ROADIDEA

D4.6 ITS Deployment in the future

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Executive summary

The main messages from ROADIDEA (2007–2010) have been summarised in two reports, D1.9 "Roadmap" mainly on innovations and defined barriers, and this report D4.6 "ITS Deployment". This report is summarising the state-of-the-art of the deployment situation, technology development and emerging technology areas, as well as giving a broad strategic look on services and business opportunities and generally, directions of technology supported development. Most of the reported issues are based on material and findings reported already in various ROADIDEA documents but this focused approach is completed with recent findings and developments.

The main objective of this report is to assess the trends of technology development and what applications and services are already close to the market or emerging. A related main other objective is to enrich the summary view of innovations and barriers with a more detailed analysis on barriers related to technology utilisation. This all seen from a comprehensive roadmap perspective starting from enabling technology, developed applications and services processes and ending up in the fulfilment of user needs and requirements.

The EC together with Member States and the active ITS organisations, via their various policies, research activities and citizen needs, have been able to recognise the importance of transport system development and utilisation of intelligent transport systems (ITS) in their activities towards a more sustainable future. It has also become evident that the strategic policies aiming at keeping Europe at the main edge of this development call for a systems concept accelerating innovation production, market creation, service provision, citizen acceptance and political commitment. This same need for a new direction has not been identified only in Europe but also in the U.S. and other countries having a major impact on innovation based global markets.

Without a comprehensive concept and policy the deployment of ITS will be slow. This is seen in Europe in the identification and implementation of Europe-wide systems having a remarkable and proven effect on the main strategic transport and other policy objectives (e.g. eCall). Both European Commission and industry based many major initiatives have been launched but no radical changes in the uptake and markets of ITS have been seen before joining the efforts with MoU's and stronger tools. This same observation is seen in many Member States with missing political commitment and real trust in private sector and companies. Organisations seem to be more waiting for opportunities being brought out than opening up opportunities by their own efforts. The recent major initiatives can also be seen towards the business strategy philosophies and the future as we cannot predict the future but we have to try to make it.

We have identified and recommended many necessary actions to fasten the ITS uptake and service development. We have seen firstly, that there are many general activities e.g. agreeing on European rules for access to public data, but also major other pressing activities as (1) to improve the innovation process, (2) to fasten the slow development and deployment process, (3) to improve availability of data and deployment of necessary models, (4) to develop business models and (5) to enhance use of standardised technology.

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1. Background and objectives

The main messages from ROADIDEA (2007–2010) have been summarised in two reports, D1.9 "Roadmap" focusing on innovations and related barriers, and this report D4.6 "ITS Deployment". This report is summarising the state-of-the-art of deployment situation, technology development and emerging technology areas, and providing broad strategic look on services and business opportunities and generally directions of technology supported development.

Most of the reported issues are based on results and observations reported already in various ROADIDEA documents but this focused approach is completed with recent broader findings.

The main objective of this report is to assess the trends of technology development and what applications and services are already close to the market or emerging. A related main other objective is to enrich the summary view of innovations and barriers with more detailed analysis on barriers related to technology utilisation. This all seen from a comprehensive roadmap perspective starting from enabling technologies, moving on to developed applications and services processes, and ending up in the fulfilment of user needs and requirements.

We chose a basic and rather simplistic classification of barriers as the starting point of the analysis:

Technical

- Security
- Accuracy
- Data Privacy
- Reliability
- Quality
- Functionality

Organisational

- Ownership
- Data Handling
- Billing
- Value Added Services

Legal

- Enforcement
- Liability

2. Technology development

Many technology foresight research results exist concerning the next decades. One of the major sectors driving the development has been the automotive industry and the related networked partners. The first major development steps were mostly taken after the identification of the immense global road safety problem and the need for turning down the rising amount of fatalities due to fast increasing mobility needs. Later on, the climate change and the emission problems entered into the political agenda and into the heart of transport and technology policies.

The strategic focus has been on e.g. safety and security problems and congestion reduction and management to reach safety improvements and emission reductions. Some of the key areas in transport supported strongly by new technologies are e.g. road pricing, advanced traveller information systems, intelligent road network improvements, public transport management and information systems and working while travelling. In business, telecommuting and e.g. video-conferencing and of course supply chain management have been under quick development as new technologies have become mature and widely available. Many innovations presented during ROADIDEA Futures Seminars were new or improved service ideas in aforementioned areas.

The developed basic technologies have been integrated into applications and concepts ending up in innovative solutions within the transport sector. Major research resources have been allocated to make the applications and concepts mature enough, although basic technology problems had been earlier solved.

In the U.S., vehicle related technology foresight studies have focused primarily on: (1) nanotechnology, (2) communication technology, (3) computing and Internet technology, (4) transport, vehicular, and automotive technology and (5) sensors. Nanosensors and nanomaterials are of interest in transport. Communication technologies are in fast development phase including e.g. WiMax, MobileWiMax, Ultra Mobile Broadband, 4G. In vehicle-to-vehicle communication DSRC is one of the basic technologies. In vehicle-to-vehicle communication networks VANET-related applications are emerging into piloting. Transport and vehicular related research is opening new directions. Fully automated vehicles capable of providing door-to-door services are also emerging (PRT, personal rapid transit). (Ukkusuri, S., Gitakrishnan R. 2009)

We have seen all kinds of new mobility systems already in the market (segways, hybrid systems etc.). New directions include also piloting of flying cars. Public transport systems such as undergrounds are becoming driverless because of advanced automation.

The list of the identified emerging technologies is following (Ukkusuri, S., Gitakrishnan R. 2009):

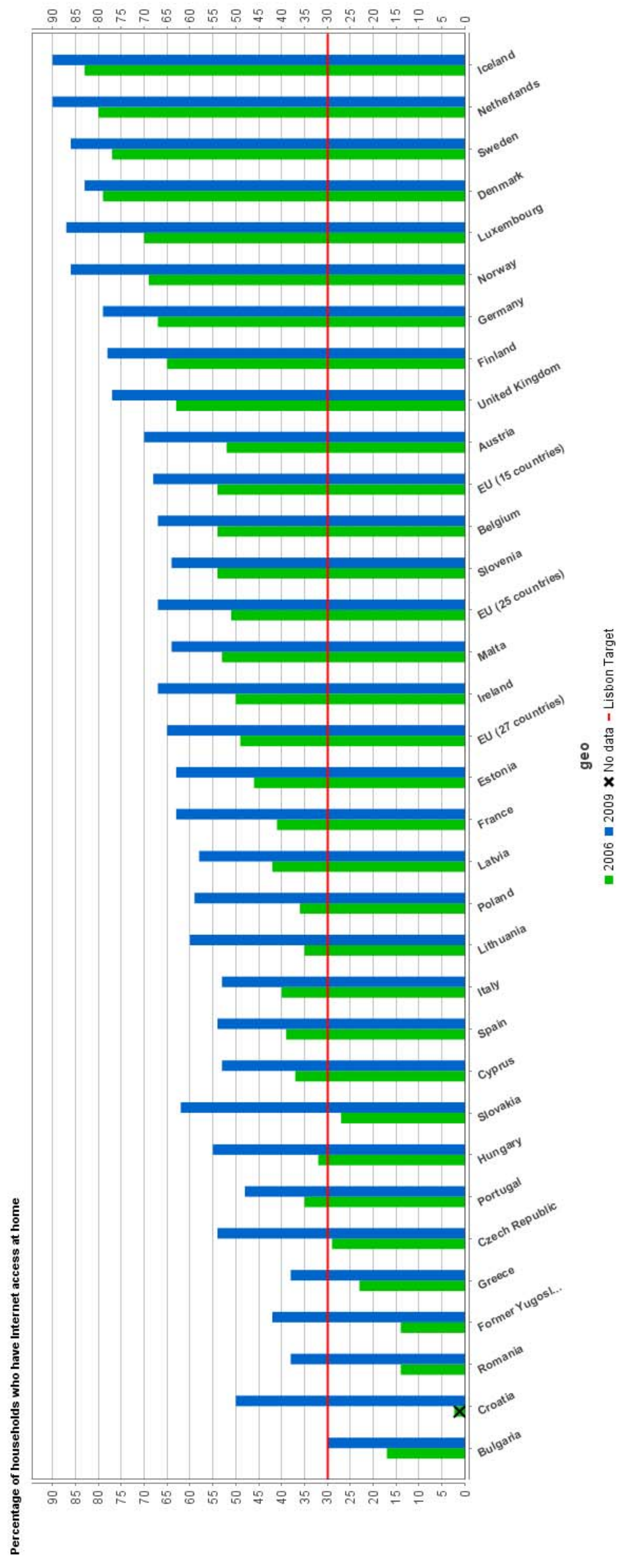
1. Nanotechnology
    - Nanobatteries, -sensors
    - Carbon-based nanofibers
    - Nanocoating, reinforcing
    - Nanomaterial of pavements
    - Automatic healing material

2. Communication
   - DSRC
   - Wide-area wireless communication
   - Ultra-high-speed internet
   - VANET´s
3. Computing and Internet technology
   - Collaboration software
   - Augmented reality
   - Personal travel assistants
   - High-definition video conferencing
   - Advanced route guidance systems
   - Adaptive ramp metering
4. Transport, vehicular, and automotive technology
   - Small-wheeled transport
   - Personal rapid transit
   - Automated vehicles
   - Flying cars
   - Waterbridge
5. Sensor technologies
   - Satellite positioning, RFID
   - MEMS sensors (microelectrical mechanical systems)
   - Smart cards
   - Machine vision

The study of Ukkusuri and Gitakrishnan(2009) dealt mainly with technologies that could be utilised within the New York metropolitan area. It also identified the likely degree of penetration of various key technologies. According to their study, in 2030, GPS coverage in personal travel would be 50–100% (average 81 %), that of smart cards and RFID 10-100% (average 76%), that of collaborative technologies 20–99% (average 72%), and work trips replaced by collaborative technologies in 3–60% (average 30%) of cases. Automated vehicles penetration rate was estimated to be on an average 30% and V2V and V2I about 51%.

