D4.2 Utilisation of advanced information by private end users

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Summary of this report:	Report analyses utilisation of advanced information for driver and traveller support services, the state-of-the art of the main services and directions of development in the form of emerging services, summarises the barriers and problems related to the development of services and applications and suggests next steps in the development of architecture, standardisation, and business-models.
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Executive summary

Innovative transport services are creating befits to service users but also societal benefits as improved safety, security, environmental protection and of course to mobility in many sense. Service production is a process including usually many networked operators who have different roles in the production.

ROADIDEA is studying major components of the services development and production. It has been working with the data needs and availability, methods, technology development, business models and especially with innovations of new and useful services. One of the core areas with the project has been weather related problems, data and services.

Work package 4 (WP4) in concentrating on utilisation of advanced information for driver and traveller support services trying to reveal what kind of services are existing and emerging in various phases of the transport chain. The main objectives of this deliverable have been: 1) review the state-of-the art of the main services and directions of development in the form of emerging services, 2) to summarise the barriers and problems related to the development of services and applications and 3) to pave the way towards the necessary next steps needed e.g. in the development of architecture, standardisation, business-models.

The results shown indicate clearly the need to cater to user needs as only that will bring about real benefits to both the users and the society as a whole. Many technologies, systems and services exist but few have provided substantial benefits on the large scale to European citizens and companies (good examples are ESC, navigation, public transport ticketing, scheduling and priorities).

Private end users are usually the final beneficiaries of both public and private services. Private services are directed either to personal users as normal citizens and also to companies and different types of organisations with various functions. In many cases a wider services platform is offered by public operators or public-private cooperating operators offering then also access to many kinds of data for private services operators and new value-added services production.

Many public transport information services are available either operated by public transport companies, public authorities or by private providers. Most of journey planners and this type of services are national and regional. Cross-border trip planning is available for combined car and ferry, air transport and train transport. Many trip planners, especially for long distance travel, also allow purchasing tickets on-line.

The transport information services require the creation of a service network of partners complementing each other's competencies and resources. The main challenges from the business modelling viewpoint include: (1) Creation of sufficient revenue to cover the costs of information services and (2) Sharing the revenues in the service network.

Several actions to remedy the situation are needed of which the most urgent are e.g.:

- agree on European rules for access to public data in affordable manner
- quality level recommendations (target is optimal data quality, optimising the benefit to cost ratio as attempted by the QUANTIS project)
- explore and demonstrate new business models in targeted research activities funded by the EC and governments

  - likely the large scale spreading of mobile IP will result in the explosion of peer to peer services with quite new business models

- support the activities in the EU ITS action plan and the eSafety Forum
- carry out systematic evaluation studies and present their results in tangible manner
- maintain benefit and costs databases of ITS applications
- utilise the code of practice approach to solve the liability issues
- always take up privacy issues in the beginning of the development circle
- mandate interoperable interfaces in Europe, and preferably globally at least including USA, Japan, China and India.

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1. Introduction

1.1 Background

The work package 4 (Utilisation of advanced information for driver and traveller support services) is focussing on the information utilisation process where versatile data and information from different sources including developed and integrated methods are translated to various types of services. The main user groups are private and public users. The private end-users are either private personal users or companies or also different operators making use of the services and utilizing them further on in their processes and service development.

The public users can be both public service types of organisations and administrative organisations e.g. road authorities. In many countries, the public sector is responsible for at least some part of the service production and often especially for collective basic services that are related to general public needs as safety, security, environmental needs.

1.2 Objectives

The work package 4 is getting its background information from the other ROADIDEA work packages dealing with data collection, method and model development, business models and innovation procedures.

This deliverable is concentrating on different existing public and private services to end-users and added value producers. The focus is on context aware location based services and also on mobile services. The deliverable deals with the existing and emerging services in EU countries including examples also outside Europe. The main objectives are (1) review the state-of-the art of the main services and directions of development in the form of emerging services, (2) to summarise the barriers and problems related to the development of services and applications and (3) to pave the way towards the necessary next steps needed e.g. in the development of architecture, standardisation, business-models.

1.3 Approach

The need for services is defined by the users and the services should be based on user needs and requirements. Generally, the users do not need the service as such but the value and benefit that the using of the service will bring about.

This approach summaries firstly the user needs and requirements according to the various many studies already available on this matter. Then the existing services, their business models and implications on their use in different parts of Europe is discussed. The general technical architecture and technologies behind the services production are analysed. The possibilities to deliver the needed services are then reviewed taking into the account that ROADIDEA has already analysed the data needs and availability of data in various countries in Europe. Finally, the state-of-the-art results and implications of the emerging services and development are integrated into conclusions of the services development.

The identified innovative services from the ROADIDEA innovation process and the detailed pilots are also involved in the analysis especially to support the process of identifying barriers, problems and successes.

2. User needs and requirements

2.1 Introduction

A transport system is a large technological system which contains messy, complex, problem-solving components. The state of the transport system is a result of the measures and actions carried out by the producers, operators and users of the system. The ultimate purpose of the transport system is to serve the needs and expectations of private and public end users, who in turn shape the system by their own behaviour, actions and investments. (Tuominen, Ahlqvist et al. 2007a; Tuominen, Järvi et al. 2007b).

Individual people are the users of the passenger transport system. In freight transport, users are companies and organisations in the fields of industry, transport and commerce. Recently, interest in and understanding of the systemic nature of transport has increased and this development has highlighted the importance of the user-centric approach, especially in ICT-related transport technology development (Tuominen, Järvi et al. 2007b)

During the last decades, several Intelligent Transport Systems (ITS) were introduced in road traffic. Real time traveller information systems are becoming an integral part of urban transportation systems, and the challenge for traveller information system designers is to provide options that are acceptable to the service users. (e.g. Penttinen 2005, Yang et al. 2001, Khattak et al. 2004, User Services US 2004). New technology brought into the transport system changes the nature of schemes, strategies or measures as well as the roles of the different actors within the system. In the ubiquitous society of the future, it is argued also that the functioning of the transport system is based on different mobile, flexible and personalized ICT services. Hence, the field of the transport policy and management expands from macro-scale infrastructural level towards the micro-scale end-user level. (Tuominen, Ahlqvist, Rämä, Rosenberg, Räsänen, 2007a).

User needs are all the prerequisites and requisites of the user before and during his travel. The user needs depend on the type of user, his characteristics, his type of travel, his mood, the day of the week, his fellow travellers, and so on. The user needs are divided into information needs and general needs. Information needs say something about the kind of information that the traveller needs. General needs say something about how this information should be presented, what requirements the information should meet or how the user reacts to the information. Anttila et al. (2003) suggested that the development of ITS services should be based on stated user needs and requirements. User involvement is therefore an integral part of the whole design process of any new product or service. From a social point of view, any decisions in the implementation of ITS services should take into account all the possible benefits, costs and effects of the different services for the users as well as the other relevant stakeholders.

User requirements emanate from the users and are entirely user-oriented. User requirements are statements of what the system is expected to provide and the constraints under which it must operate. For each of the users there are requirements, what the user expects and requires from the system. (Rennemo et al. 2008)

In an everyday context, people often act as they did before in the same or similar situations. They reconsider the way they act only if situations are completely new or unknown so that previous behavioural patterns do not fit. The actions taken also depend very much on the potential user groups, because general requests for mobility information exist throughout diverse social classes. (Lenz & Franken 2005 and Franken & Lenz 2006, in Tuominen, Järvi et al. 2007b)

Penttinen (2005) pointed out that the main questions while planning new systems to be implemented into vehicles or roadsides are:

- How will the users take the technology into use?
- How will it affect the individual users of the system?
- How about non-users?
- Is it expected to have an effect on interaction between the road-users?
- Does the system always operate, even in adverse weather conditions?
- Which are the specific usage situations to take into account when planning the systems?

Also, according to (Franken & lenz (2007), we should keep in mind especially the following questions when we talk about the mobility information services:

- Who are the current users or user groups of mobility information services?
- How do people assess the potential. use of mobility information?
- Which influence does the use of mobility information services have on travel behaviour?

2.2 Needs and requirements of private end users

The role of the private end-user has become more and more important lately when several Intelligent Transport Systems (ITS) have been introduced to road traffic. Hence, it is crucial that the needs and requirements of the users are taken into consideration when planning these new services. In this context, a concept called technology service becomes an important tool for understanding the dynamics between the transport system and the end-users. Technology service is a flexible and tailored combination of technologies and services and it takes into consideration the travelling or transportation preferences, needs and expectations of the different transport system end users, both private and public. The emergence of tailored technology services brings new challenges to decision makers, businesses, and other societal actors. Consequently, the roles of public and private parties in the transport system will intermingle in different ways, and new business models and operational practices will arise. (Tuominen, Ahlqvist et al. 2007a)

Penttinen (2005) states that the development of socially beneficial systems needs user-centered design and information about user needs and requirements. User needs are frequently connected to solving existing problems, but identifying the user requirements for new and innovative technology applications and service concepts is especially challenging. User services can be bundled or grouped for example like this, according to (ITS User Services US (2005):

- Travel and traffic management,
- Public transport management,
- Electronic payment,
- Commercial vehicle operations,
- Emergency management,
- Advanced vehicle safety systems,

- Information management and
- Maintenance and Construction Management.

Among the services listed above, especially the Travel and traffic management bundle will be of interest to transportation policy makers, public and private sector operators of transportation management centres, those involved in accident response or travel demand management, and private sector vendors supplying travel information products and services. Also the Electronic payment services will be developed, deployed, and operated by both public and private organisations. The Information management bundle, as well as the first two bundles (Traffic and travel management, Public transport management) focuses on monitoring transportation data for real-time use and disseminating it to the travelling public. This data is also useful to planners, safety personnel, and other organisations.

The requirements set for user interfaces in traffic are exceptionally great for a number of reasons. The main reason is that user interface deficiencies can critically endanger traffic safety. The second reason is that usage situations and circumstances vary and they can be very demanding especially when using the system while driving. Thirdly, the system used while driving must usually be suitable for users varying in knowledge, skills and experience. The systems must be equally suited for young and old, inexperienced and experienced, professionals and other road users etc. (Rämä, Luoma & Öörni 2007)

In chapters 2.2.1 and 2.2.2, needs of individual travellers as well as freight user needs are described as examples of needs of private end users of transport system and its services. Several private and public end users and user groups can be identified within the transport system, and these user groups all have their special needs and requirements for the system and services. These user groups include for example information providers (maps, time-tables, weather etc.), travel and tourism services, entertainment, car industry, road operators, city authorities, police, rescue, and so on.

The needs of road operators and city authorities as well as needs of other public sector user groups are described in detail in Deliverable 4.3.

2.2.1 Needs of individual travellers

Classification of individual travellers

There are several possibilities to classify or group user information needs and traveller types, for example:

- the frequency of trips
- the purpose of the trip
- the trip character (regular vs. special)
- the availability of transport modes
- the particular socio-demography.

User characteristics differ from user types. User characteristics are ‘psychological’ features of the traveller which are ‘fixed’ whereas user types are variable and depend on the context the traveller is in. The user needs develop from a combination of these user characteristics and user types.

Tuominen, Järvi et al. (2007b) have examined the possibility to categorise users of the transport system into homogeneous segments on the basis of their differences in daily mobility and transportation of goods. They showed that in Finland, users of the passenger transport system can be initially clustered into 11 segments and users of the freight transport system into 6–11 segments based on the differences in daily mobility and transportation of goods. The aim was that the groups could be predictable in the future and thus could serve as a basis for the development of new ICT services. The findings suggest that a basic, system-based framework for identifying the users' needs for the development of transport-related technological innovations, as well as the system itself, can be initiated by the segmentation approach.

Transport system users use ICT services to improve their travel process. All transport system users should be able to make information-based decisions on the choice of transport modes and routes, which would hopefully lead to optimal travel behaviour. By offering ICT-based services tailored to the special needs of the end user groups, the best acceptance rate and benefits can be achieved. (Tuominen, Järvi et al. 2007b.) Anttila et al. (2003) found out in their study that the users in Finland considered the most important ITS services to be automatic camera enforcement (speeding, obeying red traffic light), variable speed limit control and real-time weather and road condition information. These services were also defined as the most important development targets for allocation of public funding. Incident information both before and during the trip were indicated as the most important services for drivers.

It is evident that user needs are also very much connected to the transport problems experienced by the users during their travels. For example, weather and road condition information is very important on networks experiencing frequent severe weather related problems whereas incident and congestion related routing is important for truck drivers having to reach their destination via an incident- and congestion-prone network. The general assumption is that the use of infrastructures can be optimised by improved information to transport system users (Lenz & Franken 2006, in Tuominen, Järvi et al. 2007b). there are no general restrictions to the supplying of traffic information services from a technological point of view, but the users are still quite reluctant to accept these services. (e.g. Lenz & Franken 2006, in Tuominen, Järvi et al. 2007b.) In some recent studies on mobility information services (e.g. Lenz & Franken 2006, in Tuominen, Järvi et al. 2007b, Franken & Lenz 2005, 2007) a technological application is defined as useful if: (i) the potential user can profitably use the functions of a service for the tasks in his (everyday) life context and (ii) the configuration of the system fulfils the requirements of the user in terms of both operability and functionality.

In the past and even currently, drivers and travellers are used to get traffic related information via several media: radio, newspapers, text-television, and even television. During the last 20 years traffic related internet services have become very popular and are among the most used web pages in many countries. Most of the existing information sources have been provided to the users without direct costs often by governmental bodies such as road authorities. It may be challenging to convince the users to pay for new traffic related services, no matter sophisticated, real time or personalized those are. It has been said (e.g. Penttinen 2007), that the consumers, at least their majority, will not buy ITS just to get the latest technology. They want to get services that provide them with real value. Especially, when there might already be a "cheaper" substitute, such as paper map compared to the map in the navigator. Majority of the users is still quite critically cost-benefit oriented, and if they don't find the new information service or device to bring them more value than the "traditional" one, they might not be willing to obtain it. (Penttinen 2007)

Anttila et al. (2003) designed their study to investigate how important the end users find different ITS services, how much they are willing to pay for them, and how much they would like the government to invest in developing these services. Generally, the Finnish users would allocate more public funding to public transport services than to services directed at drivers. Services directed at drivers were probably perceived as more personal, in which case the users were more often seen as responsible for the cost of the service.

The research carried out by Shomik et al. (2000) produced some estimates of the average monetary values that the sample of current users attached to information improvements of various kinds. While these values varied among subgroups in ways that fit a priori expectations, it is not clear whether they provide an unbiased picture of the users' absolute levels of willingness to pay, such that they could be used reliably to inform (for example) information pricing decisions.

The perceived benefits and willingness to pay for dynamic information were also discussed by Khattak et al. (2004). They suggested that the personal benefits of high quality travel information may motivate individuals to pay for information. This study analysed travellers' willingness to pay for better quality information received from a traveller information system offered through a public–private partnership in the San Francisco Bay Area. The data were collected in 1997 through a computer-aided telephone interview. The results indicated that customised travel information, longer trips, work trips, and listening to radio traffic reports were associated with higher TATS (Traveler Advisory Telephone System) calling frequency and with greater willingness to pay for information.

Willingness to pay was studied also by van Dijck (2005). The results showed that an advanced driver assistance system VisionSense is most appreciated when it uses a light signal to warn the driver in a possibly hazardous situation on a highway. Another conclusion based on this survey was that frequent car users want less assistance than less frequent drivers. In this study of an advanced driver assistance system, the willingness to pay was estimated at 300 €.

It was concluded in the research carried out by Shomik et al. (2000) that the prospects for self-sustaining ATIS services are unclear. In response to a direct question, a majority of users (perhaps influenced by a strategic bias) indicated that they were unwilling to pay for traveller information services; some of these same people, however, indicated later that they might indeed be willing to buy a particular enhanced information service package, in direct competition with free broadcast services. It can be concluded that driver needs in specific situations, as well as anticipated modifications in their behaviour due to implementation of the new systems, are topics that have not yet been thoroughly studied. In order to achieve user and social acceptance, the analysis of user needs and requirements in several areas of ITS is needed. Hence, user needs analyses support the development of socially beneficial transport systems. (Penttinen 2005)

2.2.2 General needs of freight transport

McLeod et al. (2008) studied general freight user needs. Since there are many different actors involved in freight movement, either directly or indirectly (e.g. freight distribution companies, retailers, city or regional authorities, police etc.), it has been recognised in many places that forums which bring the different organisations together, at a local level, for effective communication with one another are very useful. In the UK, these forums are known as 'freight quality partnerships' (FQPs); in the EU-funded START project[1] they are referred to as "local freight networks". Typically they have identified the main problems encountered by the freight industry and sought ways to improve them. A good practice guide has been written in 2003 by UK Department for Transport.

In general, lorry drivers would like to know about abnormal network conditions (e.g. traffic jams, accidents, road works or other incidents) that might affect their journey. The information they need could include the location of the incident, the length of queue, the likely duration and the estimated delay. Timeliness and accuracy of the information are vitally important, as inaccurate or out of date information could be worse than having no information at all. (McLeod et al. 2008)

The fundamental freight user needs from ITS systems were listed as (McLeod et al. 2008):

- cost and cost effectiveness
- flexibility and control
- interoperability and suitability of systems
- security
- efficiency
- open standards
- user friendliness and good support
- availability and reliability of the systems

The user needs identified by CVIS (2006) and of relevance to SmartFreight (McLeod et al. 2008) were:

- Reliable and up-to-date on-trip information on the current traffic conditions and incidents in certain urban areas for the drivers to be able to adjust their intended routes.
- Optimal routing advice based on high quality traffic information on the urban network. In case of incidents on the intended route, the driver needs to receive updated routing advice and information as to why the intended route has changed.

According to the research done by the Finnish Road Administration, predictability of door-to-door operation (e.g. expressed in journey time) is the most important single need in goods transports (Tiehallinto 2009).

2.2.3 Weather conditions and weather information

There are a considerable amount of specific situations in which an ITS solution would be able to provide remarkable support to a driver. For instance, ITS solutions could have potential by improving situation awareness by raising the drivers' awareness of critical situations. Some of the situations are difficult for all of the driver groups, for instance adverse weather conditions. The drivers' abilities to recognize slipperiness and adapt their behaviour to the conditions when driving in adverse weather conditions have been found to be poor, especially if the friction decreases unexpectedly. (Penttinen 2005)

Rämä (2001) studied the effects of local and frequently updated information about adverse weather and road conditions on driver behaviour. The information was transmitted by several types of variable message signs (VMS). The results of the study illustrated

[1] *http://www.start-project.org/*

that the slippery road condition sign and minimum headway sign decreased the mean speed of cars travelling in free-flow traffic by 1-2 km/h. The minimum headway sign also decreased the proportion of short headways. In addition, drivers' reports suggested that these variable message signs have other effects on driver behaviour, such as the refocusing of attention to seek cues on potential hazards, testing the slipperiness of the road, and more careful passing behaviour. The system proved most effective when adverse weather and road conditions were not easy to detect. The system also decreased the standard deviation of speed. Most drivers accepted lowered speed limits and found variable speed limits useful. (Rämä 2001)

Sihvola, Rämä et Juga (2008) studied the Road Weather Information Service in Finland in order to determine how well the objectives of the service were met. The road weather service is a traffic information service that provides road users (both private and public end users) with information on predicted road weather conditions, via the Internet and as part of weather forecasts broadcast on television and radio. The service collects and combines data on road weather, road maintenance and current weather, and forecasts the development of road and weather conditions based on this data for the next 24 hours. Based on the study the road weather service has in its ten year history succeeded in its objective to focus the attention to road weather warnings. It is important to forecast poor road weather conditions already the previous evening. It is also important to predict the first and last slippery road conditions. During the three more detailed studied years, poor or hazardous road conditions on accident-prone days were well warned of in advance. In the studied data the most typical poor road weather condition was a low pressure and snowfall coming from West. In many cases the difficult road conditions were also caused by the very cold temperature. Predicting these conditions is especially important, since the slipperiness caused by cold temperature is especially hard to notice by the driver. (Sihvola, Rämä et Juga 2008)

Sihvola, Rämä (2008) studied drivers' experiences on road weather conditions, and they found out that the information on road weather conditions corresponded well to the drivers' own experiences. Drivers that were less experienced, had driven for a long time before the interview and were on a trip they did not do frequently, were more likely to have acquired information on weather and road conditions than other drivers. In general, those who had looked for or received information on the current weather and road conditions rated the conditions worse, the road surface more slippery and the accident risk higher than those that had not received this information. In some of the survey locations those drivers that had received information on road weather conditions drove more slowly than other drivers. Studies showed that those drivers who had been acquiring information actively were more likely to make changes in their trip plans than the passive information acquirers or those reporting no information acquisition.

According to these two studies carried out by Sihvola, Rämä in 2008, every fifth respondent stated that they had changed or considered changing the travel plans for their current trip because of the road weather conditions either before the trip or during the trip. The change mentioned most often was allocating more time to the trip. The results indicate that some trips are postponed or even cancelled during very bad weather conditions. With the very bad conditions rating in the media, drivers were significantly more often on a work related trip and more seldom on a leisure trip. The road weather condition information was most often stated to lead to increasing the following distance to the preceding vehicle, focusing attention to the road surface, avoiding overtaking and lowering travel speed. As the information affecting behaviour the most efficiently the drivers estimated warnings affecting main roads shown on a map on province level as well as verbal descriptions of the weather and road conditions. Also individual and focused information, e.g. information on road maintenance, was supported. (Sihvola, Rämä 2008)

Skarpness et al. (2002) pointed out that there are two key challenges to be met in delivering WIST (weather information for surface transportation) to users:

- WIST is for decision support. Transportation system managers, infrastructure operators and maintenance personnel, vehicle operators, shippers, and travellers. The estimated annual economic cost, just from weather-related crashes (deaths, injuries and property), amounts to nearly $42 billion.
- WIST users have diverse needs. Because the kinds of transportation-related decisions made by WIST users differ, as do the circumstances in which decisions must be made, the information content and its attributes vary from user to user.

The FORETELL evaluation (Skarpness et al. 2003) focused on six user groups over three winter seasons. Each of these user groups had different needs and potential uses for the weather and pavement condition information. Each had different decisions and processes they aimed to impact with this new information. These user groups were selected because they needed weather and road condition information and they were interested in participating:

- Highway Maintenance Operators
- Commercial Vehicle Operator (CVO) Personnel
- Highway Patrol Personnel
- School Administrators
- Transit Operators
- Traffic Managers

In many cases, accurate weather information helps determine when and if to take a trip, the route, and expected travel time. It guides the actions of state departments of transportation that maintain the interstates and state highways. It also affects how and when commerce is transported. (Skarpness et al. 2003.) A market analysis conducted by FORETELL indicated significant deficiencies with the current weather and road condition information development, production, and dissemination approaches. These deficiencies included:

- Lack of information and geographic coverage
- Insufficient timeliness
- Inaccuracies that result in lack of confidence in making decisions
- Lack of necessary detail
- Difficulties in acquiring information and the high cost of acquiring it

In response to these apparent deficiencies in the current system, FORETELL proposed to provide both nowcasts and forecasts of weather information and road conditions to highway maintenance operations staff, commercial vehicle operators, highway patrol, school administrators, transit operators, traffic managers, emergency medical units, and commuters and leisure travellers. (Skarpness et al. 2003)

2.2.4 Fog warning and information

The foggy weather influences the movement of means of transportations directed by people unfavourably primarily due to the reduction of the distance of sights. An essential aim of the warning system informing on the weather conditions is to avoid accidents by calling the divers' attention and assuring the most detailed and exact information as possible. Some main features of the road accidents causing personal injuries and having occurred in the public roads within Hungary between 2001–2008 are summarized briefly below. The information relevant to the weather are based on Police Accident Report Forms. (RODS, 2009)

Altogether 160 000 accidents causing personal injuries occurred in Hungary in 2001–2008. Of these, 9.5% occurred in adverse weather conditions (rain, snowing, fog, storm, shower) and 1.6% of all accident causing personal injuries took place in foggy weather. Hence, the number of cases in foggy weather is so low that it would probably not give reasons for the installation of the costly traffic management systems and other interventions by itself. However, the average severity of the accidents taking place in foggy weather is definitely greater than in case of other accidents. In the last 8 years 5.6% of all accidents causing personal injuries were fatal in the Hungarian roads, but at the same time the same ratio in case of the accidents taking place in fog was 8.4%. (RODS, 2009)

The fog usually occurs during the winter months in Hungary. It can be seen in Figure 1 how the number of accidents causing personal injuries and taking place annually is distributed according to the months of the year. The monthly distribution of the accidents taking place under favourable weather conditions primarily depends on the seasonal variation of the traffic volume, more accidents happen due to the heavier traffic in the summer months. The distribution of the accidents in foggy weather depends on the occurrence of foggy periods, nearly a half of these accidents occurred in Hungary in December and January between 2001–2008. (RODS, 2009)

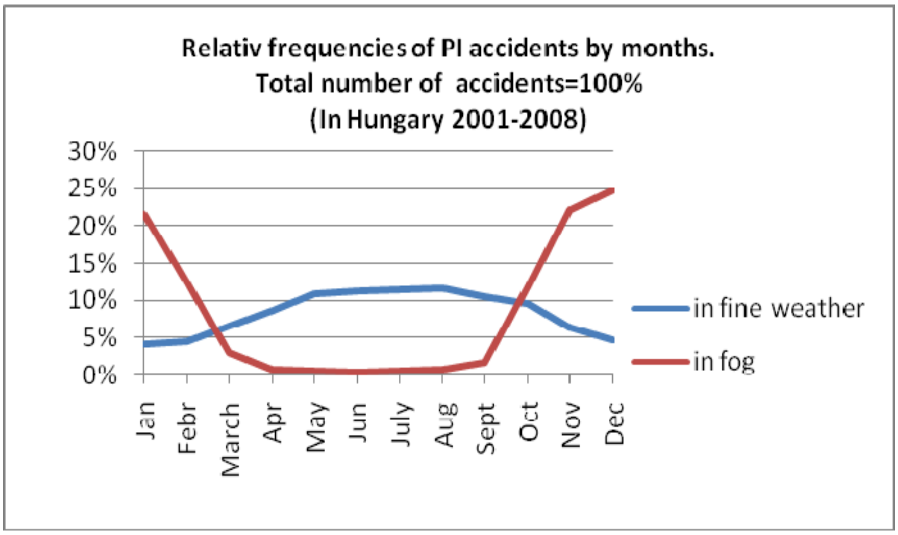

Figure 1. Monthly distribution (%) of personal injury accidents in Hungary in the years 2001–2008 according to whether the weather conditions were fine or foggy.

