the user on the one hand to repeat the admission of his personal data (origin, destination, etc.) several times and on the other hand to get accustomed to the functionality of yet another system or service. Other identified deficiencies of existing systems and services are:

- Rather low degree of potential customisation of the services and systems to personal needs
- Too less real-time traffic information provision (especially by pre-trip services)
- Rather low facilitation of cross-boundary travelling
- Incomplete investigation of information presentation and timing on several systems
- Inadequate application of research findings

These and other aspects are subsequently addressed. The focus is on on-trip systems, both in-vehicle systems and roadside information systems, as well as the integration of both.

4.5.1.1 Areas of improvement in the field of in-vehicle systems and services

The services related to in-vehicle-systems and adressed in TRAVEL-GUIDE are:

- Traffic congestion information (either on request or automatically: location, cause and (estimated duration)
- Dynamic navigation on demand (step-by-step routing for unfamiliar drivers (visually and acoustically supported or reduced routing with main emphasize on congestion warnings for familiar drivers)
- Parking area information (either on request or automatically: location, (estimated) number of free spots, price per hour)
- Parking area routing (either on request or automatically: nearest parking zones are uploaded from server -> The parking zone becomes target for the dynamic navigation on demand system)

The selection of these services and their information content has been made as a result of insufficient information provision today. These services will be delivered to the driver through an in-vehicle system integrated within the Traffic Management System. The optimum distribution of information between in-vehicle and infrastructure based systems and services are examined in TRAVEL-GUIDE pilots where the need for user group dependent information provision (familiar / unfamiliar drivers) is also considered.

4.5.1.2 Areas of improvement in the field of roadside traffic information systems

Advanced roadside traffic information systems like Variable Message Signs (VMS) and Variable Direction Signs (VDS) play a major role in strategies trying to influence individual and collective traffic behaviour. Roadside, generally location-specific infrastructure-based traffic information systems aim at efficient and safe use of the capacities of the traffic network. VMS systems 'have been one of the most implemented and used telematics systems' in the European transport area (CODE TR1103). Traffic flows can be influenced by VMS systems by provision of dynamic on-trip traffic information and / or traffic regulation messages adapted to real-time traffic conditions.

In order to achieve this goal messages have to be:

- consistent
- easy to perceive
- easy to read
- easy and immediately understandable for the road-user
- highly reliable (compliance of drivers to VMS advice depends heavily on driver trust into the accuracy of the messages)

All these requirements lead to the postulation that -besides considering the relation between this particular information provision method and driver's traffic information needs- VMS standards should be mainly based on the driver's information processing capabilities; the "Human-Machine-Interface harmonisation" is very important in order to maximise the benefits of dynamic information provision by VMS systems.

4.5.1.3 Areas of improvement in the field of integrating in-vehicle systems and roadside information systems

The integration of in-vehicle systems and roadside information systems is by far not developed enough, the potential of it is not exhausted yet.
Traffic information provision can benefit from an integration of roadside information systems and in-vehicle systems with respect to the following:

- Real-time, up-to-date traffic information provision
- Information provision differentiated to user group
- Language independent information provision

Traffic management can benefit with respect to the following:

- Data collection
- Differential data analysis
- Information provision as traffic management tool

It can be imagined that the following information categories are relevant for road users:

- Traffic information (traffic density, flow, travel time, etc.)
- Incident information (emergencies, accident, construction, etc.)
- Weather information (fog, snow, etc.)
- Regulatory information (speed limits, access restrictions, etc.)
- Infrastructure information (tunnel, junction, automatic tolls, etc.)
- Navigation information (route guidance, trip planning, etc.)
- Additional information (tourist information, Internet, infotainment, advertisements, etc.)

Before integrating them into a system, several issues like:

- Which type of information has to be/can be presented on which system
- How to present information (in a more or less universal language)
- Requirements of TIS and TMS with respect to hardware, software, structure and organization

have to be examined and the specific adaptability of both types of system to each other is yet to be explored.

The proposed evaluation pilots in TRAVEL-GUIDE WP 5 concentrate mainly on informational aspects (presentation, content etc.). Other issues to be addressed are effects on driving performance and user acceptance when using both systems. Several categories of road users will be considered (standard, foreign, elderly and disabled), where under the light of the objective of TRAVEL-GUIDE special attention will be devoted to foreign drivers. Technological issues of integration will however only be addressed indirectly.

4.5.2 Optimisation of Information Presentation Modules, the matrix layout.

The major gaps identified in T4.1 were the main points of interest in the pilot tests of WP5. To check the coverage of the TRAVEL-GUIDE pilot tests and to visualize in how far identified needs are to be covered by the TRAVEL-GUIDE interface

solutions a matrix has been developed. It has been extended by the integration of user needs identified in the KAREN project (Karen TR 4108).
After being modified with respect to the input and the annotations of all project partners, the matrix contains the following user needs:

- General Road User Needs
- Needs of Different Road User Subgroups
- Additional Needs of Elderly and Disabled Traffic Participants
- Additional Needs of Foreign Road Users
- Additional European Road User Needs

Each partner involved in the pilot tests in WP 5 marked the relevant constellation of gaps recognized that are addressed in his respective pilot test. Furthermore an explanation will be given how this is realized. After describing each single pilot test layout, the synthesis of all matrixes gives an overview over the entity of pilot tests carried out.

4.5.3 Development of integrated information provision aids and services

The tests executed in WP5 have been planned in this part of WP4. They are mainly concentrating on the optimisation of the link between the traffic information which is provided by advanced systems and services and the driver as the user of traffic information. Structural aspects of traffic information provision (format/HMI, content, timing etc.) are therefore of main interest in these tests. The effects of different manners to provide traffic information on driving behaviour and on user acceptance have been examined with respect to different needs of different driver groups.

Although the technical background of the pilot experiments is rather of secondary importance (as the objective of TRAVEL-GUIDE is to develop best-practice guidelines for the use of already existing traffic information systems and services, and for the development of prospective systems and services) giving insight into the development of those information provision aids and services that are tested by the empirical studies of TRAVEL-GUIDE WP5 is important to understand their results and declarative ability.

Suggested improvements of systems and services in the field of TIS (Traffic Information Systems) in the TRAVEL-GUIDE pilots are:

- a telematics support infrastructure and ITS systems to analyse and identify types and levels of PT-related user information needs (ATAF)
- a synchronized network for the traffic information process including evaluation of communication protocols between subsystems; Evaluate and compare all information output given by TIS (AUTh/CT)
- various pictograms to test the comprehensibility of information that is presented on roadside information systems (RUG)
- an instrumented vehicle providing different feedback-levels and driver monitoring; Study of work load in real traffic (VTT)
- an instrumented vehicle with LCD display that provides various information to the driver like Traffic Congestion Information, Dynamic Remote Navigation

on Demand, Parking Area Information and Parking Area routing; Test of usability/ acceptability (CRF)

- a HTML-based virtual HMI simulation to test visual and acoustic information provision in a fast and uncomplicated way with a standard PC (IAT)

4.5.4 Implications for TMS (Traffic Management Systems).

The TRAVEL-GUIDE research has raised problems and difficulties related to present and prospective traffic information services. The knowledge of many systems is a very important resource. Each of them presents some interesting solutions and also limits, or problems. We have tried to suggest how to solve the problems and how to approach and meet the user needs. In the previous of the present report the reader can find proposals for new methods and interfaces in travel information. They require some trick also in traffic management systems, especially in the information gathering functions, which are directly involved in the information provision to users.

Three main subjects of management systems are addressed by TRAVEL-GUIDE new proposals. First which data content should be supplied to user service providers, in order to allow the production of effective and reliable services. Second the roadside information provision, usually directly controlled by traffic management systems, is target of suggestions and evaluations. At last, many technical operational questions on the design of the management systems.

Traffic warnings are an important class of information service to travellers. Experiences in the sector suggest to diffuse only verified messages. The sensibility of an operator cannot be replaced by a computer for taking decisions on the opportunity to broadcast an event. To define the entity of a congestion one parameter is not enough for complete information. In particular expert drivers and foreigners have different perception of anomalies in frequently congested networks.

Other user addressed services are processed on the observed traffic condition of the whole transport network. Then management systems will integrate direct measurements with estimations as accurate as possible on the rest of the transport network. The need for future conditions can be satisfied with provisions, or also with historical series, which are less onerous to supply.

Roadside information provision – especially in the form of variable signs – in consequence of the next diffusion of in vehicle systems will specialise on general interest information and messages that must be widely diffused. At the moment variable roadside information, where available, is generally well accepted by users. Exceptions can exist in case of low reliability or difficulties to understand.

The solution of the information technical problems identified by TRAVEL-GUIDE, provokes several requirements also on management systems. Strictly related to user needs is the possibility to be understood by foreigners, that can be solved by language independent communications or with different translations of messages.

On a more technical level, the design of traffic management systems defines data protocols. Regarding the location of information on the transport network, Alert C is at the moment the most diffused way, but will probably be replaced by *on the fly* systems.

At the moment the high number of existing exchange media discourages data exchange between traffic centres. Standardisation is strongly needed in this field. Between traffic centres and in vehicle systems data exchange will develop in both directions as its potential is impressing.

The question of data exchange involves also database structures and relative interfaces. The correlation among systems managed independently can be the federation, that needs no central authority.
When providing information the reliability determines the success among users. When a management system supplies data to a service provider, it can join a reliability index to each piece of data, depending on the gathering instrument, if it is directly measured or estimated, if checked and confirmed. In case of information sale, reliability will be defined by contract. Anyway the commercial orientation in communication media is generally towards free and wide distribution.

4.6 Evaluation of pilots and testing

4.6.1 Introduction

TRAVEL-GUIDE WP5 aims to demonstrate and test the implementation of existing driver information systems and services and to identify the possibilities for further improvements. Furthermore, activities in pilots and tests have demonstrated and evaluated the new methods of driver information provision suggested by TRAVEL-GUIDE and investigated the efficiency of driver information and driver management systems in actual situations. A set of tests has been run: from the tests in actual situations to computer and simulator tests for existing and suggested methods. In total, nine pilot studies have been conducted:

- Actual large scale demonstration with driver information systems already developed (A.U.Th. tests)
- Actual on-road tests to evaluate the impact of the information systems on the user traffic awareness (IFADO tests)
- Computer mock-up's (using available software), for concept evaluation (IAT and A.U.Th. tests)
- An expert workshop in which ergonomic experts completed a questionnarie on the design of the information panels (RUG tests).
- Projector experiments in a classroom for preliminary tests for the information panels evaluation (RUG tests).
- Driving simulator tests for the information panels evaluation (RUG tests)
- On-vehicle test using an available demonstrator in order to evaluate acceptabilty and willingness to pay for dedicated services (CRF-MIZAR).
- Vehicle test for buses (ATAF tests)
- Vehicle tests for reinforcement of roadside information by means of integration with additional in-vehicle information (VTT)

The pilot sites are located in areas with a considerable number of foreign and professional drivers.

4.6.2 Overview of the pilots and tests performed

The Pilots and tests performed in TRAVEL-GUIDE are related to four different kinds of evaluation methods and objectives.

The pilot and test performed by A.U.Th. concerns both the evaluation of an information providing system in a real context of use (the city of Thessalonics) and the evaluation of a computer mock up of the TRAVEL-GUIDE system. The aim of the first is to understand if and how a traffic information system can influence the mobility, the city accessibility and the city friendliness. Furthermore, it has been evaluated if an appropriate mix of traffic information systems in a particular area could make travelling quicker, safer and more comfortable. The mock up evaluation aimed to understand the user acceptance, interface usability, the efficacy of the monitor location and of the presentation of acoustic signals related to the TRAVEL-GUIDE system.

Starting from the assumption that a Situation Awareness plays a key role for safety and performance in dynamic environments (because an appropriate mental picture indicates that an operator has a suitable perception and comprehension of a given situation) the tests performed by IFADO examine components of drivers' Situation Awareness in real traffic scenario as a function of traffic situation complexity and the drivers' task. Starting hypotheses were:
1 Situation complexity influences drivers' SA.
2 Depending on the traffic situation and its corresponding driving task, different traffic
components (vehicles, pedestrians, non-traffic elements etc.) are considered relevant.

The CRF study focused on determining if users' parking and traffic information needs are satisfied in an easy to understand and useful manner by the TRAVEL-GUIDE system.
In particular, the aim of CRF analysis was to explore the general acceptability and perceived usefulness of these two services. In particular, the activity aims to understand:

- How people nowadays obtain parking availability and traffic conditions information;
- Whether or not people would like to have such services directly on their cars, with these features ("on-demand" services);
- Whether or not information content is suitable to drivers needs;
- How people perceive the potential cost of these services and which could be participants' Willingness to buy.

Finally the study conducted by RUG focuses on roadside information systems. In particular the road demonstrator assessment is intended to evaluate design and layout aspects of route information panels and to evaluate the impact on driver behaviour of different information provided by roadside information panels. The design session has been slitted in three parts. The first one was intended to study basic design features related to comprehensibility and preference. So twelve basic information panels were designed and evaluated with respect to comprehensibility and user preference. The second one aimed to test, in the driving simulator of the University of Groningen, seven of the panels designed according to the results of the first phase; comprehensibility and effects on driver behaviour have been evaluated. The last session was intended to evaluate a final selection of route information panels, made on the basis of the results of the second part. The information panels have been implemented in an actual road environment, namely the A-12 motorway that leads into The Hague. By means of direct interviews road users could evaluate the route information panel with respect to comprehensibility and mental workload

The deliverable 5 reports the test sessions run during the project task "Evaluation of pilots and testing". The report shows the results of the demonstrations and tests that have been performed in different scenarios (mock up, simulator, on-vehicle, on-road, vehicle test for buses) in order to evaluate the impact of information provided by telematics systems and to obtain information on the driver usability and acceptability. To ease the reading a general description has been reported before the full details of the specific pilot and testing methodology and results.
The final results have been exploited in next steps of the project, in particular for the WP7, aimed to identify the guidelines for the information providing.
In the following paragraphs a brief overview of each test has been provided and a short description of the methodology adopted as well as of the results achieved have been reported.