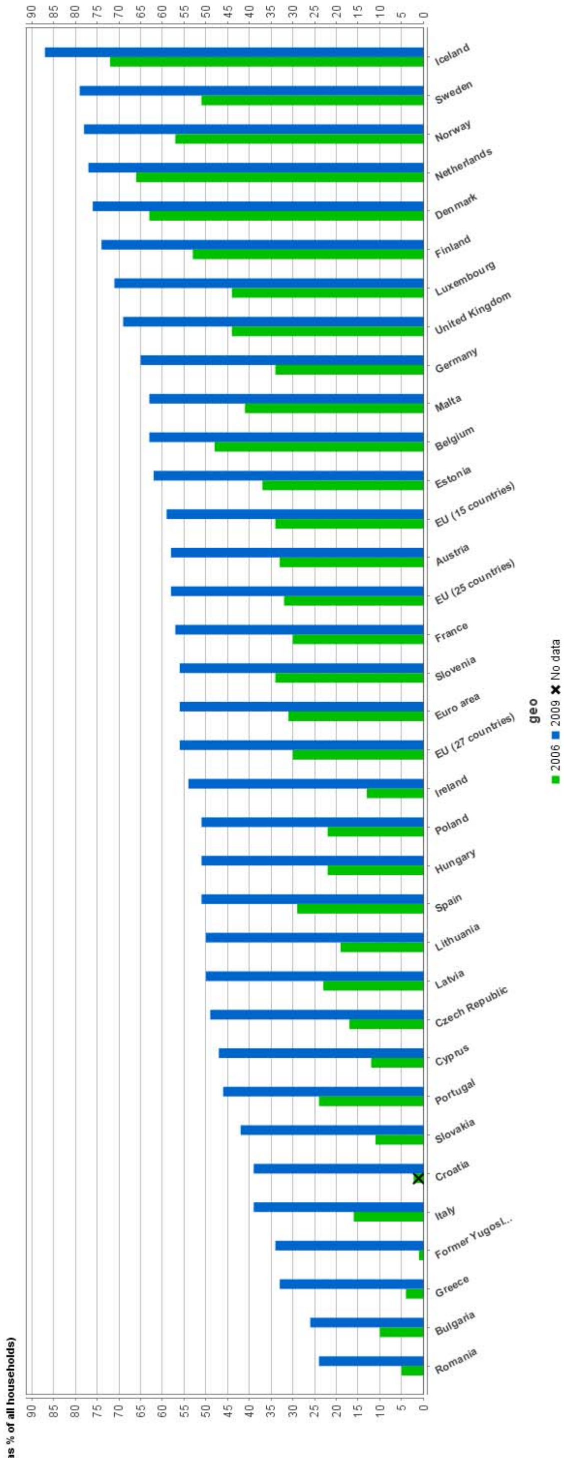
2.1 Communications

The share of households having Internet access at home has been increasing rapidly during the last three years both in countries with already high penetration rates and countries behind them (see figure below) (Eurostat 2010a). The figure shows the share of households having Internet access in different European countries in years 2006 and


Percentage of households who have Internet access at home
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
80
85
90
Iceland
Netherlands
Sweden
Denmark
Luxembourg
Norway
Germany
Finland
United Kingdom
Austria
EU (15 countries)
Belgium
Slovenia
EU (25 countries)
Malta
Ireland
EU (27 countries)
Estonia
France
Latvia
Poland
Lithuania
Italy
Spain
Cyprus
Slovakia
Hungary
Portugal
Czech Republic
Greece
Former Yugosl...
Romania
Croatia
Bulgaria
geo
2006
2009
No data
Lisbon Target

2009. Between those years, the share of households with Internet access has grown significantly in all European countries, and it is unlikely that this trend will reverse.

The share of households having a broadband connection to Internet has increased even more rapidly, but it is still between 45% and 65% in many European countries (see figure below) (Eurostat 2010b).



The growing share of households having Internet access has several important consequences. The first of them is the impact on the size of market for services such as web commerce, social media, traffic information, public transport information and electronic ticketing. The increase in the number of households connected to the Internet usually increases also the number of potential users, customers or audience of any internet-based service.

The second possible but not less significant impact is the partial or complete replacement of traditional service channels by Internet services. This development is possible when the share of households having Internet access is large enough. A development path like this can be observed, for example, in banking services and sales of flight tickets. In these cases, remarkable benefits in terms of productivity have been achieved. It is possible that similar developments will be observed also in the transport sector, in connection to tasks that the user can perform himself or herself.

At present, two important barriers to the use of mobile information services seem to be the limited battery life and lack of transparency in billing for the mobile data connection (Kaikkonen 2009). However, the problem with the transparency of billing will probably be solved by availability of 3G data connections with flat-rate pricing model.

Always-on wireless broadband technologies are developing quickly in terms of capacity, quality of service and cost. At present, the two most potential wireless broadband access technologies are LTE (3GPP Long-term evolution) and Wimax. LTE has been standardised by 3GPP (Third Generation Partnership Project) as an enhancement to the existing UMTS 3G network technology. If widely implemented by mobile network operators, LTE will increase the capacity of mobile broadband connections and reduce the time delays in data transfer. This will improve the user experience and enable new and enhanced services to mobile users. This will, in turn, result in an increasing number of mobile users.

At present, LTE is under testing by mobile network operators and the first commercial LTE networks have been opened in Stockholm, Sweden and Oslo, Norway in December 2009 (TeliaSonera 2009). It is probable that the geographical coverage of LTE-enabled networks increases over time, but this will take time because upgrading to from 3G/UMTS to LTE requires investments from operators and changes to the net.

Despite the recent advances in data communication technologies, challenges still exist in some applications such as vehicle-to-vehicle (V2V) communication. For example, developing communication protocols for ad-hoc V2V networks that perform well both in high-density situations with a large amount of vehicles in a small area and low-density situations in which there are few other vehicles to communicate with has been a non-trivial task (Füssler et al. 2007). Vehicular ad-hoc networks have to also cope with other factors typical in V2V communication such as rapidly changing network topology, the hidden terminal problem, signal fading and interference, and the high relative speeds of vehicles. However, vehicular ad-hoc networks are still an active topic of research, and it is likely that V2V communication solutions improve during the next five years.

2.2 Identification

A distinction should be made between two concepts: identification and authentication. Identification can be explained as a process in which a real-life observation is matched to an image of the object in human mind or data stored by a computer. Identification does not necessarily require cooperation of the object being identified. The concept of authentication refers to process in which the recipient of data tries to ensure that the information he receives is trustworthy.

The use of RFID in ITS applications and logistics has increased slower than originally expected. The basic reasons for that are the fragmented market of RFID technologies and the limited benefits over the existing solutions perceived by potential users.

Before most present-day RFID technologies came into mass market, barcodes were extensively used by the whole logistic chain to identify and track shipments and equipment. This means that the information systems of most companies involved in the logistic chain already had support for traditional printed barcodes at both hardware and software level. In most cases, making changes to the existing business-critical systems would need require considerable investments and be a source of increased operational risk. While most companies have considered RFID to have only limited benefits over traditional barcode systems, only some large companies have deployed RFID technology in large scale.

Important prerequisites for increasing the use of RFID technology during the next five years will be possible decreases in the prices of RFID readers and tags, understanding on the limits of RFID technology and redesign of business processes.

Near field communications (NFC) is a short-range communication technology based on magnetic field induction. NFC is compatible with many RFID devices operating on the 13.5 MHz frequency band. For example, a mobile phone having the NFC feature can read RFID tags, emulate a tag or exchange information with other NFC-equipped devices. Even though NFC has been on the market for some years, the availability of mobile phones equipped with NFC is still limited. Some trials with public transport ticketing systems using NFC exist, but the number of NFC deployments in ITS systems is still limited. At present, NFC suffers from the chicken-and-egg problem: when NFC is supported only by a small share of mobile phones, software developers and service providers have only limited incentives to support NFC in their applications. This situation will probably continue, unless some participant in the value network takes a driving role to increase the use and support for NFC.

Identification of human users is also possible on the basis of biometric techniques such as electronic fingerprint readers or iris scanners. The false identification and false rejection rates of these technologies have been going down during the recent years, and similar development can be expected to continue. An equally important question as the detection or rejection rates is how these technologies should be used in practise to build up secure systems.

PIN-based authentication together with a smartcard is commonly used in financial applications to authenticate the human user. Even though EMV which uses a combination of smartcard and pin code to authenticate users is secure against many attacks, no system should be considered flawless or absolutely secure (Murdoch et al.

2010). It is probable that EMV based systems will stay on the market at least during the next three or five years. Some further improvements to their security will be introduced.

In most information systems, users are authenticated on the basis of user name and password or a list of one-time passwords. It is also possible to authenticate user on the basis of an electronic key such as RFID or smartcard. These methods will probably remain in use in ITS systems requiring user authentication during the next five years.

2.3 Positioning, location

The European satellite positioning system GALILEO is expected to be operational in 2014. In the first phase, GALILEO will offer three different types of services for different user groups: (1) open service intended for mass-market applications such as car navigation, (2) public regulated service for use in law enforcement applications and special infrastructure, and (3) search and rescue service for emergency use. When fully operational, GALILEO will also provide a commercial service for professional markets, and a safety-of-life grade service for use in aviation, road and rail sectors. (European Commission 2010)

In mass-market applications, the main benefits of GALILEO are related to additional satellites offering better availability and coverage (particularly in northern Europe), high precision (e.g. in urban environments) and reliability, provided by an integrity function that inform user of failure of any satellite. (European Commission 2010). GALILEO has planned to work in cooperation with GPS.