It can be observed in Figure 2 that the accidents in fine weather conditions occur most often in the afternoon hours (4.00–6.00 p.m), of course, it is influenced by daily variation of the traffic. However, the accidents in foggy weather occurred most often in the morning traffic "rush hour" around 7.00 a.m. In the winter months it is dark at that time and the limited visibility due to the fog jointly often contribute to accidents. The curve of relative frequency of the fog-accidents shows increase in the afternoon period, however, it is a significantly smaller "peak" than that one in the morning. This fact is of interest from the point of view of the operation of the system warning of the fog and wording the "messages". (RODS, 2009)

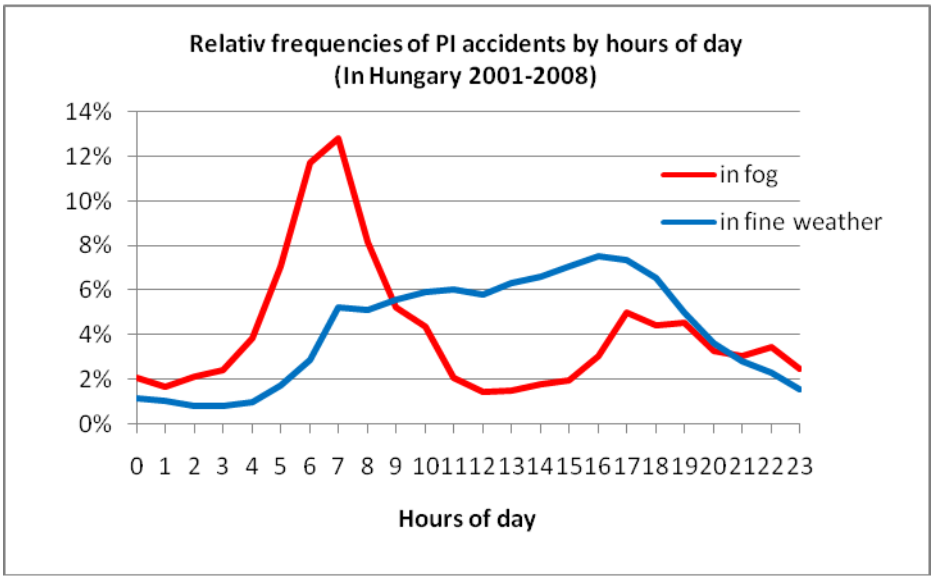

Figure 2. Hourly distribution (%) of personal injury accidents in Hungary in the years 2001-2008 according to whether the weather conditions were fine or foggy.

Table 1 shows the frequency of the most important accident types in Hungary in 2001-2008 according to whether the accident occurred in fog or fine weather. (RODS, 2009)

Table 1. Distribution (%) of personal injury accidents in Hungary in the years 2001-2008 by accident type according to whether the weather conditions were fine or foggy.

Accident type	relative frequency % (Accidents/all accidents)	
	in foggy weather	in fine weather
Rear- end collisions	11%	12%
Head-on collision	17%	7%
Single-vehicle collision	29%	16%
Accidents at junctions	9%	19%
Others	34%	46%

The statistical data - in a slightly surprising way – show that the rear-end accidents occur with nearly the same frequency in foggy weather as in fine weather, although these cases are called typical “fog accidents”. However, it is a fact that the so-called pile-up accidents typically occur in foggy weather, their avoidance is one of the essential aims of the traffic management systems. However, in case of two types of accidents significant differences are shown in the frequencies. Usually the frequency of the head-on accidents with the most serious outcome is significantly higher in foggy weather than with good visibility (17%–7%), and the relative frequency of single-vehicle accidents is remarkably higher in fog (29%–16%). As both types of accidents are correlated with the speed and sight distance, a fog warning system should thereby aim at the selection of the correct and safe speed. (RODS, 2009)

Table 2 shows the distribution of the personal injury accidents in Hungary in 2001–2008 by accident "causer" according to whether the accident occurred in fog or fine weather.

The "causer" is the accident participant labelled by the police as the participant mostly responsible for the occurrence of the accident. (RODS, 2009)

Table 2. Distribution (%) of personal injury accidents in Hungary in the years 2001-2008 by accident "causer" type according to whether the weather conditions were fine or foggy.

Accident "causer"	Relative frequency % (Accidents/all accidents)	
	in foggy weather	in fine weather
motorbike	0,4%	5%
passenger car	72%	60%
truck	12%	8%
bicycle	4%	11%
pedestrian	5%	8%
Others	6,6%	8%

The data in Table 2 shows that the motorbike drivers are rarely among the "causers" of accidents taking place in foggy weather (0.4%), but nearly three-quarters of such accidents (72%) are "caused" by the passenger car drivers. The truck drivers "cause" 12% of the accidents taking place in fog, while in fine weather this ration is only 8%. This indicates that the target groups of the fog warnings could primarily be the passenger car and truck drivers. (RODS, 2009)

Circa 68% of all accidents causing personal injuries in Hungary between 2001-2008 occurred in built-up areas, and 32% in rural or inter-urban sections of the roads (out of built-up areas). A greater part of the cases occurring in foggy weather (62%), however, occurred outside built-up areas. Only 5% thereof occurred in motorways, most of them took place on the main roads and on the secondary roads (Table 3). (RODS, 2009)

Table 3. Distribution (%) of personal injury accidents in Hungary in the years 2001-2008 outside built-up areas by road type according to whether the weather conditions were fine or foggy.

Accidents in roads outside built-up areas (In Hungary 2001-2008)	Relative frequency % (Accidents/all accidents)	
	in foggy weather	in fine weather
Motorways	5%	7%
Main roads	48%	48%
Secondary roads	38%	33%
Others	9%	12%

Some fog related warning and traffic management systems targeting these safety problems have been deployed and evaluated. (RODS, 2009)

Adverse Visibility Information System Evaluation (ADVISE) was tested on a two-mile section of I-215 subject to recurring fog in Salt Lake City, Utah. The purpose of the system was to reduce the variation in road speeds and provide a more uniform traffic flow during fog. The system used four roadway visibility sensors, a central computer system, wireless communication devices, and two roadside dynamic message signs to communicate speed recommendations to freeway travellers. The visibility sensors were installed on low lying sections of roadway to measure sight distance every 60 seconds. This information was communicated to a central computer that used a weighted average algorithm to evaluate visibility conditions and post ADVISE messages on roadside dynamic message signs. (Perrin & Coleman 2003)

The field study evaluation results indicated the deployment was successful at promoting more uniform traffic flow during fog events. As a surrogate measure of safety, the improved uniform traffic flow indicated there was less risk for drivers travelling in recurring fog zones. The data showed that when recommended travel speeds were provided, the number of excessively slow drivers decreased. The ADVISE technology effectively reduced the average standard deviation of speed between vehicles by 22 percent, from 9.5 mi/h to 7.4 mi/h. The average vehicle speed measured during fog events increased from 54 miles per hour (mi/h) to 62 mi/h after the system was deployed. The report concluded that the increase in average speed was indicative of the overall 6 mi/h increase in average speed observed during non-fog days since 1996, and was partly attributable to the reduction in excessively slow drivers during fog events. (Perrin & Coleman 2003)

The automatic fog-warning system on the M25 motorway in England displays the “Fog” legend on roadside matrix signals. The assessment of this system showed that the net mean vehicle speed reduction was around 3 km/h, when the signals were switched on as a result of the formation of fog (Cooper & Sawyer 1993).

MacCarley et al. (2006) studied the response of traffic to messages displayed on a changeable message sign (CMS) warning of fog ahead and advising specific speeds at increasingly lower visibility levels. Over a 2-year period, the speed, length, and time of detection were individually recorded for all vehicles at four sites: two before and two after a CMS. Mean speed, speed variance, and potential collision speed (PCS), a new metric, were calculated with a 45-s moving window and averaged over each constant message state. PCS is a predictor of impact speed in a potential chain collision that considers visibility as well as speed and separation between individual vehicles.

When the CMS was activated, mean traffic speed decreased 1.8 km/h on average over all fog events in comparison to mean speed in the absence of a message. However, average PCS increased differentially by 13 km/h because of platoon compression and the sensitivity of this metric to increasingly worse visibility after the CMS during most activations. Speed standard deviation among proximate vehicles did not appear to be significantly affected-within 8 to 11 km/h across all lanes in most cases. The warning messages evoked a measurable effect on driver behaviour but well below design expectations. Drivers appeared to respond predominantly to their own perceptions and reduced speeds in fog, but not nearly enough to compensate for the reduced visibility. When the advised speed was 30 mph (48 km/h) in dense fog, mean speeds averaged 61 mph (98 km/h). (MacCarley et al. 2006)

A variable speed limit system integrated with a fog warning system reduced the number of injury accidents on a German motorway by around 20 % (Balz & Zhu, 1994). The study reported significant reductions in mean speeds (3 to 9 km/h) in adverse weather conditions.

A Dutch fog warning system including a text warning (“fog”) and dynamic speed limit VMS signs on a motorway, reduced speeds in fog by 8 to 10 km/h, although in extremely dense fog, the system had an adverse effect on speed. This was due to the too high “lowest possible speed limit” display in the VMS (60 km/h). A more uniform speed behaviour was obtained due to the introduction of the system. (Hogema et al. 1996)

2.2.5 Mobility and traveller information services

The intention of the so-called "mobility information services" is to support individuals before and during travel. In general, mobility information services provide information for the user concerning traffic. A 'service' is created if the information is provided regularly and in a standardized form with a given level of quality. Road users use mobility information services, because they are able to make decisions which lead to an optimized travel behaviour (Hirschhausen et al., 2001, in Franken et Lenz. 2007). In an advanced version, mobility information services shall not only assist the users in their way finding but also enable them choosing the optimal way in terms of time or distance or individual preferences. In an ideal case services do not only provide information on the "best" route but also on alternatives for routes, departure times and transport modes. (Franken et Lenz 2007.)

Yang et Fricker (2001) have proposed a driver's information processing model for the traveller information systems. The results of the driving simulator study indicated that, because of the limitations of human memory, drivers prefer to have short, simple traffic and travel information conveyed to them whenever the circumstance allows. (Yang, C.Y. 2001) Sugiyama et al. (2007) concluded that even if the information represents only possible scenarios and the certainty is not complete, it can be accepted and effectively utilised. Their study dealt with the evaluation of a detour guidance system during a disruption of train operations, and they emphasized the importance to provide passengers with accurate information facilitating the rest of their trip. They carried out a field test in which subjects used their cell phones and investigated their route choices.

2.2.6 Traffic information

Recent traffic information related user tests and studies carried out in the Nordic countries have attempted to find out e.g. what kind of traffic/travel related information people need and want, how the information should be provided and how different people act when they are travelling. The needed information differs greatly if people have choices to make before the trip (pre-trip information) or when they have already made the travel decision and modal choice (on-trip information). Also the feedback after the trip is relevant for the service developers (information and feedback after the trip). Nowadays there is a new need for developing guidance on how to use all information correctly; people can become too reliant on different information channels (e.g. navigators and different driving assistants) that they delegate their own responsibilities to the machines, which is not (yet) acceptable.

According to the studies (Forum Virium Helsinki 2007-2008) the choice of a transport mode is most of all based on the following three things: (1) convenience and ease of travelling, (2) assumed routines and (3) cultural issues. Recently, also ecological aspects have become one of the major factors at least within some user groups. This means that in the future there is likely to be an increased demand for transport services that are sustainable in the ecological sense. Other issues that have great influence on people's choices are quickness and hurry as well as the local traffic culture.

People are curious by nature so in a situation where traffic is disturbed most people usually want to know the reason for it. Unnecessary announcements should, however, be avoided. Traffic information should also be proactive since the possibilities to react are often very limited in traffic congestion (although knowing the reason is likely to interest and calm down most people).

In one of the studies (Forum Virium Helsinki 2007-2008), the participants were divided in three groups: technology adopters, development mergers and traditional travellers. Technology adopters use navigators and mobile phones regularly to get traffic information and are familiar with many kinds of web-based services. Development mergers use both traditional (maps and paper timetables) as well as some web-based services (like journey planners) and can sometimes try new techniques like order a taxi by SMS. Traditional travellers trust on paper timetables and maps and like to write route instructions on paper beforehand.

Asking the users about their information needs may be an incorrect method since most likely people are not aware of all the available information. On the other hand, it may be difficult to find out the real information needs by doing only expert interviews. One solution could be a questionnaire where the existing (and other possible) information is listed and users are asked to prioritise the information according to their own feelings. When this kind of method was used in one of the studies, the top 4 of traffic information types was the following (Forum Virium Helsinki 2007-2008):

1. Public transport incidents
2. Traffic incidents
3. Road works
4. 24-hour weather forecast.

The best way to disseminate traffic information depends on the type of information. For example, public transport incident information needs different dissemination methods than traffic information directed to private car users.

When test users were asked about the unfavourable ways for dissemination of traffic information for example the following things were mentioned (Forum Virium Helsinki 2007-2008):

- additional devices in any form (people do not want to carry many devices with them or buy new ones)
- chargeable services
- hard-to-use, technical devices
- public displays
- radio (has both pros and cons in traffic reporting; was mentioned unfavourable as most people turn the radio on because they want to relax and listen to music etc. and not traffic announcements)

The terminology used in traffic reporting can sometimes cause problems since people tend to interpret the verbal information in different ways. One also has to be familiar with the terms in order to interpret them correctly and act according to the message. It is also essential to have earlier baselines for certain terms; e.g. travel time or speed.

The research participants were eager to create some visions for future traffic information services as well as for future traffic. Here are some of them (Forum Virium Helsinki 2007-2008):

- An automatic mobile phone service that can be switched on and off
  - Accurate information of own routes stored
  - Announcements of incidents
  - When waiting for a bus, the user can see how far the bus is (visual, no minutes etc.)
  - Real-time personalised information available

- During traffic incidents, detour options are shown visually
  - During congestion some code colours (like green, yellow, red) are used to present the traffic flow
- All navigator functions in the same device:
  - Road maps & nautical charts
  - Touch screen
  - Traffic information (e.g. traffic jams) included

Visions of traffic:

- Better public transport connections, no changes needed
- Traffic information available “at home”, i.e. very easily
- Staggered working hours
- Restrictions for private cars: “tolls”
- Public transport 24/7
- “Odourless” public transport

The studies also showed that people can be categorised as lifestyle motorists or ecology enthusiasts based on their principal travel habits but, after all, the choice of the transport mode is very often dependent on the situation. (Forum Virium Helsinki 2007-2008)

2.3 Conclusions on user needs

The role of the private end-user has become more and more important lately when new technology has been introduced to road traffic. When specifying the user needs and requirements, one must keep in mind, that there is no such thing as an average driver. Neither can the services be planned and addressed for such a driver, or traveller. The driver – vehicle – environment –interaction is getting even more complicated in the situations, where driver is not only “traditionally” interacting with other traffic and car controls but also in-vehicle technologies, including both information providing systems and advanced systems aiding driver in critical situations (ADAS). (Penttinen 2007.)

Drivers and travellers are used to get traffic related information via several media, and most of the existing information sources have been provided to the users without direct costs. Recent traffic information related user tests and studies have attempted to find out e.g. what kind of traffic/travel related information people need and want, how the information should be provided and how different people act when they are travelling. The ITS applications have provided new and potentially effective means to improve the quality of information. However, according to Rämä (2001), providing information does not guarantee that drivers will use it optimally by modifying their behaviour. The majority of the users is still quite critically cost-benefit oriented, and if they don’t find the new information service or device to bring them more value than the “traditional” one, they might not be willing to obtain it. (Penttinen 2007.)

The evaluation studies demonstrate that services catering efficiently to user needs have the expected impacts and benefits. For instance, real-time warning services reacting automatically and quickly to dynamically changing conditions produce more substantial benefits than slower reacting services. Warning services integrated with speed control services are more effective that either warning or speed control services alone. It can be concluded that driver needs in specific situations, as well as anticipated modifications in their behaviour due to implementation of the new systems, are topics that have not yet been thoroughly studied. There are a considerable amount of specific situations in which an ITS solution would be able to provide remarkable support to a driver. For instance, ITS solutions could have potential by improving situation awareness by raising the drivers' awareness of critical situations.

For example, predicting difficult road conditions is crucially important, since the slipperiness caused by cold temperature is especially hard to notice by the driver (Sihvola, Rämä et Juga 2008). In many cases, accurate weather information helps determine when and if to take a trip, the route, and expected travel time. For drivers, the most common sources of weather information were radio and TV, but the share of information received via the Internet was notably higher than in previous studies. In every transportation sector, users stressed the importance of getting weather information tailored for the activity or decision-making process for which they are responsible. They want detailed, location-specific forecasts and situation reports. and they also need multiple ways of getting this information: from radio and television, the Internet and other electronic data links, and other communications End users stated the importance of information that is much more precise, focused, and relevant to their operations.

The COOPERS vision (Frötscher 2008) says that in the future "Vehicles are connected via continuous wireless communication with the road infrastructure on motorways, exchange data and information relevant for the specific road segment to increase overall road safety and enable cooperative traffic management." However, the users of the traffic system are as diverse as humans in general, and the human beings don't always behave the way the authorities, road operators or providers of information have thought. Therefore, the user-centred design process must take these different users and different needs and requirements into account while reaching for the optimal – or at least best possible solutions.

3. Data and information availability

The working hypothesis of ROADIDEA is that effective accessibility to all kinds of useful background information combined with advanced data fusion methods are prerequisites for creation of innovative mobility services. A starting point is also that sophisticated technology platforms utilising standardised systems for European wide and cross-border service delivery are necessary. Data as such is a prerequisite for the development of proper services but there are also more intelligent ways to utilise data for service development.

ROADIDEA includes a separate work package, WP2 Data Collection, concentrating on data problems and mainly on defining data sources, data availability, new type of data, integration data and improving the ways utilising data in service development. The backbone of the approach is the ROADIDEA system concept and platform defining the necessary technological process of services development and basic architecture.

3.1 Existing road, traffic, weather and other data

An extensive Data Collection Survey identifying the different data sources in countries participating in ROADIDEA has been carried out including an analysis on data availability and utilisation

During the data collection survey the further issues were examined:

- Who owns the data?
- Can the data be used in the ROADIDEA project?
- What about data charges?
- What kinds of data are available?
- What are the spatial scopes?
- Is the data accessible using an automated procedure?
- Access method?
- What are the data formats?
- Are related information available?

Within Task 2.1 “Data Source Identification – Present Data”, 46 data sets were described, their content, coverage and general availability examined and assigned to 11 categories, and each category into classes, which consists of types of data (Roadidea 2008a, Tables 1-1 to 1-11, pages 18/64-21/64).

Table 4. Availability of data (frequency) according to the Data Collection survey.

A.	INFRASTRUCTURE (Geodata, Transport system)	2
B.	INFRASTRUCTURE (Transport management system)	7
C.	INFRASTRUCTURE (Public Transport Management)	3
D.	PUBLIC TRANSPORT AND PASSENGERS INFORMATION	6
E.	TRAFFIC MONITORING (Road observations)	24
F.	TRAFFIC MONITORING (Vehicle observations)	1
G.	TRAFFIC MANAGEMENT	
H.	FRIGHT / SERVICE TRANSPORT	
I.	CLIMATE AND WEATHER CONDITIONS	49
J.	ENVIRONMENTAL IMPACT OF TRAFFIC	3
K.	OTHER DATA	3

As can be seen in the Table 4, the best available data sources are Climate and weather conditions, Traffic Monitoring (road observations), Infrastructure (transport management system) and Public transport and passengers information, whence data classes G. - Traffic management and H. - Fright / service transport”, as well as barely filled classes A. and C. – Infrastructure and F. – Traffic monitoring, are left to be reconsidered within the task 2.2. – New types of data needs.

Although the countries participating in ROADIDEA project are (more or less) covered with almost the same data sources, and general data availability is guaranteed all over the Europe, the availability of road and grid weather sources is much better than the availability of reliable road traffic observations. With partners from the weather monitoring and forecasting sector a very good experience in terms of acquisition and utilisation of weather data can be applied immediately. In gaining some other data, there are some bureaucratic obstacles and problems, and a lot of work remains to convince data providers to collaborate in a research project. The best way to do so is to show the success of innovative ROADIDEA services, based on the data which are covered by those public and private data providers.

The data ownership, which is almost 50:50% divided to government and other parties and to common ownership, can be seen in Figure 3.

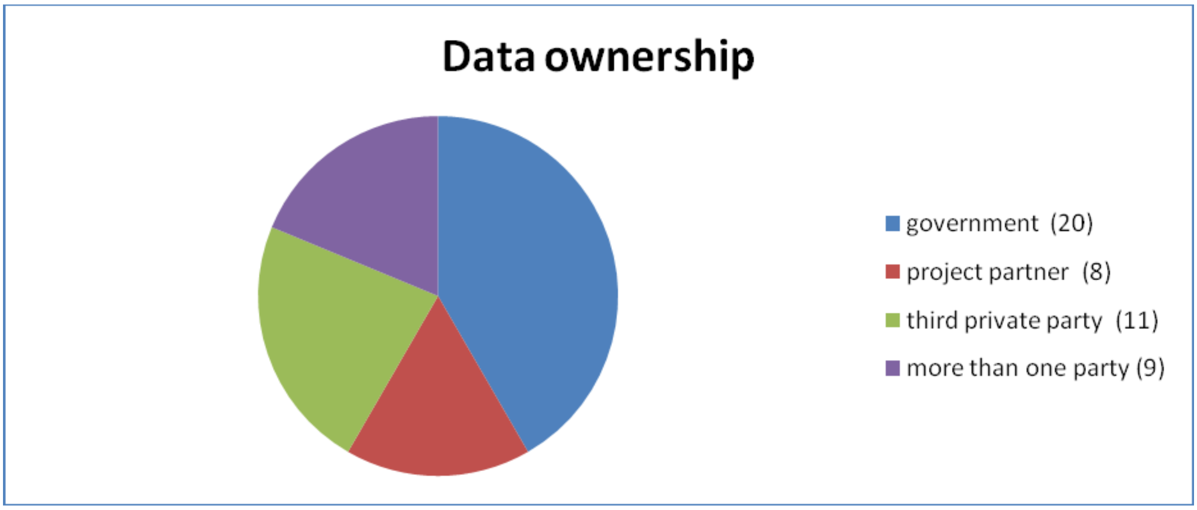

Figure 3. Data ownership.

The data included in survey is mostly free of charge.