4.6.3 Tests performed by AUTh

In the Thessaloniki pilot, various different traffic scenarios by various drivers/user groups have been examined in urban environment, i.e. in the Thessaloniki city center. Existing and under development, infrastructure and roadside, pre-trip and on-trip information systems have been used. Thus, traffic information was available through a synchronised network of, Variable Message Signs, Radio, RDS, GSM-SMS and Web service.

Pilot plan – pilot realisation

32 drivers, have been selected: 12 typical (average age: 38), 6 elderly (average age: 61), 6 disabled (average age: 29) and 8 foreign drivers (average age: 25).
A route map with two alternative ways was pre-defined, departing from the two main city entrances and targeting to arrive at one of three selected parking areas within the city center.

- The 10 scenarios created, covered the use of every system itself and systems combinations, by every user group.

Data collection – analysis and results

A detailed questionnaire was filled in after each user's task completion by AUTh's staff, who were located in the two "terminals" where drivers concluded after their trip. It has 9 main sections of questions covering various issues. An effort was made, where possible, to quantify answers thus having a measurable result. There was though place for receiving many qualitative remarks and suggestions which were proven very useful. All the questionnaires were next processed using the MS Excel computer program. The qualitative answers have been processed separately. Analyses were made by driver group and next by system.

In addition, a set of Design Guidelines have been produced concerning:

- o Information Providers
- o Traffic Information Systems
- o Authorities
- o Road Operators

Some main results and suggestions are the following:

- Each Traffic Information System plays a particular role in the information chain and “areas” can be defined during the travelling task where the usability of system is particular strong.
- Where many Traffic Information Systems exist they should work complementarily utilizing their particular strengths.
- An appropriate mix of Traffic Information Systems in an area can make travelling quicker, safer and more comfortable.
- For elderly and disabled drivers appropriate relevant Traffic Systems can be enabling factor for realizing a journey, thus influence significantly their mobility.
- For foreigner drivers appropriate Traffic Information Systems can significantly influence their mobility, city accessibility and finally city friendliness.
- The pilot has resulted in many data concerning the usability of systems used i.e. V.M.S., Radio, R.D.S., S.M.S., Internet as well as the views of various driver groups such as Typical, Elderly, Disabled, Foreigners. They can be utilised in various ways and mainly in the productions of design guidelines concerning information systems.
- The different user groups have shown different requirements concerning the use of information systems. This on the one hand requires that their implementation should take into consideration and try to synthesise their particular needs, on the other it is important to have many systems working in an area so that each user group will be addressed to the one that suits better to them.
- *Common data exchange protocols and smooth co-operation between the different information providers and operators:* Different actors on information providing must agree to a common way of exchanging data in terms of ease of communication and compatibility. A smooth TIS/TMC operation is required, providing to the users the impression of a unique and robust information provider.
- *Additional info is required and appreciated by the users (weather contitions, addresses, telephone numbers, incidents, roads to be closed, estimated travel times):* Many users require – beside the traffic/parking info - additional information concerning the weather current and estimated conditions, addresses and telephone numbers of the parking areas e.t.c. This seems to be useful and applicable in certain systems (i.e. internet), though attention must be given to the increase of information on a each single system.
- *Incident information provision requires by the users an explanation about causes:* In any information provision system (VMS, radio, RDS, internet, SMS, in car devices e.t.c.), an incident message must be presented together with a brief cause explanation. In that case, users pay more attention to the warning message and understand better the situation.
- *Special interest on info for disabled users – “Awareness raising”:* Whenever applicable, special information for disabled users – even for non-drivers – has to be provided: traffic info, parking availability, city guidance when using only the wheelchair e.t.c. A side effect of this will be the “awareness raising” of all the other people. This is particularly recommended for “2003 the European Year of people with disabilities”.
- *Special info for people with disabilities by various means:* Taking advantage of new technologies and the internet, a special and detailed information provision for people with disabilities could take place. Detailed web sites with transportation information, route guidance, city accessibility info e.t.c. is the best information

provision system for disabled people. Additionally, a printed leaflet/book with the same more or less information could exist.

4.6.4 Tests performed by IFADO

According to Jones & Endsley (2000), understanding the relation between information extraction and adjustment of the corresponding mental model to the current situation is important, because it can provide insight into the nature of representational errors, and thereby into accuracy of an operator's situation awareness. The test performed by IFADO examines components of drivers' situation awareness in real traffic as a function of traffic situation complexity and the drivers' task. Key hypotheses are:
Situation complexity influences drivers' situation awareness.
Depending on the traffic situation and its corresponding driving task different traffic components (vehicles, pedestrians, non-traffic elements etc.) are regarded as relevant.
The study focused on traffic situation assessment of active drivers, the indicators were purely behavioral. Subjects provided a retrospective verbal report about their awareness of a traffic situation immediately preceding the verbal report. Written protocols of the verbal reports were analyzed as data.

4.6.5 Tests performed by CRF and MIZAR

The pilot studies joining the experience from MIZAR and CRF are related to the telematics services of parking and traffic information plus an experimental test for the remote navigation. The pilot involves the following items:

- the technical aspects of the service implemented;
- the coherence between the data collected in the central station and the data oncoming on the vehicle;
- the user point of view.

The global, or general, result is quite positive. From the technical aspect a strong coherence is verified between the data collected and the data provided by GSM to the vehicle. All the data actually acquired on the field are enough to ensure the services and the delay between the request to the service and the data provision on the vehicle is positively evaluated. It's different the judgment coming from the user experience when they consider the data related to the traffic jam: a cartographic information is requested by the user instead to the cross or street name. To satisfy this requirement the only GSM technology is not enough. On the other hand a voice interaction, in terms of input to the system, is not demonstrated but underlined by the experience and by the user observation (i.e. the system need to be used in quite and safe condition during the data input, it can be used normally when the data are provided to the driver). Finally the user judgment is quite positive but it seems evident that it will be necessary in future that more activities will guarantee a full and safe service. On the other hand also the commercial penetration of these type of services, is not clarified well. The services for the parking information and traffic congestion are positively considered but it's not emerging a practical indication to understand the type of payment: pre paid, subscription, pay on demand.

4.6.6 Tests performed by RUG

The test focused on roadside information systems and was intended to evaluate the layout aspects of route information panels and to evaluate the effects of information provision by roadside information panels on driver behaviour.

The test has been split up in four consecutive parts. In the first part, twelve basic information panels were designed and evaluated with respect to comprehensibility and user preference, in several separate trials. The objective of this explorative part was to study basic design features related to comprehensibility and preference. It is important to keep in mind that some of these features will be context-specific and should not be regarded as universal design guidelines.

In the second part, experts in human factors were asked to give their opinion on a selected number of information panels. This was done in the form of a workshop during the annual conference of the Europe Chapter of the Human Factors and Ergonomics Society in Turin (November 2001). People of five different nationalities took part in this study.

On the basis of the results of the first evaluations, in the third part, seven FCIP (Full Color Information Panels) designs are tested in the driving simulator of the University of Groningen with respect to comprehensibility and effect on driver behaviour. Six of the evaluated route information panels are designed on the basis of the results of the first part. These panels incorporate the design features derived from the first part and can thus be regarded as route information panels with maximised potential in meeting the demands of the actual situation. In addition, a seventh, existing standard text route FCIP design is evaluated.

In fourth part a final selection of a route information panel has been made on the basis of the results of the second part, which have been implemented in the actual road environment for which it is intended, namely the A-12 motorway that leads into The Hague. By means of direct interview road users evaluated the route information panel with respect to comprehensibility and mental workload.

4.6.7 Tests performed by VTT

The study was designed to investigate driver needs for the integration of traffic sign information provided by conventional traffic signs and an IVT (In Vehicle Terminal). Specifically, four message conditions were compared in the field experiment carried out by an instrumented vehicle. The message conditions were: visual sign, visual sign + auditory message, visual sign + auditory feedback, and visual sign + complete instruction.

The main results showed that the subjects accepted the integration of traffic sign information and the effects of gender and age were in general unremarkable. More specifically, there were a number of spontaneous responses favoring this sort of system; the subjects assessed that many aspects of the system were useful; they would like to include these aspects in the IVT if purchased; and the IVT information was reported to increase the effect of traffic signs and to improve traffic safety. In addition, a vast majority of the subjects was willing to pay for purchasing the IVT that has the properties they defined as most desirable. One reason for many favorable assessments was probably the successful HMI of the IVT, which was also appreciated by the subjects. Overall, the most preferred message condition was the visual sign.

However, there were also a couple of less favorable assessments. First, the subjects did not favor auditory messages. This finding suggests that drivers prefer information but not in the way the instructions were given by the system. Second, many subjects reported driving problems while using the IVT. The most frequently reported problems included unintentional speed decreases and late detection of another road user, vehicle or obstacle on the road. Given that the secondary task was relatively easy, including simple visual and auditory messages and no control tasks, this finding is striking.

The study also included objective measurements of driver behavior. However, the obtained differences should be viewed only as possible trends. Comparison of the message conditions in terms of glances in the vicinity of warning signs showed that there were no substantial differences between the message conditions. However, the number of glances indicating search for pedestrians or bicyclists was greatest for the visual sign and complete instruction. In contrast, the number of glances at the IVT was lowest for these message conditions. The number of glances at the IVT was relatively low (1.9 – 2.6) in all conditions and the gaze duration was short on average. The speed results showed that the message condition did not affect substantially the speed behaviors in the vicinity of warning signs. However, during the visual and complete condition subjects tended to drive somewhat slower and the information seemed to lower the speed more than in the other conditions. The subjects were also informed about the speed limit in the 40 km/h zone. The mean speed was lowest for the visual and feedback condition, as well as in the visual and complete condition. Consequently, it seems that even if drivers do not like auditory messages and consider them irritating, the auditory messages have a safety-increasing effect on driver behavior.

The main implication of this study is that integration of traffic sign information is a promising approach. Drivers seem to appreciate many aspects of this sort of system and find that it has many advantages. However, they frequently reported problems with the use of the IVT while driving. In addition, the results on driving behavior suggest that the message conditions that included less favorable aspects such as instruction resulted in desirable behavioral changes. Further research is therefore needed to investigate the various effects of this kind of systems on driver behavior.

4.6.8 Tests performed by ATAF

The pilot activity has investigated two main categories of end-users, directly involved in the in the physical environment (vehicle) in which the service is carried out and the information is provided: the passengers and the driver.
Together with the direct users, we can identify another category in the information provision, that includes all the people with some interest in the system but not directly involved:

- maintenance staff

- operators of the TDC/Control Room
- PT company and Local Authorities stakeholders (managers, members of the Administration Board, etc.)
- Mobility Agency at the level of Metropolitan Area

The Florence test site contributes to the overall TRAVEL-GUIDE project as a test case study of the Collective/Public Transport user needs.

The main objectives are the analysis and the identification of the types and levels of PT-related information needs of users under different collective transport service operational contexts (regular, DRTS, door to door, etc.), taking into account a well set-up telematics support infrastructures and ITS systems (AVM/AVL, Demand Responsive Transport, GSM/PRN long-range communication network, short-range communication network, on-board computer, static and dynamic user information, etc.).

More in details, on the basis of the work already carried out in D1 and of ATAF's experience both as an information system provider and user, the work carried was meant to understand the actual needs of the different PT users. This has permitted to define a list of requirements of the different users, and to evaluate this list by means of on-field tests in terms of a set of elements such as:

- information usability and reliability (which categories of information are really important for the different users, which are the problems of reliability that must be solved in order to establish effective schemes in the information provision and in the related feedback);
- information content (which information are essential for the service and for the different users, etc.);
- relation between the above factors and the quality of the service, mostly for the PT operator and for the customers.

The survey on passengers (one of the two categories of direct users together with drivers), showed that they are not very concerned about information on the service: when they take a bus, they want to be assured that it will be as sharp, as fast, regular, as it is possible: this can be translated into functional requirements of the AVM/SAE system by stating that the primary need for the Company, in order to guarantee an adequate quality and level of service, is to have an effective localisation and regularisation system, so that passengers information is a secondary aspect, almost a "consequence" of a good AVM environment.

According to drivers and to operators, current systems are a bit lacking for what concerns the quality and reliability of voice communication, that is the main concern in order to guarantee the management of the ordinary service and of the related emergency situations.

Drivers don't care much about having a localisation system, on the contrary some of them are afraid that it can be used as a control of their operation, being a limitation in their freedom and privacy.