Together with the American GPS and the Russian Glonass, GALILEO will provide more precise and reliable positioning for fast growing Location-based services (LBS) market.

2.4 Computing

Computing has always been one of the key areas of intelligent systems development. Some years ago it was a major barrier due to lack of computing capacity, but gradually this basic barrier has been mostly removed also on mobile system level. Internet has also in computing opened completely new directions during the recent years.

Increases in the capacity offered by communication networks as well as improvements in the quality of service offered by them have facilitated the development and utilization of new computing technologies: cloud computing, virtual desktop infrastructure (VDI) and service-oriented architecture (SOA). Cloud computing will be discussed in more detail under Information management.

In the category of mobile devices, no single hardware or software platform has gained a dominant position like Windows operating system and PC (personal computer) architecture in case of desktop and laptop computers. This means that any software developing wanting to serve all potential customers having a smartphone has to write the code of his software several times or at least port the same application to several different software platforms. This increases the cost of developing new applications or offering any application to all potential users.

The main software platforms available for mobile devices are currently Symbian, iOS, Android, Windows Mobile and Blackberry OS. The Symbian OS mostly used in Nokia phones has been in use for several years. Currently Symbian is the most widely used OS in smart phones. However, the market share of Symbian has recently been declining as other (e.g. Linux-based) software platforms have been introduced into the smartphone market. iOS will most probably be used only in devices sold by Apple which does not seem to be interested to compete in the lower middle or low price segments of mobile phones. The market share of Android is increasing, but still limited at present.

The number of major computing platforms used in mobile devices such as smartphones will probably decrease in future. The benefits of using a common platform with other hardware manufacturers will become more and more important. The complexity of mobile devices and smartphones will increase all the time, which means that significant resources are needed for development and maintenance of the operating system, which provides a platform for applications. Benefits could also be obtained in the development cost and availability of applications to end users. However, it is likely that a large selection of mobile phone models with different features and capabilities and corresponding software platforms will remain on the market also in future.

One of the main challenges in software development is how to maintain an adequate level of quality in released software and firmware and at the same time bring new applications and devices to market as quickly as possible. This has been the challenge in the case of the desktop and laptop PC platforms, and it will stay as a challenge to some extent. Many software manufacturers are dependent on revenue they receive from selling new versions of the same software, and they commonly have an incentive to introduce new versions with a rapid cycle. At the same time, private and corporate end-users do not always have enough bargaining power to demand high-quality software and services.

When the available computing platforms offer more and more resources to developers and applications, and applications themselves get more complex, improvements in tools used by software developers are needed. It is probable that the tools available for software developers will advance together with the new computing technologies and paradigms.

One of the factors limiting the development and use of mobile devices is the limited battery life. While requirements for computing power, memory and communication bandwidth have increased in mobile devices during the last five years, improvements in battery and power management technologies have barely been able the respond to increasing needs for battery power. During the next five years, improvements in battery capacity, deployment of fuel cell technology in mobile devices or reduction in the energy used for communication and computation will be needed, if the development in mobile computing platforms and applications is to be maintained.

The component technologies used to implement processors, microcontrollers, memory components, hard disks or displays will probably continue developing rapidly. In general, this means that the performance offered by individual components will increase or new functions will be integrated into existing components and sub-components. An equally important phenomenon is the price erosion. This means that the price of any component or a component providing same performance will decrease with time. Price erosion in components is usually driven by improvements in technology providing more performance for the same price, increase in manufacturing yield over time, and cost structures typical in electronics manufacturing business.

2.5 Information management

The cost of storing, processing and transmitting a single byte of information has been steadily going down during many years. This trend will most probably continue. Increasing performance of various hardware and software platforms and improvement in data communication networks allow new service models to emerge and become more cost-effective than the existing ones. For example, the applications which are today run on users' own desktop or laptop computers might as well be run on a server or a cluster of servers connected together.

The concept of cloud computing will most probably become more and more important during the next three years. Cloud computing is commonly understood as a combination of the concepts platform as a service (PaaS), software as a service (Saas) or infrastructure as a service (IaaS). At present, there is no single commonly accepted definition for cloud computing (Rimal et al. 2009), but a report published by EC provides a broad definition for a cloud:

"a 'cloud' is an elastic execution environment of resources involving multiple stakeholders and providing a metered service at multiple granularities for a specified level of quality (of service)" (Jeffery and Neidecker-Lutz 2010).

At present, there are multiple competing platforms which offer computing services based on clusters, grids and clouds. In future, the main challenges related to cloud computing are interoperability, service provision and management, security and trust and changes to applications needed to benefit from cloud computing environment or even to run the applications on the chosen cloud computing platform.

Potential benefits of cloud computing for service developers and service providers include shorter time to market, less need for large investments in computing infrastructure and infrastructure maintenance, possibility to transfer costs from capital expenses to operational expenses and greater flexibility in the amount of resources available.

Cloud computing has the following positive aspects: (1) it is infinitely scalable, (2) it provides effective infrastructure for various platforms, (3) full outsourcing, (4) shift costs from CAPEX to OPEX, (5) cloud providers have themselves invested in the necessary infrastructures, and e.g. (6) include datacentres as a services. It is likely that it is in Europe's interest to participate in the "Cloud Movement". The main identified opportunities are related to (1) needed platforms, (2) growing interest in tele-communication industry, (3) enhanced service provisioning and meta-services, (4) support to business development. (EC DG INFSO 2009)

High-quality raw data is an important prerequisite for effective and successful ITS services. When more and more services are built on the existing data sources and traffic data is shared between different organisations, methods and processes are needed to express the quality of existing data or services and the requirements for data quality and service quality. The framework for the evaluation of data and service quality in ITS services has recently been under development in the European project QUANTIS (http://www.quantis-project.eu). The providers of traffic data should document their data quality and provide this information to service developers which could then assess whether a particular data source meets their quality requirements of not.

2.6 Data, standardisation and architectures

ITS architectures

Several European countries have formulated their own national ITS architectures. The national ITS architectures are different from each other in some aspects, and some of them are based on the approach used in the European ITS Framework Architecture (FRAME). It is most likely that there will be no switch to FRAME in short term and that one has to deal with many national ITS architectures and the ways they describe ITS systems in near future. In future, there are three possible development paths for national ITS architectures: further development of national ITS architectures, development of national ITS architectures towards FRAME and gradual replacement of existing national ITS architectures with FRAME-compatible architectures.

Data provision models

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 (Britschgi et al. 2009):

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 of 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 results in a situation, where 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 Service Oriented Architecture or 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.

Standardisation in ITS

The number or stakeholders involved in the transport system and provision of ITS services is still increasing. Therefore, the needs for interoperability between systems implemented with different technologies and operated by different organisations are increasing all the time.

On the one hand, interoperability between systems and development of competitive market can be facilitated by the standardisation of the interfaces and service logic when needed. The standardisation of the key elements for interoperability such as essential interfaces should be accelerated in the case of key services and technologies. However, in many situations standardisation alone is not sufficient, but we also need other measures to reach interoperability such as discussions and agreements between countries and organisations on common visions, objectives and roadmaps.

3. Mobility related services of the future

3.1 Data as Information infrastructure

Two of the priority areas of the Action Plan for the Deployment of Intelligent Transport Systems in Europe are focused on data issues, namely *Optimal use of road, traffic* and *travel data and Data security and protection, and liability issues.* Relevant and reliable data is the key element in every traffic- and transport-related service. Enormous amounts of sensor data can be gathered through mobile phones, navigators, vehicle sensors, radars and video cameras to be used as raw material for processed information in services (e.g. real-time alerts and guiding) or for controlling means of vehicle behaviour (e.g. for emergency braking or lane keeping) or traffic in real-time management (e.g. reducing speed limit in congestion). Three challenges can be identified as the key ones related to data: the *availability, quality* and *the use of data*.

Efforts in regulation and research work have been allocated to open the public data bases for services and to create open interfaces for data transfers from different sources; in Europe the Directive 2003/4/EC on the Public Access to Environmental Information, Directive 2003/98/EC on the Re-Use of Public Sector Information, Directive 2007/2/EC establishing an Infrastructure for Spatial Information in the European Community (INSPIRE) regulate the use of data, also there exist national strategies for opening the data for different use.

Europe is behind the U.S. in the use of public data for services. In USA, there have been many innovative openings (competitions, rewards etc.) from the federal U.S. government and the States to encourage to use and create beneficial services from public data. For example Social Media professional Peter Corbett from iStrategy Labs in Washington D.C. was helping Washington's local government to organize the *Apps for Democracy* competition where local citizens were making new technology innovations on local public data which was opened for common use. The competition produced 47 applications, which were worth for 2.6 million dollars. (FVH 2009) The future will be for *Mobility-Data-Marketplaces* where professional developers and end-users as amateurs both produce and mine public and commercial data for service development to be used themselves and for business. Social media acts as an ecosystem for rapid mediators of innovative services. Mobility related data merges with entertainment and games and is part of everyday life.

For safety critical services like automated emergency alerts and calls (e.g. abnormal weather alerts and eCall), Advanced Driver Assistance Systems (ADAS) and for Pay-As-You-Drive taxation there is the evident need for almost 100 percent reliable and correct data mediation in a timely fashion. This kind of data communication must be highly regulated and secured, whereas standardisation is needed for country-to-country roaming services. A system providing this kind of data can be costly especially if done separately for one purpose. The standardisation organs, EU community and governments have done a lot of work last years to provide frameworks and guidelines for minimum data sets, architecture, interface and communication specifications etc. for these services (EETS Application guide, eCall standards, ADAS specifications etc.). Numerous research and development projects, which have done valuable contributions in this area, have been published.