It has to be emphasized that, when thinking of development of new services, the necessary data still has to be determined and additional attention has to be paid on the derivation of additional content by combining different data sources. So far, there is not available general European common minimum data catalogue and a lot of efforts on data standardisation are necessary. (ROADIDEA 2008a).

As the innovation process within ROADIDEA project must not be limited to available data, and might cause new data needs, the data source identification is regarded as an ongoing process.

3.2 Emerging road, traffic, weather and other data

It seems to be clear that there are different needs in different countries of Europe, not only because of the geographical location and the resulting climate and other issues but also on differing cultural and social matters and development phases. The data needs are mainly rising from the needs of identified service development (related to user needs) and not from the possibility that a certain kind of data availability would enable creation of services and business.

Future development of traffic assumes its growth with increased energy consumption, greater environmental pollution and noise, as well as overload of traffic routes. The same development has been burdened by two opposing tendencies. One is subjected to short-term interests and oriented exclusively to profit, the other is a long-term care of environmental protection and energy savings, which often excludes immediate profit. Giving priority to this second tendency is a must, and it requires joint efforts invested by scientists, traffic entrepreneurs and government institutions within legal regulations.

Approach to gathering and disseminating traffic data these days is significantly different from the close past, where news media play the dominant role with its use of traffic information for spot news broadcasts. Other market segments, particularly enterprise (fleet companies, high-level telematics end-users) and mass market telematics (navigation systems and other devices), are surpassing news media to the point where access to traffic information over the radio and the television is less and less significant, though there will always be some media value for traffic headlines as part of news reports.

Real-time traffic information is emerging as a must-have feature in automotive navigation and telematics solutions, causing global revenue from service subscriptions to rise by nearly a factor of 18 during the period from 2008 to 2014, according to iSuppli[2].

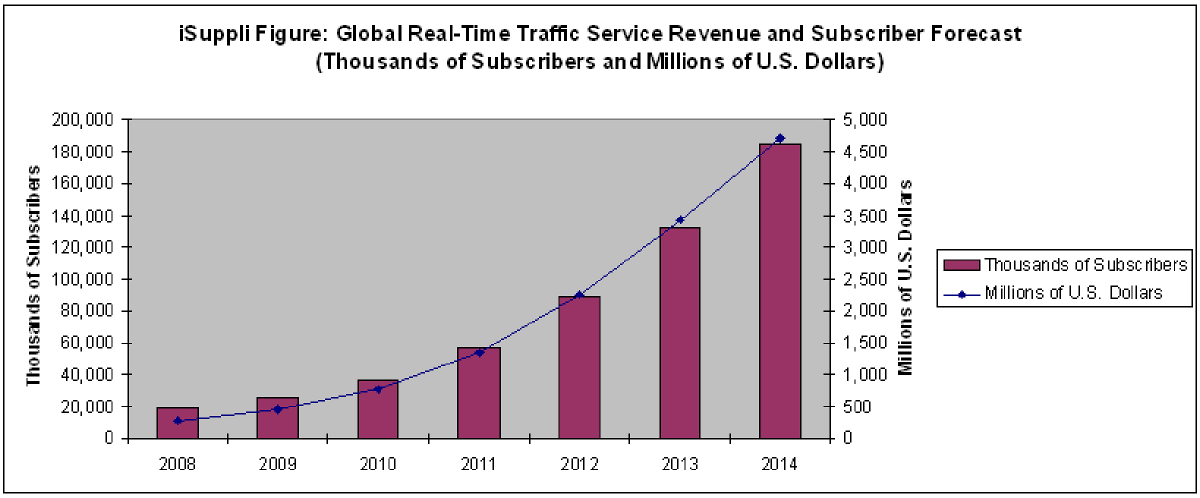

Figure 4. Global Real-Time Traffic Service Revenue and Subscriber Forecast.

Worldwide revenue generated by real-time traffic services delivered to telematics and navigation devices will soar to $4.7 billion in 2014, up from just $268 million in 2008. The number of global subscribers for these services will rise tenfold during the same period, reaching 184.9 million in 2014, up from 18.5 million in 2008.

In an automotive electronics market characterized by commoditization and rapidly declining price points, traffic data represents critical and time-sensitive information that can make the difference between a nice-to-have and a must-have navigation device. Real-time traffic has the potential to be a key differentiator and major opportunity for device makers and service providers to distinguish themselves from their competitors.

The need of government agencies, consumers, fleet operators and other enterprises for fast, accurate, real-time traffic data, as well as the demands of individual telematics end-users for personalized, high-level traffic information, is still unfulfilled.

2 *http://www.isuppli.com/News/Pages/Real-Time-Traffic-Service-Revenue-to-Boom-Over-the-Next-Five-Years.aspx?*

Road and traffic data are the traditional elements in transport planning. They are usually necessary and needed in defining the road and traffic improvements that are borne by the development of economies, regions and communities. The data is also mostly public.

Weather data seems to be largely available in Europe. The offered potential should be better utilized in traffic management, information and warning purposes. This what ROADIDEA has been developing through the new methods and pilots.

Recent development of ITS has in many sense been connected with the development of vehicle telematics systems. Private services, partly also public services, are today short of adequate real-time data on traffic and traffic conditions. Therefore, vehicle as sensor concept is becoming more and more attractive. There is also a win-win situation with the vehicle industry because the autonomous vehicle systems also need better sensors and data.

V2V and V2I data

In the past, the technology dedicated to **intra-vehicle** communication was limited to blowing the horn or perhaps catching a radio report of an accident up ahead. Modern vehicles have a significant number of **intra-vehicle** communication systems and busses and hundreds of sensors connected, delivering information at high data rates. The sensor density in modern cars is comparatively high as in pervasive computing environments. Interconnecting sensor-equipped vehicles enables novel types of applications. The idea of **vehicle-to-vehicle** (V2V) and **vehicle-to infrastructure** (V2I) communication is to collaboratively share information such as vehicle speeds, vehicle density and length of queues, to increase road safety, efficiency and comfort.

In the past, safety systems have focused on reducing driver injury in case of an emergency. The current trend in safety is not just to mitigate the effects of automobile accidents, but to prevent their occurrence all together. This involves making vehicles and roadways “smarter” through Intelligent Transportation Systems. The hope is that these new safety systems will be able to warn drivers of dangerous situations in time to take preventative action. Two areas of active ITS’ research are advanced – sensor technology and inter-vehicle communications. With better sensors and data communication techniques, a driver can be more aware of his or her environment. This allows the driver to react appropriately to situations such as slippery roads and poor visibility. Add vehicle-to-vehicle communications, and drivers can share this information with each other, providing warnings before danger is imminent.

<u>Vehicle can-bus</u>

The main new identified data sources are related to vehicle can-bus data and mobile phone tracking data. For the time being, can-bus data is not openly available for the third parties meaning that the systems are not standardised and there are major difficulties to take the source in wider use.

<u>Floating car data (FCD)</u>

Mobile phone tracking is connected to floating car method based development. Today many development projects are going on e.g. in Europe, US and Japan. The new intelligent mobile phones are an increasing market and systems based on their capabilities and services are competing with aftermarket or factory installed vehicle systems such as navigators.

FCD based on mobile phones believe to have significant advantages over GPS-based or conventional methods such as cameras or street embedded sensors: it is much less expensive, offers more coverage of more streets, it is faster to set up (no work zones) and needs less maintenance. Based on these data, traffic jams can be identified, travel times can be calculated, and traffic reports can be instantly generated.

Satellite systems

Global positioning systems as satellite based systems (Galileo/GNSS - GPS) are improving their services. The new European Galileo satellite system is offering many basic services that can be utilized in new traffic services development and in enhancing the existing services.

Integrating GPS-equipped cell phones into traffic monitoring systems could help provide information on everything from multiple side-street routes in urban areas to hazardous driving conditions or accidents on vast stretches of rural roads. Critical deployment factors still are bandwidth costs (the phones are capable of sending their position and speed every three seconds, but an efficient traffic monitoring system should not need to transfer such a large amount of data, which would require enormous bandwidth) and personal privacy issues. A big challenge is to find the optimum subset of the data for effective traffic monitoring.

The efforts of development of EETS (European Electronic Toll Service) will also contribute to ITS services development in various countries and harmonising the processes. The EU proposal on a directive on ITS is defining the main principles of deployment of ITS applications and services. The general principles are: (a) effectiveness, (b) cost-efficiency, (c) geographical continuity, (d) interoperability and (e) degree of maturity. (EU 2008).

3.3 Data management and information processes

For getting insight into desired traffic related phonema, for example how weather conditions affect on traffic, individual data sources are not enough. Instead, efficient data fusion methods and tools are needed. The central concept is model, that summarizes high-level characteristics of the relevant data sources. A schematic view of the model-based data management and information processing system is depicted in Figure 5.

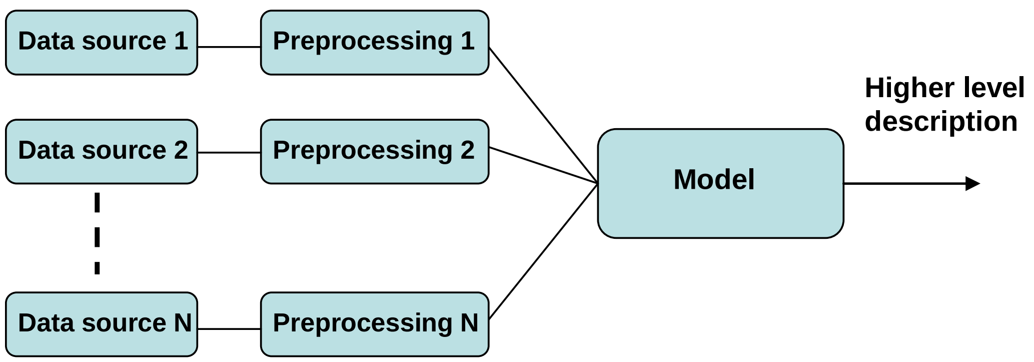

Figure 5. Schematic view of the model-based data management and information processing system.

The model can be either descriptive or predictive. Descriptive models provide a summary or a human interpretable view of complex dataset and hence allow us to make decisions based on the data. Predictive models try to predict a value of the process form which the data is collected, for example estimate of the future traffic density.

Raw data available from data sources is rarely directly suitable for modelling. During the data collection phase, measurement process itself includes many potential error sources:

- Even in a constant environment variance of the measurements is large due to the measurement device itself; precision is small
- Measurement devices can be badly calibrated and the measurements are not even close to the real value of the measured variable; accuracy is small
- Measurement device is not measuring the right phenomenom; the measurements are not valid
- Measurement process itself can be disturbed, for example due to the communication problems; data contains outliers

Therefore filtering and preprocessing steps are required before data can be used as an input for the model. A typical preprocessing step contains outlier detection and correction procedures.

4. Existing services to private end-users

4.1 State-of-the-art of transport information services

An inventory of the existing services was necessary for the background of the services and their business models analysis (ROADIDEA 2009h). The gathered information included altogether 130 different information services related to transport from 9 countries (Germany, Finland, Sweden, Norway, Belgium, Holland, UK, Slovenia and Croatia). More than 50 % of the identified services were directed to drivers. The general finding was that mainly the same types of services are being provided in different countries.

Many of the existing transport information services are getting financing from the end-user payments as expected, but also the public financing is included in many services. In user oriented analysis the services have been mapped by the user group and financing structure where user groups are: Services to drivers (business or individual), Services to users of public transport, Services to bicycle and pedestrian traffic and other services (Table 5).

Table 5. ROADIDEA survey on existing transport services in 9 countries in Europe (ROADIDEA 2009h).

Name of service	Public finance	Finance of transport operators (rail/bus companies)	End-user payments	Advertis-ing	Device or services providers
Services to drivers (business or individual)					
Radio announcements about real-time situation	x			x	
Text television information about weather and road-works	x			x	
Internet information: maps, routes, traffic situation, disturbances, roadworks, weather, services	x	x	x	x	
RDS-TMC - digital road traffic information service	x		x		x
Personal navigation, routes, traffic situation, etc.			x		
Variable message signs: road works, congestion etc.	x			x	x
Parking services, incl. mobile services, variable mes-sage signs etc.					x
Mobile toll/parking payment			x		x
Private weather information				x	
Mobile communication warnings			x		
Mobile traffic information: congestion, road construc-tion	x		x		
Vehicle register information, also mobile	x		x		
Services with GPS navigators: congestion, construc-tion, weather etc.	x		x		
Caravan driving in rough weather	x				
Services to users of public transport					
Travel planning and timetables of public transport	x	x		x	
Route guides	x	x	x	x	x
Real time public transport situation	x	x			
Nearest taxi - ordering		x	x		x
Public transport payments	x	x	x		
Weather services	x		x		
Services to bicycle and pedestrian traffic					
Internet maps and bicycle routes incl. trip planning	x		x		
Mobile information			x		
GPS navigation			x		x
Other services					
Multimodal route and trip planning			x	x	
Incident and maintenance	x				
Rainfall and predictions				x	
Weather data, e.g. for fee	x				
Digital displays in public spaces				x	x
Port transport information			x		
Truck fleet management			x	x	
Dispatching of cargo for trucks and routing					

4.2 Objectives and classification of services

Several ways exist to classify the services produced to end-users and to others who will use services to their own needs for management and business purposes. Behind the delivered services are the motivations that direct the service production. They can be defined in general, depending on the organisation type and roles.

The main division is usually based on the responsibilities at large in the society. This means (1) public sector services and (2) private sector services, which are directed either to end-users or companies and other organisations. Public sector services are mainly open services to all of the citizens and transport system users, most often via collective media such as broadcasting. In many countries, the public sector is responsible for at least the basic services that guarantee safety, security, accessibility etc. fulfilling the general needs of the citizens and their impartial possibilities to take part into the societal actions.

The public sector services are dependent on the objectives of the public sector, which include e.g. (McQueen et al. 2002):

- obtaining the best value for public funding
- maximizing the use of legacy systems and sunk investment
- leveraging the efforts of others
- addressing as many organisational objectives as possible
- investing public money in opportunities appropriate for common funding
- leveraging the motivation and desire of the private sector
- travel behaviour change
- jurisdiction-, mode-, or corridor-focused activities
- promotion of particular travel mode
- reducing intermodal travel times
- improving quality of service
- maintaining an appropriate level of control and management direction.

Accordingly, the private sector has its own objectives behind the services delivery, which can be summarized in general as:

- making profit
- developing sustainable business
- leveraging the power of the internet and technologies
- identifying and managing risks
- effective interface with the public sector
- regional and market focused activities
- exploiting the wider market for information services
- identifying and applying the best business model
- obtaining and preserving a competitive advantage
- developing the market for new products and services.

The pan-European system architectures, as Karen/FRAME and national architectures define the services classification that is necessary for services activities and strategy development. According to the European FRAME architecture, services should be based on the user needs and requirements that are transferred to needed functions and towards more detailed definitions. Functional viewpoint defines, according to FRAME, the following areas of services (Bossom 2004):

1. Electronic payment

2. Safety and emergency
3. Traffic management
4. Public transport operations management
5. Advanced driver assistance
6. Traveller journey assistance
7. Law enforcement
8. Freight and fleet management
9. Other.

The US National ITS architecture consists of following user services bundles and user services (US DoT 2009):

1. Travel and traffic management
    - Pre-trip travel information
    - En-route driver information
    - Route guidance
    - Ride matching and reservation
    - Traveller services information
    - Traffic control
    - Incident management
    - Travel demand management
    - Emissions testing and mitigation
    - Highway rail intersection

2. Public transportation management
    - Public transportation management
    - En-route transit information
    - Personalized public transit
    - Public travel security

3. Electronic payment
    - Electronic payment services

4. Commercial vehicle operations
    - Commercial vehicle electronic clearance
    - Automated roadside safety inspection
    - On-board safety and security monitoring
    - Commercial vehicle administrative processes
    - Hazardous materials security and incident response
    - Freight mobility

5. Emergency management
    - Emergency notification and personal security
    - Emergency vehicle management
    - Disaster response and evacuation

6. Advanced vehicle safety systems
    - Longitudinal collision avoidance
    - Lateral collision avoidance
    - Intersection collision avoidance
    - Vision enhancement for crash avoidance
    - Safety readiness
    - Pre-crash restraint deployment

- Automated vehicle operation

7. Information management
   - Archived data

8. Maintenance and construction management
   - Maintenance and construction operations

The European Commission published in 2007, in preparation of the Action Plan on Intelligent Transport Systems (ITS) for Road Transport the European ITS Roadmap outline including an analysis of the potential of ITS applications to contribute to safe, efficient and clean road transport (EU 2007a). ITS applications were classified there into (1) Network operations (e.g. near-term traffic predictions and weather forecasts, fast alert system), (2) Traffic & Travel information, (3) Electronic Payment, (4) Public transport operations, (5) eCommerce, (6) Commercial vehicle operations (freight), (7) Advanced Safety Systems, (8) Emergency management and 9) Enforcement systems.

The European Easyway project has defined core European ITS services and actions (EasyWay 2008). EasyWay Core European ITS Services are such services for European haulers and travellers, where road operators play a key role in their implementation and operation. A core European ITS service means: (1) the travellers shall know when to expect it (operating environment), (2) it shall offer a minimum level of common content and functionality and (3) it shall offer a common "look and feel" when relevant.

EasyWay Traveller Information Services include pre-trip, on-trip and co-modal traveller information services (Figure 6).

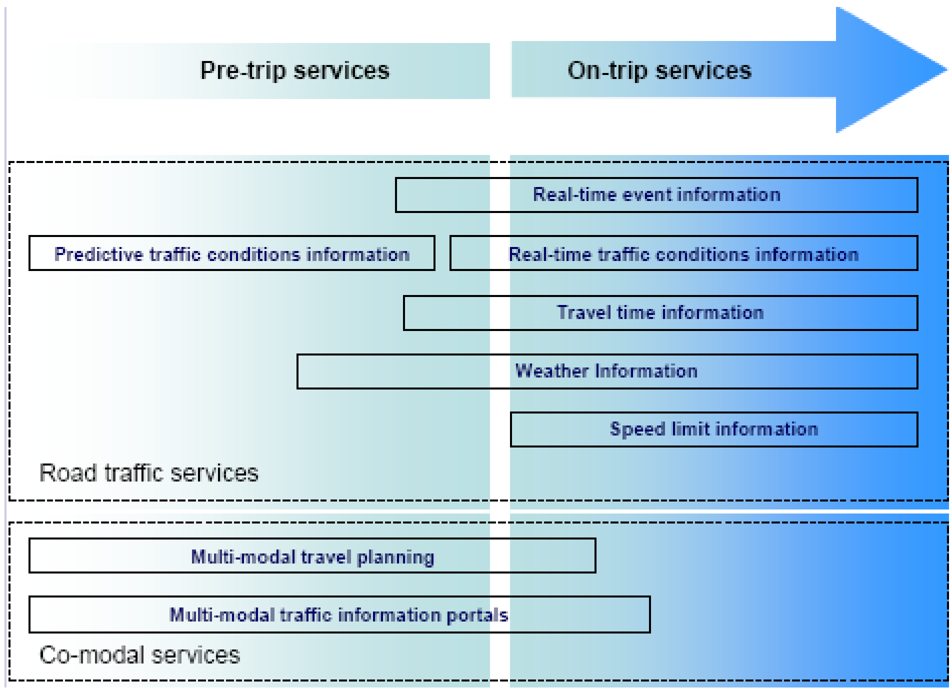

Figure 6. Core European Traveller Information Services according to EasyWay.

The EasyWay Traffic Management Services are (1) Strategic traffic management for corridors and networks, (2) Traffic management of sensitive road segments and (3) Incident management.

The EasyWay Freight and Logistics Services are: (1) Access to abnormal and hazardous transport regulations and (2) Intelligent truck parking.

Monitoring, data processing, exchange and management, data bases and (traffic) centre operations form the basis of ITS service. The objective is that the various ITS services can all utilise the best information available on the status of the transport system (Figure 7).

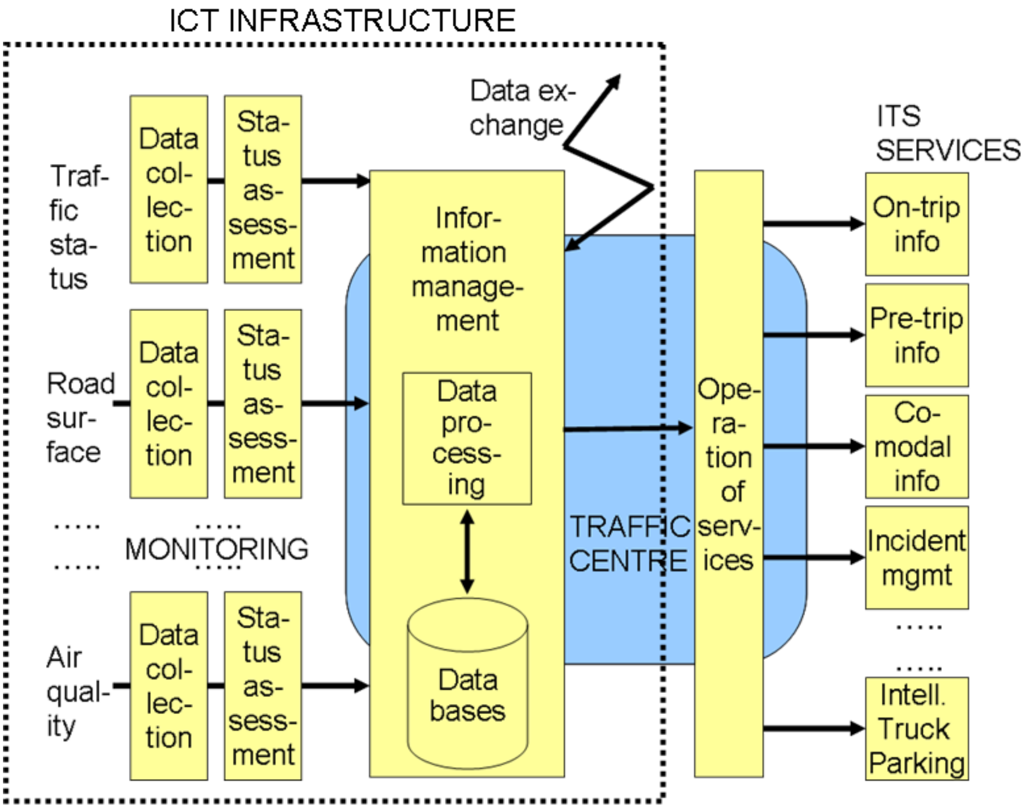

Figure 7. Connected ICT Infrastructure according to EasyWay project.

The needed basic services classification for ROADIDEA should identify the main state-of-the-art and emerging services but should also be detailed enough to support the strategy analysis and services development processes. Therefore, we decided to follow also the EU ITS Roadmap Outline definition. The final services classification has 9 service classes and the necessary sub-classes that define the main applications within each class:

1. Travel demand management

2. Traffic and travel information
    - Navigation
    - Real-time traffic information (pre- and on-trip)
    - Parking information
    - Real-time public transport information (pre- and on-trip)
    - Multimodal journey planning

3. Electronic payment
    - Electronic fee collection (toll payment, tolling & charging, congestion charging, value pricing)

- Public transport payment and ticketing
- Parking management

4. Public transport operations
    - Vehicle location, timetables and reliability
    - Demand responsive public transport

5. eCommerce (B2B/B2C)
    - Mobile communication & location based added-value services

6. Commercial vehicle operations (freight)
    - Intelligent logistics, timetables and reliability
    - Electronic manifest and customs clearances
    - Lorry routes and truck navigation
    - Truck stop, loading bay and truck parking real-time information
    - Sensitive goods cargo tracking and management
    - Hazardous materials security and incident response
    - On-board safety and security monitoring

7. Advanced safety systems
    - Emergency call systems
    - In-vehicle HMI
    - Speed warning
    - Longitudinal collision avoidance
    - Lateral collision avoidance
    - Vision enhancement
    - Pre-crash restraint systems
    - Co-operative vehicle-to-vehicle systems (v2v)
    - Co-operative vehicle-to-infra systems (v2i)
    - Crash avoidance at intersections
    - Electronic Stability Control
    - Lane keeping and warning systems
    - Tyre pressure monitoring

8. Emergency management
    - Emergency notification and personal security
    - Emergency services vehicle management

9. Enforcement systems
    - Emission testing and control
    - Speed enforcement
    - Non-payment of fees and charges
    - Unlicensed vehicles and drivers
    - Over-loading enforcement
    - Drivers´ hours enforcement
    - Road worthiness enforcement

The ITS business development is depending on the possibilities that technologies can offer but today even more on the innovative business model development. In many cases a successful business model means bundling of services offering different choices for users and integrating different user groups into the same major service. New and innovative services may arise within the stated basic services classes, integrating them and even producing entirely new classes.