The PT Company Operators and Managers, instead, (indirect users of the system) are strongly convinced that an effective AVM system can be a great help in providing a better service to customers, by means of three main different functions:

- on line service regularisation and optimisation
- off line service report with daily updated travel times and other information on the service provided, so that the scheduled service can be day-by-day fine-tuned with actual operational data
- real-time passengers information on the service and on buses arrival times, to be provided both at the main bus stops/terminals, (that have electronic panels),

and in other innovative ways for the whole ATAF network (internet/wap services, on-request SMS displaying real-time buses predicted arrival times at a selected bus stop, etc.); this last category of customers service is not considered as important as the first two, but it is seen anyway as an important step towards PT service evolution.

4.6.9 Tests performed by IAT

A html-based HMI simulation, based on a standard PC environment, has been developed to compare and optimise different methods of information provision in vehicles under laboratory conditions. It simulates on the basis of a simplified driving situation the different methods of information provision, which will be relevant for the recommendations given in TRAVEL-GUIDE. Three main issues are addressed:

1. standardisation of visual icons, ensuring unambiguous interpretation of the meaning of messages and traffic signs,
2. identification of optimal formats for different types of information (including pictorial and verbal formats)
3. timing of messages

For the test, 18 subjects in 3 countries each (Germany, Greece and Netherlands) carried out standardised sequences of driving tasks on the HMI simulation. A test leader observed the subjects, noted driving errors in relation to programmed events and carried out a questionnaire assessment. Goal was it to identify best practice solutions for output modalities.

The main findings of the test are:

- In general, the PC can be called a well accepted tool to assess questions that do not require physical involvement. But it must be stated that subjects show a comparatively high expectation towards the graphical image quality and the degree of photo realistic simulation. This was not given here which might have had a negative influence on the user acceptance.
- Concerning language independent information presentation with symbols shown on on-road VMS displays, subjects showed a high affection towards well known symbols. In the experiment carried out, the existing traffic sign for “queue” has been slightly modified to express LOW; MEDIUM AND DENSE traffic. The performance leads to the recommendation to avoid such modifications since recognition of a familiar pattern seems to suppress careful reading.
- Timing of an incident / queue warning needs further examination. On the one hand it is supposed to be released early enough to give the driver the option to detour, on the other hand it should not be presented that early that it is forgotten. In the simulation there was no option for detouring. Under these circumstances even a time headway of 10 sec. was perceived as too long.
- The feature "Traffic Jam Warning" is graded positively, but the subjects wish to receive additional information like location of the incident and expected time delay.
- To convey language independent information related to new functionalities (here: the presentation to a bus driver about his position in the schedule), a

balance has to be found between unambiguous understanding of the meaning (new) and use of familiar graphic elements. The pictograms used here were not correctly interpreted by the subjects. After giving an explanation, they found it logical and understandable.

- No conclusion can be drawn in terms of earcons. The reason might be the comparatively low workload during the tests. Still, subjects articulated their objections against the warning tone used. Also here further research is required since sounds are an important element of acceptance. The same is true for the differentiation between male and female voice messages. New investigations are necessary to examine significant differences, especially with a higher workload of the subject.

Remark for future testing: the more realistic the simulation is made in terms of graphics and sound, the more convincing it is, the more are subjects involved (result: "workload") and the more they enjoy carrying out the test. In this respect, PC games set the benchmark.
A mock up for testing purposes should try to get as close to that level as possible.

4.7 Design guidelines and best practices issues for driver information systems and services.

4.7.1 Introduction

A main objective of TRAVEL-GUIDE was to provide to all actors involved, i.e. road operators, authorities, information providers and manufacturers, guidelines for enhancement of integrated information provision services.
User needs and technological gaps have been analyzed in WP1 based on them evaluation scenarios, methodology and criteria have been set in WP3 and next in WP4 and WP5, appropriate pilots and testing have been performed to verify several issues. The results of pilots and tests have been processed appropriately resulting in the guidelines presented in Deliverable 6. This Deliverable has been designed in a way to be easily usable, facilitating the searching and the identification of relevant guidelines.
Deliverable 6 is a main product of the project containing guidelines resulted from the TRAVEL-GUIDE pilot studies. The Guidelines are not ordered on the basis of pilot project partner. Instead they are firstly based on:
The pilot environment (context),
i.e. on-site (OS),
in-vehicle (IV),
public transport (PT).
Secondly, the guidelines are based on the guideline target group, i.e.:
authority,
system developer/information provider,
end user.
Each guideline is presented in a specific format to facilitate its comprehension and utilization. The different fields are as follows:
Code:

The classification can be tracked from the guideline number; in general:

AABC.DE

with	AA	= test environment (OS = on site, IV= In vehicle, PT = Public Transport,
	EI	= Environment Independent)
	B	= Guideline number
	C	= target group (A. authority, B. system developer/information provider)
	D	= pilot partner
	E	= partner guideline number

e.g. OS1A.CRF1 = On-Site 1st guideline for Authorities prepared by CRF (no. 1).
Category: Refers to the main categories of the guidelines.
Target groups: Which target groups interests this guideline.
Short title: A short title of the guideline to provide its contents in a glance.
Problem identified: Which problem identified attempts to remedy this guideline.
Example: Example of its application.
Documentation: Where can be found a more comprehensive documentation about the stated guideline.
References: Relevant references concerning the guideline.
Testing verifications: Any testing performed in order to verify the validity of the guideline.
Suggestions for further research: Suggestions provided for further research in relation to the specific guideline issues.
Remarks: Any comments, remarks dremming from the relevant TRAVEL-GUIDE work.

The different fields are filled in according to the type and maturity stage of the guideline. The data given to the reader provide the opportunity to judge its status, usefulness and if further verifications are required prior to its application.

4.7.2 Overview of pilot studies and focus of tests.

D6 is the result of the work performed in WP6 of the TRAVEL-GUIDE project entitled: "Development of design guidelines for driver information systems and applications". It is a comprehensive integration of the TRAVEL-GUIDE Pilot studies and tests. The Pilots and tests concern a total of eight studies which were carried out by the various Consortium partners.
The TRAVEL-GUIDE project is about the development of guidelines for the enhancement of integrated information provision services. This information provision is carried out by various actors which ideally act in harmony. The pilots will be looked at from a helicopter-view: a cross-section between the guidelines of interrelated pilots are made, whilst taking the context-dependency of the guidelines into account.
After this integrative section, the guidelines as they were formulated by each individual pilot partner were enumerated according to a coding system. The content of these guidelines is unmodified by the authors of this document.

In Table 1 an overview of the contributing partners and the focus of their pilots is given, in practice pilots 3 and 4 were combined in one.

Table 1. Overview of the Pilot Studies carried out for WP5 per partner

Pilot Partner	Pilot	Focus of test
IAT	pilot 1	Comprehensible design of the output of in-vehicle information systems (Simulated: Computer mock-ups)
RUG	pilot 2	Comprehensible design of Roadside information panels (Projected & driving simulator)
CRF	pilot 3	IVIS (On-road: existing and new)
MIZAR	pilot 4	In-vehicle, Roadside, External-to-internal
VTT	pilot 5	Reinforcement of roadside information by means of integration with additional in-vehicle information.
AUTh	pilot 6	GSM-SMS, RDS, VMS, interneet, Radio use (non-prof.)
ATAF	pilot 7	GSM, GPS, Radio use for professional drivers
IFADO	pilot 8	TIS road tests on driver awareness (extra pilot study)

4.7.3 Contribution of TRAVEL-GUIDE to the improvement of transfer and integration of information

All pilot studies are about the characteristics and the areas of improvement information transfer. The IAT pilot addresses the interaction between in-vehicle system and user. The VTT pilot is both about the information transfer from roadside information panels to the user and in-vehicle system to user. More specifically, this pilot focuses on the use of in-vehicle systems as a reinforcing means of increasing comprehension (increase of information transfer) of roadside information panels.
The RUG pilot deals with roadside information systems (FCIP, Full Color Information Panels). In this pilot, the information transfer from roadside information panel to the user is the central theme. This pilot aims at gaining insight in the design aspects that play an important role in the comprehension of information panels. Here the optimization of information transfer is also a key theme.
Though this has not been systematically (dynamically) investigated, the RUG study has a link to the IFADO study. In the IFADO study, Traffic Management Systems (TMS) and Traffic Information Systems (TIS) have been studied. Both their individual (dys) functioning and the quality of their mutual co-operation have been reviewed. The link with the RUG study is in the fact that often parts of the content of FCIP, VMS, GRIP and the like are dynamically offered by for TMS or TIS. Although not dynamically in the RUG pilot, in the parking availability feature of the FCIP is something that in reality is a dynamic feature, and hence related to the IFADO study. Next to offering information to road operators, TIS and TMS also offer information to public transport (PT) operators and hence indirectly to the public. In the ATAF pilot, peoples' motivation for using public transportation is charted. TMS and TIS enable PT being more reliable in the sense that possible delays become more predicable. The ATAF study mainly focuses on the traveler characteristics, and their likes and dislikes concerning public transportation.

In-vehicle - On-site (RUG, IAT, VTT, CRF)

There are three areas of improvement in this section. Firstly the in-vehicle HMI can be improved by optimization of message content, form, modality and timing. The IAT study emphasizes it the importance of:

- **Timing.** In order for the driver to notice the contingency or correlation between the warning message and the object of the message (e.g. the incident) it is important that the time interval between these two events is not too long. Conversely, the message looses its function if this interval is too short. Therefore, a balance between preceding too long and too short in advance has to be made.
- **Pictorial information.** In principle a graphical representation is better than textual information. However, expectancy bias does not allow familiar signs to be altered in order to represent intensity (e.g. level of traffic density). Generally, the intensity variation is not observed when one variation is presented alone (as is the case in real-life situations). Unless the difference is great enough, pictorial variations in order to indicate intensity variations are to be advised against, because reference is lacking.
- **Language independence.** An advantage of the use of graphical coding is its language independence. Or rather: the exclusion of verbal information leads to the inclusion of graphical information. This was found to be true for non-native language speaking foreign drivers.

The emphasis of the CRF pilot is similar to that of the IAT study. The CRF study also underlines the importance of message format to HMI quality and message comprehensibility. One of the findings of the study is that dynamic information is not always understood as such; e.g. when 'parking availability' is displayed it may be unclear to the user whether either current or total parking space is provided. Next to this, congruency between roadside and in-vehicle message format is recommended (e.g. the street names on the display have the same format as the road signs they refer to) as well as miscellaneous specific recommendations for message content and form of information about traffic congestion and parking availability on in-vehicle displays. Finally, guidelines with respect to graphical user interfaces are re-phrased and refined. Topics of physical-perceptual nature are addressed in this part of the pilot: font dimensions, color, brightness, contrast, luminance, all in relation to display background and external (light) conditions are discussed.

Secondly, the presentation of roadside information can be improved. From the RUG study it is concluded that pictoral (as opposed to textual) presentation of information on route information panels can be most optimally applied by taking both the quality (content) and the quantity of the portrayed information into account. Employment of qualitative factors like graphical map representation, layout, color coding, and use of pictograms allows for more information elements to be presented. Cognitive load can be divided into two types, load induced by the inherent nature of the learning contents (intrinsic cognitive load) and load induced by the manner of presentation (extrinsic cognitive load). Qualitative and quantitative factors together increase safety by reducing both the intrinsic cognitive load (use of readily understandable information elements), and the extrinsic cognitive load (improvements of layout).

Thirdly, the interaction between in-vehicle device and roadside information panel can be exploited. As has been investigated in the VTT study, additional in-vehicle information can be utilized to reinforce the information given by the roadside information panels. Whether the employment of such in-vehicle 'reminders' increases

the effectiveness of traffic signs (i.e. is safety enhancing) or not, depends greatly on message content and modality. The VTT experiments show that instructions and/or messages, as well as visual and/or auditory presentation have differential effects with respect to their effect size on traffic safety. However, this does not lead to the conclusion that message form and modality per se have one ideal configuration.
The level of safety enhancement of a system integrating roadside and in-vehicle information is determined by the specific information content and modality, and the domain of application (e.g. route guidance, speed control). Therefore it can be concluded from the VTT study that use of in-vehicle information to reinforce conventional, roadside information is a promising approach.
However, prior to the implementation of suchlike novel techniques, legal (i.e. liability) issues will have to be clarified. Liability issues can become significant in case roadside (VMS) and in-vehicle information dissociate, e.g. if the in-vehicle device displays 70 km/h, whereas there is a roadside painted sign with a speed limit of 50 km/h. In short, in order for authorities to justly penalize a traffic participant it has to be legally grounded whether either in-vehicle or roadside information has a 'veto' when information content is incongruous.

Overall conclusion is that all four studies aim at reducing the hazard of information overload by taking various psychological characteristics into account. A message can be visually and cognitively distracting. In the first case the driver has to physically move his/her head towards a screen, and then perceptually process the image. In the second case the information content (the message's complexity) causes the distraction.

In summary, some of the recommendations of the above-mentioned studies concern:

-Improved layout: decreased visual search time;
-Multimodal messages: decreased attentional interference;
-Improved content: increased chunk size in short-term memory, decreased complexity;
-Improved timing: decreased memory seek time.

Roadside (MIZAR-AUTh-ATAF-IFADO)

The guidelines extracted from this quartet of pilots refer to the roadside context. The studies mentioned in this section also confirm the notion of information overload, and various ways to overcome this, e.g. reduction of the number of information elements pictogram use, omission of textual information, use of color coding, design of orderly layouts, etc.
Non-physical characteristics of information provision are addressed here. Examples of such characteristics are message reliability and frequency (MIZAR and ATAF) and message medium and sequence (AUTh).
As far as the application of alternative message media are concerned, their use can be restricted because of data limitations (RDS has certain system limitations) resource limitations (SMS is too mentally demanding to be used for other than pre-trip purposes.)
AUTh also re-states the interest of protocol use in order to accomplish unification of information transfer, both between information providers (unification of computer data formats) and between countries (unification of traffic sign formats).