The use of common citizens' mobility sensor data (location data of identified users) can be seen as a threat for privacy. The main principles for rightful use of this kind of personalised sensor data is that (a) the user must accept the use of data, so he or she *gives the permission* to use the data by an agreement and (b) the location transmission must be able to switch off when the user wants so. This holds true also for employees of a company, which uses location data for mobile work flow management and operations. On the other hand, there are security and emergency related transportations and freight shipping where the location transmissions from the route are vital and the employees must accept tracking and tracing of their locations. In the other end, there exist more and more social media applications where the users send voluntarily their whereabouts and private data to their friends through unsecured networks and applications.

In Europe, the directives which regulate the use of mobility related data are 2010/40/EU on the framework for the deployment of Intelligent Transport Systems in the field of road transport and for interfaces with other modes of transport; the Data Protection Directive (Directive 95/46/EC on the protection of individuals with regard to the processing of personal data and on the free movement of such data) is a European Union directive which regulates the processing of personal data and the directive 2002/58/EC concerning the processing of personal data and the protection of privacy in the electronic communications sector (Directive on privacy and electronic communications). For anonymous use of sensor data (e.g. for Floating Car Data) all implications and references for separate user identifications must be technically eradicated in early phases of collection of the data. It is vital to show this openly for the public to prevent any misunderstandings and distrust.

3.2 Services and Applications

The inevitable change from centrally controlled top-down Traffic and Mobility Management into heterogeneous and fragmented autonomous Mobility Ecosystem is going on now and this process will continue in even faster pace. In the future, the mobility services are on-line and the user devices are inside the pockets of people helping them to get on buses and airplanes etc. on-time (real-life vehicle movement instead of timetables). People get alerts of delayed take-offs or disturbances on transport systems to their personal devices before they start they journey. They can change their plans, choose another mode of transport or use the spare time wisely.

The control of driving and personal traffic behaviour management are more and more in technical systems which adjust to different driver's needs; the systems which are installed to vehicles are communicating directly with environment and other systems and each others. Service providers are promoting already the connectivity and control of life not making any separation between the mobility and other activities at all: "*open, end-to-end vehicle connectivity platform that will enable vehicle owners to safely connect to what matters in their lives. AutoLinQ™ extends the vehicle ownership experience by creating an "always connected" environment where users can have meaningful interaction with their vehicles from home, from the office, or from their mobile devices."* (AutolinQ 2010)

The hot topic today concerns the open platforms (in pockets, in homes and in vehicles, e.g. in figure 1) and the new Internet behind all different applications (which are sensing, controlling, guiding, aiding and entertaining) to merge and work together. Information and communication technology is becoming smarter, smaller and faster and at the same time, society is progressively becoming more densely connected. Internet and cloud computing supported services are entering a new phase of mass deployment. This is a challenge especially for public authorities - what is their role in this fast development of varieties of mobility aiding services and open platforms.

Figure 1. Meego Chosen as the In-Vehicle Infotainment Platform By GENIVI Alliance (Guim 2010)

To address these challenges the European Future Internet Initiative (EFII 2010) has started to map the issues to be tackled, covering all building blocks from users, services and applications down to the networks. The target of EFII is to establish a Future Internet pan-European coordinated partnership, which aims to reinforce and boost the competitiveness of enterprises and administrations, create new economic opportunities, while empowering innovators and citizens to benefit from the future Internet. This needs a multidisciplinary approach led by strong European industrial stakeholders, supported by academia and innovative SMEs, to develop the devices, interfaces, networks and services required to support the future networked society and economy.

The concept of "Digital Society", which will be characterised by a multitude of pervasive ICT technologies ranging from ubiquitous communication and computing facilities over various kinds of actuators and sensors to new modalities of user interaction, is recognised as a theme that can represent the integration of the Future Internet visions. In these visions traffic (intelligent traffic systems, public transport, and pedestrian guidance) is seen as a significant part. Traffic related services are also context-aware. They find, format and deliver content. They must be seamlessly available for the users e.g. for information search, guidance and entertainment. (EFII 2010)

In this rapidly changing selection of traffic and transport related services we can try to make a basic grouping of services in (a) mandatory services, (b) regulated services and (c) optional and commercial services and applications.

In the ITS Action plan services to provide *Road safety and security* can be seen as mandatory or regulated services and the applications there are e.g. eCall, Hazardous Goods monitoring, traffic management in general etc. Also *the continuity of traffic and freight management ITS services on European transport corridors and conurbations* has elements where the services and applications must be partly mandatory and regulated e.g. Pan European electronic tolling service EETS, digital tachograph, monitoring the freight and cargos.

The new *Integration of the vehicle into transport infrastructure* can be seen as partly mandatory and regulated and partly industry driven. Industry and service developers create the possibilities and innovative solutions to provide systems connected to vehicles and public sector has to adapt their current traffic management and network planning, systems and TM-centres to be in cooperation with the vehicles. Cooperative systems are ITS systems based on vehicle-to-vehicle (V2V), vehicle-to-infrastructure (V2I, I2V) and infrastructure-to-infrastructure (I2I) communications for the exchange of information. (Figure 2) Safety critical V2V and V2I are based on a dedicated short-range communications (DSRC) radio on the 5.9 GHz frequency in the vehicle and in the infrastructure. (COMeSafety 2009)

Figure 2. In-vehicle signage (Jandrisits 2010)

As an example of industry driven systems Advanced Driver Assistance Systems (ADAS) are in-vehicle technologies designed to improve safety by aiding the driver in his/her driving task. ADAS are based on environmental sensing to create a view of the vehicle surroundings. The systems enhance the driver's perception of hazards and in some cases partly automate the driving task. (eSafety 2006)

The European Commission can influence the market introduction or boost the penetration of given ADAS if the benefits are clear. For example, Electronic Stability Control (ESC), which assists the driver in maintaining control of the vehicle in a critical situation, will be mandatory for new car series and commercial vehicles to be phased in from 2012, with all new cars being equipped by 2014. In the ITS Action Plan in years 2009–2014 actions include promotion of deployment of advanced driver assistance systems and safety and security-related ITS systems, including their installation in new vehicles (via type approval) and, if relevant, their retrofitting in used ones. Services on the safety and comfort of vulnerable road users are also mentioned in the Action Plan and the harmonised introduction of pan-European eCall is the major endeavour. Use of ADAS in wider range of vehicles will grow constantly until 2020. The research and development is now moving more and more from stand alone ADAS towards cooperative systems.

The recently published policy white paper from IntelliDrive describes the current status of cooperative systems in the US in the following way: While V2V promised dramatic safety gains, it would take 15 to 20 years for the vehicle fleet to turn over so that a sufficient number of vehicles would be equipped with the V2V technology and start to yield tangible benefits. IntelliDrive embraces a multi-pathway approach that uses DSRC capabilities for safety; and explores aftermarket DSRC devices for their ability to more quickly provide benefits through faster penetration into the vehicle fleet. IntelliDrive also takes advantage of data collected by non-DSRC devices for mobility applications. The paper states that further research is required to explore Cooperative application development, testing, and validation of effectiveness, and is included in the *ITS Strategic Research Plan, 2010-2014*. (IntelliDrive 2010)

After results from European cooperative FOT´s and the U.S. IntelliDrive are available, the concrete deployment planning of cooperative systems might have enough information for making decisions on actual deployment actions such as regulation. Sufficient lead time for deployment will be required for all stakeholders once standardisation and other open issues will have been fully completed. Therefore, large-scale deployment of cooperative safety applications seems unlikely before 2020. However, cooperative infotainment applications via aftermarket and nomadic devices may well come available earlier.

Fast development and adoption of satellite positioning and wireless communication via cellular networks (3G, 4G) will continue, replacing broadcast technologies such as RDS-TMC and DAB-TPEG. Navigation systems will develop into fully-fledged information systems, with dynamic content like fuel prices, weather information, flow-based traffic through embedded probes and local search will be amongst the features that will become commonplace.

Eco-driving applications gain momentum, especially as the introduction of electric vehicles pushes OEMs to develop new applications. Telematics for electric vehicles needs to provide information for the range anxiety factor (limited range of electric vehicles). Mixtures of vehicle embedded and smart phone applications seem likely. Electric vehicles have been unveiled with specific mobile applications which allow consumers to check the state of battery charge, monitor charging and find the nearest charging station. OEMs will focus on using vehicle related information to create applications for eco-driving and vehicle diagnostics when electric vehicles come widely available around 2012. (Frost & Sullivan 2010)

The automotive industry will not accept applications download from an application store to the vehicle head-unit without certain control. A certification process for applications is used while driving needs to be set up. The problem is that the consumer electronics suppliers do not feel the necessity to adhere to the automotive specification requested by OEMs. For this reason, liability and warranty issues need to be cleared in a large industry-wide joint effort. The ITS Action Plan also calls for defining the necessary measures to guarantee the safety of road users with respect to their on-board Human-Machine-Interface and the use of nomadic devices, as well as the security of the in-vehicle communications. The target date for this action is 2010.

4. Deployment outlook

The ITS Action Plan and Directive summarise the current status of ITS deployment from many angles. According to the summary, for a high number of mature applications, the benefits and return on investments are highly depending on the scale of deployment, but the uptake is fragmented and slow including large differences between countries and low degree of intermodality. This explains the problem why ITS has not been effectively used and its potential remains largely untapped. Commission summarises rightly the situation as lack of interoperability, awareness and shared vision based also on unsolved data privacy and liability issues.