As this deliverable focuses on services for private end-users we will cover existing services related to Safety and emergency, Advanced Driver Assistance Systems (ADAS), Traveller journey assistance and Freight and fleet operation services. The main focus is on traveller journey assistance services which include information services for road traffic and public transport private end-users.

4.3 Traffic and traveller information

In ROADIDEA D7.1 information about current transport information services were gathered for business model analysis. Nearly all of the services analysed in this task were traveller journey assistance services. Furthermore, most of the analysed services were pre-trip information services based on public data, mainly national (or even regional) coverage and provided via web pages. This section extends the existing list of traveller journey assistance services for private end-users, compiled in D7.1. The services for road traffic, and public transport and services for multi-modal users are presented.

Many road traffic information services are based on traffic data produced by the public sector (road authorities and operators). Some of the end-user services are also provided by the public sector. In a few European countries like Finland, road traffic and weather data is available free of charge, but in many countries there are high barriers for the further use of such data. The collected traffic data and the quality of the data (e.g. speed limit information in road databases and digital maps) vary across Europe and therefore hinder deployment of cross-border ITS services.

Therefore, harmonisation and improvement of the quality of data is still needed. (ROADIDEA 2009b). In fact, the EU ITS Action Plan (European Commission 2008) has an action point on optimal use of data. It calls for the definition of procedures for the provision of EU-wide real-time traffic and travel information services, addressing notably the following aspects:

- provision of traffic information services by the private sector
- provision of traffic regulation data by the transport authorities
- guaranteed access by public authorities to safety-related information collected by private companies
- guaranteed access by private companies to relevant public data

EasyWay is a project for Europe-wide ITS deployment on main trans-European Road Network (TERN) corridors driven by national road authorities and operators with associated partners. The main scope of EasyWay is to improve the situation on European roads, concerning safety, mobility and environmental impact, by deploying harmonised ITS services for the European traveller. EasyWay has proposed an Optimal Quality Levels support action to produce quality recommendations for each core European ITS service. The quality recommendations would cover both the quality of information delivered to end-users, the original data quality and other aspects of service quality. EasyWay 2008. Currently, an EU-supported project called QUANTIS is attempting to explore the optimal quality levels for a few services in Europe.

The Euro-Regional Traveller Information Services (TIS) Expert Group has in 2007 analysed the deployment of traveller information services in Europe based on the experiences from TEMPO Euro-Regional Projects. The reported success stories were split into 8 services categories: (1) Real-time journey prediction (pre-trip and on-trip information), (2) Roadside information (on-trip information), (3) In-vehicle information (on-trip information), (4) Internet based services (pre-trip information), (5) Mobile services (on-trip information), (6) Freight services (pre-trip and on-trip information), (7) Multimodal interfaces (pre-trip and on-trip information and 8) Other services. (TIS 2007).

Real-time journey prediction includes (a) instantaneous journey time estimation, (b) short-term journey time prediction (less than 2 hours) and (c) personalised real-time journey time estimation. Of these services instantaneous services are mostly available, short-term prediction services promising and personalised services still emerging.

Road-side information using variable messages Signs (VMS) on high-level motorway networks with dynamic messages was already in widespread deployment. Experiments towards harmonisation had started.

On-trip in-vehicle information from local and national radio was seen to be heterogeneous. Broadcasting of traffic alerts through RDS was in widespread deployment but needs an active RDS audio system. In-vehicle navigation systems without traffic information have been taken into use but the problems still is the cost of the system. In-vehicle systems with RDS-TMC have also reached widespread use but problems with receivers and quality of information exists. Traffic information with DAB (Digital Audio Broadcasting), real-time on-board alert and including floating car data and real-time on-board information about speed limits, traffic signs and regulations are all just emerging.

Internet services are in widespread deployment. Static route planners are in use. Real-time event information has been implemented in many countries but aggregation of information to high-quality pre-trip information is emerging. Added-value services (e.g. travel time, traffic forecast, weather) seem to be promising as interactive real-time information services.

Dedicated freight websites and portals are already in use. On-trip dedicated information for heavy goods vehicles, dynamic information on parking spaces and rest areas and long-distance information services are just emerging. Some multilingual freight services are already in operation.

Multimodal traffic information is looking promising and the need for it has been identified. Multimodal portals, route planners are also looking very promising and mobility comparisons with travel times and environmental impacts are resulting in emerging new services.

4.3.1 Navigation and related services

During the last few years portable satellite navigation devices such as Personal Navigation Devices (PND) and smartphone-based navigation applications have seized the European market. These navigation devices provide many services in compact package and they can be used for pre-trip planning and on-trip information services. Most of the above mentioned road traffic services defined in EasyWay project are already available across Europe via mobile navigators with real-time information support. Navigation devices provide pan-European and cross-border services. But the quality of the service is always depending on the quality of the data.

The private service development is led by portable navigation device and service providers like TomTom and Nokia. Today, navigation is the most widely used on-trip ITS service in Europe. There are around tens of millions of PNDs and GPS navigation enabled smart phones in the European market. Today, navigation is also the most popular Location Based Service (LBS) as the flat rate charging schemes for data have enabled the use of mobile services.

In addition to stand-alone navigation, real-time traffic and also weather warning information is broadcasted to the end-user PND devices e.g. via FM Radio Data System (RDS) - Traffic Message Channel (TMC). There are free (based on public data) and commercial TMC services available in Europe. Payment of the commercial TMC traffic information is usually bundled with the cost of the navigator (e.g. PND device or factory installed OEM navigator).

4.3.2 Real-time traffic information

As already described above, EasyWay has defined core European traveller information services as pre-trip, on-trip and co-modal services. The main sub-services are: (1) real-time event information services, (2) real-time traffic conditions information services, (3) predictive traffic conditions services, (4) travel time information services, (5) speed limit information services, (6) weather information services, (7) multi-modal traffic information portal and (8) multi-modal travel planning services. These services are partly already available in Europe but in many sense also under constant development (EasyWay 2008).

Drivers and other road users make decisions in pre-trip and on-trip situations. These decisions are partly based on the current information about traffic and other conditions e.g. weather but also on the expectations of the future development. Therefore, there is a major need for predictive information including flexibility and adaptation ability into the variable human behaviours. Speed limit information has been integrated into many navigators and in-vehicle on-board systems but some problems has also been identified e.g. updating and data quality. The speed limit related service has been defined in many cases as a Speed Alert Service because in many applications there will be some kind of alert message in speeding situations.

General weather information services are in widespread use through internet, radio and e.g. mobile systems, but for safety and security reasons special warning services are needed. The countries with cold weather and countries that frequently have some major weather disturbances could benefit from early warning systems. These studies are with ROADIDEA and included also in the main pilots on traffic, skidding and fogginess problems. According to a study on flooded roadway warning systems in US weather-related fatalities in Texas in 1973-2007, there were altogether 274 fatalities of which flood/flash flood accounted for 203, tornado 39, lightning 12, winter storm 8, extreme heat 6 and thunderstorm/wind 6 (Gibbon 2009).

For smartphones and connected PNDs (with a SIM card or connected through a Bluetooth-equipped mobile phone), dynamic traffic information is provided via cellular network packet data connections (e.g. 3G, GPRS). Dynamic traffic information, connected services and many of the newest features in navigation systems involve an internet connection.

Pan-European navigation device and service providers utilise traffic and weather information from data aggregators like Destia or ARC Transistance which gather public data from several countries and combine it with other data sources to provide multinational data sets. These data aggregators may broadcast traffic information via TMC and sell their data also to other private sector stakeholders including news, media and OEM navigators. Navigation device providers have recently started to collect their own traffic, map and speed limit data and updates straight from the users (e.g. TomTom). This has enabled collection of data updates and corrections much faster and enhanced the quality of the data.

A few years ago, the European traffic information market consisted of local players. Now, pan-European traffic information providers have emerged including TeleAtlas (acquired by TomTom 2008) and two North American players, NAVTEQ (acquired by Nokia 2008) and INRIX. All these companies utilise a mixture of data sources and data types (such as traffic incidents, road sensors, GPS probes, cellular probes, etc.) and fuse them to increase data quality, but today none of the existing players are able to control all these data feeds in a majority of the European markets. Therefore, harmonisation of traffic data and importance of the quality issues need to be taken care of in the near future. (GPS Business News 2009)

The navigation device manufacturers (e.g. TomTom and Nokia) are expanding their device based services to web pages with real-time information (e.g. real-time traffic information in TomTom route planner) and easy synchronisation and data exchange between web and the device. Information provided via web and basic navigation service is provided for "free" (e.g. bundled with device cost) and enhanced services are sold as extra (e.g. monthly rate). These extra services include traffic information, fuel prices, weather, local search, etc.

Researchers from Nokia Research Center Palo Alto, Navteq, and UC Berkeley, with support from Caltrans and US DOT, have built a traffic monitoring system using GPS equipped mobile phones. The Mobile Millennium project, officially launched in November 2008, is an early instantiation of participatory sensing in the form of a traffic monitoring system which collects anonymous traffic data from GPS-equipped mobile phones and fuses it with the data from static traffic sensors to estimate traffic conditions in real-time. Information about the current traffic conditions are then broadcast back to the users' mobile phones, enabling commuters to make more intelligent route and trip decisions. (Berkeley 2008). More detailed information on the services by TomTom and Navteq is given below.

TOMTOM pan-European services

TomTom is a leading provider of navigation solutions and digital maps, originating from the Netherlands. In 2001, TomTom published their first navigation product for PDAs, and their first PND came to the market in 2004. In a couple of years, the TomTom GO series became the Europe's most popular PND (Chandrasekar 2007). During 2008, TomTom sold over 12 million PNDs (TomTom 2008).

TomTom offers a wide range of services, most recently fuel price information searches in the UK, Netherlands and France. Their connected PNDs are able to

- download map updates
- use historical speed data recorded by other users to improve route calculation ("IQ Routes")
- warn about speeding and speed cameras
- download scenic routes and audiobooks
- reroute in case of traffic delays
- share map corrections
- operate as a hand-free device, when connected to a mobile phone using Bluetooth.

The company has implemented several features in their PNDs for the user community to share information. TomTom's Map Share community collected a million suggestions for map updates during just first six months of operation (TomTom News 2008). Map Share allows the users to select different levels of trust for which corrections they want to use. Either the improvements have been verified by TomTom or changes that are submitted by trusted sources or by some people.

TomTom is an active traffic information producer and utilises the information in route planning. IQ Routes was the first large-scale implementation of using historical speed data collected by user community to calculate faster routes based on e.g. time of travel. TomTom's HD Traffic provides users with TMC-like traffic information but through an internet connection. They recently published a widget for personal web pages to show traffic information also on PCs.

TomTom HOME software allows controlling and updating the PND by connecting it to a PC. Along with tuning the visual looks and sounds, it allows to search a destination using Google Maps and then transmit this information to the PND.

TomTom's work business unit offers professional solutions for commercial fleets. Their products allow enterprises to monitor, manage and communicate with their drivers and fleets of vehicles. The TomTom WORK solution exists of 3 integrated components: WEB-FLEET (web-based tracking and tracing service), LINK (small GPS logger placed in the vehicles, connected with GO) and GO (navigation device). (TomTom Work 2009)

Through stategical parnerships with JCI and Fujitsu, TomTom also aims at OEM markets (Frost & Sullivan 2007). TomTom is becoming a "one-stop-shop provider" of navigation series for OEMs as well as for end-users. Several functions such as continuous speed limit warning (inside tunnels), eCall (airbag inflation notification) and extended FCD have been listed as discussion items with OEMs and having future safety potential (Kamalski 2008).

NAVTEQ's traffic information services

NAVTEQ is a leading global provider of digital map, traffic and location data for in-vehicle, portable, wireless and enterprise solutions. The Chicago-based company was founded in 1985 and has approximately 4000 employees. In 2008, it was acquired by Nokia.

NAVTEQ offers dynamic traffic information in more than 120 markets. The number of subscribers to the traffic services has exceeded two million in North America, mainly through Garmin and Verizon Wireless navigators, NAVTEQ Traffic Satellite, RDS-TMC channels and Traffic.com. NAVTEQ Traffic.com is the leading U.S. traffic-only website for online and mobile traffic information. (NAVTEQ 2009a)

Traffic.com features a location-aware homepage, finding user's geographic location based on IP address. The page can be configured according to personal preferences, for example to show information regarding regular destinations. It shows a real-time traffic summary including colour coded indications, travel times, vehicle speeds, delay times and a news ticker that continuously scrolls real-time traffic information and alerts. The site is designed to keep the users informed of major incidents through several channels: RSS news feeds, personalised widgets that can be used on computer desktop and web pages, SMS and voice call alerts, WAP services[3]. Many of the services are available for free.

Traffic.com benefits from NAVTEQs comprehensive information from data sources including probe vehicles, proprietary sensors, government sensors, as well as incident and event data gathered through local operations centres. NAVTEQ as well as Tele Atlas, the two market leaders of map information, measure thousands of kilometres yearly using specially instrumented vehicles. According to their web site, NAVTEQ provides 260 road properties (e.g. road class, speed limit) for the measured road network in 77 countries (NAVTEQ 2009b). Additionally, NAVTEQ's Discover Cities offers additional information for pedestrian and public transport navigation services (NAVTEQ 2009c). The detailed information about cities is already used in several navigators.

4.3.3 Real-time public transport and pedestrian information

There are many public transport information services available, partly operated by public transport companies, public authorities, but also private providers. Most of journey planners, described also in ROADIDEA D7.1, are national and regional. Cross-border trip planning is available for combined car and ferry journeys[4], air transport (e.g. Amadeus.com) and train transport (e.g. d-bahn.de). Many trip planners, especially for long distance travel, also allow purchasing tickets on-line (e.g. d-bahn.de, vr.fi).

Google Transit also started to provide information on public transport. Google have developed the GTFS (Google Transit Feed Specification) format for public transportation schedules and associated geographic information. Google Transit and similar public transport trip planners with large coverage could assist in integrating the information from different countries to be available for developers. However, numerous agreements are generally required with local operators and getting all information and every operator to join has been difficult even for large companies.

Trip planners mainly cover static timetables and conventional line-based lines. Flexible lines and Demand Responsive Transport are included in a limited extent. For instance, the Flemish bus operator De Lijn[5] includes flexible lines in the trip plan, by giving the timetable and guidelines for ordering the trip.

Provision of real-time information: Public transport companies gather real-time information from vehicles and forward it to road-side displays. This information is also often available in mobile services, where users can check for the next arrival of buses. The use of the information in trip planners is not yet common. The trip planner from VBB, the public transport authority of Berlin-Brandenburg, provides alternative routes in case of delays and disturbances[6].

Some portals allow comparing both multimodal public transport and private car trips (e.g. transportdirect.info, 9292ov.nl). Information portals allow comparing travel costs, fuel consumption and CO_2 emissions. Also social web applications are being used for providing public transport information. For instance 9292ov.nl provides information on transport disruptions to Twitter.

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3 *mobi.traffic.com*
4 *www.ferry-routing.com/*
5 *www.delijn.be*
6 *http://www.vbbonline.de/*

NAVITIME[7] is an of example of point-to-point route search and navigation service that uses any major transportation method - walking, driving, trains and subway, buses, taxis and airlines - to direct users to their destination. NAVITIME is an off-board (on-line) mobile service. NAVITIME started in Japan but it is now also available in many countries in Europe.

Many providers have mobile versions of their trip planners. However, GPS-supported public transport navigators featuring dynamic information are still very new (earliest prototypes 2004). By using mobile device built-in GPS positioning, the user friendliness of the application can be improved (e.g. 9292ov.nl). Other ways to provide location based information to mobile phones is the use of NFC tags, which are attached to bus stops. The user can access information in a fast way using the tag. This has been demonstrated in the KAMO project in Helsinki. (VTT 2007)

Pedestrian navigation is gradually going forward. Today, most of the currently available portable navigation devices can already guide pedestrian in a walking mode via road network (just by ignoring some driving restrictions). Navigation maps for pedestrians are being developed in order to support multi-modal navigation. For example NAVTEQ Discover Cities enables routes that take into consideration the location of bus and rail stations stops and their entrances/exits in relation to the pedestrian route as well as the train/bus network information, including transfer locations. Development of digital maps enables implementation of new accurate navigation services. (NAVTEQ 2009c)

4.4 Commercial vehicle operations

EU has recently paid a lot of attention on logistics problems including freight in Europe and in the main transport corridors. Without efficient logistics and fluent freight deliveries the competitiveness of European industry would be in danger. The EU Logistics Action Plan directs the efforts towards sustainable quality and efficiency, simplification of transport chains, "green" freight transport corridors urban freight logistics and vehicle dimensions and loading standards (EU 2007a). The main solution has been the application of ICT in Freight Transport, use of new technologies, improved standardisation and open systems and services for the whole logistics processes. Location based services supported by Galileo/Egnos and new tracing and tracking technologies as RFID are some of the key drivers of the development. Different new services and services producers are needed. Actually, the major European wide concepts mean networked service chains and new logistics ecosystems.

Fleet management is used in reference to a wide range of solutions for different vehicle-related applications. In general, a fleet management solution is a vehicle-based system that incorporates data logging, satellite positioning and data communication to a back office system. Freight and fleet solutions are usually tailored to the company in question so that general views are rather difficult to draw.

Many international aftermarket solution providers compete on the European market. Furthermore, Personal Navigation Device manufacturers are trying to broaden their supply to cover also business users and vehicle fleets with their connected PNDs and fixed in-vehicle devices (e.g. Tomtom Work). But the market is packed with various aftermarket and OEM telematics solutions. The in-vehicle devices are all supporting the heavy duty vehicle defector FMS standard and can generally be deployed in mixed fleets. A major

[7] *www.navitime.com/*

trend in 2008 has been the announcement of solutions for remote downloading of digital tachograph data. (Berg 2009)

Digital maps have been updated recently to support also heavy duty vehicles. For example, NAVTEQ Transport includes map data featuring specific information for transport industry routing and NAVTEQ has produced a rich POI data set about filling stations (accessibility by lorries, the availability of HGV pumps, type of fuels sold, truck wash facilities, payment options, on-site shower facilities etc). This enables the development of new information services for transport operators.

4.5 Advanced safety systems

Safety and emergency services have been developed by both vehicle manufacturers (OEMs i.e. Original Equipment Manufacturers) and aftermarket solution providers. Advanced Driver Assistance Systems or ADAS have so far been solely an OEM playground.

ADAS are in-vehicle technologies designed to improve safety by aiding the driver. The systems enhance the driver's perception of hazards and in some cases partly automate the driving task. Examples of ADAS are lane departure warning, collision mitigation, intelligent speed adaptation and automatic parking. The term is still quite new and there's a need to clearly define what constitutes an ADAS. (eSafetySupport 2009)

One definition is that the systems use environmental sensing to create a view of the vehicle surroundings. A vision system to track pavement markings or a radar to detect obstacles in front of the vehicle are examples of used sensors. A digital map can also be considered as a sensor. (eSafetySupport 2009)

Currently ADAS are not really services, because they are stand-alone applications running on in-vehicle computer, usually without external communication out of the vehicle. But Cooperative safety systems are being developed which utilise vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) communication. These are described in section 5.1 Identified new applications and services.

The pan-European in-vehicle emergency call system (eCall) has been under development for several years. eCall is a high priority topic within the European Commission. eCall is an emergency call, generated manually or automatically via activation of in-vehicle sensors, to the relevant PSAP (Public Safety Answering Point) with data about the accident. It has been expected that eCall in-vehicle devices, with satellite positioning and communication capabilities, would also enable variety of in-vehicle telematics applications and connected services. The first eCall standards (e.g. the eCall minimum data set definition and the in-band modem solution) have been finalised 2009. Currently, it has been agreed that eCall will be introduced as standard option in all new vehicle models entering the market year 2012.

The eCall development has been a slow process and there are still open issues before the pan-European eCall can be realised. For instance, important countries such as France and the UK still haven't shown any intention of signing the pan-European eCall Memorandum of Understanding.

The car manufacturers have developed their proprietary emergency telematics systems, which compete with the standardised pan-European eCall solutions. For instance, PSA Peugeot Citroën have their own eCall-like solution, since 2003, with over 700 000 cars equipped (PSA 2009). (eSafetySupport 2009)

Vehicle manufacturers have been developing connected safety and emergency services. European OEMs have their own proprietary solutions such as BMW - Assist, Volvo - On Call, PSA - Peugeot Services Mobiles, Fiat - Blue&me Nav. For example BMW Assist and On-line services includes breakdown and emergency calls, traffic information, remote door locking, information regarding vacancy in car parks in most large cities and airports in Germany, email and web access (BMW 2009). Similar services are also available from other above mentioned OEMs. OEM telematics services are available in central European countries such as Germany, Great Britain, Italy and France.

For usage based insurance solutions the leading market is Italy, where technology is provided by OctoTelematics for over 800 000 users (Frost & Sullivan 2008). An in-vehicle GPS unit is used to simultaneously provide eCall, stolen vehicle tracking, real-time traffic information (collection) and support for new insurance models such as "Pay-Per-Use" and "Pay-As-You-Drive."

4.6 Emergency management

Eurowatch is a security service enabling to locate and recover stolen vehicles and shipments, targeting especially crimes that cross national borders. Eurowatch provides 24-hour service across Europe. In case of incidents, drivers can contact their local service provider (speaking the same language), which forwards the request to the country where the incident has occurred. A key component is the on-board telematics device, which transmits positioning data which is relayed to the police in the country of the incident. This allows the police to trace the position in real-time during the emergency. (Eurowatch 2009)

The most widely available aftermarket safety and emergency services in Europe are stolen vehicle tracking and usage based insurance solutions. Stolen vehicle tracking services are mainly available via aftermarket providers such as OctoTelematics in Italy and Cobra in UK. Although, the premium segment OEMs in Europe also provide stolen vehicle tracking within their telematics packages.

4.7 Business models and revenue logic

4.7.1 Introduction

Defining a business model for a product or a service requires the identification of the value proposition. To create revenue the service must be beneficial to a party in the value network or chain, and this value should be made evident for the end user, customer or financier. This is not always simple for intangible products, like information services. There are studies which show the societal impact of certain transport information services and thereby justify their public financing. However, it is not easy to convince the private end users to pay for the services. For example, the end user cannot know in advance the value of information about traffic incidents at a specific point of time because if there are no incidents and resulting disturbances, the information value is less than in case there are incidents.

4.7.2 Service value for users

Traditionally transport information services have societal impacts towards safety, transport network efficiency, economic effects and decrease of environmental hazards. The advanced information services are expected to create increased benefit also for private end users. The value to the users is realised mainly by saving time and costs, increasing safety and reducing stress. The following private end user benefits of current transport information services were identified in ROADIDEA 2009h:

- saving time & costs
  - avoid traffic incidents and unexpected slowdowns
  - planning, finding and tracing routes
  - finding a parking place
  - saving fuel costs
  - avoiding getting fined
  - finding stolen cars
- reducing level of stress and anxiety
- increasing safety by preparing for weather conditions and changing behaviour
- finding and planning public transport routes and schedules
- paying the public transport fare (easiness of transport)
- quality of travelling
- finding places and road side services.

Additionally business users may benefit by increased efficiency for logistics and transport.

4.7.3 Stakeholders

As described above, the current transport information services to private end users are based on many different types of data and information: real time traffic data, map and location data, weather data, road condition data, route information about public transport and for specific groups like cargo drivers and bikers. Advanced information services integrate different data types to be able to give travelling recommendations, to present a real time status or even a forecast about the future situation in traffic.

The different data types, for example weather or geographic data and traffic identification require different data sources, different measurement and processing methods and thus also different resources and competences. One organisation is not typically able to provide all the measurement, data handling and integration competencies needed for an advanced service; participation of different data and information providers is needed.

Generation of the traffic information is not yet sufficient to create value to end users. Additional stakeholders are needed to distribute the information. This may be performed through several channels which again may increase the number of different stakeholders included. Also technology partners and other service providers may be required.

As a conclusion, the transport information services require the creation of a service network of partners complementing each other's competencies and resources. Typically one of the partners operates as a central point, service integrator or a network manager taking care of the service delivery and management.