The latter remark is also made in the MIZAR study. More specifically, in this study a recommendation is made about an inherently language-free way of informing the traffic participant about abnormal traffic conditions. According to this study this could be accomplished by displaying an alphanumerical index that indicates the ratio between normal and abnormal travel time.
The issues of message reliability and message frequency are addressed in both the MIZAR and the ATAF study, in an onsite (OS) and a public transport (PT) context, respectively. Both studies warn for the pitfalls the introduction of new technologies may feature. On the OS level (MIZAR) this could -if left unsupervised- appear as an overflow of messages. This would result in an information overload and an ability to prioritize the messages.
The ATAF pilot also deals with the issues of information reliability and frequency, but on a PT level. Key question in this study is in obtaining a high degree of accuracy and up-to-dateness of PT information. Although new ITS technologies like AVM have a great potential for overcoming reliability issues and improving performance, caution should be taken with their introduction. Incorrect use of these applications could easily lead to decrements of overall performance and reliability, rather than improvements. Also, the introduction of new technologies requires training for those who maintain these complex systems. Lack of training could especially become manifest in the case of calamities.
The presentation of roadside information is being investigated on yet a higher level of aggregation in the IFADO literature study. Here the top level of the information hierarchy is looked at, i.e. TMS and TIS. In line with the IAT, CRF, AUTh, MIZAR and ATAF study it is here also concluded that message reliability and quality is of paramount importance, in this case for traffic management. In order to ensure high quality output, regular maintenance, as well as, close co-operation at the data level is required. Another requisite is a shift from incident management (prediction) to incident prevention. Finally, the emphasis on language free information is characteristic for the TRAVEL-GUIDE project in general, and for all pilot studies in particular. In the IFADO study the use of the English language next to local language is advocated in the context of PT.

Next to all this, a general 'meta-conclusion' of these studies is that every new technique or way of presentation requires thorough testing. Variation of information content, modality and timing yields a myriad of combinations. Moreover, technological advancement results in unforeseeable developments. Together with the fact that the user group is equally diverse (differences in experience, age, personality etc.), it can be concluded that although efforts have to be made to do so, this vast combinatorial space cannot be completely captured in rigid guidelines. Testing is a must.
Related to the aforementioned expectancy bias is a general human tendency towards familiarity that has to be taken into consideration during new systems' design. Though one can design novel interface types which have a high potential from an information processing or HMI point of view, one should be aware that people are often reluctant to interact with such novelties.

4.8 Cost Benefit Analysis, Dissemination activities and exploitation plan.

A brief market analysis of Traffic Information and Traffic Management systems has been performed not focusing on relevant technologies, as this topic is well-covered in D1 of the project, but on relevant costs, market penetration levels and benefits.

Based on the previous market data, as well as on the relevant results of four project pilots (the ones of VTT, CRF/MIZAR, AUTh/CT and ATAF) regarding users' willingness to have and to pay for the tested services and functionalities, a rough estimation of their costs and benefits is given. As data from the pilots are rather qualitative, emphasis is given on the estimation of the proposed service / functionality viability, target market, target price and implementation policy than on calculating particular cost-benefit ratios.

The market and cost-benefit results have lead to the definition of the Consortium Exploitation Strategy, which include the identification of 12 specific project results and their exploitation horizon, market and leading forces.

Besides, the competitive advantages of TRAVELGUIDE-compliant services / systems are specified, the role of each group of partners (industrial, research) is defined and the rod to standardization and uptake of project results is discussed.

In addition, the analysis of an exploitation / business related questionnaire from 32 experts from 8 countries verifies and extends relevant project plans.

Dissemination activities of TRAVEL-GUIDE took several forms such as: organisation of three workshops, setup of a www site, issue of quarterly newsletters, production of leaflets and posters, a project video, the sue of a Virtual Advisory Board and publication of several scientific papers).

The TRAVEL-GUIDE results suggest that there is a high potential for the production of better systems and services for the citizen and more competitive products for the European Industry provided that they are utilised appropriately. The TRAVEL-GUIDE partners in their exploitations plans indicate their willigness to utilise and extend each one from his own stand point the project outcomes.

5 List of deliverables

5.1 Contractual Deliverables

Deliverable No.	Title	Issue date	Project planning
1	Traffic information and management systems, user needs and technological gaps	December 2000 (9)	6
2	System architecture and organisational issues for driver information provision systems	May 2001 (14)	12
3	Evaluation scenarios, methodology aand criteria	June 2001 (15)	12
4	New schemes for integrated driver information provision services combining different information sources	March 2002 (24)	18
5	Evaluation report	March 2002 (24)	20
6	Design guidelines and best practice issues for driver information systems and services	June 2002 (27)	24
7	Cost-Benefit analysis and exploitation plan	June 2002 (27)	24

5.2 Additional deliverables

Deliverable No.	Title
I1	Survey of existing situation concerning traffic management and traffic information in selected countries
I2	Demonstration and testing in actual conditions of a driver information service
I8	TRAVEL-GUIDE Quality Manual
TG video	TRAVEL-GUIDE pilots video

6 Comparison of initially planned activities and work actually accomplished

No deviations concerning the work content of the Description of Work in the Technical Annex have been made. Despite the leave of the CH2MHILL partner his work tasks and resources were distributed among the partners and all of them were accomplished effectively.

In addition the Consortium has produced work not described in the Technical Annex but considered useful such as:

- The production of three internal reports I1, I2, I8.
- An additional pilot test performed by a new partner which is the Municipality of DEN HAAG and volunteered for that.
- An additional test performed by IFADO.
- A video production performed by AUTh and city of Thessaloniki with contributions from all pilot and tests partners.

No additional resources have been requested by the Commission for the additional work.

7 Management and co-ordination aspects

All Consortium partners were dedicated to the project, contributing effectivelly to what has been requested to them.
Partners have been contributed in tasks where their involvement was not foreseen in the Technical Annex.
The fact that the project partners have produced additional deliverables to what were their contractual obligations proves that there was a very good understanding and commitment among partners.

The TRAVEL-GUIDE Consortium

Contact List

1. Aristotle University of Thessaloniki (AUTh) Aristotelis Naniopoulos Tel. No.: +30 310 256033 Fax No.: +30 310 256037 E-mail: naniopou@spark.net.gr E-mail: naniopou@civil.auth.gr	**2. Consorzio Intercomunale Area Fiorentina (ATAF)** Giorgio Ambrosino Tel. No.: +39 055 5650406 Fax No.: +39 055 5650409 E-mail: ambrosino@ataf.fi.it
3. Rijksuniversiteit Groningen (University of Groningen) (RUG) Karel Brookhuis Tel. No.: + 31 50 363 6772/6758 Fax No.: + 31 50 363 6784 E-mail: k.a.brookhuis@ppsw.rug.nl	**4. Forschungsgesellschaft fuer Arbeitsphysiologie und Arbeitsschutz e.V. (IfADo)** Willem Verwey Tel. No.: +49 231 1084 313 Fax No.: +49 231 1084 340 E-mail: verwey@mail1.arb-phys.uni-dortmund.de
5. University of Stuttgart (IAT) Manfred Dangelmaier Tel. No.: +49 711 9702107 Fax No.: +49 711 9702299 E-mail: manfred.dangelmaier@iao.fhg.de	**6. Automazione S.p.A. (MIZAR)** Fabrizio Biora Tel. No.: +39 011 6500411 Fax No.: +31 011 6500444 E-mail: fabrizio.biora@torino.miz.it
7. Societa Consortile per Azioni (CRF) Luisa Andreone Tel. No.: +39 011 9083 071 Fax No.: +39 011 9083 083 E-mail: l.andreone@crf.it	**8. Navigation Technologies B.V. (NavTech)** Kees Wevers Tel. No.: +31 499 331 585/414 Fax No.: +31 499 331 410 E-mail: kwever@navtech.nl
9. Communities and Infrastructure (VTT) Rämä Pirkko Tel. No.: +35 89 456 4551 Fax No.: +35 89 464 850 E-mail: pirkko.rama@vtt.fi	

For further information:

Aristotelis Naniopoulos
Aristotle University of Thessaloniki
Ermou 61, 54623, Thessaloniki, Greece
Email: naniopou@spark.net.gr

8 Results and Conclusions

Main Conclusions

- A complete traffic information system or service supporting drivers and travellers during all relevant trip stages (pre-trip, motorised trip, public transport trip etc.) is still not available on the market. Most systems and services are restricted in that they provide only very particular support. In order to plan a trip in detail separate systems have to be used for different transport modes and / or trip stages.
- Whenever an individual system or service is used personal data like origin, destination, route type etc. have to be entered anew. As system and service interfaces are generally not standardised road-users have to learn interactions necessary for each system and service anew. Even advanced systems and services do not allow customisation of information provision to individual needs and preferences at a deeper level.
- A pressing issue regarding traffic safety is the timing of information provision. Where on-trip support is not called self-paced but provided regularly message timing is usually system - or service - controlled. Ill-timed messages may distract the driver or lead to intolerable driver workload increases during demanding driving manoeuvres.
- The US experience has proven that timely and reliable recognition of incident / congestion can not be performed if based only upon on site detectors and calculation algorithms and that data collection and confirmation by key actors should be maintained, and in fact intensified.
- Integration between traffic management at different levels (i.e. urban, inter-urban etc.) in order to provide drivers with homogeneous support and advice when they enter different levels of the traffic network..
- Funding of generally cost-intensive traffic management systems is a crucial issue. For making investments feasible partnerships and alternative ways of funding are important. Alliances between private and public operators have to bring alternative financial resources for the implementation and maintenance of traffic management systems to the traffic sector. As a consequence there is a need for a general policy framework facilitating co-operation between traffic information and traffic management systems as well as the co-operation between all actors involved. As the preconditions in different countries and areas vary they should be taken into consideration.
- The TI/TM Market is still not very well established and rather new; therefore specific client cohorts (i.e. E&D) have not yet received extra support. However, tests (i.e. performed in the Netherlands by RUG) have proved that elderly drivers seem to appreciate traffic info and route guidance much more than young ones. From the discussion also it became evident that although some work has been performed on information layout that is appropriate for all, there is no particular information content for any driver cohort yet.
- There is a clear need for dynamically updated systems, that are able to follow the user throughout his/her travel and update all relevant info. One possible such system may come from NOKIA PTA evolution. Relevant efforts have also been made in the German national project MOTIV and the new project MOBIN. As the driver can’t use his/her PTA while driving, this system should

be connected to in-vehicle devices (i.e. navigation or route guidance system). Such an interface does not exist in the Market yet, thus PTA's are mainly used by travelers and not by drivers.

- Few inter-border TI systems exit (i.e. between Cologne and the Netherlands). However some TM centers seem to reject the aim of total information coverage by TI systems and even further inter-border emphasis. The reasoning behind it is that VMS'es are needed to cover critical spots and not the whole network (true also for other TI systems). And critical spots are not necessarily around country borders. Instead some critical corridors, including the relevant country borders, should be considered. INFOTEN has worked on the issue of inter-border information exchange in such corridors and TRIDENT established a network of regional info Centers in different Countries around the Alpine area.
- The integration of TI and TM services in single systems might further confuse the driver on which message is informatory and which is mandatory.
- A clear need was recognized on customized TI systems. Today there are systems where the driver may receive customized info upon request (i.e. the expected weather and traffic condition in a specific route, between a predefined time margin). However, it is hoped that in the future will exist such automatic systems, able to detect the user's position by GPS, route and direction and advise him/her on issues that are directly relevant to it.
- Significant criticism was made in TRAVEL-GUIDE workshops on RDS-TMC systems usefulness and even reliability. Currently their receivers are too expensive (around 3 times the cost of a standard radio) and too few users are connected. In Germany only 200.000 cars are equipped with it (from the 40.000.000 cars in total), although the service is in operation since at least 2 years. In France, 3.500 kms are covered by RDS-TMC but there are still very few receivers. RDS alone took 20 years to be actually implemented. Another related problem is that by providing rerouting guidance by RDS-TMC to all drivers, one just shifts the traffic jam to the new location (i.e. relevant test realized in the Netherlands). For this reason it was proposed that RDS-TMC will only transmit the problem and not re-routing information. Still, foreign drivers need re-routing info, as they are not familiar with the traffic network. For this reason it was proposed to transmit rerouting info only in foreign languages. This however is not feasible with the current architecture of RDS-TMC systems, that only translate messages from language to language (some info content is supported in all languages exclusively). It seems that RDS-TCM info might soon be integrated to certain navigation systems.
- There is a chance that mobile phones will be used to transmit navigation, traffic and route guidance info in the future, especially using UMTS technology. Their small screen is an obstacle but also a virtue, as it necessarily reduces the messages to the essentials. Their full integration would require their interface with current navigation systems or just with navigation databases in the future. Some experts in TRAVEL-GUIDE workshors expressed their view that current transmission speed and extensive service cost limitations would push the usage of mobile phones for such services further in the future.
- Reliability checks between different TMC info seems to differ a lot. In Bremen every message transmitted is double-checked. In Paris the info comes from the Center, own employees and not external sources, thus the validity of

the info is considered to be pre-established (closed system with quality procedures throughout its steps). In Turin there is no message verification but samples of info are checked afterwards to monitor the reliability level.