4.1 Strategic options

Intelligent Transport System has a long history in reality. The history started with traffic signals and system level green wave on a corridor or a road section trying to solve more comprehensive road network level traffic problems. In principle, in many countries, traffic problems have been seen as societal problems belonging to the public sector. Therefore, for a long time, the definition and solving of the traffic problems has been devoted mainly to the public sector with minor other societal and commercial motivation.

During the years, the private sector has been gradually needed more and more when innovative solutions have been necessary and technology has been seen as an enabler. In addition, the development away from policy silos has also opened eyes to understand that the policy problems are often related to each other and need comprehensive solutions. Development has become a separate field of action also in the public sector as case-wise problem solving was proven to be an inefficient way in solving challenges and providing answers. Gradually it has become very clear that the private sector is really often more dynamic than the public sector, and a deep cooperation is as must. Hence, PPP could be defined giving win-win situations and directing critical mass to research and development as part of the innovation process.

Deployment and production of innovations in the field of intelligent transport systems have been following this general trend during the recent years. A summary on the situation has a long time been that the problem is the so-called chicken and egg problem. In this, the public sector is often regarded either as the main owner of transport problems and thereby the driver of development activities or as slow in actions and as a barrier restricting effective market operation. Therefore, three main strategic options of deployment are defined as (figure 3):

- Public sector led development
- Private sector driven option
- Hybrid, PPP type of approach.

Public sector led development is including market regulation and often either leaves out completely other strategic drivers than transport solutions or takes the lead and necessary responsibilities. The private sector option leaves room to market development and adjusts private sector activities to that progress. Finally, the hybrid PPP type of an option has been seen as a main alternative just because the private sector cannot alone solve the major strategic societal problems very often related to both political priorities and privacy and institutional issues raising necessary regulation and legal actions.

Public Sector Led?

- Central coordination, a European version of 'Transport Direct' or the 'National Data Warehouse'
- Requires numerous agreements, service levels, performance monitoring and so on

Private Sector Driven?

- Involves agreement on making information available to a required standard, and meeting certain service levels,
- Anticipates that distribution is taken forward by various private sector partners (perhaps global operators looking to provide European coverage with the common data available)

Hybrid Approach?

- Involves a hybrid approach, with national governments taking ownership of the process on a national level
- Committing as 'provider of last resort' in situations where private sector does not take active role

Figure 3. Prototype Business Models (Abou-Rahme 2010)

The U.S. Department of Transportation has released a policy white paper "Achieving the Vision: From VII to IntelliDrive" in 2010. The DOT has recognised the need to provide stakeholders with an explanation of the major strategic issues that drove the deployment of its current plans for IntelliDrive research and explanation how, and when, the research results will enable decisions regarding the future development. This White Paper identifies the chicken and egg problem trying to define the roadmap towards effective services through defining needed milestones and timing of necessary decisions taken to reach the goals. (U.S. DOT 2010).

Recently more tools have proven to be necessary in deployment even though EU regulation and processes have been used. The so-called ELSA task force was nominated in 2010. The Commission has launched this new action to speed up the achievement of specific societal goals with focused projects of significant scale and duration that cut across the innovation cycle to develop modern pan-European service infrastructure.

These initiatives, tentatively called European Large Scale bridging Actions (ELSAs) are mobilising a critical mass of resources, pre-commercial procurement and support for innovation deployment. The ELSA initiative has identified goals across many policies affecting citizen and economy wellbeing towards sustainability identifying the importance of CO2 emission reduction, road safety, efficient use of infrastructure and opportunities of co-modality. It stresses the need for technology utilisation but identifies the various problems e.g. financial, entrepreneurial, organizational and other factors slowing the market development. The ELSA initiative addresses the interdependent issues involved in an integrated approach, with contributions from public and private partners in a coordinated pan-European programme.

4.2 Challenges of transport development framing ITS deployment

The European Commission has envisioned a sustainable future for transport in its consultation document summarising the future challenges of transport sector and opening the discussion for a new White Paper for the next decade. The corner stone of this opening is an integrated, technology-led and user-friendly transport system able to manage the major trends, threats and opportunities in Europe. The major trends and challenges include ageing, migration and internal mobility, environmental challenges, increasing scarcity of fossil fuels, urbanisation and other main global trends affecting transport. The motivation on strategy level is very clear because the transport industry accounts for about 7 % of GDP and over 5% of total employment in the EU. Transport is also a major element in GHG emission (24 %) and CO2 production (28%) contributing to the climate change. (European Communities 2009)

The major challenges include also the need for satisfying a rising demand for mobility. However, the policy goals of the future transport system aim at quality transport that is safe and secure but paying also attention on privacy issues and data protection. The transport network should be well maintained and fully integrated utilising effectively different modes of transport. More environmentally sustainable transport is in the heart of the policies but it requires new long-term deployment strategies. EU should be kept at the forefront of transport service and technology development. Intelligent transport systems (ITS) are expected to be able to optimise the use of the network. Protecting the human capital is necessary to guarantee effective transport services and production. The economic efficiency of the transport system should be based on a clear balance of prices and both internal and external costs. The introduction of a correct pricing system affects also the location of activities and e.g. the urban structure. Information technology will contribute to transport needs and accessibility.

The regulatory framework towards more harmonised approaches calls for improvements. Effective and coordinated actions are needed e.g. in the field of standards and interoperability and in the urban transport system development.

Long-term scenarios facing the challenges identified have been analysed in many EU research projects (foresight scenarios). The TRANSvisions project defined scenarios with a 20- and 40-year horizon and including external, internal and policy drivers. Today's emerging technologies were seen still important in 2030. Road traffic was still expected to remain the dominant transport mode. The defined scenarios for 2050 were defined according to different drivers and as "Move Alone" (Individualistic transport and market spontaneous self-organisation), "Move Together" (Pricing etc.), "Move Less" (Behavioural policies and regulation) and "Stop Moving" (Technology, regulation and banning). Usually these foresight studies have analysed challenges and possible directions of development and defined the future arising from alternative choices as scenarios. The TRANSvision project included also case studies shedding light on possible new ways to tackle the mobility needs as mega link projects, dedicated roadways for trucks, high-speed rail, road-pricing in cities, emerging vehicle technologies such as hybrids and electric cars, new urban developments (TRANSvisions 2009).

4.3 European activities supporting the deployment

European Commission defined in the 2007 ITS Roadmap Outline "Intelligent Transport Systems (ITS) for more effective, safer and cleaner road transport" (EC 2007). Major challenges in transport were then identified as congestion, safety and negative impact on the environment and summarised as towards safe, efficient and clean road transport. ITS was considered to contribute in many areas including e.g. applications of real-time and seamless information, public transport information, journey planners, freight management services, car sharing and electronic payment. Community initiatives and programmes related to ITS were defined as: GALILEO, SESAR, ERTMS, RIS, SafeSeaNet, Intelligent Car Initiative, and the Euro-Regional projects (TEMPO programme) (Annex 1).

The current Action Plan for the Deployment of Intelligent Transport Systems in Europe aims to accelerate and coordinate the deployment of ITS in road transport. ITS is expected to contribute to transport efficiency, sustainability, safety and security and EU Internal Market and competitiveness objectives. The Action Plan defines actions and timetables for six priority areas of: (1) Optimal use of road, traffic and travel data, (2) Continuity of traffic and freight management ITS services on European transport corridors and conurbations, (3) Road safety and security, (4) Integration of the vehicle into transport infrastructure, (5) Data security and protection, and liability issues and (6) European ITS cooperation and coordination. (EU 2008)

Action Plan identifies the barriers and bottlenecks of services development. It stresses the importance of harmonised EU-wide real time travel information, collection and provision of data, digital maps, free minimum information services and promotion of multi-modal journey planners. Services should be continuous, include eFreight (freight transport and logistics), utilise European ITS architecture framework and include also interoperable electronic toll systems. Safety related services require the promotion of in-vehicle systems, introduction of Europe-wide eCall and interfaces also to nomadic devices. Integration of vehicle and transport infrastructure as cooperative systems is supported. Need for security, data protection and addressing liability issues are emphasized. A proper legal framework is necessary for the introduction of major services. Target dates of the actions are within the timeframe 2009–2014.

The ITS directive accepted in June 2010 focuses on the same priority areas as in the Action Plan. Priority actions include travel information services, data provision and road safety related universal traffic information free of charge to users, EU-wide eCall, truck and commercial vehicle parking information and reservations services. The Member States are responsible for taking actions according to the directive. (EU 2010)

Recently more tools have proven to necessary in deployment even though EU regulation and processes have been used. The European Large Scale Action or ELSA targets include connected vehicles, connected travellers and connected goods in the context of (eSafety Forum 2010a and 2010b):

- Smart traffic management
- Advanced driver assistance systems
- European wide service platform for traffic and transport information
- Green freight and intelligent freight transport on corridors and in urban areas
- Electric vehicles, and
- New mobility services.

EU has in its deployment and supported actions utilised both the hybrid approach e.g. in alliances with industry (eSafety Forum) and public policy led actions based on voluntary member state authority led cooperation combined with some regulative actions (such as Easyway) ensuring effective transport problems solving e.g. in common Trans European Road Network (TERN) with modern tools. The common actions are today integrated into the Easyway project. In most of the countries, the national and cross-border Easyway projects are integrated into the public sector or public sector supported activities. Easyway has defined core European Services in five categories of: (1) Traveller Information Services, (2) Traffic Management Services, (3) Freight and Logistics Services, (4) VMS Harmonisation and (5) DATEX. Easyway is giving a roadmap covering services definitions, supporting infrastructure, deployment guidelines and a description of the organisational framework. (ROADIDEA 2009a)

The first applications of cooperative systems are mature enough to be next tested in large-scale field operational tests (FOTs). There is a general understanding now of the potential benefits of co-operative systems but so far they have only been demonstrated in small-scale experiments. European cooperative system FOTs will be running during 2011–2014. The current activities focus in the development and evaluation of cooperative systems via a harmonised approach including the assessment of deployment strategies, needs for investments, and intelligent infrastructure.