ROADIDEA 2009h analysed the transport information service stakeholders in more detail. Based on the collected information about current services in Europe altogether 37 types of actors were identified:

- 11 user groups (partly participating in financing)
- 7 groups of financiers

- 12 groups of information providers
- 5 groups of service providers
- 2 other types of stakeholders.

Most actors may operate in several roles. Users may participate in financing and even providing information. Many financiers may at the same time be providers of specific information. Altogether 20 actor groups providing information were identified.

4.7.4 Business model challenges

The main challenges from the business modelling viewpoint include:

1. Creation of sufficient revenue to cover the costs of information services.
2. Sharing the revenue in the service network.

Many information services have problems to create sustainable services, with revenue streams covering the costs. The data, information and service providers, integrators and distributors all have costs which must be reimbursed. In general, the costs should be compensated by the stakeholders benefiting of the services. However, it is a challenge to make private end-users to pay about information services. The users tend to select free information instead of a paid service even if they receive worse quality. In some cases more detailed and tailored information can make the users to pay for the service.

ROADIDEA 2009h presents information about current European transport information services and their financing modes. The information collection resulted in listing 132 services from different countries. About half of the services have only one financing mode and about half have several financiers. So far public financing seems to be the most common; it is present in about 60% of the listed cases. In these cases, the services are expected to have impact to the society. In addition to the service users other financing stakeholders may come from transport operators, advertising etc. All financiers expect to get some return of value or benefit for their investment. The transport operators can get more customers, the advertisers attention to their products and services, etc.

A ROADIDEA workshop classified the current financing models in 5 categories (ROADIDEA 2009h):

- Public service A: “full” public services
- Public services B: outsourced public services
- Public-private: sharing the costs and risks
- Private services
- Non-profit, non-government services.

A service network description (ROADIDEA 2009h) has been used to present the relationships between the stakeholders. The description shows data/information and money flows between the partners. As most of the services still rely on public support the question of sharing the revenue has not become real. In many cases there has been a public start-up aiming for a private take-up but the services have not always become sustainable in a business sense. In case of fully private services there is typically a service manager or integrator which takes the risks, collects the funds and pays the costs to other partners. Typically there is no collaborative risk and profit sharing. Also for many private services, the government may give support by providing data with nominal costs.

The bundling of services together with infotainment/entertainment services utilising the same base device and communication platforms has been proposed to cut down the marginal cost of traffic related service.

4.8 Services architectures, standards and specifications

The European ITS Framework architecture (FRAME) was created between 2001 and 2004. The architecture is partly based on earlier work in KAREN project.

The FRAME architecture consists of three main parts: functional architecture, physical architecture and communications architecture. In addition to these three parts, the architecture contains a list of user needs. The three parts of the framework architecture are used to describe what needs to be included in a system that can fulfil the requirements set on the basis of the user needs (Bossom et al. 2000).

The functional architecture describes the functional areas, individual functions inside functional areas, databases, and terminators which represent the entities the architecture is supposed to interact with. However, the FRAME architecture does not specify individual technologies or the way the information is represented in various systems.

The FRAME architecture can be used when defining national ITS architectures or service architectures for individual ITS services. An overview of relationships between FRAME, national ITS architectures, individual system and service architectures and other ITS architectures is described in Figure 8 (Bossom et. al 2000).

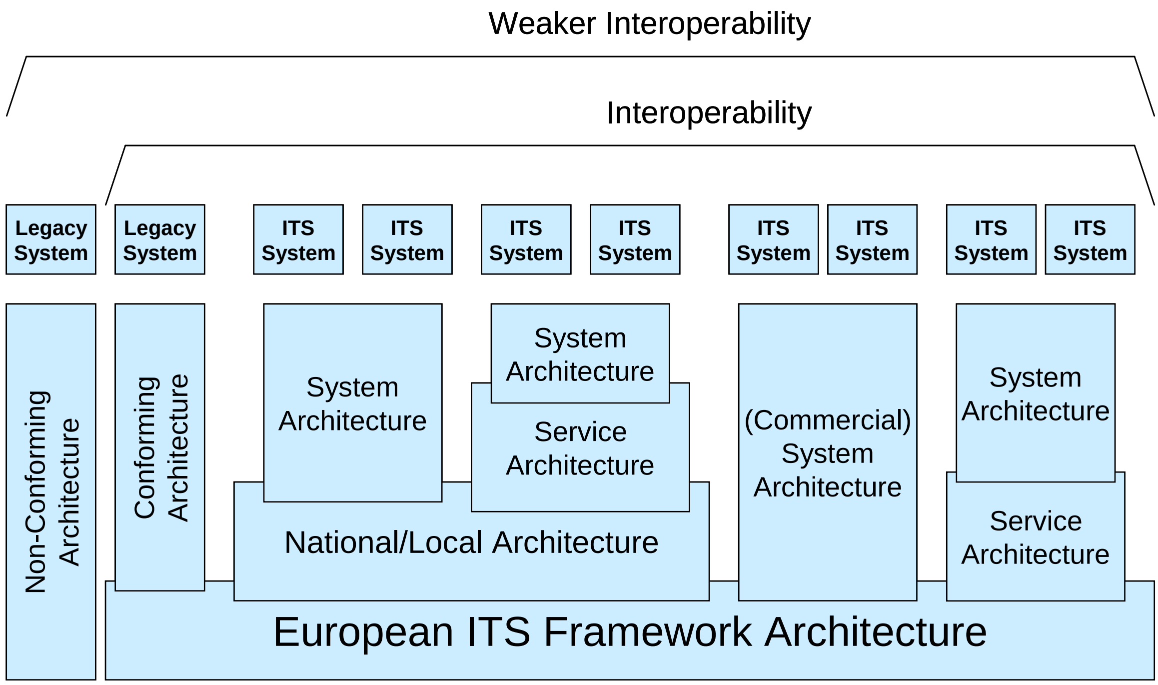

Figure 8. Overview of relationships between various architectures.

At present, the FRAME architecture is being developed further by the E-FRAME project (Jesty & Bossom 2009). The E-FRAME project is preparing a new version of FRAME which will include also cooperative systems and advanced driver assistance systems. The new version (version 4) of the FRAME architecture will be published in February 2010.

As a framework architecture, FRAME has not been designed to be used as a basis for implementation of individual software applications or subsystems. It is also technology-neutral and it does not specify which technologies should be used to implement the components and communication links specified in the reference architecture.

An overview of the ongoing standardisation activities and existing standards related to ITS was produced by the KAREN project in 2000 (Winder et al. 2000). However, the FRAME project has not actively maintained nor updated the list of relevant standards or standardisation activities since 2000.

Most European countries have their own national ITS architectures. Some of these architectures are compatible with FRAME while others are only partly compatible.

TelemArk

TelemArk (Mäkinen et al. 2000) is the Finnish national ITS architecture. TelemArk does not strictly conform to FRAME because FRAME was not publicly available at the time when TelemArk was developed. In addition to TelemArk, Finland has a national ITS architecture for freight transport (Granqvist et al. 2003).

The method used in TelemArk to describe various ITS systems is somewhat different from the method used in the FRAME architecture. The TelemArk architecture consists of two main parts: conceptual architecture and logical architecture. Conceptual architecture describes the service processes the architecture is supporting while the logical architecture describes the structure that supports the processes. A service process is described as a diagram which consists of the roles of actors, functions performed by actors and data flows between various functions performed by the actors involved.

ARKTRANS

ARKTRANS (Natvig et al. 2004) is a Norwegian national framework for ITS services. ARKTRANS includes both freight and passenger transport and all traffic modes. The ARKTRANS reference model consists of transport demand, transport service management, on-board support and control, transport network management and terminal management (Figure 9).

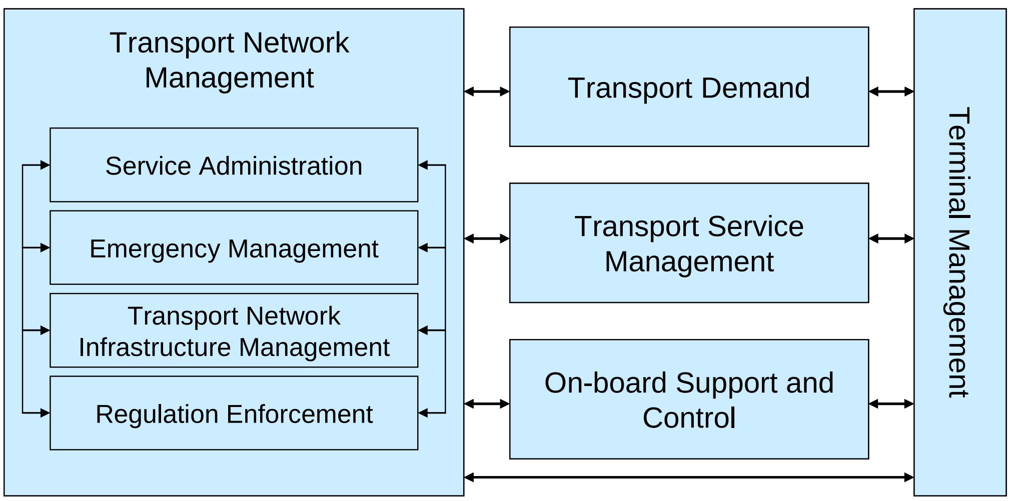

Figure 9. ARKTRANS Reference model (Natvig et al. 2004).

In addition to reference model, ARKTRANS defines the roles of various actors and objects in the transport system (Roles) (Figure 10). The functional view describes the functionalities related to the various sub-domains of the reference model.

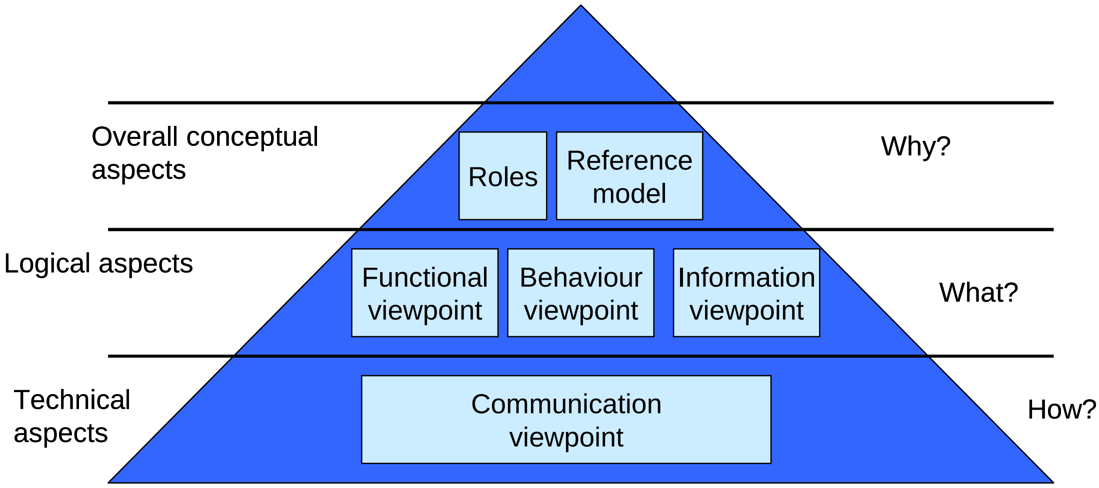

Figure 10. ARKTRANS Contents (Natvig et al. 2004).

The behaviour viewpoint aims to describe the interactions between various actors in the domain of transport. The interactions are described with scenarios which have been built on the basis of the needs of various stakeholders and the functional viewpoint of ARKTRANS. the scenarios are described as UML activity diagrams. The information viewpoint describes the information shared by various sub-domains at conceptual level.

ARKTRANS has a web site http://www.arktrans.no where one can find the latest version of the architecture documents and other publications.

The development of cooperative systems has meant the need to develop the system architecture for the cooperative systems, especially in view of the extra elements brought about by the communications between the vehicles as well as the vehicles and the infrastructure. Figure 11 shows the main components of the system architecture compiled by the COMeSafety consortium (Bossom et al. 2009)

The COMeSafety document consists of three main parts. The first part takes on the overall architectural aspects, the second part concerns communication technologies and their specific use for the addressed application scenarios and the third part describes certain aspects of the communications network implementation. The document is a basis for complementary work that will be done in liaison with European and global projects and actions to further prepare and support the implementation and exploitation of cooperative systems. As the development of a European ITS communications architecture for cooperative systems is currently an ongoing process, the document will be continuously adapted and updated. (Bossom et al. 2009)

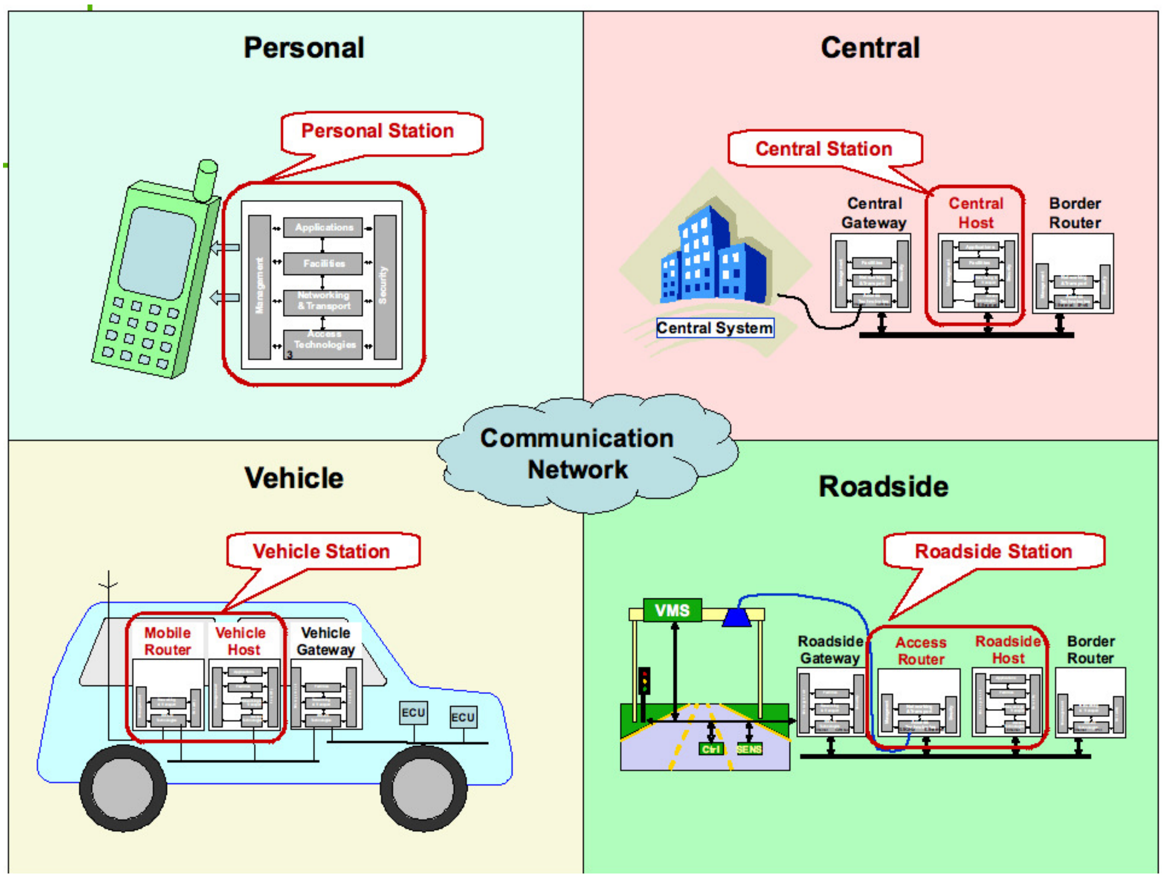

Figure 11. COMeSAFETY architecture (Bossom et al. 2009).

Overview of standardisation related to ITS

Standards having their focus on ITS applications have been published by several standardisation organisations like ISO (International Standardization Organisation) and CEN (European Committee for Standardization). Standards related to telecommunication in the context of ITS are prepared and published by ETSI (European Telecommunications Standards Institute) and ITU (International Telecommunications Union).

A large part of the work in CEN is carried out by the technical committees (TCs) and standards related to ITS are usually prepared by CEN/TC 278 Road transport and traffic telematics. TC278 has prepared standards related to several applications like road electronic fee collection, eCall, travel and transport information (TTI), electronic license plates, recovery of stolen vehicles and public transport payment systems. Some standards formulated by TC278 are related to enabling technologies like DSRC rather than individual applications. Lists of standards under preparation or already completed by CEN/TC278 are available on the CEN web site http://www.cen.eu

ISO has a technical committee ISO/TC204 whose main focus is standardisation related to ITS. ISO/TC204 defines its scope to be "Standardization of information, communication and control systems in the field of urban and rural surface transportation, including intermodal and multimodal aspects thereof, traveller information, traffic management, public transport, commercial transport, emergency services and commercial services in the intelligent transport systems (ITS) field." At present, TC204 has 17 separate working groups (WGs). In-vehicle transport information and control systems are standardised by ISO/TC22 (Road vehicles).

In addition to formally recognised international standards, a large number of national or de-facto standards exist and are being used actively. Good examples of these are the protocols used in Internet like http and smtp defined in RFC (Request for comments) documents published by IETF (Internet Engineering Task Force) or the serial port in computers defined by EIA (Electronics Industries Association).

The standardisation process from proof-of-concept testing or pilots to a published standard takes usually several years. This may be problematic in case of applications with short lifecycle or applications whose functionality or technical implementation is changing over time.

Functional and technical architecture around the ROADIDEA platform

When the ROADIDEA project was started, the working hypothesis was that the availability of various types of information and raw data together with sophisticated data fusion methods are important prerequisites to the development of new innovative ITS services. Technological platforms with high level of standardisation were seen as an enabler for the new services. In other words, supporting innovation with the availability of various types of information and data to service developers was one of the main requirements for the architecture around and within the ROADIDEA platform. The original plan for the ROADIDEA platform is shown in Figure 12.

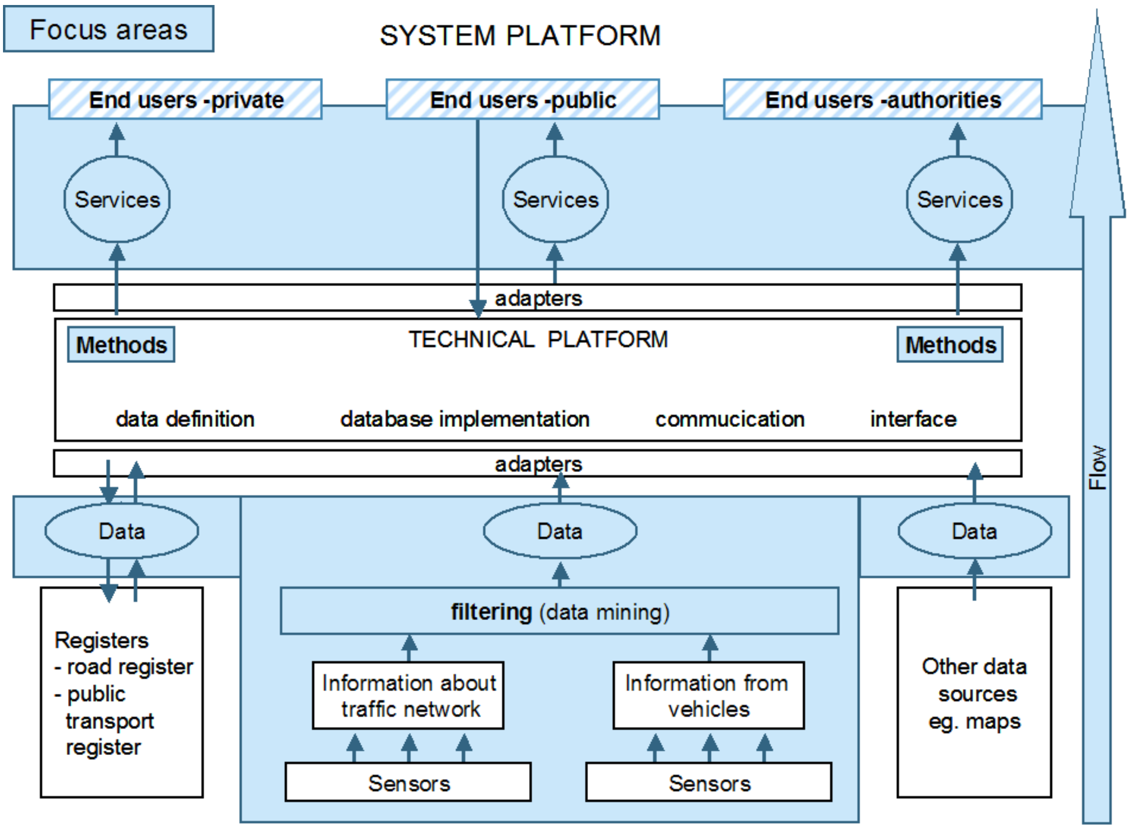

Figure 12. Plan for the ROADIDEA platform and interfaces to services and end-users

An overview of the technical platform realised in the ROADIDEA project is described in Figure 13.

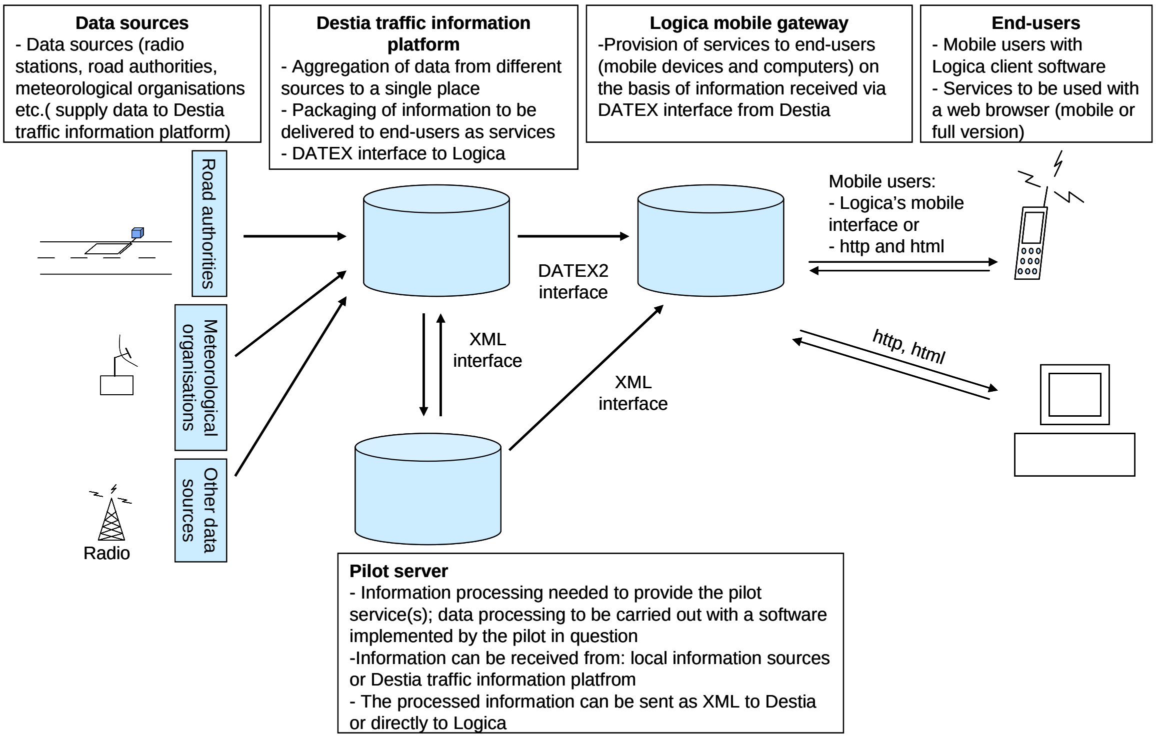

Figure 13. Overview of the technical platform realised in ROADIDEA.

In addition to making various types of information and data available to service developers, the other main requirements for the ROADIDEA platform were not systematically identified. However, the functional requirements for the platform in supporting ROADIDEA pilots were outlined in deliverable D6.1.

The plan for the ROADIDEA platform described the functional architecture around the platform at very general level in a simplified way. For example, the roles of various actors were not defined at all in the plan. The absence of well defined roles caused some confusion among the various actors implementing the ROADIDEA pilot services. The tasks and responsibilities of various actors were not clear in the beginning but they were clarified during the project. This experience outlines the importance of well-defined roles when defining architectures for ITS services.

The planned functionality of the ROADIDEA platform was to collect various types of information and data into a single platform to make them more easily available to support the development of new innovative services. The platform was expected to create value to service developers by providing several data types needed by services from a single point in a common format or at least in a well-defined formats. In case of ROADIDEA, the service developers were the organisations responsible for the pilots in Finland, Italy and Sweden.