- Standardisation of info reliability and quality assurance methods of TMC's may be obstructed by the very different methods employed for information acquisition and processing.
- It seems that TCM traffic signs standardization is a major issue, where TMC operators would welcome help. A new TMC rerouting sign has been proposed by TMC'es in Germany, North of France and Benelux. However, any new traffic sign needs to go through the Vienna convention procedures to be standardized, thus requiring too much time and effort.
- Furthermore, TROPIC project tested different traffic signs for TI/TM, concluding to relevant guidelines and best symbols. Nevertheless, it was notable that such sings were understood different by people from different countries, thus making standardization more difficult.
- An issue of equal importance for the TM operators, which is also easier to standardised, is that of information content for each type of service provided.
- VMS standardisation has been an on-going activity in many countries (i.e. France, Finland, Germany, the Netherlands) since at least 1992. In many countries relevant guidelines and even standards exist. However, there is no guidelines or standard on pan-European level and it is something desirable
- Should the information (service) provider pay for the information content or not. The service providers present stated that today there is a trend to establish a free flow of information and to "pay" info by information exchange actions rather than with actual funds. An architecture was proposed, where all content providers would deposit their information in a common Information Platform, from where info providers would uptake it through info exchange actions. Authorities present highlighted however that they are willing to provide free of charge info that they acquire anyway for their own scope. Additional info however, according to the needs of the service provider, may only be acquired if the service provider is willing to pay the relevant acquisition cost. Furthermore, they would not be willing to guarantee the service quality (i.e. info reliability) if it is provided free of charge. It seems that for static information indeed service providers might be willing to pay but for dynamic info they would expect a more flexible deal (such as information exchange), because its dynamic nature prohibits any purchase negotiation.
- Datex seems to be the only system in use in Europe today for TM info. It seems appropriate for motorway but not much for local networks. There is a standardization body working on it. Datex should not be compared to SQL. Dates has two major modules. "Datex Net" and "Datex Dictionary". "Datex Net" is an interface to exchange messages and could be compared to SQL. "Datex Dictionary" however, has a semantic part and include attributes. Such a part is not relevant to SQL. As a major reason for the move to replace Datex it was mentioned the trend to make use of new technologies and the fact that Datex technological basis is rather old. Another reason is its limits in a rural/regional environment. Still, it is not sure that Datex will be actually replaced in the near future.
- Traffic management is mainly a public sector affair. The role of the private sector is restricted to equipment supplier. Traffic information provision services on the other hand are mainly a private sector affair. The role of the

public sector is restricted to that of data provider, although public sector actors are known to operate information provision services

- Above all a major problem exists the fact that there are a lot of different systems, models and architectures across Europe - in many cases incompatible - not utilizing each other's strengths. Different service models are unavoidable, as there are different stakeholders, different philosophies and different degrees of technological development. But whatever the model used there can and should be a common framework where all different service models should fit in, giving and taking as much as possible from each other
- The evaluation methodology developed in TRAVEL-GUIDE D3 is tailored to the WP 5 pilots and is not as a description of an evaluation framework applicable to the evaluation of TIS in general, although some aspects can certainly be considered universal. The evaluation criteria outlined in TRAVEL-GUIDE are useful for evaluation methodologies of other projects as long as the same impact area is of interest. In the evaluation methodology three areas are covered; driver behaviour, user acceptance and system reliability
- The integration of in-vehicle systems and roadside information systems is by far not developed enough, the potential of it is not exhausted yet.
- Traffic information provision can benefit from an integration of roadside information systems and in-vehicle systems with respect to the following:
    - Real-time, up-to-date traffic information provision
    - Information provision differentiated to user group
    - Language independent information provision

  Traffic management can benefit with respect to the following:
    - Data collection
    - Differential data analysis
    - Information provision as traffic management tool
- The following information main categories are relevant for road users:
    - Traffic information (traffic density, flow, travel time, etc.)
    - Incident information (emergencies, accident, construction, etc.)
    - Weather information (fog, snow, etc.)
    - Regulatory information (speed limits, access restrictions, etc.)
    - Infrastructure information (tunnel, junction, automatic tolls, etc.)
    - Navigation information (route guidance, trip planning, etc.)
    - Additional information (tourist information, Internet, infotainment, advertisements, etc.)

  Before integrating them into a system, several issues like:
    - Which type of information has to be/can be presented on which system
    - How to present information (in a more or less universal language)
    - Requirements of TIS and TMS with respect to hardware, software, structure and organization have to be examined and the specific adaptability of both types of system to each other is yet to be explored.

Main results and suggestions

General

- 8 pilot studies in total have been performed by the TRAVEL-GUIDE partners. Investigating different issues and problems. The pilots have taken the form of design guidelines and their descriptions is presented in Annex I. These are the main results of the project and are not repeated in this section due to their extensive number and text size.

- Each guideline is presented in a format containing specific fields such as: Code, category, target groups, short title, problem identified, example, documentation, references, testing verifications, suggestions for further research and remarks. In total 63 guidelines have been producted. The full description of guidelines as well as the other data field are presented in D7.
- For international transport, cross-border drivers and travellers face great difficulties when they try to plan their trip without much knowledge about international traffic situations. Therefore, integration of separated travel and traffic information systems and services to an European traffic information network is a pressing issue for Transeuropean road transport.

Pre-trip information systems

- Most web-based route recommendations are still static. Integration of real-time traffic information for web-based dynamic pre-trip information provision has to be extended. The on-line route builder services offered in the US (where the user provides his/her travel data and gets on-line route recommendations and time estimations) provide a good example of available technology for the task. In addition, pre-trip services can effectively support personalised information needs, by providing access through the Internet to local TI/TM sensors, such as real-time screen shots or even real-time video from particular TI/TM cameras, displaying to the user the current traffic situation at a given traffic node.
- Regional and national traffic information services should be connected to a traffic information service for the whole Paneuropean road network.
- Although advanced Internet sites provide information already in several languages a user-selected output language choice should be standard. Demand spreading by intermodal information provision has to be intensified.
- Pre-trip information should be provided adapted to the needs of different road-user subgroups. Succeeding steps have to deal with customisation of internet-based pre-trip information services to individual travel criteria.
- Alternative pre-trip information modalities, such as the Traveller Advisory Free Telephone Service or the Highway Advisory Radio, being standardised in USA, should also be promoted as alternative modalities to the Internet or fixed info points.

On-trip in-vehicle information systems

- In-vehicle dynamic navigation systems, digital radio channels and mobile phone services face overlapping difficulties: In order to decrease negative impacts of in-vehicle information provision complexity of system input activities and output should be kept to a minimum. Where possible, voice-controlled input and output seems desirable, in order to keep additional loads on the visual channel low.
- Regarding European transnational road transport, current systems and services do not support cross-border drivers efficiently. At this point, the potential of digitised traffic messages for foreign drivers has to be emphasised. Further

development of in-vehicle systems capable to translate coded messages into a driver's native language should have priority for Transeuropean road transport. In addition, the standardisation of a single and common European Traffic Radio (in accordance to the US "Highway Advisory Radio") would help European citizens to have easy access to such info wherever in the EU.

On-trip roadside information systems

- In order to facilitate message comprehension for foreign drivers self-explaining pictograms harmonised across boundaries should be used for roadside information provision.
- Text-based VMS should not present too much information to avoid intolerable distractions of the drivers. As for all other systems and services, the guiding principle for traffic information provision to road-users should be maximum driver information value by minimum driver efforts to perceive, understand and use the provided information.
- The less a driver is involved in interactions with a system the higher a system's contribution to traffic safety is graded. It seems to be reasonable to restrict provision of information not directly related to car control and manoeuvring to non-driving situations and to reduce the amount of information of all on-trip messages to a minimum.
- The system should also provide background information like type of incident, benefit of the new route etc. in order to reduce the mental strain of the drivers.
- Contradictions between in-vehicle and roadside information systems have to be avoided. Otherwise drivers have to solve difficult and distracting cognitive conflicts resulting in drastic decreases of traffic safety.
- Balancing a high system functionality offering many user options with an increased mental strain caused by higher system complexity is certainly an important issue for further development, especially regarding the required adaptation of traffic information provision to road-user subgroups and individual preferences, as all adaptation options will necessarily result in higher system complexity.
- Guidelines and practices defined at a European level can be of great help at lower levels. The public sector has the possibility to determine the role of each actor, including its own. Minimum obligations and types of services to be provided should be identified. A common policy should be developed defining what kind of information can be given to the private sector on what conditions and also how quality of information can be assured.
- Integrated networks co-ordinating data from different sources have to minimise conflicts between the actors involved.
- In a multilingual European traffic environment the presentation of information to foreign drivers is an important problem. A common set of obligations should be defined amongst the E.U. members so that this issue is not left to the free will of each country's operators.
- The definition of a common framework should help reducing risks of investment for both the public and the private sector. The very effective TI/TM standardisation scheme of Japan (where specific technical characteristics lead to three systems clusters) should be carefuly considered. Valuable private funds will only be attracted to the traffic information and

traffic management area if there is a secure and clearly defined investment environment.

- An important related issue is the development of cross-border, multinational TI/TM networks, where one TM Centre can cover adjacent areas of more than one EU countries alone or in cooperation with TM Centres of other countries. The relevant cross-border, inter-state TI/TM in USA can be used as a good model to follow.
- Providing info from some systems (i.e. DVD, Internet), while the car is at zero speed is not enough, as it might just be stopped at a traffic light. Their input should ideally be limited to engine-off situations. In this way, however one actually separates the use of such systems from the car and thus affects the industrial interest of car manufacturers that wish to include such systems (already cars with Internet and DVD exist, at least at prototype level). The complex issue of establishing scenarios of use and priorities for them is dealt within COMUNICAR project of DG INFSO.
- Regarding the common functionalities between in-vehicle and infrastructure systems that cause information overload (due to info repetition) and even puzzle the driver (due to the possibility of contradictory info transmitted from the two sources) it was underlined that infrastructure based systems (especially VMS and VDS'es) constitute by law traffic signs and thus should have priority over in-vehicle systems, that are meant as only informatory. Furthermore, as VMS and even RDS-TMC info comes from authorities, such info carries out responsibility. However, it is still possible that the driver may fail to understand the above priority and still be puzzled by repeated and especially contradictory info coming from different systems. For this reason, it was proposed to consider a telematic link and a common architecture between infrastructure and in-vehicle systems. In this way some messages from in-vehicle systems could be locally suppressed, in case the system recognizes an infrastructure-based system being around and providing the same info content.
- A warning should be issued; the critical spots along a long journey (trans-european networks) are not necessarily (only) at the borders, they cross different areas and / or regions with diffferent rules, standards etc.

9 Acknowledgements.

The TRAVEL-GUIDE Consortium wishes to thank all those contributed to the collection of data, participated in interviews, and provided any type of input to the project.
In particular wishes to thank the members of the Quality Control Board.
Also many thanks are due to the project's project officers Mr. Rene Bastiaans and Mr. Patrick Norroy who have helped significantly the project with their suggestions especially during the early stages the former and during the late stages the latter.

Disclaimer
This handbook presents the results of careful collation of available evidence regarding guidelines for the design of ATT systems to ensure the usability by elderly and disabled travelers. Nevertheless, neither the TRAVEL-GUIDE project partners, nor the institutions of the European Union, nor the authors whose work is quoted, accept any responsibility for any use which may be made of the material contained herein.

Annex I
Guidelines Summary Table

(Title and content only)

GUIDELINES SUMMARY TABLE

<table>
<tr><td>In-car traffic sign information</td><td>IV-1-A-VTT1</td></tr>
<tr><td colspan="2">The results suggest road authorities to promote further development of this type of information systems which seem to be proper to various user groups.

Integration of traffic sign information on an in-car device is a promising approach. It seems to contribute to improve the effects of warning signs and speed limit signs.</td></tr>
<tr><td>Traffic congestion & Parking information provision</td><td>IV-2-B-CRF1</td></tr>
<tr><td colspan="2">- If possible, use a map to provide information about parking and congestion location. Information about name of parking/street should be displayed in a different font/characteristics, e.g. in italics or quoted. For congestion, present names of roads in country specific way, e.g. Via/Corso ABC or C. ABC, V. ABC.
- Mark with arrows (or other scrolling widgets) every page in which message content continues
- Provide users with the following parking information: Park timetable, €/hour, number of free slots, total slots, distance from destination, parking address, type of parking, payment modalities, public services available from the parking, presence of slots for disabled, park name.
Information on free slots had sometimes been misunderstood by participants. To avoid this possible ambiguity on free slots number, make a clear distinction between slots free now and slots which will be free in 15-20 minutes, as shown in the following example:
Free now: 359
Free in 15 min 365
- If parking space in a larger area than just one street is indicated then this must be made clear to the user</td></tr>
<tr><td>Graphical Interface features</td><td>IV-3-B-CRF2</td></tr>
<tr><td colspan="2">1. Capital/Lower letter format
Except for the title and for labels, avoid capital letters to present information.

2. Minimum contrast ratio
The minimum contrast ratio between symbol and background shall be:
5:1 for night conditions
3:1 for day conditions
2:1 for sunlight conditions
(higher luminance to lower). This is especially important if characters are close to the minimum specifications for the dimensions (see 4.4 below). Lower contrast should be avoided unless dimensions are properly increased and/or the reading task is simple.