4.4 Business models

Delivering ITS services is a value adding chain which starts from basic data units like traffic monitoring and incident sensoring data, static and dynamic location data, Points-of-Interests, digital maps and routes, parking, timetables, vehicle type and emission data, weather forecasts etc. etc. Each stakeholder or operator delivers more value to the chain by processing and refining the data into information or service. The service is then provided to the end-user or used in some controlling method by a third party like a traffic management authority. Many aspects of the services needs to be described and verified by a business model architecture of the delivering chain, such as:

- How the data is processed and mediated?
- What devices and user-interfaces are used?
- Is it linked or bundled with advertising or other type of services?
- Is it by itself so tempting that the end-user wants to buy it installed and paid with the device or is he/she a monthly subscriber?

- Who provides what, how the costs are financed, what are the revenues etc.?

ITS services are clearly products of chained and collaborating enterprises and service provision as business belong to one of three main categories: (a) common safety related or traffic controlling services on roadsides and cities (automated cameras, traffic lights, VMS etc.) are specified and procured by public sector, (b) mandatory and regulated services and devices must be attained by end-users' own cost: digital tachographs, road tolling devices, alcolocks etc., (c) and there are huge number of different services or devices which end-users want to buy voluntarily such as PND – navigators, mobile phone applications or fixed equipment in cars (for safety, entertainment etc.). Roles of these typical ITS services can be seen in figure 4. It is still unclear in what business category the V2X services go, and therefore also the business models for V2X are still on development phase.

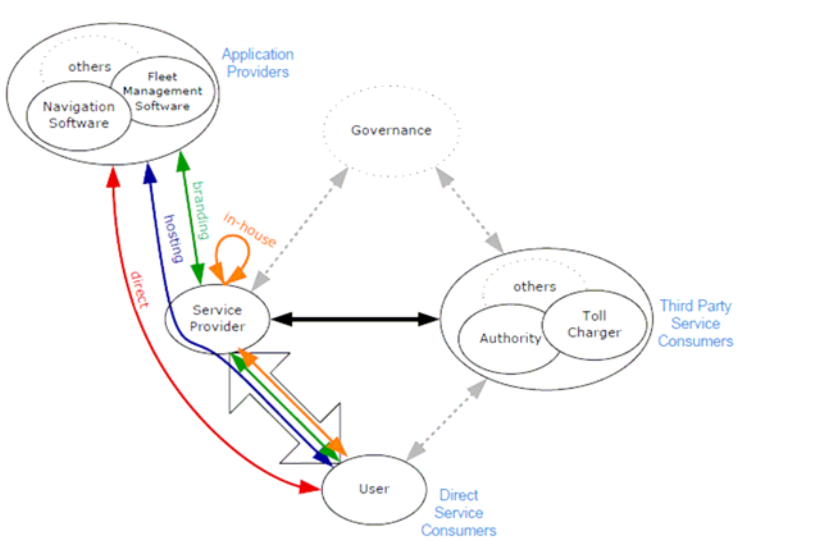


Figure 4. One example of ITS business model role description (Oehry 2010)

In 2008, the most popular and used information content was Real-Time Traffic information (figure 5). It still holds the top place this year according to the latest market data from ABI Research. Traffic Information maintains its position as the most important feature of navigation services with the global number of traffic information users expected to grow from 57 million in 2010 to more than 370 million in 2015. Navigation users continue to appreciate the value of traffic information allowing calculation of the fastest routes and accurate Estimated Times of Arrival (ETA) predictions. The emergence of historic speed profiles and predictive traffic information has extended the use case to trip planning. (ABI Research 2010)

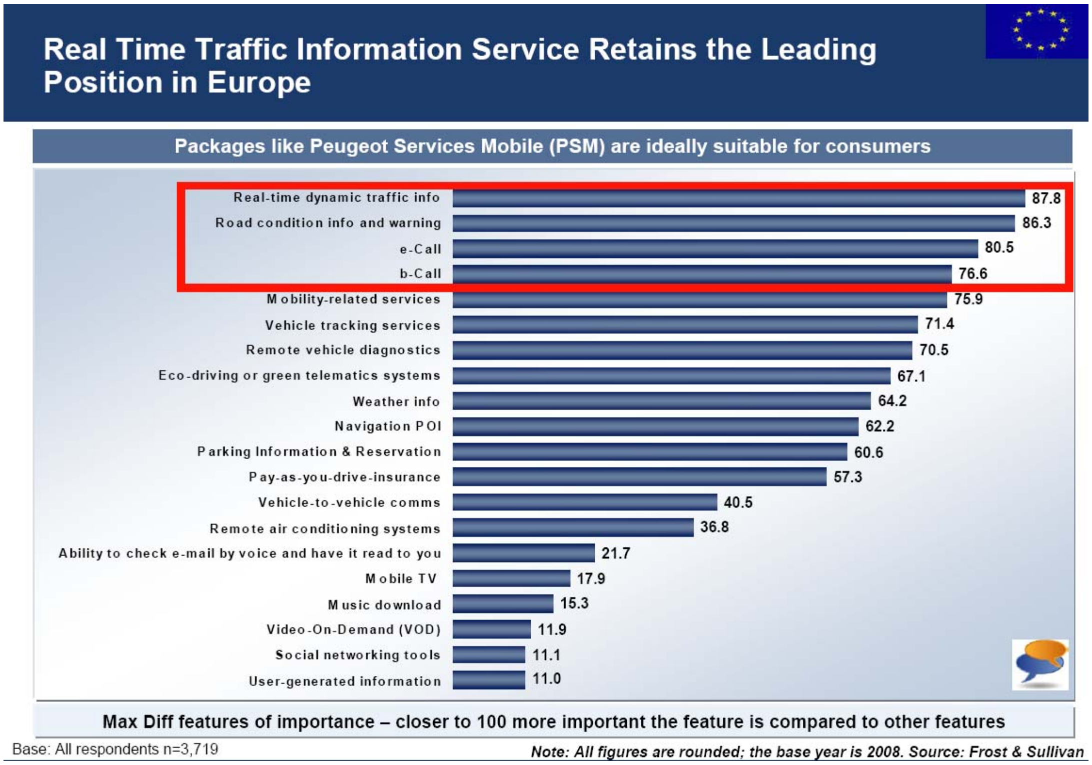


Figure 5. The most popular services in Europe 2008 (Frost & Sullivan 2008)

The surge in handset navigation (increasingly available for free) is resulting in GPS probe data becoming more widely available, improving quality as well as spatial and temporal granularity. This boosts the adoption of high speed cellular connectivity technologies, replacing broadcast technologies such as RDS-TMC and satellite. While TomTom, IntelliOne, AirSage, and Cellint use cellular probe data as the main source for their traffic solutions, the lack of accuracy continues to be a major issue at times and on sections with low traffic. Likewise, the importance of fixed road sensors is decreasing, reduced to key junctions and highways. (ABI Research 2010)

Major navigation brands such as Nokia (NAVTEQ) and Google leverage probe data from their customer bases to offer traffic information as part of their free navigation services. Smaller navigation vendors are shifting to lifetime traffic offers bundled with the navigation device or software. This puts pressure on independent traffic information vendors such as INRIX, TrafficCast, and ITIS to lower their prices and increase data quality. For these players the high margin automotive and government segments will become key markets, compensating for the declining revenues in the competitive mobile and consumer electronics markets. At the low end of the traffic ecosystem, pure crowd sourcing startups such as Waze and Aha Mobile have entered the market with traffic information based on passive and/or active community feedback. (ABI Research 2010)

42.3 million personal navigation devices (PND) will be shipped in 2010. Recently, PND manufacturers are facing increased competition from GPS-equipped smartphones, and some manufacturers have found their sales of PNDs declining according to market experts. Free map access from Google and Nokia on mobile phones has also caused a fall in sales and average selling prices. However, Stand-alone PNDs still have an advantage over smartphones, because of their larger screens. (TheWherebusiness 2010a)

It is also believed that PND survival is incumbent on its ability to become a viable component of the open mobile environment. Generally speaking, the whole mobile industry is quickly moving to converged, open platforms, which leverage third party applications for customers. The future of the connected PND will not stop once a base layer of applications has been developed and the subscriptions start growing. The development is likely similar to that of mobile phones; when the operating system allowed for the device to be used beyond just phoning, an array of services appeared. Once a device is in the car with a valid set of applications that pushes its sales and opens up opportunities for further revenues from third party developers, there won't be any reason for more services to become available. It is also very conceivable that once the set of applications starts growing beyond the feeble basic layer that today's connected PNDs offer, the need for better and faster connectivity will become a priority. At that stage, operators will have a valid business case to subsidise the connected PND as they do with the smartphone - especially if the applications are theirs too. (TheWherebusiness 2010a)

Key challenges in creation of business models for open platforms, Vehicle-to-Business communication and ICT backed mobility services may lie in following areas:

- Limited bandwidth of today's mobile telecommunications technologies
- Intermittent connectivity of vehicles caused by their mobility and the incomplete coverage of today's mobile telecommunications technologies
- Scalability: Vehicle-to-Business communication covers billions of vehicles that send a huge amount of messages with varying priorities to business applications
- Reliability/Quality of Service: Messages should be delivered according to their priority (e.g., Pay-As-You-Drive messages delivered every second vs. critical engine status information to be sent to the vehicle manufacturer as the critical event occurs)
- Interface complexity of business applications and services (e.g. SAP Claims Management System)
- Heterogeneity of in-vehicle hardware and software components
- Creation of new types of virtual enterprises which combine the competences of SME:s and big companies with a common reference architecture from product modelling through implementation into life cycle phases…with modular components for provision of ITS products for customers (figure 6)