The expected benefits from the improved availability of information and raw data were not fully realised. At least some reasons to that can be identified, when the functional architecture of the ROADIDEA platform and the ROADIDEA pilots is analysed.

The ROADIDEA pilots were located in different European countries. This contributed to some problems with the platform observed during the project. The information processing related to ITS services is in some points still connected to the countries where the data collection and service provision takes place. For example, maps and TMC codes used to specify locations on the road network are specific to an individual country and they can only be obtained by paying a license. Secondly, controlling the quality of received data is easier if the data collection platform is located in the same country with the data source. In other words, data processing can be carried out almost anywhere, but presence of the stakeholders in the same geographical area is still important in the development of ITS services.

WP200 produced a comprehensive list of data types related to weather and transport. The list contained a large number of data types from different sources. Due to limited resources and the fact that all of them were not really needed by the pilots, only some of them were made available via the ROADIDEA platform. In the beginning of the project, the ROADIDEA platform had significant coverage of data types only in the northern countries with the best coverage being in Finland. This means that the Italian pilot could have obtained only limited benefits by choosing an implementation in which all Italian data sources and information processing related to the pilot service were integrated into the ROADIDEA platform in Finland.

It is quite common that service developers want to use their own tools for software development, choose the hardware and software platform they use and to control the platforms on which their services are being tested. Controlling the platform on which the information is processed helps to find the causes of problems encountered in the development work and to fix them quickly. These facts had to be taken into account when defining the functional and technical architecture of the ROADIDEA platform. The architecture of the ROADIDEA platform allows a service being developed to exchange information in XML format with the ROADIDEA platform as well as deliver the service via Logica mobile gateway (Figure 13).

The amount of resources needed to integrate a new data source into the platform depends on the functional and technical architecture as well as the technical implementation of the system acting as a data source. If the system has been designed in a modular way and the relevant interfaces have been well documented, integration into the platform may be possible with only some hours or days of work with the configuration of interfaces at the transmitting and receiving end. On the other hand, some systems producing raw data are “black boxes” with proprietary architectures and implementation and have been designed to operate as stand-alone systems. In these cases, integration of a potential data source into the platform becomes a much more complicated task.

Benefits related to improved availability of information and raw data can only be realised if the owner of the platform is both willing and able to distribute the collected and processed data the developers of ITS services which may be private companies, public authorities or non-profit organisations. In addition to technology, the organisational and business aspects have to be carefully considered.

The operator of the platform or data pool may not be willing to share the collected data and information unless it is compensated for its efforts in some way or another. The operator of the platform or data pool has to pay the costs of data processing infrastructure, data communications and electricity as well as the costs related development of interfaces and maintaining the metadata and other documentation on at least some minimal level.

A potential conflict of interest exists, if the owner of the data pool is also providing ITS services on commercial basis. The owner and operator of the data pool may see the other service developers as existing or potential competitors. A possible but not wanted outcome is an effective monopoly of traveller information services within the country in question. In this case, competition between service providers would be reduced which would lead to higher prices and reduced incentives and opportunities to innovate.

Distributing information and raw data to service developers via ROADIDEA-like platform is not possible without adequate metadata and documentation on the available data types. Naturally, this metadata has to be accessible to service developers before they can utilize the data types available. The metadata related to each data type has to contain at least the information content of the data, format in which the data is stored and transferred as well as licensing information.

Conclusions

The world today is a networked world where intelligence is ubiquitous and anyone or anything can be made to communicate with anyone or any physical object. However, this does not mean that geographical area or location has no significance in the development and provision of ITS services. ITS services are bound to geographical areas by information infrastructures such as maps and TMC points but also on organisational level. For example, controlling the quality of received data may require knowledge of the changing physical environment and obtaining metadata related to a data set may be impossible to a person with no local contacts. Organisations providing ITS services are usually also organised on the basis of geographical area or mode of transport.

At present, most European countries have a national ITS architecture. Some of these are based on the FRAME architecture method. Other architectures may be partly compatible with it like the Finnish TelemArk architecture or be different in significant points like ARKTRANS. However, all aspects of ITS service provision are not defined in the architecture documents or existing standards. The FRAME architecture and most of the national ITS architectures are now some years old. It is obvious that some updates and revisions to the architectures are needed during the next three years to keep them up-to-date.

The availability of information and raw data to the developers of new ITS services will be limited unless the systems operating as data sources have been designed in a modular way and the interfaces between various systems and subsystems have adequate documentation. Integrating systems designed to be stand-alone black boxes into any data pool will be a difficult and costly task. This underlines again the benefits of modular and clearly defined architectures in ITS.

Benefits related to improved availability of information and raw data can only be realised if the owner of the platform is both willing and able to distribute the collected and processed data the developers of ITS services. In addition to technology, the organisational and business aspects have to be carefully considered. The operator of the platform must have an incentive to make the collected raw data available to potential service developers as well as maintain adequate metadata and other documentation on the data types included.

Standardisation is commonly required to achieve interoperability between different kinds of systems from different vendors. However, convergence to a single commonly accepted interoperable solution can happen also without formal standardisation process. For example, no ISO or CEN standards exist for protocols used to send email. This is most probable in cases when software and hardware manufacturers, system integrators and subcontractors have incentives to produce interoperable solutions and the core functionality to be implemented is reasonably well defined.

5. Emerging services to private end-users

5.1 Background

Services and tools based on telematics systems as terminals in vehicles are expected to be developed fast. About 2.2 billion person cars were estimated to have a telematic equipment in 2007. In 2013 this figure has been estimated to be globally so that already 30 billion vehicles would have a telematics equipment. Navigation has been estimated to reach a balanced level near 2010 when the other main services still continue their growth in the market (Table 6). (Scholliers et al. 2008).

Table 6. Forecast of the growth of markets of the main telematic services (Scholliers J., Koskinen, S., Öörni, R. 2008).

Service	Situation in 2007	Forecast 2012	Comments
Navigation	Growing	Balanced growth	
Insurance, pay-as-you-drive	Coming into use	Growth	Growing with eCall
eCall	Coming into use	Growth	Regulated us by 2012 in Europe
Stolen Vehicle Recovery	Coming into use	Growth	Some services already available, synergies with eCall
Remote Vehicle Diagnostics	Coming into use	Growth	Slow progress because of missing business model, synergy with eCall

EU has been supporting the development of eCall (Emergency call) system towards a Pan-European service and as a driver of location based services and systems. The estimates of the benefits of eCall are quite positive and show e.g. about -5 % reduction of fatalities in Europe meaning saving of thousands of lives in a year if in wide use. However, the commitment in implementation of eCall nationally has been slow. Therefore, EU Commission presented a Communication in 2006 where the goal was set as introduction of eCall as a standard option in all vehicles type-approved from the first of September 2010 onward (EU 2006). Today this date is shifted to 2012 due to delays in standardisation and EU Member State commitments.

The automatic location identification using e.g. satellite systems such as GPS and the coming Galileo and the mobile phone location systems make it possible to develop all kinds of innovative new services. In the field of insurance business, the developed systems open up a new concept to tie the insurance pricing of drivers into the adopted personal risk-level and behaviour in traffic. There seems to be a lot of interest in taking into use this kind of insurance pricing systems (PAYD, Pay-As-You-Drive) and services are already available e.g. in Italy and in UK.

Stolen Vehicle Recovery Systems and Services have come into the markets as private and business service to be able to monitor the use of own car or car fleet. In international freight hauling and trucking the concept is also attractive when valuable freight and vehicles are directed into sensitive and in-secure regions of the world.

Charging systems e.g. congestion charging, road charging, and environmental charging are coming into wide use in Europe and globally. A major driver is the success of the development of location technologies and especially the need for solving major traffic, safety and environmental problems and the challenges of climate change. EU has decided to adopt infrastructure charging systems and has presented the main details of EETS (European Electronic Toll Service) in 2009.

These new emerging services can either be produced as separate and independent services or as integrated services using the same technology platform. The business model and business concept is usually of major importance for the service production and process.

Traffic problems especially in major urban areas have stimulated the take up of intelligent public transport system services. In the competition with private vehicle use public transport has to be made more and more attractive and modern in order to get citizens commitment and confidence. New and innovative public transport systems and services are needed in the future to be able to meet the challenges of sustainable transport system development strategy. So far, the focus has mainly been on development of different mode specific services. In the future the expectations are going towards integration the different mode specific services stressing the user requirements of fluent and transparent trip-chain.

5.2 Identified new applications and services

5.2.1 Traffic information

In major urban areas and also in some regional and state level a comprehensive and integrated approach has been defined. In US many of these approaches are private but can also be developed towards PPP (Public-Private Partnership). Some major integrated services are operated by INRIX and Clarus. In Europe this integrated approach has also raised interest because of possibilities to cover larger areas and customers, use of multiple data sources and better business opportunities.

BayernInfo delivered by VIB (Traffic Information Agency Bavaria), which is a PPP between leading industry and the Bavarian Ministry of the Interior located in Munich. The task of BayernInfo is to provide optimized traffic information for all transport modes based on current and predicted travel times. The major PPP-service is providing basic services free for the public in Internet, is a service provider for public authorities and administrators, integrates a large number of municipalities, cooperates with other traffic information centres and is developing and marketing traffic data and value-added services (Figure 14 and 15). (Pollesch 2009)

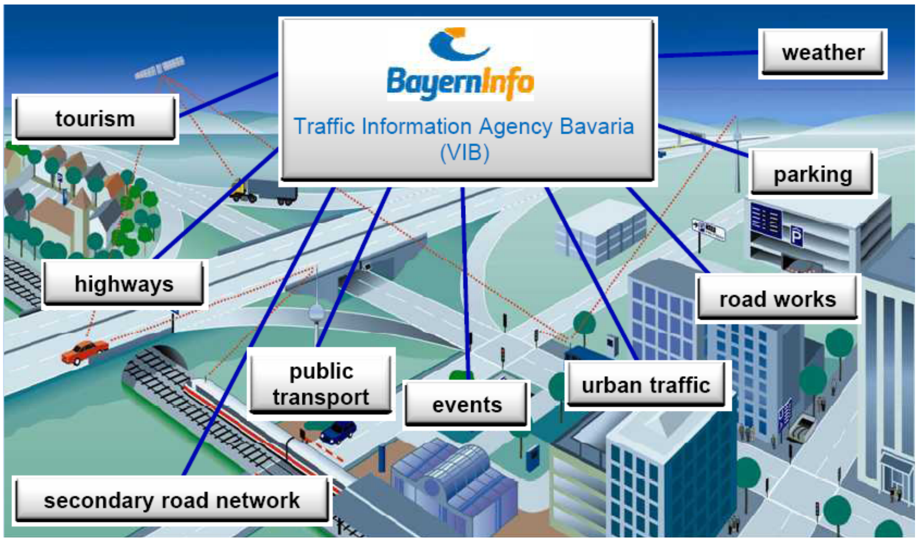

Figure 14. Integrating of different data sources (Pollesch 2009).

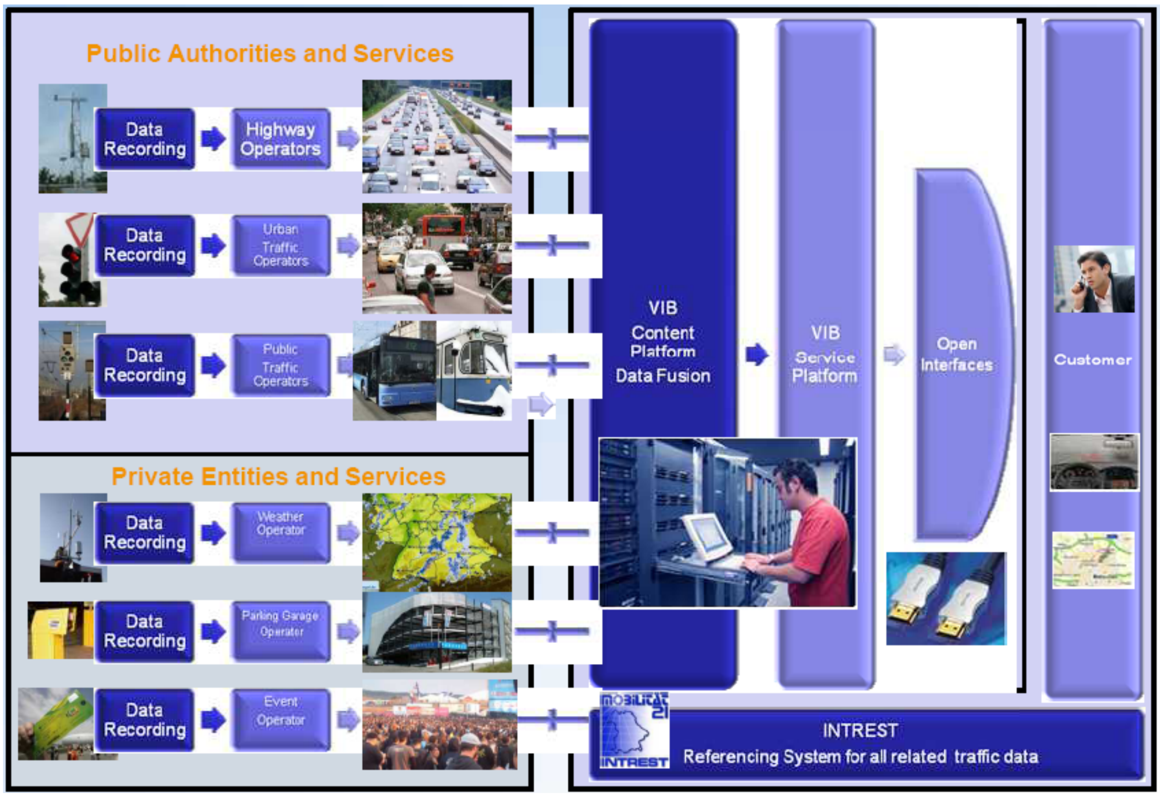

Figure 15. BayernInfo system description (Pollesch 2009).

Traffic information together with navigation is the most widely used ITS service in Europe. Traffic information will evolve in the near future via enhanced traffic data collection, data fusion from various sources and traffic prediction and new traffic information delivery systems.

One major change from today is that traffic monitoring emphasis will move from fixed monitoring infrastructure to mobile monitoring stations, where vehicles or phones in vehicles act as floating sensors capable of transmitting information of congestion, speeds, weather, road conditions or even friction, air quality, visibility etc. Some of these systems will be factory fitted, whereas some will be aftermarket or nomadic systems. In many cases information will be collected by private sector and in many cases multinational players. These companies are large enough to invest R&D into development of sophisticated data fusion and traffic prediction methods.

Privacy is a key issue in collecting measurements from private users. The concepts that are being developed place a high emphasis on making the data anonymous by e.g. collecting speeds on a certain road segment but not about who is where or who is speeding.

Real-time traffic information will evolve from currently utilised RDS-TMC. The deployment of next generation traffic services could be, in part, based on the shift from the already aged RDS-TMC to pan-European Transport Protocol Experts Group (TPEG) services. TPEG improves the support of additional travel-based information such as dynamic parking availability, weather, fuel pricing or even public transport information via broadcast information delivery (over any digital bearer; DAB, DVB-H, satellite radio or even cellular networks). However, there are still some open issues. For example, TMC has succeeded, because costs are hidden into the overall price of the navigation systems and consumers therefore perceive TMC to be free. The cost of TPEG services and hardware are likely to be too expensive (at least in the short-term) to hide into the cost of the navigation system. (SBD 2009)

Traffic information that used to be provided via web-pages is now being provided over internet in a more interactive manner and also access to information is available via mobile devices. As an example NAVTEQ in US provides real-time traffic information via dedicated location-aware web page (www.traffic.com) with geographic location of the user is based on IP address of the PC. Users across the USA can access city area traffic information or their own personalised updates about current conditions and congestion trends. Users can register at the web-site and save their daily commutes or weekend travel routes. The site can be accessed with a PC web browser or with a mobile phone web browser. It provides traffic information in easily understandable format: NAVTEQ's Jam Factor, a numerical traffic measurement scale that indicates the traffic state along the user's route. The user can schedule traffic alerts, which can be sent as email, SMS text message or even voice calls right to the phone of the user. Furthermore, personalised traffic information is also provided via RSS (“Really Simple Syndication”) service to user’s personalized portal page, blog or favourite news reader. MyTraffic account in NAVTEQ traffic web-site is free.

5.2.2 Public transport information

A main vision is to have a one-stop web and mobile portal for seamless door-to-door information and ticketing. Interoperability in ticketing requires different operators to work together, not only on technical level but requires also a full co-operation model for e.g. revenue management and sharing rules. Work on interoperable ticketing is currently performed in the IFM (Interoperable Fare Management) project[8] .

However, a centralised, standardised European intermodal door-to-door information and ticketing system is currently quite unrealistic due to organisational barriers and huge management hurdles that would have to be overcome (LINK 2008). One way forward is

[8] *www.ifm-project.eu*

a distributed approach for providing the information: locally collected information is collected in integrated data pools. This information and interface is then available for application providers. Such developments are ongoing e.g. in the EasyWay[9] action.

Standardisation is still required to create an overall interoperable service: common standards to share information which cover a transactional process, database and content harmonisation, standardised data and messages. A major challenge is in finding a business case for providing long-distance intermodal information on a European scale. Another issue is the quality of data (reliability, timeliness, availability, accessibility) (LINK 2008)

Public transport navigation and information services are currently developed as separate products, mainly due to the difficulties in collecting information from different cities and due to pedestrian guidance in general being at a prototype phase. If the information could be integrated in mainstream navigation systems in a similar way that city guides, this could possibly make the information easier to access for tourists.

When providing a traffic information service for commuters, the main topic is the time and trouble that is needed to access it. Even turning a navigator on may be too much for commuters, let alone typing in a destination. Navigators may have special buttons for home and work locations, making them faster to use in everyday life and providing an option to retrieve traffic data for familiar routes. Also new web services are being designed that can be configured with personal preferences to see the information on e.g. Windows desktop (as a widget). Traffic.com can send alerts to registered users via widgets, email, phone or RSS feeds. However, the easy access remains a target for development.

5.2.3 Cooperative systems

Development of cooperative safety systems that utilise Vehicle to Vehicle (V2V) and Vehicle to Infrastructure (V2I) communication has been started in order to enhance and extend traffic safety currently provided by onboard Advanced Driver Assistance Systems. Communication is used to support the driver e.g. with advance warnings before coming to a location of accident.

Cooperative systems are being developed in US e.g. IntelliDrive[10], in Japan e.g. DSSS – Driving Safety Support Systems[11], and ASV-4 – Advanced Safety Vehicle phase 4 and several projects in Europe. European projects CVIS[12] is focus-ing on core cooperative technology. The SAFESPOT project[13] uses cooperative systems to process highly critical tasks. The COOPERS project[14] is using the road operators' view for the conception of co-operative sys-tems. The COMeSafety project[15] supports coordination and con-solidation of research results, worldwide harmonisation and standardisation cooperative systems.

Cooperative systems build and expand on the functionality of the autonomous and stand-alone in-vehicle and infrastructure-based systems, such as Intelligent Vehicle

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[9] *www.easyway-its.eu*
[10] *www.intellidriveusa.org*
[11] *www.utms.or.jp/english/system/dsss.html*
[12] *www.cvisproject.org*
[13] *www.safespot-eu.org*
[14] *www.coopers-ip.eu*
[15] *www.comesafety.org*

Safety Systems, including Advanced Driver Assistance Systems (ADAS), traffic control and management systems and motorway management systems. On the contrary to the stand-alone and autonomous systems, many of these benefits require a minimum level of penetration in the vehicle fleet and in some cases a minimum level of infrastructure coverage. The initial deployment of the Cooperative systems is a huge technical, legal and economic challenge, requiring cooperation of all public and private stakeholders. (COMeSafety 2009)

Deployment is the crucial issue in cooperative systems. Considerable investments are necessary on the vehicle side as well as on the infrastructure side. So far, ideas exist about the benefits that can be expected from cooperative vehicular communication but these have not yet been quantified and verified in financial terms and there are no clear business cases. The EC-funded project PRE-DRIVE C2X is currently seeking for sustainable business cases from cooperative safety to infotainment applications. (PredriveC2X 2009)

5.2.4 Connected OEM telematics services

Connected telematics services provided by vehicle manufacturers in Europe are mainly concentrated to safety and emergency services as described in previous sections. However, the variety of the services is gradually moving towards infotainment. The number of users of OEM telematics services in US and in Japan is much higher than in Europe. GM’s Onstar in US has the most users and in Japan Toyota G-book, Nissan Carwings and Honda InterNavi have a significant role. (Frost & Sullivan 2008)

Consumers will likely have increasing expectations of entertainment available in the car. Users want the same content, similar quality, ease-of-use, use of portable audio-video devices, also in the vehicle. Consumers’ work-, home-, leisure- and travel environments will converge. Consumers access their personal content, services, and applications anywhere, anytime. This has created a need for internet access in vehicles and also connectivity to portable devices.

The need for vehicle connection with mobile consumer electronics (nomadic devices) and retrofitted devices is increasing. Bluetooth has become the de-facto wireless technology in most automotive applications mainly due to legislations of mandatory hands-free telephony while driving. According to Strategy Analytics one third of cars would feature a Bluetooth connection in 2012. Connectors for media players have also been added to vehicle audio systems.

The difference between the product cycle of consumer electronics and vehicles brings challenges for the automotive industry. Furthermore, the safety risks of using portable devices while driving is evident. The Nomadic Device Forum was established in 2005 and the development of an Intelligent Nomadic Gateway was started to solve the problem of consumer electronics and vehicle integration. Consumer electronics integration with vehicle systems has several issues which need to be solved including business viewpoints, safety, standardisation, legal and liability issues, etc. On the other hand, the vehicle manufacturers have started to cooperate with CE-industry to solve this issue. Cooperation or new partnerships have been established e.g. by Microsoft and Fiat - Blue&Me and Microsoft with Ford - Sync. Low-end car models have started to utilise low-cost line fitted navigators produced by aftermarket consumer electronics industry (e.g. TomTom). (Tarkiainen 2007)

Vehicle manufacturers are now bringing connectivity inside the vehicle in order to provide internet access to large number WiFi enabled portable devices such as laptops, smartphones and portable media players. BMW developed cellular network based connectivity (based on EDGE) in the connected drive solution to enable Internet access inside the vehicle. In US in-car Wifi access to internet (via 3G) is offered by a few OEMs (developed by Autonet Mobile). This internet access is mainly targeted for passengers and drivers, when the car is parked.

It is increasingly evident that connectivity is a critical feature for in-vehicle embedded systems to enable a wide suite of vehicle services. Aside Bluetooth, the OEMs have not yet published open in-vehicle infotainment service platforms to third party developers, which would enable new services and business opportunities. But e.g. recently published Continental's AutoLinQ, open in-vehicle infotainment and connectivity solution, is one possible step into this direction.

5.2.5 Connected aftermarket navigation

Currently number of PNDs in the European market is higher than navigation enabled smartphones. But the numbers are soon to be changed. Increasing number of Smartphones like Nokia, RIM Blackberry and Apple iPhone are providing in-built GPS and maps, thereby increasing the scope for consumers to enable navigation and always-on location based services. Context awareness in mobile services will be based on GPS-positioning, selected route and travel mode data. This information can be utilised e.g. in providing targeted filtering of local search results and possibly advertising.

With PND sales reaching maturity in Europe, additional revenue streams are possible only through services and these services can be delivered through only connected PNDs (e.g. TomTom connected service package). Furthermore, connected devices (PNDs and mobile phones) enable information generation e.g. real-time traffic information acquisition by Floating Car Data (FCD) collection from larger user base (e.g. TomTom, Nokia smartphones). (Frost & Sullivan 2008)

5.2.6 Green driving

Telematics and ITS services in general are advertising the green image – reducing fuel consumption by reducing time spent on the road. Dynamic route guidance is marketed as a green driving function.