3. Luminance balance
The ratio of area average luminance of the display and of the surrounding (luminance balance) should not exceed 10:1 (higher luminance to lower). Higher ratios are often acceptable; a ratio of 100:1 (higher luminance to lower) would be expected to produce a small but significant drop in performance.

4. Polarity
Display luminance is intended as the symbol luminance if the display is driven in negative polarity (i.e. light symbols on a dark back-ground), or as the background</td></tr>
</table>

luminance if the display is in positive polarity (i.e. dark symbols on a light background).
Either polarity is known to give satisfactory performance. The choice is determined by the area average luminance of the areas that are frequently viewed in sequence. Therefore negative polarity should be used for night condition. In day condition both are acceptable, taking into account that the immediate surroundings of displays in vehicles (i.e. the dashboard) are often dark. For non sheltered displays, positive polarity could better help in order to reduce the visibility of reflections.

5. Colour

Colour combinations
When a symbol and its background are in different colours, minimum luminance contrast shall be provided. Due to physiological and psychological reasons not all symbol/background colour combinations are acceptable. Therefore, when selecting colours in full multicolour displays, symbol/background colour combinations should be chosen according to Table 1 below.

Colour discriminability
For minimum colour discriminability, a colour difference of ΔEuv = 20 shall be the minimum. The ΔEuv colour difference metric is defined in the CIE 1976 colour space model CIELUV (CIE No. 15.2). Reference white is the white produced by the display. Reference white is the white produced by the display in each condition.

Colour contrast
Concerning legibility, the relevant metric is luminance contrast.

Table 1 - Symbol/Background Colour Combinations

Background Colour	Symbol Colour: White	Yellow	Orange	Red (*), Purple	Green, Cyan	Blue (*), Violet	Black
White		-	o	+	+	++	++
Yellow	-		-	o	o	+	++
Orange	o	-		-	-	o	+
Red (*), Purple	+	o	-		-	-	+
Green, Cyan	+	o	-	-		-	+
Blue (*), Violet	++	+	o	-	-		-
Black	++	++	+	+	+	-	

++ preferred
+ recommended
o acceptable with high saturation differences
- not recommended
*(*) pure red and blue should be avoided because the eyes may have trouble focusing on these colours, due to eye chromatic aberration*

6. Alphanumerical character dimensions

Height
For alphanumeric characters, height, measured as the subtended angle from the farthest design view point, shall comply with Table 2 below.

Table 2 - Character Heights

arcminutes	radians (+)	Suitability level
24	$6.98\ 10^{-3}$	Recommended
20	$5.82\ 10^{-3}$	Acceptable if colour is a coding dimension
18	$5.24\ 10^{-3}$	Acceptable if colour is not a coding dimension
15	$4.36\ 10^{-3}$	Conditional (*)

(+) if multiplied by the viewing distance, it gives (in the same units) the actual character height

(*) when requirements for accuracy and speed of reading are modest, or when readability is incidental to the task (e.g. subscripts)

Width-to-height ratio

The alphanumeric character width-to-height ratio should be between 0,6 and 0,8. A wider range from 0,5 to 1 is acceptable, especially if factors like line length or proportional spacing are important.

Stroke width-to-height ratio

The alphanumeric characters stroke width-to-character height ratio shall be between 0,08 and 0,16.

Spacing

For character fonts without serifs, the between-character spacing shall be a minimum of one stroke width. If characters have serifs, the between-character spacing shall be one stroke width between the serifs of adjacent characters.
A minimum of one character width (capital "N" for proportional spacing) shall be used between words.
If a list is presented, a minimum of one stroke width shall be used for spacing between lines of text. This area may not contain parts of characters or diacritics.

7. Pixel matrices character format

Upper and lower case

A 5x7 (width to height) character matrix shall be the minimum used for alphanumeric characters. If lower case letters are used, or the legibility of individual alphanumeric characters is important for the task, a 7 x 9 (width to height) character matrix should be the minimum.

Diacritics

The alphanumeric character matrix shall be increased upwards by at least two pixels if diacritics (e.g. Ö, Ñ, Å, È) are used. If lower case is used, the character matrix shall be increased downward by at least two pixels, to accommodate the descenders of lower case letters.

Subscripts or superscripts

A 4 x 5 (width to height) alphanumeric character matrix shall be the minimum for: subscripts and superscripts, numerators and denominators of fractions displayed in a single character position, and for information not related to the task such as the Copyright symbol ©.

Only simple and understandable symbols should be presented. It seems that drivers prefer visual (simple) information to auditory instructions (acceptance). However, it is emphasised that the design of both visual and auditory information/instruction presentation requires further research. The instructions and auditory messages should be included in the systems carefully.	
Information content of in-car devices	**IV-5-B-VTT3**
Complicated information should be avoided. *Further research and development is needed to optimise the information content and effectiveness.*	
In-vehicle information systems should provide background information about the reasons for certain system operations	**IV-6-B-IFA7**
User trust and compliance to information provided by traffic information systems is enhanced when the users knows the reasons for certain system operations (e. g. calculation of a new route because of a congestion ahead)	
Information presentation: Information should be provided on the visual as well as on the auditory and haptic channel	**IV-7-B-IFA8**
Besides an increasing tendency for auditory output, emphasis today is still on the visual channel. Stronger involvement of auditory output and further research on haptic output possibilities is required.	
Adapt information provision to driver workload	**IV-8-B-IFA13**
Besides more than a decade of research no system is available on the market which schedules information based on online driver workload conditions. On-trip systems and Neither timing nor information complexity is based on current traffic situation demands.	
Control of message timing has to be shifted from the system to the user	**IV-9-B-IFA14**
Timing of messages is generally system-controlled, without user options to tune timing of message provision to individual preferences. Systems should offer time interval options because different drivers have different preferences and inter-individually different information processing resources as well as strategies.	
Adapt information provision to the requirement of different driver subgroups	**IV-1-B-IFA15**
On-trip systems do not provide efficient services tailored to specific driver groups yet. As different user groups have different information needs detailed identification of information requirements of subgroups is required.	
Extend 'yellow page' services	**IV-10-B-IFA16**
Advanced systems and services do provide regional cultural and logistic background like information about museums, hospitals, car garages etc. These services have to be further optimised up to the level of booking and the services have to be extended to information areas not included yet.	
All in-vehicle navigation systems should allow an effective combination of different routing types.	**IV-11-B-IFA17**
Dynamic route guidance based on TMC should be possible in connection with other user-defined routing preferences.	
Support Transeuropean traffic.	**IV-12-B-IFA18**
Traffic data collection commonly does not exceed the national level, and data exchange between different data collectors and / or content providers is difficult due	

to different kinds of data as well as different communication standards. Thus, no traffic information service supports international drivers during all parts of their journey effectively yet.	
Develop databases including qualitative knowledge about the driver	**IV-13-B-IFA20**
To support drivers effectively, intelligent information systems should have implemented not only a knowledge database about the physical layout of the road network. In addition, they should have integrated a database with qualitative knowledge about the drivers' perceptual and attentional biases in particular situation to guide the drivers' attention to those road features and traffic elements they are not sufficiently aware of.	
Timing of queue warning messages	**IV-14-B-IAT1**
The timing of an incident / queue warning has a high correlation to the driving situation and environmental aspects. Thus the effect of the information depends on the accuracy of the time interval between warning and event. Here the balance has to be found between presenting the warning early enough to react and late enough not to forget it.	
Provision of complete information for services	**IV-15-B-MIZ6**
A service provider should find all the relevant information about a specific transport network at the same source. For example the traffic management system that supplies monitoring of traffic conditions should provide also road description, maps, and traffic restrictions on the same network. These supplementary information could be forgotten because they are already available on several other traditional channels. It is more efficient and reliable if the auxiliary information is added at the source than every service provider repeats the same search.	
Information timing: In vehicle TI systems should provide more timely and accurate information with emphasis in safety restraints	**IV-16-B-AUT6**
In-vehicle TI systems can provide more personalized information. Furthermore information can be given at any time and the user may receive them at anytime. So it will be useful if the information is accurate and given as fast as possible, but it is very important to ensure that the amount of information given and the way of presenting that information will not distract the driver.	
SMS: Speed and simplification of use. Possibly better to be a service on demand.	**IV-17-B-AUT23**
Information provision through SMS requires a full automated, fast system. Upon user request, possibly at a 4-digit number, a dense message on two languages containing all the most needed information will be sent.	
Radio: a popular system, detailed announcements after a well known and understandable sound / music.	**IV-18-B-AUT24**
Most of users still prefer the radio as the main information provision system. The best plan is a radio station with many announcements during the day, with a special sound and/or music as an introduction. Slow and clear speakage is required.	
RDS: suggestions and use optimization	**IV-19-B-AUT25**
RDS should not be rather considered as a main information system. It has still many technical problems (rolling speed varies, lack of characters except Latin, incompatibility issues e.t.c.). On the other hand, if functioning smoothly, since most modern car-radios have an RDS, it can be useful to drivers, as a pre-trip mode.	
Description of Current Information Needs for the	**IV-20-B-ATAF2**

service provision and definition of the related functional and performance characteristics of the Managing System.	
The main services provided by an effective AVM system are: - *A fast voice/data connection (in particular compared to GSM communication currently operated for some services) between the control room and the vehicles* - *Possibility of one-to-one/one-to-line group /one-to-many communications (not possible with GSM system)* - *Ease of use / user friendliness (the system searches automatically the vehicle ID to be called)* - *Possibility of locating the vehicles, of controlling and regulating the service operation (still under development for DRT services) under any situation, both regular and in emergency (paths changes, road closures, ...)* - *Possibility of giving real-time actual arrival times of buses at the main bus stops/terminals (not available for DRT services)* *Possibility of having actual data on the service provided (actual running times, data on service disruptions, on the actual distances covered by the services, etc.)*	
Description of Current Drivers Information Needs and definition of the related functional and performance characteristics of the Information and Managing System.	**IV-21-B-ATAF3**
The main services provided by an effective AVM system from the drivers' point of view are: - *a fast and reliable voice connection (in particular compared to GSM communication currently operated for some services) between the control room and the vehicles* - *possibility of one-to-one/one-to-line group /one-to-many communications (not possible with GSM system)* - *ease of use / user friendliness (the system provides the connection just by pressing a button)* - *attention must be put in the definition of the general ergonomic issues of the on-board terminal like visibility, reachability, and other characteristics (terminal location and typology, etc.)* - *an accurate study of the information content and timing must be performed before introducing the system* - *on-board terminals provided with terminals alphanumeric display for the messages and a graphical display with the map of the service area/localisation of stops are preferable to the standard ones since they permit to give a clearer information to drivers, especially for DRT services, where maps can be used to locate the next stops* - *the HMI design of current AVM systems is generally satisfactory.*	
Regular inspection of traffic management systems (TMS)	**OS-22-A-IFA1**
Some surveys show a range of system failures between 10% and 15%. In order to guarantee data reliability validation techniques have to be developed and used by traffic control centres. Identification of erroneous traffic data ensures reliability by identifying wrong detectors. TMS should be inspected at least 10 to 25 times a year and ideally permanently because data have to be highly reliable and effective for efficient traffic management strategies.	
Incident prevention should have priority over incident	**OS-23-A-IFA2**

management	
The key factor for future traffic management systems is incident prevention by traffic forecasts. Goal for the future has to be reaching the driver before a congested area and redirect the driver' route.	
Standardize information provided by Variable Message Signs	**OS-24-A-IFA19**
A variety of icons is used for the same message across Europe. To facilitate journeys in international corridors uniform icons are required.	
Evaluation of Full Color Information Panels (FCIPs)	**OS-25-B-RUG1**
The studies concern development of optimal comprehensibility of screen layout and content of a "Next-generation VMS", the Full Colour Information Panels (FCIP). Different constituting elements of a FCIP were systematically varied in a four-phased experiment. Comparisons between coloured and black & white information elements, as well as pictorial vs. textual, relative vs. Absolute travel information, and stacked vs. diagrammatic road structure were made. Additionally, comprehensibility for non-native speakers was also considered. Most interestingly, comparisons between the choice distribution of the three route alternatives were made, either based on imaginary route choice (phase I and II, classroom and expert study) or on actual route choice (phase III and IV, simulator studies). Since the FCIP is ultimately implemented on a motorway near the city of The Hague in The Netherlands (phase V) the central background themes were increasing the efficiency of the use of the existing road network and promoting the use of public transportation.	
Language Independent Information: Graphical Design of Traffic Signs	**OS-26-B-IAT2**
When designing new traffic information by means of pictograms, it is not recommended to modify well known traffic signs. Recognising a familiar pattern seems to suppress careful reading and lead to misunderstanding or non recognition of the differences.	
Graphical Information Design of New Features	**OS-27-B-IAT3**
When designing new functionalities by means of pictograms, it is recommended to use carefully well known graphic elements - familiar patterns seem to suppress careful reading and lead to misunderstanding or non-recognition of the differences. To convey information related to new functionalities, a balance has to be found between unambiguous understanding of the meaning (new) and the use of familiar elements (recognition).	
Information content: Roadside Traffic Information Systems should contain only information of interest to every driver	**OS-28-B-IAT4**
The roadside TI systems are public paid, visible to all drivers (typical, elderly, disabled, foreigners, professional). Moreover due to physical and safety restraints the amount of information given should be limited. So a very careful selection of messages to be displayed should be done and those selected should concern everyone and be of great importance.	
Information presentation: A common way of presenting information should be adopted across all European Countries	**OS-29-B-AUT9**
Inter border traveling has become an everyday reality. So it is important that in every country the information is presented in a similar way so that it will be easy for drivers to understand the messages in every country. Even if they are not completely familiar	