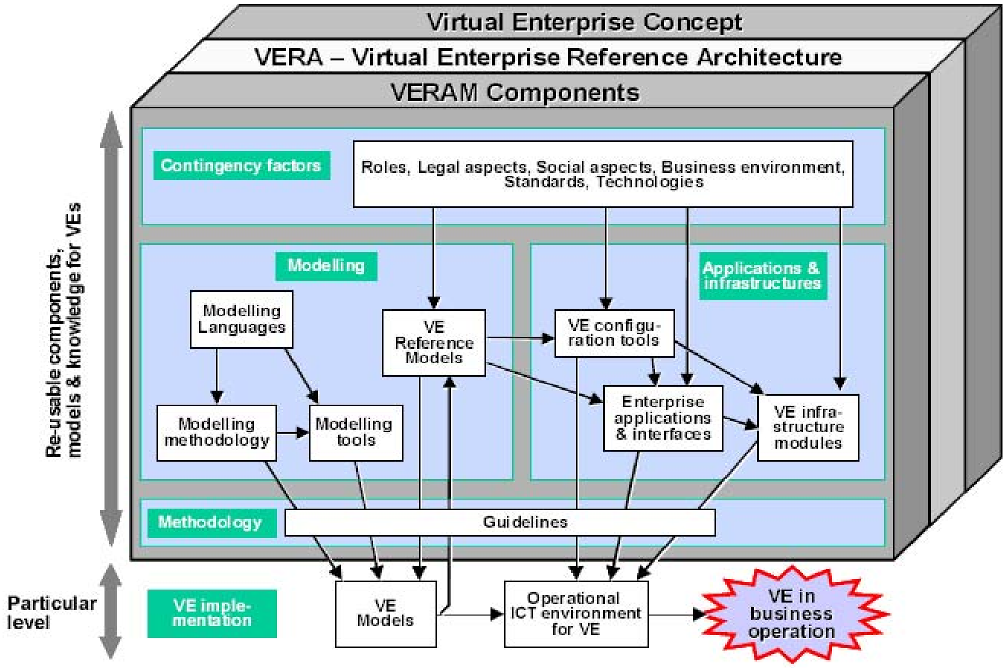


Figure 6. From value chains and networks towards Virtual Enterprises (Zwegers et al. 2003)

Business case example of Dreevo2 as a typical new type of ITS service:

"The Dreevo2 is a PND whose applications are all third party. So it is at the same time a portable fleet management system for taxis and a navigation system with live fuel price updates and access to the speed camera community.

In the commercial sector, the boxes may be sold directly to fleets. Typically, however, they will go through the application providers who want to ensure they are providing the right tool for the fleet trade. The boxes also rely on third-party service providers to deal with integration, deployment, training, billing and after-sales support.

The Dreevo2 is open, not open source. It runs on Linux with a virtual machine on top, so it's very easy to develop apps for it through its SDK. The API, however, is open to anybody wanting to write for it. …It comes with a bunch of pre-packaged apps as well, including traffic and SMS. The mobile device also provides connectivity to servers, so apps developers only need to install the app on the device, (Java language), and create a proxy to their application/ content server.

Announcing an app shop can be a risk for too high hopes. Sure, they have a bunch of apps people can choose to install on the device, but we're not talking Apple App Store here. In fact most of the consumer apps will be preloaded and right now only the enterprise apps will be available from the shop.

Right now the Dreevo comes with navigation and routing, yellow pages, local search, chat, push to talk, phone application (built in or via Bluetooth), Weather, fuel prices, parking places, SMS, email, speed camera (static and live, done by Coyote) and hazardous routing. The business models at this stage are offered free with a subscription of €26.90/month or prepaid (€390) with six months free and €10 /month thereafter."
(TheWhereBusiness 2010b)

The key players in the public sector are National Road Authorities and toll-road operators, which continue to equip their roads with Intelligent Transport Services: traffic, weather and incident monitoring equipment, variable message signs, tunnel management devices and road tolling equipment etc. with the ICT centre system ("back office") and communication networks. ITS has a totally different lifecycle than that of traditional road infrastructure, and the operation and maintenance of ITS may be much more expensive than the system investment (annually up to 20 per cent of the total investment cost).

Some basic strategies from the infrastructure provider point of view can be identified for initiating the large-scale deployment of ITS by improving the business model and case for the deployment at least for some of the stakeholders considerably, and thereby solving the chicken-and-egg problem (IIWG 2010):

- start with the locations where the customers are
  - is feasible to start a deployment of a service at locations, where many customers are concentrated in a restricted geographical area such as big cities or urban areas. This offers the possibility for large quantity deployment at a small area.
  - these areas are often also attractive for paid services (in combination with free of charge) offering various financial schemes. These areas are also attractive to start with the infrastructures via moderate investments, and in many cases some infrastructure elements are in place already
- start with the infrastructures available
  - for best cost efficiency, it is feasible to start with services that can utilise the existing communications and other infrastructures, such as e.g. the existing 2G/3G or GSM+GPRS/UMTS networks and the existing navigation devices and data bases. Often these infrastructures have been deployed where also the customers are, i.e. the first locations will be similar to those from the previous one.
  - investments will initially focus on the development of services itself creating momentum. Based on the created momentum additional services using the common ICT infrastructure can be developed having less risk and already customers avoiding the chicken and egg for additional investments.
- start with the locations where the problems are
  - in order to achieve maximum impacts, it is usually feasible to start with locations having exceptionally severe problems needing to be solved. Examples are intersections, which are accident black spots, tunnels and other sensitive spots where any incident may have critical consequences, and sections with recurrent congestion. This is especially the case for road authority services aimed to achieve policy goals, which are usually related to reducing the extent of road fatalities, congestion, greenhouse gases, mobility problems etc.
  - financing schemes within the context of policy objectives and safety give easier a positive cost/benefit ratio needed for road infrastructure investments.
- start with most important roads

  - road operators and authorities have a network operation policy and a road hierarchy, where key parts of traffic demand will be served with the most safe and efficient roads. For transport policy reasons, road operators need to attract as many road users to these highest road hierarchies such as the Trans-European Road Network or motorways in general. For private motorway operators, this is a natural policy. ITS services, which will make the roads equipped more attractive to use, would thereby be feasible to deploy especially on the high-class roads.
  - economically important national and international roads offering services for efficient and reliable traffic should result in a positive business case and investments for the ICT infrastructure for ITS.
- utilise opportunity linked to infrastructure replacement or development
  - the additional costs for new intelligent infrastructure are relatively small, if they are deployed to replace obsolete or faulty existing intelligent or unintelligent infrastructure, which must be replaced anyhow. Hence, in order to minimise deployment costs for new ICT infrastructure and ITS services, the deployments should be timed to coincide with the replacement of old infrastructure.
  - in building new transport infrastructure, the additional cost of ICT infrastructure and ITS services tends to be quite moderate and form only a fractional part of the infrastructure investment, which makes it easier to justify the additional investment.
- start with locations managed by visionaries
  - some persons and/or organisations are more open towards new ideas than others, and willing to invest in new solutions, which have the potential of fulfilling their objectives as well as improve their image. In many cases, the deployment has started with piloting and small-scale deployments supported by visionary road operators/authorities, service providers, and industry partners.

ITS services involve a multitude of stakeholders usually operating in a complex value network. In order for a service to get deployed, we know now from experience that a shared responsibility will likely fail or lead to very slow deployment. Hence, there is always a necessity to have a leading stakeholder or champion for a service. The leading stakeholder can naturally vary also according to the life-cycle phase of the service in question.

Procurement strategies play a vital role. Technology-oriented procurement, which is based mainly on technical specifications and needs a lot of effort and expertise from public side is not a good choice anymore, the trend for the future will be more towards function-oriented and service-oriented procurement, which is based on functional and service demands and specifications and long-term service contracts. (ROADIDEA 2009a)

CEDR (Conference of European Directors of Road) believes that international competition and multifaceted service consortiums with modular systems would solve some of the cost problems. The exchange of best practices for procuring ITS services are sought too, also the standardisation of products and possibility to use ‘Commercial, off-the-shelf (COTS) product should be preferred. But there is clearly a need for new service oriented "packaging" of NRAs' ITS or "one-stop service", sort of "turnkey" services with open interfaces and standardised equipment with secured quality maintenance in reasonable pricing. New innovative businesses can be seen in this area. (ROADIDEA 2009a)

In table 1 a comparison is made of public sector's different business model possibilities to acquire traffic related services. (ROADIDEA 2009i)

Table 1. Comparison of business models

Business model	Public sector	Private sector
Public centred model	- easy to implement public goal - high risk of public funding - data fusion by the public	- low revenue for private - low possibility of market growth
Contract-based mutual system model	- system design by the contract with private - public's overall control of the system – wealthy amount of information provision to the public	- data fusion by private with contract - low revenue for the private
Franchise-based operation	- public's ignorance of data fusion - easy to implement for the public due to the decrease of expense	- privates data fusion - exploiting private sectors marketing and technical expertise - free delivery of used information to the public - revenue maximization
Private sector competition model	- data provision by public to many private companies	- minimization of the information fee and maximization of diverse traffic information and qualities - full competition with each private company

EC published a Communication in 2007 for the activation of Pre-commercial Procurement, which is hoped to drive innovations and boost well targeted research and development ensuring sustainable high-quality public services in Europe. (European Commission 2007)

The communication aims for the product development to be done in phases to bring down R&D costs and for better efficiency and outcomes. This should be done together with many companies based on the following principles (figure 7, European Commission 2007):

- Challenging the market in an open and transparent way and inviting a number of companies to develop in competition the best possible solutions to address the problem.
- Exploring and comparing the pros and cons of alternative solutions. This mutual learning process for public purchasers and companies helps to get a firm confirmation both about functional needs and performance requirements on the demand side, and the capabilities and limitations of new technological developments on the supply side.