The driving style can be even a more significant parameter influencing fuel consumption. Therefore, car manufacturers and aftermarket solution providers have started to provide economic driving style advisor systems. At present, simple gear shift indicators are in use in several passenger cars. But more advanced economic driving advisor systems have started to emerge. For example, Eco Assist from Honda optimises fuel consumption by tuning motor and CVT transmission, provides economic driving guidance and gives simple feedback about economic driving style. Another example from OEM is the Fiat Ecodrive which collects in-car diagnostics and driving style information from vehicle to an USB-memory stick and the driving style is analysed afterwards with free PC software. (ROADIDEA 2009c)

Aftermarket solutions for passenger cars are usually connected into vehicle On-Board Diagnostics (OBD) connector and the fuel consumption is calculated in a software running e.g. in a smartphone or dedicated device. PNDs have also started to include fuel saving and CO2 emission functions. Aftermarket solutions for fuel consumption monitoring and economic driving style advisors have been available for a while for heavy duty vehicles because there is a clear business case to reduce transportation costs. (ROADIDEA 2009c)

5.2.7 Others

eCall, stolen vehicle tracking (SVT) and pay-as-you-drive insurance (PAYD) are expected to remain as niche markets even by 2012 – unless the vehicle manufacturers start installing in-vehicle eCall devices with open platform for third party services. This is highly unlikely scenario considering the current situation in eCall voluntary agreements (Frost & Sullivan 2008). On the other hand, European Commission (2008) is seriously considering mandating the equipment of eCall in new type-approved vehicles. This could be realised by 2014.

5.3 Services innovations produced by Roadidea seminars

5.3.1 The First Innovation Seminar

Two major innovation seminars have been arranged by work package 4 of ROADIDEA project. The first seminar was held in Prague in May 2008 and the second in Dubrovnik in May 2009. Both seminars were mainly based on futures research methodologies Futures Worksop and Charrette.

The first innovation seminar studied altogether 34 ideas, of which 19 were short-listed after the evaluation. Dedicated idea teams chose 12 of the short-listed ideas for further studies and ended up to ideas for piloting, modelling and general development as follows (ROADIDEA 2008e):

Ideas for piloting:

- Cross border weather alerts
- Mobile phones as sensors
- MyRoute, mobile pocket guide
- MyTravel, toilet-tomtom
- In-vehicle information
- Eurodmap, European road weather database

Idea for modelling:

- Pulp friction, friction model combined with weather data and road maintenance activities
- Traffic forecast models
- Port related traffic modelling

General development ideas:

- Freedata, free geospatial and weather data
- Rtfm, better and tailored user-interfaces
- Stayhome

Later on ROADIDEA pilots were defined after the studies of the possible pilots. Altogether 4 pilots were defined: (1) Pulp-friction, (2) Gothenburg, (3) Port and (4) Fog. Only the Pulp-friction and Gothenburg pilots were defined as real pilots for implementation (ROADIDEA 2008e). The other two were defined as theoretical pilots that are only evaluated as concepts, not after the pilot implementation.

The main ideas of the first innovation seminar were not seen as very radical according to the ROADIDEA expert team evaluation. Feasibility of the concepts was concentrated mainly on the assessment that the idea can be implemented with an average effort and risk.

5.3.2 The Second Innovation Seminar

The second innovation seminar summarised the state-of-the-art of the existing ideas and pilots. The chosen pilots are being analysed and the two real pilots going ahead will be implemented during the coming months. Some of the ideas of the first innovation seminar will be covered during the implementation of various work packages of the project (e.g. Mobile phones as sensors, MyRoute, MyTravel and Euroadmap). The others will be monitored but no further actions are included.

The second innovation seminar concentrated mainly on more radical and long-term ideas. The background material consisted of 8 main documents of which the scenario material of four alternative world in 2030 was the main basic document (ROADIDEA 2009f). The seminar aimed at radical ideas using alternative worlds as the future scenarios (1. Business as usual, 2. Environment backlash, 3. High-tech Economy-Technology Pushes Off the Limits and 4. Political Turmoil).

After the innovation process a common evaluation selected five ideas for more detailed development:

1. Semi-public transport: Service production & support systems of advanced private public transport services.
2. Dynamobi: Cooperative multimodal and scalable dynamic navigation
3. No-man driving: Autonomous driving.
4. Waste to energy: Bio-waste used as energy for cars.
5. Trawork: Travelling on offices - working on transport.

Most of these ideas are strategic of their nature. They are broad concepts that aim at solving the situations in the chosen alternative world with the help of intelligent transport systems in one way or another.

5.3.3 Conclusions of the ideas of the seminars

Many of the proposed ideas were seen as business-as-usual because a lot of research and development activities are today directed to ITS (Intelligent Transport System) development.

The way to look ideas as innovations also means that the ideas should be so good that they would be also worthwhile for implementation. Then, the implementation means that the business model should also be identified and seen as fruitful and profitable. Private value-added services are therefore quite sensitive to the national situation, objectives, traditions and policies, although many harmonising and standardisation activities have been carried out in the field of ITS.

It is clear that there exists a wide variation between different EU member states already on the available data (ROADIDEA 2008g). In addition, the analysis of the ROADIDEA pilots have indicated that in every case some new data and information has to be created either adding some basic data elements or adding some methods needed to provide the necessary data or information.

5.4 Roadidea pilot services

Two out of the four chosen pilots were defined as real pilots: (1) Model Pulp-friction - Modelling road surface friction and (2) Merging of traffic and weather data in Gothenburg area. These two real pilots are finalised so that the ROADIDEA platform and developed systems will be used in demonstrations when services are delivered to pilot end-users via mobile systems and internet.

The Pulp-friction pilot is integrating produced road weather and friction data using a new modelling method into a road condition classification expressed as a road weather index (very good road weather, normal road weather, and bad road weather). The integration of friction into the services makes it possible to develop an automatic road weather warning and monitoring tool that is highly reliable and usable for services.

The Gothenburg pilot includes creating a new flow prediction model that is able to estimate the effect of weather and road condition data on traffic volumes using historic data in the background. Several data sources are used, such as traffic information from sensors and cameras and road weather information from the Swedish Road Administration´s road weather system and some additional weather sensor data. Destia will gather the data from Sweden to the ROADIDEA platform and through that the necessary information is formulated and translated into the demonstration of the service.

The traffic management process needs short term predictions of the flow conditions in order to be able to assess the need for different management policies to cope with the possible effects of changing road weather and road conditions on the network. Road users may also respond to the changing conditions in their behaviour and choices e.g. with more anticipatory driving, altered route choice, and/or using public transport instead.

The Port pilot is too large a concept to be implemented and demonstrated within the time span of ROADIDEA. However, the pilot plan will be evaluated and its potential as a service will be assessed. The Port Pilot is aiming at forecasting the generated traffic in a port area (Hamburg) and especially freight traffic as the vessels are arriving into the port and generating road traffic onto the local and regional road network. The port management and information systems to be developed are necessary elements in the basic data production and in the service development. Complicated modelling is needed in managing such a complex system as a port.

The ports are logistic gates and nodes, which are usually supported by other logistic service systems as logistics villages and terminals that feed freight into the nodes using the road and also rail network. The managing of port traffic and traffic generation is therefore needed also in the management of the whole logistic supply chain not forgetting the importance of the information of the effects of generated flows on the normal road users.

The second theoretical pilot or defined concept is the Fog Warning System in the Venice Region. The main goal of the system is to deliver information to the end-users on the visibility situation and enable informed pre-trip or on-route decisions. Fog warning is especially needed in occasions, when there is a thick fog resulting in very limited visibility.

The current experiences with existing systems indicate that the system needs to be effectively targeted towards user needs.

5.5 Need for new business models and revenue logic

In many forums the received experiences have raised the question of traffic and travel information collected by public authorities could be available for free for all possible service providers. The eSafety Forum's Working Group on RTTI has presented a basic business case structure for RTTI services (Figure 16). (RTTI 2007)

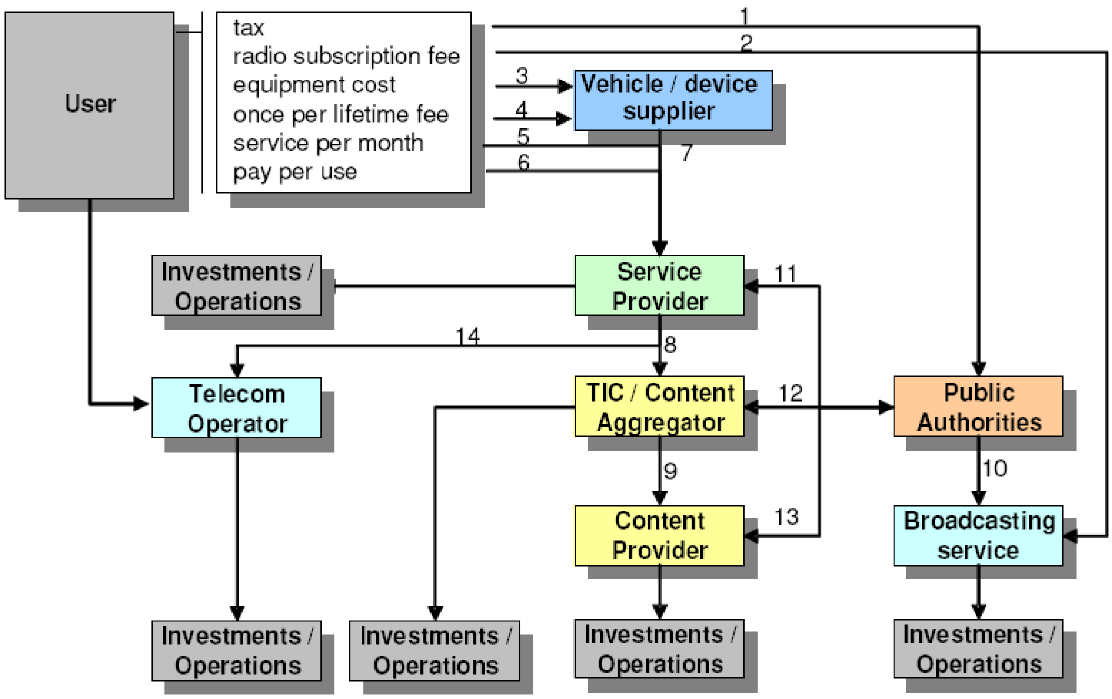

Figure 16. Cash flow dependencies for traffic and traveller information service (TTI). (RTTI 2007).

The necessary value chain in TTI services is complicated and many platforms and needed functions can de defined (Figure 17). (RTTI 2007)

Content Platform	Service Platform	Distribution Platform	Delivery Platform
Data collection	Service development	Infrastructure provider	Owner centric applications
Data validation	Service aggregation	Access network provider	User centric applications
Content aggregation	Customer care, helpdesk	Communication provider	Car centric applications
Content enrichment	Billing	Service provider	Equipment service
Content provision	Application portal, server	Retail service provider	Vehicle integration
Content storage	Application service provision		

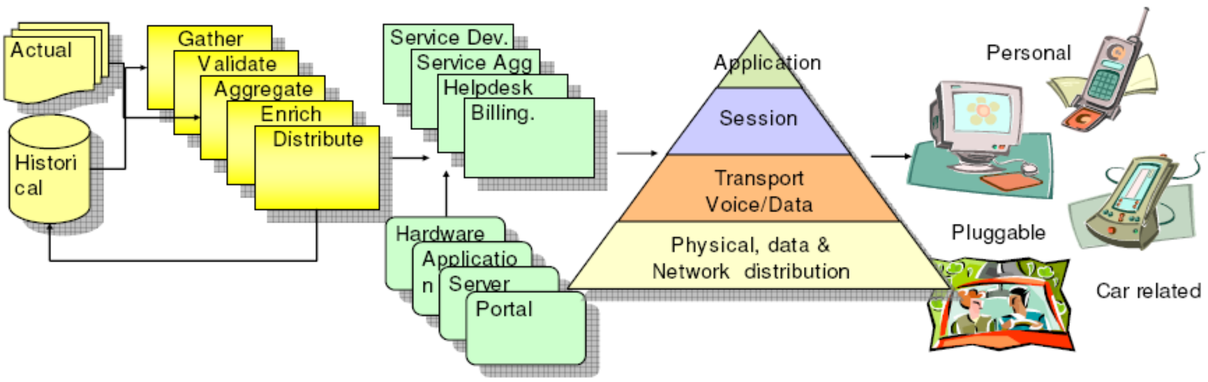

Figure 17. Value chain and different platforms with functions of traffic and traveller information services (TTI). (RTTI 2007).

The value chain of the services and networked cooperation are some of the main elements in the business models (see Figure 18). The value chain integrates both private and public operators. The source of all information services is the content provider. Data processing is carried out by the application provider who generates information from the data. The data clearance function ensures the appropriate classification of information. The service provider is responsible for data customising and contact to the customers. In safety critical services a Traffic Control Centre is in the leading position in the value chain (COOPERS 2008).

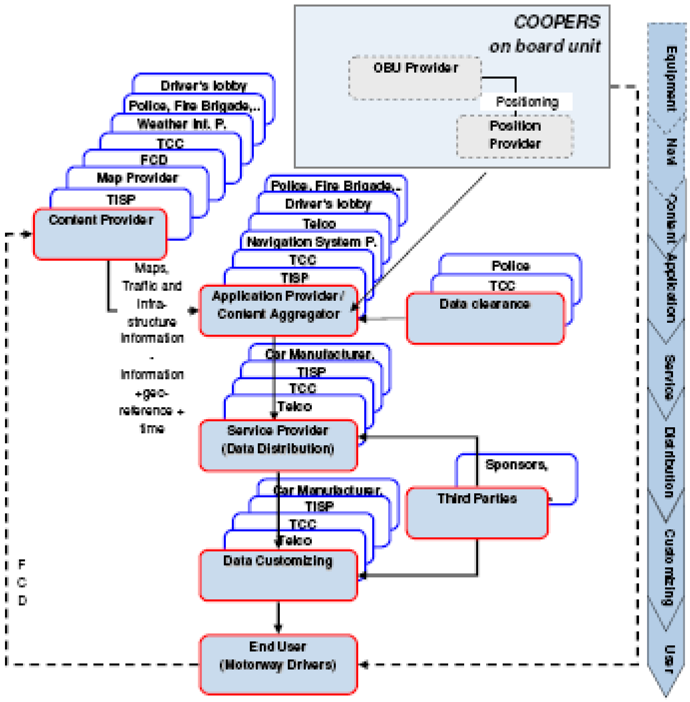

Figure 18. COOPERS basic Value Chain. (COOPERS 2008)

The real challenge is to make this complex value chain or network operate in practice and find the key financial or economic interests that push for the build-up and realisation of the value chain that delivers the service.

As pointed out in chapter 4.7.4 Business model challenges (p. 46), the finance must come, at the end of the day, from end users, public sector or from NGOs or similar ad hoc, non-official groups. All businesses are there for profit. However, indirectly the businesses might find motivation to finance services if they are able to boost other business segments such as equipment sales or other service sales by offering lucrative service packages to end users. Advertising falls to this category with the freebies.

Given the experience on logistics information services (Leviäkangas et al. 2007), the emergence of new business models that are able to deploy complex value chains might be harder than expected, unless the strong stakeholders find it worth while. One example of the latter is the tracking information provided by class I railroads of the US through their Steelroads service (see e.g. Herrala 2007). In Europe, we have not been able to build similar systems for railways, despite attempts (see Leviäkangas & Ludvigsen 2005 for one example). Successful information services have been built with public sector funding supplemented with advertising money. The San Francisco Bay Area 511 services are probably one of the best examples, well described by Mononen (2008).

Innovative non-government and non-profit services are probably the most potential segment for entirely new business model, if that is even the correct term for it. These models would likely benefit if they could freely utilise information from publicly hosted data bases that would be open. But there is no certainty that even openness would guarantee the emergence of new services, it would merely increase the likelihood of innovations.

Table 7 summarises the primary issues related to new business models, new service ideas and financing of them.

Table 7. Summary of main questions related to new business models, ideas and financing.

<table>
<tr><td>Business model</td><td>Who is the seller, i.e. who is motivated to deliver the service?</td><td>Who is the buyer, i.e. who must be persuaded to invest the money?</td><td>Who is the end user?</td><td>What are the critical prerequisites? How many challenges?</td></tr>
<tr><td>Public service A: “fully” public</td><td>Public entity</td><td>Those who grant the budget</td><td rowspan="5">Travellers, drivers, transport operators, ...</td><td>1) The benefits must be clear to justify budget allocation</td></tr>
<tr><td>Public service B: outsourced</td><td>Private business</td><td>Public entity and those who grant the budget</td><td>1) The benefits must be clear to justify budget allocation and 2) procurement of the service</td></tr>
<tr><td>Public-private: sharing of costs and risks</td><td>Private business</td><td>Public entity and those who grant the budget + private investors</td><td>1) The benefits must be clear to justify budget allocation and 2) procurement of the service + 3) there must be the business case for private investing and risk taking + 4) adequate commercial demand</td></tr>
<tr><td>Private services</td><td>Private business</td><td>Private investors</td><td>1) Partnerships in building the value networks, 2) risk and profit sharing in a satisfactory manner to all, 3) adequate demand on given price level that recovers risk-adjusted costs within reasonable time</td></tr>
<tr><td>Non-profit, non-government</td><td>?</td><td>?</td><td>?</td></tr>
</table>

It is clear from the table that private services as well as public-private partnerships are most challenging in terms of value chain functionality and adequate revenue generation, simply because they contain most critical elements and are complex by definition. And yet it is here where the great hopes lie in these times of reduced budgets. Little has been said about non-profit non-government based services and these models’ functionality remains to be seen. But great potential might lie there if the activities are encouraged to the right direction. What is the ‘right’ direction is a fundamental question and not easily answered, though. Ad hoc, informal networks that build services for their members might easily go also to a ‘wrong’ direction allowing misuse of information. For example, the position of speed control cameras could be given as a warning to speeders. It is likely, that the unwelcomed emergence of these of misuses would call for more active control concerning the use of traffic-related information. So far, these controls are not effectively in place.

The steps that would probably enhance new services and business models would call for at least the following:

- liberalise the possibilities to access and utilise public data; this would create new data for information services market and new innovations could well be witnessed
- regulate the utilisation so that misuse cases can be controlled and prevented
- identify the lead players in each case and let them do the job which is theirs; for public services this would mean infrastructure administrations and other authorities at state and local levels and in private services the ICT and automotive industries. In public-private partnerships the leader could be from either or both sides. A great risk is taken is wrong actors with insufficient incentives are taking leadership in new service development.

5.6 Need for new data and methods

The amount of traffic related data will expand in an exponential manner with the increased penetration of navigation systems and the advent of cooperative systems, providing extremely high numbers of probe vehicles and travellers providing data in real time on their speeds, delays, weather, any problems encountered related to a specific node or link in the transport system. This means vast amounts of data, which need to be checked, filtered and processed to provide good quality content to a number of existing and totally new services.

In order to do this, we need to develop new kinds of tools for processing the vast amounts of data in real time in an cost-efficient manner. This means tools capable of identifying false data and outliers while not missing real problems such as accidents and other incidents.

The vast amounts of data from all over the network will also mean that we can develop tools and methods for traffic status, travel time etc. prediction for the whole network instead of just the main roads with most traffic. This is essential for future cooperative traffic information and route guidance system, which will give individual routing information to different travellers in order to avoid overloading some links and nodes of the transport network.

An important opportunity arising from the vast amounts of data is to be able to predict also accidents and other disturbances in traffic from disaggregated traffic volume data based on probe vehicle data. This will raise traffic management services to a totally new level of proactive operation, where the focus is on preventing incidents instead or reacting to incident already having occurred.

Mobile devices such as mobile phones, PDA devices and car navigators have several built-in sensor units, for example acceleration sensors, location sources such as GPS and audio recording possibilities. These sensor units provide a novel enabler for totally new type of services. In Europe majority of adults have their personal mobile phones that are carried with almost everywhere and all the time. By using information available from these devices, traffic flows can be estimated accurately and it is possible to react to sudden changes rapidly.

However, there exist two major challenges in using data from mobile devices: data communication problems and requirements for the devices. Sending sensory data directly from mobile phones to external servers would cause a huge load in communication networks and also extra expenses to the mobile device users. Therefore data has to be processed already in the devices and then send only higher-level descriptions to the external servers. On the other hand, processing sensory data in the mobile devices with limited resources decreases user experience and make these applications unsatisfactory to use. Therefore there exists an urgent need for light-weight data processing methods for mobile devices.

5.7 Need for new service architectures, standards and specifications

The development and realisation of new ITS services will most probably continue in several different ways. To describe the possible ways forward, four different scenarios or development models were formulated.

Islands of technology

The first one of the scenarios can be called "Islands of technology". This refers to the fragmented model in which each transport operator or infrastructure manager operates its own data collection and processing systems and develops its own services. In this model, development of new ITS services is possible only for the producers of raw data or organisations in close co-operation with them. In this model, the systems actually implemented are most probably closed systems with little documentation and no public metadata for the produced raw data.

This model offers only limited possibilities for innovation. The first obstacle is the restricted access to information and raw data and the scarcity of metadata and other documentation. Another major obstacle to the re-use of already collected data is the absence or clearly defined licensing policies. This leads to uncertainty and negotiations on case-by-case basis which translates to high transaction costs.

Data pool model

The data pool model involves the collection of various or at least the most widely used data types into the same data pool. The data pool provides the one-stop availability of various data types via a common interface as well as licensing information and adequate metadata for each data type. Public financing in some form or another is required for the implementation and operation of the data pool. In addition to that, some resources are needed from the raw data producers to integrate their data types into the data pool. The providers of raw data are entitled to define the terms and conditions for the use of their data types or choose from a group of pre-defined licensing models. The operator of the data pool has to work in close cooperation with the raw data producers to ensure the successful integration of the various data sources into the common platform.

The data pool may be implemented in a centralised or distributed way. The most centralised approach would be to place all the data types into the same database server cluster and related metadata into one single web server. A more distributed approach to build a data pool could be an ITS data registry with links to databases containing the data types and a repository for the related metadata.

The data pool may be operated by public authorities or a private company or non-profit organisation. Examples of the data pool model include the DigiTraffic system commissioned by Finnish Road Administration as well as the ITS data pool created by DLR in Germany.

Vertical integration

A model called vertical integration is a variant of the data pool model. In this model, the operator of the data pool also processes the data and possibly provides ITS services to private or business users. The implementation and operation of the data pool is at least partly financed with the revenue obtained from providing various information services. Also in this model some resources are needed from raw data producers to implement interfaces between various data sources and the data pool. The data pool has to work in close cooperation with the raw data producers to ensure the successful integration of various data sources into a common platform.

The model of vertical integration has a potential for situation in which the data pool operator has a conflict of interest. If the owner and operator of the data pool is providing ITS services on the market it may not be willing to provide high-quality data to its competitors providing or possibly developing similar kind of services. An open question is, whether the data pool operator has adequate incentives to provide information and data to other companies, public authorities or non-profit organisations.

The data pool operator acting as a service provider at the same time may also have incentives not to share information with service providers requesting data from the data pool. For example, the data catalogue or data quality metrics may be seen as strategic assets of the company and considered to be trade secrets which may lead to only limited amount of information available to service developers.

An example of the vertical integration model is the traffic information platform operated by Destia Ltd in Finland.

Decentralised networked world

The fourth scenario is a decentralised networked world. In this scenario, most ITS data is exchanged without a centralised data pool. The producers of raw data implement different kinds of SOA-based interfaces to their IT systems and take care of the dissemination of the raw data themselves. They are also free to determine the terms and conditions for the use of their data types. The data types available from various actors are described in the national data catalogue for ITS.

The cost related to the dissemination of raw data is paid by the organisations producing the data. The data producers have to spend resources to make their data available and to maintain the needed level of metadata and other documentation. It can be questioned, whether the infrastructure managers, transport operators and other organisations producing raw data have enough incentives to make their data accessible to external ITS service providers or developers and to produce data with high quality. It is probable that some regulation or public funding for dissemination of the most important data types would be needed.

Discussion

The availability of information to service developers is best in the data pool model and most limited in ‘islands of technology’ scenario. The most probable outcome is some combination of these four models. In any of the models described one should avoid creating a single point of failure with a centralised implementation with no backup systems or communication links.

A relevant question is how to make information and data available in a cost-efficient manner. A possible answer could be to integrate the most widely used data types into publicly or privately funded data pools and to describe the remaining known data types into national ITS data catalogues.

6. Conclusions

This deliverable has looked at existing, new and emerging services directed towards private end users starting from the user needs and requirements.

The results shown indicate clearly the need to cater to user needs as only that will bring about real benefits to both the users and the society as a whole. Many technologies, systems and services exist but few have provided substantial benefits on the large scale to European citizens and companies (good examples are ESC, navigation, public transport ticketing, scheduling and priorities).