with the language and the road network, a familiar format of the messages will make it easier for them to understand the meaning of it.	
VMS: Information presentation: Use of two VMS at the same time when traffic and parking info is displayed.	**OS-30-B-AUT18**
Even if the VMS screens timing is ideal, the idea of using two VMS, one dedicated to present traffic info and the second presenting parking availability info, is the most desirable by the subjects/users. NOTE however that this guideline contradicts the FCIP layout guidelines provided by RUG (OS-25-B-RUG1 in this document)	
VMS: Information presentation: Appropriate roadside system location (spot, height, horizontal distance)	**OS-31-B-AUT19**
VMSes seem to be extremely useful when located at city entrances and generally at an appropriate distance before places where one has to choose one of a number of possible alternatives. The roadside system's height correct, being high enough (higher than the highest estimated truck/vehicle), but not very high (to be easily seen from the drivers).	
VMS: information timing: Road side systems time interval/information density	**OS-32-B-AUT21**
Road side systems must change their screens approximately every 5 seconds, having in mind that the urban speed limit generally is 50 km/h. The momentaneous density of the provided information deserves special attention. NOTE however that this notion of alternating information presentation contradicts with the FCIP layout guidelines provided by RUG (OS-25-B-RUG1 in this document)	
VMS: information presentation: languages, text position and use of pictogram	**OS-33-B-AUT22**
If applicable, a good and tested VMS screen template is the following: ➢ *Left: Local language text* ➢ *Middle: appropriate pictogram* ➢ *Right: English (or other internationally known language)*	
Co-operation between the actors involved should be organized at the data processing level	**EI-34-A-IFA3**
The traffic data collection, data processing and dissemination of traffic information has to be organised in order to avoid confusion among the partners involved. Otherwise road-users might be confronted with uncoordinated or even contradictory information from different information sources. The traffic data processing level has proved to be a suitable level for this organisation procedure. At this level, all key actors have to communicate and agree on issues like information content and reliability of traffic data. If successful conditions are achieved at the data processing level it will not be necessary for the public sector to co-ordinate the data collection and information dissemination levels.	
Definition of a framework for the co-operation between the actors involved	**EI-35-A-IFA6**
Setting the rules and guidelines for an effective co-operation between traffic information and traffic management systems is one of the key responsibilities of the public sector. The need to develop a policy context for this area is not yet completely realised. A common approach, defining the role of the public sector is necessary, in order to create confidence for commercial traffic information services to develop in the transport sector. A general policy framework has to create an overall structure for the provision of traffic information and management services. Each level of the traffic information provision chain can be performed by collaboration between the public and the private sector. The roles of key actors collaborating towards an effective	

traffic information provision chain have to be identified and clarified. Key questions which have to be considered include the provision of public information to private sector agents, the obligations placed on private service providers and the monitoring and regulation of service quality as well as user charges. In order to tackle the problem of co-operation, traffic information and traffic management services have to be integrated, at best into a European context.	
Public authorities must create the conditions that will permit the development of the transport services and of related information provision	**EI-36-A-AUT1**
The public authorities should try to accomplish societal relevant objectives like optimized use of infrastructure, reduction of congestion and thus travel-time, increase of road safety and decrease of detrimental effect of traffic on the environment. They will also have to safeguard users from any effort to reduce the quality of information in order to gain more profit, or risk the safety of the drivers, by mishandling the right to inform them. But public authorities also should set clear rules of the competition, define the kind of information that should be public and free, set safety restraints and then leave the private sector to find the way to optimize the services offered and finance, partly perhaps, the operation of the TI systems.	
Incident (emergency) management: All incident (emergency) management functions should be managed by one master authority	**EI-37-A-AUT2**
Today, in different European countries, different actors are involved in the execution of several of these functions, and in many cases more than one control centers. The main actors involved are: • *the police* • *the fire department* • *the ambulance service* • *the roadway assistance* • *the traffic management* *However the tendency and unanimous actors' opinion is that all functions should be managed by one master authority. This authority will not substitute any of the existing authorities, but it will supervise and coordinate the existing ones. Most likely this authority would be the Traffic Management Centre.*	
Utilization of Municipal resources (Municipal radio, website etc.) in Traffic information provision.	**EI-38-A-AUT3**
In certain cases, a department of the local municipality takes the role of a TIC/TMC. It presents some obvious advantages such as better and new services, better co-operation with road operators and public transportation systems, improved image of the local authority. In most cases, municipal authorities have some infrastructure which can be utilised also for traffic information provision. Such an infrastructure which usually exists is: www site, telephone center, radio station.	
Common data exchange protocols and smooth co-operation between the different information providers and operators	**EI-39-A-AUT12**
Different actors on information providing must agree to a common way of exchanging data in terms of ease of communication and compatibility. A smooth TIS/TMC operation is required, providing to the users the impression of a unique and robust information provider.	

Pre-trip information: Integrate up-to-date traffic information into route recommendations	**EI-40-B-IFA9**
Only very few web-based pre-trip systems integrate up-to-date traffic information into route recommendations. As a consequence of static support, drivers and travellers might be confronted with delays or even dangerous situations due to unexpected events on their route. Route recommendations should be based on online traffic situations	
Local or regional web-based services should be provided in several languages.	**EI-41-B-IFA10**
In order to facilitate transnational journeys, foreigners should be able to understand information provided by regional pre-trip services as well.	
Provide customized pre-trip information services	**EI-42-B-IFA11**
Requirements of different user groups (elderly and disabled, tourists, professional drivers etc.) are not sufficiently taken into consideration by most pre-trip systems. In addition, individual journey criteria seldom exceed preferred departure or arrival time and general route options (fast, short etc.). 'Yellow pages' services are not implemented into most sites. Intermodal services combining different transportation modes, especially those combining public transport means with individual road transport, are still rare, too. Most web-based services are only provided in local native languages. As most services inform drivers and travellers about conditions in traffic networks at the local, regional or, at best, national level, no effective web-based service is currently available providing information about international traffic situations.	
Standardize interactions with web-based pre-trip information systems	**EI-43-B-IFA12**
If a driver or traveller plans an international journey exclusively via the Internet she / he has currently to initiate several sessions, communicating with hardly inter-linked websites, each for different journey stages. As the procedures are not standardised the user has to put efforts in comprehending interaction with each trip-planning site anew in a time consuming skill acquisition process. Use of web-based information systems will be facilitated by uniform interaction processes.	
advice to travelers on confirmed events	**EI-44-B-MIZ1**
Automatically or on request, information about traffic congestion is presented to travellers. The content of information can include location of the congestion, cause and estimated duration, when possible. *Reliability and limitation of the number of messages provided to a user are fundamental to the success of such a service. Experiences in the sector suggest providing only verified information. When the detection of congestion is automatic, an operator will verify and confirm it before the information is published.* *Fully automated information can be used for other services, as route suggestion, but not for direct advice to travellers.* *Also experience of the Titos system in Turin confirms that automatically detected congestion is not suggested to be supplied to final users as explicit messages, unless they are confirmed manually by an operator. The amount of the anomaly warnings would be out of control. They can be used as input for other services or displayed on a map, for example.*	
Expression of the entity of traffic anomalies	**EI-45-B-MIZ2**
On routes or on road trunks it is possible to define indexes based on observed average speed, which help to express the traffic conditions. The perception of a traffic anomaly	

is different by familiar or foreign travellers, since the first ones can know the usual traffic condition in the current time and day of the week, while the unfamiliar drivers can not have a particular reference. *A possibility is to provide two indexes.* ♦ *Congestion index, the ratio between the observed travel time and the free flowing travel time. 100% means that the observed travel time is equal to the free flowing travel time.* ♦ *Anomaly index, the ratio between the observed travel time and the historical travel time referred to the current time and day of the week. 100 % means that the observed travel time is perfectly typical.* *The most diffused TMC encoding represents congestion by a variable with six possible values called level of service and a classification of the kind of event. The level of service represents in six steps the congestion index.*	
Complete and reliable traffic monitoring	**EI-46-B-MIZ3**
Information services like dynamic routing and tele-navigation need the traffic situation in real time on the entire transport network. *Traffic management systems should gather traffic conditions on the whole transport network, through sensors and estimations where sensors are not available.* *A traffic management system has generally several kinds of sources: detectors, estimations based on traffic models, police and other operators. Even detectors have not all the same accuracy, and the quality of estimations where detectors are not available depends on a quantity of factors.* *Then observed traffic data can be from sure to "perhaps". It is important to advise a service provider on the reliability of each piece of information, joining an accuracy index.*	
Use of national languages	**EI-47-B-MIZ4**
The union through the countries in Europe becomes steadily stronger. Cross border journeys and presence in foreign countries increase. The limitations of information provided only in local language become more and more obvious. *Information can be provided in different languages at the same time or also in language independent ways.* *1. Language independent information: the presentation uses only icons, numbers, locality names, standard measurement units, earcons (an 'earcon' is the auditory equivalent of the (visual) icon). All these symbols, even if they cannot be of global use, can be understood over a wider range of users than the local language. Sometimes information details cannot be language independent, and then it is advisable to have the essence of the information language independent and only details in local language.* *2. Language choice: the information is provided in several languages. In case of private access to the information, the language can be selected (internet, car on-board devices…). In case of public presentation (road signs) it is necessary to display all the languages. In this case the size of the display can represent a limit.* *The recommendation of this paper can seem obvious and needless, but sometimes it was forgotten.*	
Data exchange between information centers	**EI-48-B-MIZ5**
Existing information systems are often concerned with only one transport operator, or different operators strictly bound on the same network. One service informs about one mode, one area, one kind of road (urban or motorway). *Transport management and control are mainly based on self-collected information.*	

Urban road administrators, motorway operators, public transport companies have got their own monitoring system, composed of detectors, communication links, processing and databases. In the same region different operators – for example managing different travel modes – have their separated information systems.

The provision of multimodal user information is a major target of a transport environment. In a complex transport network a number of applications introduce measures that affect flow patterns. Co-operative monitoring and control are key functions for ensuring optimal use of the supply network. The greater the effects that desired by telematics, the greater the need for collaboration between applications in elaborating and actuating control strategies. It is clear that data exchange can improve the effectiveness of management and control of their specific systems.

Meantime travellers require complete and integrated services. Traffic information collecting centres are beginning to develop and would be the essence of the improvement.

At the moment data exchange is limited. The lack of standard is perceived as a high obstacle. Also the variety of used media indicates the lack of a standard. Most of them are generic media, except Alert C and Alert + which are specific for traffic. XML and internet are increasing in use. Different system architectures have been designed for exchanging transport information, covering different requirements between data centres.

A secondary problem is the confidential nature of data and their commercial protection. These questions need to be still studied.

The co-operation cannot reach a unique centralised travel information system for all Europe. The whole information system has to be thought distributed.

Information reliability: All messages displayed by TI systems should be send to the TM centre where they would be checked	EI-49-B-AUT5

As different actors exist in the TI area, and messages are unavoidably sent by them, at least they should send the messages, at the same time to the TM centre. Then messages should be checked and in case of conflicts, the conflicting TI actors should be informed to change their messages accordingly.

Information sequence: Issues of interest for the drivers should be categorized according to their importance	EI-50-B-AUT7

In a lot of cases there is a need to transmit one message that is not programmed and priority rules should be set in order to interrupt or not interrupt the message that is set to be displayed. There are, also, messages that should be understood by all drivers (including E&D and foreigners) and those messages should be defined in order to study and find a way of making them understood to everybody. A categorization of the messages will also help to identify which of them should be free and which could be commercially exploited.