The consumer response to purchasing travel information services seems cost-sensitive and future efforts can focus on commercialization of travel information, beginning with where demand for information is relatively inelastic and improvement or customization of travel information is achievable. Defining the services one must keep in mind, that there is no such thing as an average driver. There are different users (by age, driving experience, physical capabilities etc), and even one user may have many different needs and requirements depending on the situation (mode of transportation, purpose of trip, even motivation and emotion). Users seem to rely on real-time services and especially services that produce personal benefits e.g. warning services reacting automatically and quickly to dynamically changing conditions.

Reliable and good quality data is one of the main prerequisites for proper services development. Although, same kinds of data sources are available in most of the European countries, the effective and practical use differs. There are no recommendations available on minimum data set and catalogue. Although, the needs of services are not the same in every country, there is a need for data standardisation and harmonisation activities because of developing European wide services such as eCall and because of cross-border traffic and freight operations.

Many road traffic information services are based on traffic data produced by the public sector (road authorities and operators). Some of the end-user services are also provided by the public sector. In a few European countries like Finland, road traffic and weather data is available free of charge, but in many countries there are high barriers for the further use of such data

Private end users are usually the final beneficiaries of both public and private services. Private services are directed either to personal users as normal citizens and also to companies and different types of organisations with various functions. In many cases a wider services platform is offered by public operators or public-private cooperating operators offering then also access to many kinds of data for private services operators and new value-added services production.

Many driver assistance and support systems are already in the markets and under the development. ABS, ESC, lane keeping etc. autonomous adaptive systems are available today in most of the car brands. Cooperative safety systems are being developed (V2V and V2I). One of the main new safety systems is the Pan-European in-vehicle emergency call system (eCall) that has to be in new cars from 2010 onwards.

The private service development is led by portable navigation device and service providers like TomTom and Nokia. Today, navigation is the most widely used on-trip ITS service in Europe. Pan-European navigation device and service providers utilise traffic and weather information from data aggregators like Destia or ARC Transistance which gather public data from several countries and combine it with other data sources to provide multinational data sets. Navigation device providers have recently started to collect their own traffic, map and speed limit data and updates straight from the users. Pan-European traffic information providers have emerged including TeleAtlas and two North American players, NAVTEQ and INRIX. All these companies utilise a mixture of data sources and data types and fuse them to increase accuracy.

Many public transport information services are available either operated by public transport companies, public authorities or by private providers. Most of journey planners and this type of services are national and regional. Cross-border trip planning is available for combined car and ferry, air transport and train transport. Many trip planners, especially for long distance travel, also allow purchasing tickets on-line.

The transport information services require the creation of a service network of partners complementing each other's competencies and resources. Typically one of the partners operates as a central point, service integrator or a network manager taking care of the service delivery and management.

The main challenges from the business modelling viewpoint include: (1) Creation of sufficient revenue to cover the costs of information services and (2) Sharing the revenues in the service network. Many information services have problems to create sustainable services, with revenue streams covering the costs. In general, the costs should be compensated by the stakeholders benefiting of the services. However, it is a challenge to make private end-users to pay about information services. The users tend to select free information instead of a paid service even if they receive worse quality. In some cases more detailed and tailored information can make the users to pay for the service.

In summary, there are number of reasons why the development and deployment of ITS services has been slow e.g.:

- poor prerequisites for services
  - inferior access to data in affordable manner
  - inferior quality of data
- poor business models and cases
- fragmented policies of governments with regard to priorities prevent combined efforts resulting in fragmented European market end users willingness to pay does not match the prices demanded
- benefits of services have not been shown in tangible manner
- privacy issues
- liability issues
- lack of interoperable interfaces e.g. between nomadic/aftermarket devices and vehicles; between vehicles and infrastructure (such as traffic signals); etc.

Hence, we need to take several actions to remedy the situation of which the most urgent are e.g.:

- agree on European rules for access to public data in affordable manner

- quality level recommendations (target is optimal data quality, optimising the benefit to cost ratio as attempted by the QUANTIS project)
- explore and demonstrate new business models in targeted research activities funded by the EC and governments
  - likely the large scale spreading of mobile IP will result in the explosion of peer to peer services with quite new business models
- support the activities in the EU ITS action plan and the eSafety Forum
- carry out systematic evaluation studies and present their results in tangible manner
- maintain benefit and costs databases of ITS applications
- utilise the code of practice approach to solve the liability issues
- always take up privacy issues in the beginning of the development circle
- mandate interoperable interfaces in Europe, and preferably globally at least including USA, Japan, China and India

The European common FRAME architecture and most of the national ITS architectures are now some years old. It is obvious that some updates and revisions to the architectures are needed during the next three years to keep them up-to-date. The availability of information and raw data to the developers of new ITS services will be limited unless the systems operating as data sources have been designed in a modular way and the interfaces between various systems and subsystems have adequate documentation.

The operator of the platform must have an incentive to make the collected raw data available to potential service developers as well as maintain adequate metadata and other documentation on the data types included. Standardisation is commonly required to achieve interoperability between different kinds of systems from different vendors. However, convergence to a single commonly accepted interoperable solution can happen also without formal standardisation process.

It is likely that the amount of traffic related data will expand in an exponential manner with the increased penetration of navigation systems and the advent of cooperative systems. providing vast amounts of probe vehicle and traveller data. These data need to be checked, filtered and processed to provide good quality content to a number of existing and totally new services. In order to do this, we need to develop new kinds of tools for processing the vast amounts of data in real time in an cost-efficient manner to e.g. provide reliable traffic status forecasts for whole transport networks or to provide accident and incident prediction models. The last mentioned may lead to a new level of traffic management - the proactive network operation instead of the current reactive one.

The development and realisation of new ITS services will most probably continue in several different ways. To describe the possible ways forward, four different scenarios or development models were formulated as: (1) Island of technology, (2) Data pool model, (3) Vertical integration and (4) Decentralised networked world. The availability of information is best in the data pool model needing some kind of public financing. However, the most probable outcome is some combination of these four models.

It is also of uttermost importance to further development of existing services to better meet user needs and requirements. We have to develop a ubiquitous and tailored approach where little effort is needed from the users to be able to receive beneficial services, especially based on real-time conditions. Services have to be easy to use and their whole quality has to be high-level and adapt the users changing expectations. Services providers have to able to provide effortless user support.

Although, the development and deployment of ITS services has been slow we need to continue development of new services and their technologies, e.g. in the form of the best from the ROADIDEA innovation seminars. EU has put a lot of effort on speeding up the development recently. The new ITS Action Plan and the actions of EasyWay are good examples of necessary common actions towards better services in Europe.

7. References

Anttila,V., Penttinen, M. & Sandberg, H. 2003. Intelligent transport services. User needs and transport policy goals. (Telemaattisten palveluiden tarpeellisuus. Käyttäjien mielipiteet ja liikennepoliittiset tavoitteet). FITS Publications, Ministry of Transport and Communications. Helsinki, 2003.

Balz, W. & Zhu, J. 1994. Nebelwarnsystem A8 Hohenstadt–Riedheim. Wirkungsanalyse. Landesamt für Strassenwesen, Baden-Württenberg & PTV Consult GmbH.

Berg 2009. Berg Insight - FLEET MANAGEMENT AND WIRELESS M2M – 4th edition. December 2008. Research report summary available from www.berginsight.com/

Berkeley 2009. Mobile Millennium Project presentation from http://traffic.berkeley.edu/

BMW 2009. BMW ConnectedDrive. Available from www.bmw.com

Bossom, R. 2004. European ITS Framework Architecture, Functional Viewpoint. Framework Architecture Made for Europe-Support (FRAME-S). D3.1. Main Document. Version 3. November 2004.

Bossom, R., Avontuur, V., Gaillet, J-F., Franco, G. & Jesty, P. 2000. European ITS Framework Architecture Overview. KAREN Deliverable D3.6. http://www.frame-online.net/Karen_doc/d36final.pdf accessed 30th June 2009]

Bossom, R., Brignolo, R., Ernst, T., Evensen, K., Frötscher, A., Höfs, W., Jääskeläinen, J., Jeftic, Z., Kompfner, P., Kosch, T., Kulp, I., Kung, A., Mokaddem, A-K., Schalk, A., Uhlemann, E. & Wewetzer, C. 2009. European ITS Communication Architecture. Overall Framework. Proof of Concept Implementation. COMeSafety Deliverable D31. Version number 2.0. 5.3.2009. 165 p.

Chandrasekar, P. 2007. TomTom on an Acquisition and Joint Venture Spree – Heading to a One Stop Shop or Being Overambitious? Frost & Sullivan Market Insight, 31 Jul 2007

COMeSafety 2009. D31 European ITS Communication Architecture. Public report available from www.comesafety.org

Cooper, B. R. & Sawyer, H. E. 1993. Assessment of M25 automatic fog-warning system: Final report. TRL Project report 16. Crowthorne. 11 p.

COOPERS 2008. Co-operative Networks for Intelligent Road Safety (COOPERS). Overall description of COOPERS services and Value Chains, concerning operator/user behaviour, Integration of services in the co-operation system (M27). Version V04. April 2008.

CVIS 2006. Cooperative Vehicle-Infrastructure Systems. Use Cases and System Requirements. Deliverable D. CVIS.2.2. http://www.cvisproject.org/download/Deliverables/D.CVIS.2.2%20Use%20Cases%20and%20System%20Requirements%20v1.0.pdf

EasyWay 2008. Core European ITS Services and Actions. Deliverable 2 from ES6—The EasyWay ITS Deployment Roadmap. Public document available from www.easyway-its.eu/

eSafetySupport 2009. eSafetySupport eCall Toolbox. Available from www.esafetysupport.org/en/ecall_toolbox/

EU 2006. Communication from the Commission to the Eurpean Parliament, The Council, The European Economic and Social Committee and the Committee of the Regions. Bringing eCall back on track-Action Plan (3rd eSafety Communication.

EU 2007a. Communication from the Commission. Freight Transport Logistics Action Plan. COM(2007) 607 Final. Brussels, 18.10.2007.

EU 2007b. ITS Roadmap Outline. Intelligent Transport Systems (ITS) for more efficient, safer, and cleaner road transport. Version 12. October 2007.

EU 2008. Proposal for a Directive of the European Parliament and of the Council. Laying down the framework for the deployment of Intelligent Transport Systems in the filed of road transport and for interfaces with other transport modes. SEC(2008)3083.

European Commission 2008. Action Plan for the Deployment of Intelligent Transport Systems in Europe. Commission of the European Communities, Communication from the Commission, COM(2008) 886 Final. Brussels,16.12.2008.

Eurowatch 2009. EUROWATCH homepage. Available from secure.eurowatchcentral.com/

Forum Virium Helsinki 2007-2008. Living lab work shop material. 2007-2008

FRAME 2004. D3.1 European ITS Framework Architecture Functional Viewpoint. Public report available from www.frame-online.net.

Franken, V., Lenz, B. 2007. Influence of mobility information services on travel behaviour. GeoJournal Library, Volume 88.

Franken, V.; Lenz, B. 2005. Influence of mobility information services on travel behaviour. Symposium on Societies and Cities in the Age of Instant Access, Salt Lake City, Utah, (USA), November 2005.

Frost & Sullivan 2007. Global Trends Analysis of the Telematics and Infotainment Markets for Passenger Vehicles, Frost & Sullivan, M177-18, July 2007

Frost & Sullivan 2008. Frost & Sullivan: Executive Update of European Passenger Vehicle Telematics and Infotainment Market, September 2008.

Frötscher, A. 2008. COOPERS – cooperative traffic management. ITS World Congress, New York, November 2008. Presentation given at the Special Session 03: ICT for

Cooperative Energy-Efficient Traffic.
http://www.austriatech.org/fileadmin/documentvault/vortraege_en/ITSNY_FROETSCHER_SS03.pdf

Gibbon, Eric. 2009. Advanced Flooded Roadway Warning Systems save lives and property. The 15th World Congress and Exhibition on Intelligent Transport Systems and Services. ITS New York. Presentation.

GPS Business News 2009. GPS Business News: Tele Atlas begins real-time traffic business in Europe. Available from http://www.gpsbusinessnews.com/Tele-Atlas-begins-real-time-traffic-business-in-Europe_a1595.html

Granqvist, J., Hiljanen, H., Permala, A., Mäkinen, P., Rantala, A. & Siponen, A. 2003. Tavaraliikenteen telematiikka-arkkitehtuuri. Loppuraportti. Transport telematics-architecture. Final Report]. FITS publications 20/2003.
http://virtual.vtt.fi/virtual/proj6/fits/julkaisut/hanke1/fits20_2003.pdf accessed 1st June 2009]

Herrrala, M. 2007. The value of transport information. VTT Research Notes 2394. Espoo 2007.

Hirschhausen, Ch. et al. 2001. Ökonomische Analyse von Verkehrsinformationsdiensten. Technische Universität Berlin, Fachgebiet für Wirtschafts- und Infrastrukturpolitik, Berlin, Germany.

Hogema, J. H., van der Horst, R. & van Nifterick, W. (1996). Evaluation of an automatic fog-warning system. Traffic Engineering + Control, November 1996. pp. 629–632.

Jesty, P. & Bossom, R. 2009. Adding Cooperative Systems to the FRAME Architecture. Presentation at the EasyWay Workshop E-FRAME in Brussels on 24th June 2009.
http://www.easyway-its.eu/1/index.php?option=com_docman&task=doc_download&gid=941&Itemid=103 accessed 30th June 2009]

Kamalski, T. 2008. PNDs and Safety. Presentation at the eSafety Implementation Road Maps Working Group 14 February 2008.
http://www.esafetysupport.org/download/working_groups/Implementation_Road_Maps/18th_IRM_Meeting/PNDs%20and%20eSafety%20final.pdf

Khattak, A., Targa, F. & Yim, Y. 2004. Advanced Traveler Information Systems, Relationships to Traveler Behavior. Transportation Research, Economics and Policy, Volume 10.

Lenz, B. & Franken, V. 2006. Mobility information services – high technology, low acceptance? HITS 2005 (5th European Congress and Exhibition on Intelligent Transport Systems and Services), Hannover, Germany, June 2006.

Leviäkangas, P. & Ludvigsen, J. 2005. European Cross-Border Information System for Rail Freight – CroBIT. Technical paper at 12th World Congress on ITS, San Francisco, 6-10 October, 2005. Proceedings.

Leviäkangas, P., Haajanen, J. & Alaruikka, A.-M. 2007. Information service architecture for international multi-modal logistic corridor. IEEE Transactions on Intelligent Transport Systems, Vol. 8, No. 4, December 2007.

LINK 2008. LINK - The European Forum on Intermodal Passenger Travel homepage. Available from www.linkforum.eu

MacCarley, A. C., Ackles, C. & Watts, T. 2006. Highway traffic response to dynamic fog warning and speed advisory messages. Transportation research record 2006, no 1980, pp. 95-104.

Mäkinen, P., Ruoti, K., Lähesmaa, J., Lehtonen, M., Oinas, J., Ristola, T. & Appel K. 2000. Liikennetelematiikan kansallinen järjestelmäarkkitehtuuri – TelemArk. Arkkitehtuurikuvaus. The National Transport Telematics Architecture – TelemArk. Description of the Architecture]. Reports and memoranda of the Ministry of Transport and Communications 5/2000. Helsinki, Finland. http://alk.tiehallinto.fi/julkaisut/pdf/liikenteenhallinta/yleistietoa/telemark_arkkitehtuurikuvaus_2000.pdf accessed 1st July 2009]

McLeod, F., Meland, S., Sjosted, L., Cartolano, F., Aherne, M. & Ghali, K. 2008. SmartFreight. User need review. WP2 - Analysis of urban freight transport challenges and requirements.

McQueen, M., Schuman, R. & Chen, K. 2002. Advanced Traveler Information Systems. Artech House, Boston/London.

Mononen, P. 2008. 511 Service in USA and in San Francisco Bay Area. Service Model, Benefits and Beneficiaries http://www.vtt.fi/inf/pdf/workingpapers/2008/W97.pdf. VTT Working Papers 97. Espoo 2008.

Natvig, M., Westerheim, H. & Skylstad G-F. 2004. ARKTRANS, The Norwegian system framework architecture for multimodal transport systems supporting freight and passenger transport, Version 4.0. http://www.sintef.no/units/informatics/projects/arktrans/arktransweb/resultater/Rapportv40.doc accessed 1st July 2009.

NAVTEQ 2009a. NAVTEQ Traffic™ Surpasses Two Million Subscription Mark in North. Press release 16 Feb 2009. http://corporate.navteq.com/webapps/NewsUserServlet?action=NewsDetail&newsId=699&lang=en&englishonly=false

NAVTEQ 2009b. NAVTEQ Coverage. NAVTEQ Corporate – The NAVTEQ Database. http://corporate.navteq.com/database_coverage.html

NAVTEQ 2009c. NAVTEQ Discover Cities. http://www.navteq.com/about/advanced_discover_cities.html

Penttinen, M. 2005. User needs in HUMANIST. Humanist deliverable B3, Workshop on International Synergies, Madeira, Funchal, September 13-15, 2005.

Penttinen, M. 2007. EVASERVE – Module: User needs and requirements. User-centered design of ITS. VTT, Espoo.

Perrin, J. & Coleman, B. 2003. Adverse Visibility Information System Evaluation (ADVISE): Interstate 215 Fog Warning System, Final Report. University of Utah for the Utah DOT. Utah DOT Report No. UT-02.12, June 2003. http://www.udot.utah.gov/download.php/tid=297/UT-02.12.pdf

Pollesch, P. 2009. VIB. The 15th World Congress and Exhibition on Intelligent Transport Systems and Services. ITS New York. Presentation.

PredriveC2X 2009. PredriveC2X homepage. Available from www.pre-drive-c2x.eu

PSA 2009. PSA Peogeot Ciroen Press release. 05/15/2009. Available from http://www.psa-peugeot-citroen.com/en/psa_espace/press_releases_details_d1.php?id=942

Rämä, P. 2001. Effects of weather-controlled variable message signing on driver behaviour. VTT Publications 447. Espoo.

Rämä, P., Luoma, J. & Öörni, R. 2007. EVASERVE – Module: User interface. VTT, Espoo.

Rennemo, O., Vennesland, A., Wethal, H. & Hovland, T. 2008. ROad Safety ATTributes exchange infrastructure in Europe. Deliverable D1.2 - Requirements and Overall Architecture.

ROADIDEA 2007a. ROADIDEA Consortium Agreement – date 11/12/2007

ROADIDEA 2007b. ROADIDEA Grant Agreement – date 05/12/2007

ROADIDEA 2007c. ROADIDEA Technical Annex I – date 12/10/2007

ROADIDEA 2008a. D2.1 Report on the present availablity of data for transport systems and services. Public report available from www.roadidea.eu.

ROADIDEA 2008b. D2.2 Report of new types of data for transport systems and services. Public report available from www.roadidea.eu.

ROADIDEA 2009a. D2.3 Report on integration of data useful for ROADIDEA system. Public report available from www.roadidea.eu.

ROADIDEA 2009b. D3.1 Data filtering methods. Public report available from www.roadidea.eu.

ROADIDEA 2009c. D3.2 Data fusion – Traffic. Public report available from www.roadidea.eu.

ROADIDEA 2009d. D3.3 Data fusion - road weather. Public report available from www.roadidea.eu.

ROADIDEA 2009e. D5.2. Results of the First innovation Seminar. Public report available from www.roadidea.eu.

ROADIDEA 2009f. D5.3. Results of the Second innovation Seminar. Public report available from www.roadidea.eu.

ROADIDEA 2009g. D6.1 Pilot specification. Restricted project report available from www.roadidea.eu/documents/restricted.

ROADIDEA 2009h. D7.1 Transport Information Service Business. Public report available from www.roadidea.eu.

RODS, 2009. Road Safety Engineering Bureau, Hungary. Feasibility study. 2009

RTTI 2007. Report of the eSafety Working Group on Real-time Traffic and Travel Information (RTTI). eSafety Forum. Brussels, March 2007.

SBD 2009. SBD, Pan-European TPEG services - Ask an Expert. Available from http://www.sbd.co.uk/uknews/post/Pan-European-TPEG-services-Ask-an-Expert.aspx

Scholliers, J., Koskinen, S. & Öörni, R. 2008. Älykkään liikenteen kansainvälisten markkinoiden trendejä (Trends in the global ITS market). ITS Finland publication 10/2008.

Shomik M., Kemp, M., Pierce, S. & Lappin, J. 2000. Users of a regional telephone-based traveler information system – a study of TravInfo™ users in the San Francisco Bay Area. Transportation, Volume 27, Number 4 / December, 2000.

Sihvola, N. & Rämä, P. 2008. Kuljettajien käsityksiä kelistä ja kelitiedotuksesta – Tienvarsihaastattelu talvikelissä. (Drivers' opinions about road weather conditions and road weather information – interviews during winter conditions.) Finnish Road Administration, publications 16/2008.

Sihvola, N., Rämä, P. & Juga I. 2008. Liikennesäätiedotuksen toteutuminen ja arviointi 2004–2007 ja yhteenveto 1997–2007. (Determining the successfulness of the road weather information service 1997–2007.) Finnish Road Administration, publications 15/2008.

Skarpness, B., Kitchener, F., Boselly, E. & Thomas, A. 2002. Weather information for surface transportation. National needs assessment report. Office of the Federal Coordinator for Meteorological Services and Supporting Research. http://www.ofcm.gov/wist_report/pdf/entire_wist.pdf

Skarpness, B., Kitchener, F., Boselly, E. & Thomas, A. 2003. Final Report of the Evaluation of the FORETELL Consortium. Operational Test: Weather Information for Surface Transportation (WIST). Prepared for U.S. Department of Transportation Washington, D.C. April 2003

Sugiyama, Y., Tsuchiya, R. & Arisawa, R. 2007. Evaluation of a detour guidance system during a disruption of train operations. Urban Transport XIII: Urban Transport and the Environment in the 21st Century. The Built Environment volume 96.

Tarkiainen, M., Kauvo, K., Koskinen, H. & Alanen, J. 2007. Trends in vehicle communication and consumer electronics connectivity. Proceedings of the 14th World Congress on ITS. Beijing, China, 9 - 13 Oct. 2007. CD-ROM. Paper 2068 (2007)

Tiehallinto 2009. Asiakasryhmäkortti: Tavarakuljetuspalvelujen tuottajat (Customer group sheet: Providers of goods transport services). Updated 24.7.2008. Finnish Road Administration. 4 pages.

TIS 2007. Traveller Information Services on the Trans-European Road Network. Success stories, current practise and perspectives. Traveller Information Services (TIS) Expert Group. Version 5.3. 16/5/2007.

TomTom 2008. TomTom Annual Report and Accounts 2008. http://investors.tomtom.com/reports.cfm?year=2008

TomTom News 2008. TomTom Map Share™ hits one million map improvement upload milestone in just six months, TomTom press release Feb 14 2008, http://www.tomtom.com/news/category.php?ID=4&NID=487

TomTom Work 2009. TomTom WORK - connected navigation product components. http://www.tomtomwork.com/us/products/product-inter.xml (3.7.2009)

Tuominen, A., Ahlqvist, T, Rama, P., Rosenberg, M. & Rasanen, J. 2007. Liikennejarjestelman teknologiapalveluiden vaikutusarvioinnit tulevaisuudessa. (Research directions for future transport service assessments). VTT Tiedotteita – Research Notes 2390. Espoo, 2007.

Tuominen, A., Jarvi, T., Rasanen, J., Sirkia, A. & Himanen, V. 2007. Common preferences of different user segments as basis for intelligent transport system: Case study – Finland. IET Intelligent Transport Systems, volume 1, number 2, 2007.

US DoT 2009. National ITS Architecture, Version 6.1. U.S. Department of Transportation 2009.

van Dijck, T. & van der Heijden, G.A.J. 2005. VisionSense: an advanced lateral collision warning system. 2005 IEEE Intelligent Vehicles Symposium Proceedings (IEEE Cat. No. 05TH8792), 2005, 296-301).

VTT 2007. VTT: A mobile guide service developed by VTT in Finland. VTT press release 21.5.2007. Available from http://www.vtt.fi/uutta/2007/20070521.jsp?lang=en

Winder, A., Chevreuil, M., Estevan, N., Gautier, J-M., Jouen, J-F., Gaillet, J-F., Bossom, R., Schulz, H-J. & Franco, G. 2000. European ITS Framework Architecture: Proposed Framework of Required Standards. KAREN Deliverable D4.1. http://www.frame-online.net/Karen_doc/d41final.pdf, accessed 1st July 2009]

Yang, C. & Fricker, J.. 2001. Using human information processing principles to design advanced traveller information systems. Transportation Research Record, n 1759, 2001