Information sequence: Traffic conditions/parking availability sequence	EI-51-B-AUT8

An optimized way of informing users about traffic and parking, depending the time of the day, is to follow the template:

- *Morning until early afternoon: first the parking info and then, the traffic conditions*

Afternoon to night: first the traffic info and then the parking availability info.	
Harmonization of the content of all TI systems: the content of all TI systems in the same area should be harmonized	**EI-52-B-AUT10**
It is important for reliability issues of the TI systems to ensure that they do not provide conflicting information leading to severe problems sometimes because of the confusion that could be caused to the drivers. It would also reduce the reliability of the TI systems as drivers would not examine whether the information displayed is true or false but he/she just notice that that the information is conflicting.	
Additional info is required and appreciated by the users (weather conditions, addresses, telephone numbers, incidents, roads to be closed, estimated travel times)	**EI-53-B-AUT14**
Many users require – beside the traffic/parking info - additional information concerning the weather current and estimated conditions, addresses and telephone numbers of the parking areas etc. This seems to be useful and applicable in certain systems (i.e. internet), though attention must be given to the increase of information on an each single system.	
Incident information provision requires by the users an explanation about causes.	**EI-54-B-AUT15**
In any information provision system (VMS, radio, RDS, internet, SMS, in car devices e.t.c.), an incident message must be presented together with a brief cause explanation. In that case, users pay more attention to the warning message and understand better the situation.	
If text use cannot be avoided, use of both native and English language is preferable. This applies to every kind of information system.	**EI-55-B-AUT16**
The need of informing both local drivers and foreigners (tourists) demands high amount of information presentation (two languages minimum). There is though a possible problem of increased information density in the system.	
Different modes of information provision: system combinations	**EI-56-B-AUT17**
In a realization of a TIC / TMC, providing information through various systems, special attention must be given on how many different systems will exist, how complementarily will they work and which of them will be free for public use or used on a paying mode.	
Internet: suggestions and issues	**EI-57-B-AUT26**
Internet (web sites mostly) could have great usage percentage from people spending a respectable amount of time in front of a computer. Office workers and disabled people for example consider a web site with all the information needed, a very good way of planning their trip. The internet also gives the possibility to build a very useful, easy-to-use and friendly tool for planning a trip and learn the city.	
Special interest on info for disabled users – "Awareness raising"	**EI-58-B-AUT27**
Whenever applicable, special information for disabled users – even for non-drivers – has to be provided: traffic info, parking availability, city guidance when using only the wheelchair etc. A side effect of this will be the "awareness raising" of all the other people. This is particularly recommended for "2003 the European Year of people with disabilities".	
Special info for people with disabilities by various	**EI-59-B-AUT28**

means	
Taking advantage of new technologies and the internet, a special and detailed information provision for people with disabilities could take place. Detailed web sites with transportation information, route guidance, and city accessibility info e.t.c. are the best information provision system for disabled people. Additionally, a printed leaflet/book with the same more or less information could exist.	
Verbal at-stop and on-board information should be provided in English language in addition to the local native language	**PT-60-A-IFA4**
Where users of public transport services are supported by at-stop and on-board detailed information is commonly provided in native languages only. Thus, foreign users cannot benefit from these services as long as they do not understand the local language.	
Provide additional information to PT users	**PT-61-A-IFA5**
Very little information is provided in addition to vehicle status information (next stop, delay etc.) As PT users can hardly be distracted provision of other information is possible (yellow pages, socio-cultural info etc.).	
Description of Current Passengers Information Needs and definition of the related functional and performance characteristics of the Information System.	**PT-62-B-ATAF1**
The provision of high level (dynamic information on bus arrival times, service disruption, etc.) can help in guaranteeing a better quality of service, but more relevant needs for the service from the passengers point of view are frequency, timeliness and speed of the service: these are the primary requirements of an efficient and effective AVM system, and must be the main PT Company concern at the moment of acquiring it, starting from the definition of the call for tender: The provision of passengers real-time information is an added value to be also taken into account. In this context, providing information to passengers directly at bus stops is of primary importance; it should contain at least real-time information on timetables / other information on the service situation (delays because of incidents, traffic congestion, changes in paths because of road closures, etc.).	

10 References

1. ALM, A and Nilsson, L. 2000, Incident warning systems and traffic safety: A comparison between the PORTICO and MELYSSA test site system, *Transportation Human Factors*, **2**, 77-93.
2. BENSON, B. G. 1996, Motorist attitudes about content of variable message signs, *Transportation Research Record*, **1550**, 48-57.
3. CONVERGE TR1101, 1998, *Key user needs for transport telematics services version 1.1* (Del. 4.1.2).
4. FOX, J. E. and BOEHM-DAVIS, D. A. 1998, Effects of age and congestion information accuracy of advanced traveler information systems on user trust and compliance, *Transportation Research Record*, **1621**, 43-49.
5. GRAHAM, R., MITCHELL, V. A. and ASHBY, M. 1995, *An analysis of driver requirements for motorway traffic information*, in S. T. Robertson (ed.), Contemporary Ergonomics (London: Taylor and Francis), 281-286.
6. HANOWSKI, R. J. and KANTOWITZ, B. H. 1997, Driver memory retention of in-vehicle information system messages, *Transportation Research Record*, **1573**, 8-16.
7. JANSSEN, W. H., ALM, H., MICHON, J.A. and SMILEY, A. 1993, Driver support, in Michon, J. A. (ed.) *Generic intelligent driver support* (London: Taylor and Francis Ltd.), 53-66.
8. KANTOWITZ, B. H., HANOWSKI, R. J., and KANTOWITZ, S. C. 1997, Driver acceptance of unreliable traffic information in familiar and unfamiliar settings, *Human Factors*, **39**, 164-176.
9. KINGHORN, A. K., BITTNER JR., A. C. and KANTOWITZ, B. H. 1994, Identification of desired system features in an advanced traveler information system, in *People and Technology in Harmony: Proceedings of the Human Factors and Ergonomics Society 41st annual meeting*, Santa Monica, California, **2**, 1067-1071.
10. LAMBLE, D., KAURANEN, T., LAAKSO, M. and SUMMALA, H. 1999, Cognitive load and detection thresholds in car following situations: safety implications for using mobile (cellular) telephones while driving, *Accident Analysis and Prevention*, **31**, 617-623.
11. LANSDON, T. C. 1997, *Visual allocation and the availability of driver information*, in Rothengatter, T. and Vaya, E. C. (eds.) Traffic and Transport Psychology (Amsterdam, Oxford, New York, Tokyo: Pergamon), 146-163.
12. MOLNAR, L. J. and ELBY, D. W. 1997, Preliminary guidelines for development of advanced traveler information systems for the driving tourist: route guidance features, in Roller, D. (ed.) ATT / ITS advances for enhancing passenger, freight and intermodal transportation systems (Croydon: Automotive Automation Ltd.), 279-286.
13. SUEN, S. L. MITCHELL, C. G. B. and HENDERSON, S. 1998, Application of intelligent transport systems to enhance vehicle safety for elderly and less able drivers, in *Proceedings of the 16th international technical conference on the enhanced safety of vehicles*, Windsor, Ontario, **1**, 386-394.
14. VERWEY, W. B. 2000, On-line driver workload estimation. Effects of road situation and age on secondary task measures, *Ergonomics*, **43**, 187-209.

15. WARD, N. J. and PARKES A. 1994, Head-up displays and their automotive application: An overview of human factors issues affecting safety, *Accident Analysis and Prevention*, **26**, 703-717.
16. YANG, C. Y., FRICKER, J. D. and KUCZEK, T. 1998, Designing advanced traveler information systems from a driver's perspective. Results of a driving simulation study, *Transportation Research Record*, **1621**, 20-26.
17. TRIDENT (IST-1999-10076) "Draft User Needs and Communication scenarios", 2000.
18. IN-RESPONSE (TR1030), D3.1: "Report on User Needs", 1996.
19. SAVE (TR1047), D3.1: Driver needs and public acceptance of emergency control aids", 1996.
20. CEN ENV 12313: Traffic Message Channel.
21. CEN, prENV ISO 14821: *Road Transport and Traffic Telematics, TTI Messages via Cellular Networks*, version 2.1 draft 28th of September 1999.
22. IEEE std 1489 1999 *Data dictionaries for ITS*, orders at http://standards.ieee.org/catalog/its.html
23. Bekiaris, E., Brookhuis, K.A., De Waard, D. (1997). A system for Detection of Driver Impairment and Emergency Handling. In*: 30th International Symposium on Automotive Technology & Automation*, D. Roller (Ed.) London: Automotive Automation Limited, 223-231.
24. Brookhuis, K.A., De Waard, D., Peters, B., Bekiaris, E. (1998). SAVE - System for detection of driver impairment and emergency handling. *IATSS Research, 22:* 37-42.
25. Brookhuis, K.A., Waard, D. de, Bekiaris, E. (1997). Development of a system for detection of driver impairment. In: *Alcohol, Drugs and Traffic Safety, T'97,* C. Mercier-Guyon (Ed.) Annecy: CERMT, 581-586.
26. De Waard, D., Van der Hulst, M., Brookhuis, K.A. (1998). The detection of driver inattention and breakdown. In: *Human Factors in Road Traffic II*, P. Albuquerque, J.A. Santos, C. Rodrigues, A.H. Pires da Costa (Eds.), Braga: University of Minho, 102-108.
27. Farber, E. (1999). Comments on "Driver behavior in an emergency situation in the Automated Highway System". *Transportation Human Factors, 1*, 83-86.
28. Kulmala, R., Hyppönen, R., Lähesmaa, J., Manunen, O., Oinas, J., Pajunen-Muhonen, H., Pesonen, H. and Ristola, T. (1999). *Guidelines for the evaluation of ITS projects* (Publication of the Ministry of Transport and Communications 24/99). Helsinki: Ministry of Transport and Communications of Finland.
29. Rämä, P. and Kulmala, R. (2000). Effects of variable message signs for slippery road conditions on driving speed and headways. *Transportation Research, Part F, 3*, 85-94.
30. TRANSWHEEL Project, Del.2 'Test specification for the pilots', 1998.
31. QUARTET PLUS TR1044, Deliverable 4.1 Validation of user behavioural changes due to multimodal traffic information and related impacts on the transport system, February 1998.
32. SMITH IST12340 D2.2 Manual for the TITOS data, September 2000.
33. Ambrosino G., et al "Telecontrollo delle Flotte di Trasporto Collettivo: la complessità dei sistemi, il percorso realizzativo e la necessità di un "Global Service", TP, mensile di ASSTRA, Luglio 2001.

34. Ambrosino G., et. al. “The role of demand responsive transport services in sustainable mobility: the experience of Florence” ITS’01 Prague, May 31-1 June 2001.
35. Ambrosino G.,. P. Sassoli “Intermediate Transport based on Telematics for improving accessibility and environmental quality” EC Special Session “IST tools for better environmental integration in transport management” 7th ITS World Congress 2000, Torino, November 2000.
36. Ambrosino G., et al. “Flexible Mobility Solutions in Europe Through Cooperation Between Operators, IT Suppliers and Authorities” 7th ITS World Congress 2000, Torino, November 2000.
37. Ambrosino G., et al. “Flexible transport services in European Samplus Project” International Conference “Modelling and Management in Transportation”, Poznan&Cracow Poland, 12-16 Ottobre 1999.
38. Ambrosino G., et al. “An evaluation framework for integrated traffic planning and control policies aimed at reducing energy consumption and environmental impact” 2nd European Conference REBUILD, Florence, Italy, 1-3 April 1998.
39. Ambrosino et al. “Integration of Public Transport systems and services in the city of Florence: Demand responsive bus services in low demand areas” ” 4° World Conference Intelligent Transportation Systems: mobility for everybody , Berlin 21 - 24 October 1997.
40. Ambrosino G., M.Boero , A.Iacometti , P.Sassoli " Integration of demand responsive services for flexible management of bus operations in Florence"3° World Conference Intelligent Transportation: Realizing The Future, Orlando 14 - 18 October 96.
41. “TRAVEL-GUIDE Overview”, *Willem B. Verwey, Institut für Arbeitsphysiologie, Dortmund, Germany, Image Meeting, Tampere, March 2002.*
42. “Approach and main results of TRAVEL-GUIDE”, IMAGE Conference, Finland, 25-26/03/2002. W. Vervey.
43. Naniopoulos, “Information Provision to the Drivers Using Various Means, The TRAVEL-GUIDE Approach”, 1st International Congress on Transport Research in Greece, Athens, 21-22 February 2002, Volume of proceedings.
44. Naniopoulos A., “Including Elderly and Disabled in Intelligent Transport System Developmetn and Application”, ITSC 2001 Conference, Oakland California U.S., Volume of proceedings.
45. ITS 2001 Sydney.
46. “TRAVELGUIDE: Travel and Traffic Guidelines for safe and efficient integrated driver information services”, ISATA 2000 proceedings Vol.1 safety/interiors, pages 729-333, September 25-29/2000, Dublin, Ireland.
47. Brecker M. S. et al., Adapting advanced traffic information provision to road user needs in TRAVEL – GUIDE. A progress report. Proceedings 8th World Congress on Intelligent Transport Systems, ITS Congress Association, Brussels, (2001).
48. “Towards intergrated user friendly systems for driver traffic information and management provision”, The ICMA 2000 Conference, Osaka, Japan, 27-29/09/2000, A. Naniopoulos, M. Dangelmaier, E. Bekiaris.
49. TRAVEL-GUIDE: TRAVEL and traffic GUIDElines for safe and efficient integrated driver information services, World Congress on Intelligent Transport Systems, ITS Torino (ITS Congress Association, Brussels), 2000, K.Wevers.

50. Wevers K., Naniopoulos A., Bekiaris A., Lilli F., Breker S., Brookhuis K., November 2000, "Integration of the Provision of Traffic Information, the TRAVEL-GUIDE project", TORINO, ITS 2000, Conference proceedings.
51. "The European project TRAVELGUIDE (TRAVELler and traffic information systems: GUIDElines for the enhancement of integrated information provision services)". E. Uneken, K.A.Brookhuis, A.J. Roskam, University of Groningen, NL, A.Naniopoulos, Aristotle University of Thessaloniki, GR, A.Bekiaris, Hellenic Institute of Transport, GR. "Europe chapter of the Human Factors and Ergonomics Society Annual Meeting".
52. "Graphical information provision to drivers;
A simulator study in the EU project TRAVELGUIDE".
A.J. Roskam, D. de Waard, E. Uneken, K.A.Brookhuis, University of Groningen, NL, S. Breker, W. Verwey, IfADo, D, A.Naniopoulos, Aristotle University of Thessaloniki, GR, A.Bekiaris, Hellenic Institute of Transport, GR. "Europe chapter of the Human Factors and Ergonomics Society Annual Meeting".
53. Verwey, W. B. (1996). Evaluating safety effects of in-vehicle information systems (IVIS). A field experiment with traffic congestion information systems (RDS-TMC) and preliminary guidelines for IVIS. TNO Human Factors Research Institute, TNO Report TM-96-CO68. Soesterberg: TNO.