- Organising the procurement as a stepwise process, including evaluations after each R&D phase, in order to select progressively the best solutions. This enables public purchasers to steer development throughout the process to best fit public sector needs.
- Efforts after each R&D phase to achieve interoperability and product interchangeability between the alternative solutions under development pave the way for open standards and avoid the risk that early adopters of innovative solutions are penalised with the additional burden of making their solution compliant with standards defined afterwards.
- Retaining at least two participating companies until the last phase to ensure a future competitive market. Maintaining a positive competitive pressure on suppliers enables public purchasers to extract the best solutions the market can offer while avoiding single supplier lock-in.

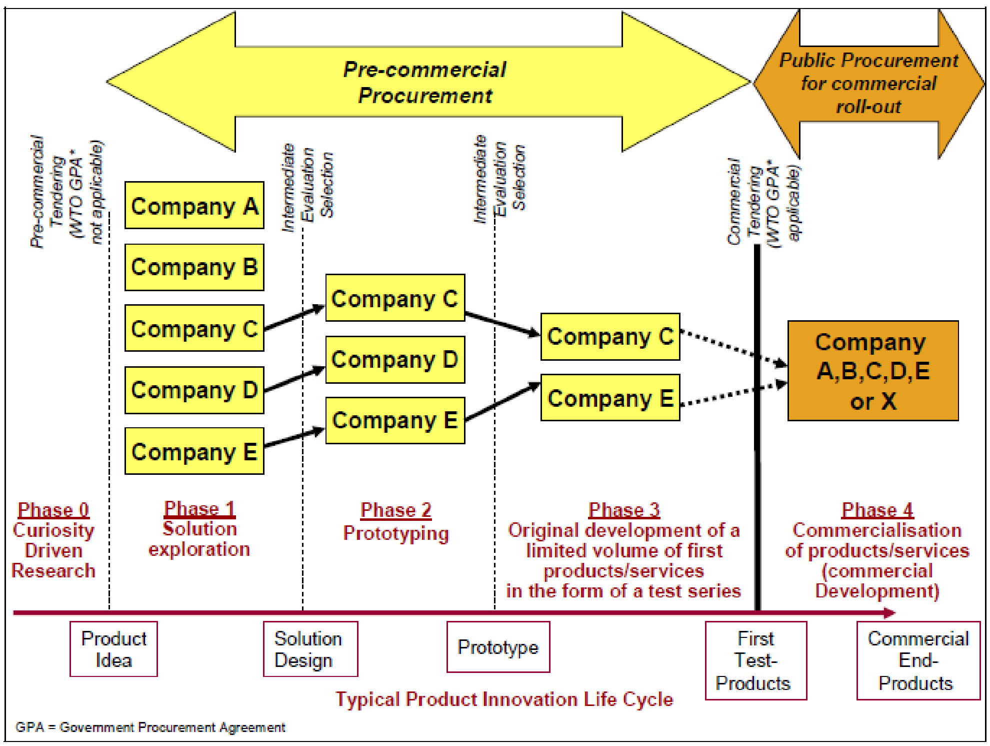


Figure 7. Example illustrating a phased pre-commercial procurement process (European Commission 2007)

A company that has been challenged in competitive development is also better prepared to address global markets and to attract external investment, such as venture capital funding, for the exploitation of further market opportunities. This is especially important for SMEs. In the short term, a competitive development process may involve a higher investment compared to procuring a limited R&D test solution from one supplier. In the long run, the quality/price ratio and the success rate of the development process are likely to be higher.

Aiming for globally accepted instead of locally tailored solutions, through standardisation and publication of R&D results, is also expected to result in lower cost of commercial end-solutions. R&D costs and risks can be further reduced through bundling of demand with other public purchasers as well as financial incentives from innovation policy agencies to public purchasers. This could comprise funding or risk sharing facilities.

Nowadays, enterprises cooperate more extensively with other enterprises during the entire product life cycle. Temporary alliances between various enterprises emerge such as those in Virtual Enterprises. However, many enterprises experience difficulties in the formation and operation of their mutual processes, for instance concerning integration issues. There is a clear need for cooperation frameworks and guidelines and business integration studies. Both the public sector and the private sector have been challenged to develop services and business in new ways and the future will tell how we succeed in this process.

4.5 Lessons learnt from ROADIDEA pilots, from pilot provider viewpoint

The service value can be estimated from three main perspectives: individual, commercial and societal. From the individual perspective saving time, increasing safety and enjoying more convenient journey can be those attributes. From the societal perspective the attributes fall into socio-economical feasibility. (ROADIDEA 2009b)

Financing models, which could be applied to the actual pilot, in this case Pulp Friction, can be divided into two main categories from a service provider point of view:

(1) Customer / user pays for the service. This usually is implemented in a revenue share model, when there are two or more parties involved in developing the service. This means that when a customer pays the service fee the revenues are divided between the providers or enablers with a mutual contract. A mobile operator or a mobile device manufacturer can, or automatically is, a revenue share party because of their business logic. This model does not exclude 3rd party funding, e.g. from commercial stakeholder or from public sector.

For example in Pulp Friction case revenues share parties could be Destia and Logica if assumed that the Finnish Meteorological Institute is involved in a public sector role.

(2) Service is free of charge but some stakeholder, a commercial sponsor or a public sector body pays the investment and fixed up-keeping costs at least partly. This case represents either (a) a marketing, positive image rationale or (b) societal, socio-economic value -rationale to finance the service. In both cases a stakeholder recognises that by financing the service the returned investment creates added value. (ROADIDEA 2009b)

Main challenges can be recognized in three main categories: data quality, pricing/ willingness to pay and mobile handsets application version control. Data quality is a problem in a case like pulp friction where the source data provider actively develops the data and modelling. In a case where the data is acquired from a public source without contractual commitments (e.g. SLA=service level agreement) no further guarantees for the data can be given by the service provider. Mobile handset version control is always a challenge when the service is an application and not web service. In the Pulp Friction case, the pilot application is created to S60 version 3rd platform and every time a new OS version comes out it must be versioned and technically tested. This requires resources and investments in product management. Price adjustment was also a challenge. When offering a service for free for a certain time of period, the service provider easily loses the option to add a price tag for that particular service or application in the future. Customer behaviour and rationale for use is also a challenge, especially with services which are a part of your everyday life, even adding safety, but not necessarily outreaching individual motives for use or willingness to pay. (ROADIDEA 2009b)

Different combinations or mixed models seem to be needed. In some cases it is seen reasonable to use also public funding for the services, which have a high societal impact. The mixed models may combine end user payments, advertising, sponsors and public funding. One alternative to be reckoned is to combine the transport information services with other types of information or "real" services, for example with social media or transport or tourist services. (ROADIDEA 2009b)

5. Conclusions and recommendations

It is very clear that Information and Communication Technologies (ICT) or rather intelligence and innovation are cutting across the major sectors of society and industry reforming them in many respects and opening up completely new opportunities for utilisation of modern technology as well as novel services and business innovations. This is also affecting the traditional ideas of transport, possibly changing the whole systems thinking e.g. transport system operation, electrical cars, automation and new urban forms. The challenge of deployment is not anymore as simple as how to utilise the emerging technology in producing new transport services and products but also on the system level. This in turn may well revolutionise the role of the public sector from being partly a purchaser of products and services and partly a service provider to being a purchaser of transport system performance and policy impacts.

The scope and role of private sector stakeholders will enlarge and create very large markets for ITS services and solutions, while completely changing the service provision industry.

5.1 General recommendations for actions

In ROADIDEA, we have identified several real deployment barriers as well as needs for actions and made several recommendations that are mostly in line with the major recent initiatives (ROADIDEA 2010a).

There are number of reasons why the development and deployment of ITS services has been slow e.g.:

- inadequate prerequisites for services
  - poor access to data in affordable manner
  - inferior quality of data
  - availability of useful data
- inadequate business models and cases

- fragmented policies of governments with regard to priorities prevent combined efforts resulting in fragmented European market, where the end users' willingness to pay does not match the prices demanded
- benefits of services have not been shown in tangible manner
- privacy issues
- difficulties related to commercial interests of stakeholders
- liability issues
- lack of interoperable interfaces e.g. between nomadic/aftermarket devices and vehicles; between vehicles and infrastructure (such as traffic signals); etc.

We recommend the following general actions to be taken:

- Agree on European rules for access to public data in affordable manner ROADIDEA 215455 74/81.
- Specify quality level recommendations aiming towards optimal data quality, optimising the benefit to cost ratio by e.g. utilising the approach piloted by the QUANTIS project.
- Explore and demonstrate new business models in targeted research activities funded by the EC and national governments
- e.g. likely the large scale spreading of fast mobile internet 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 and security issues in the beginning of the development circle.
- Mandate interoperable interfaces in Europe, and preferably globally at least including USA, Canada, Japan, China and India.

5.2 Improve the innovation process

Innovation work as idea creation is necessary for finding new, unforeseen ideas that are imperative in the complex multidisciplinary R&D of ITS. Methods used in ROADIDEA proved to be well applicable to this work, since they allowed for continuous readjusting and redrafting of work during the project. Where innovative people meet there guidance for work needs to be adjusted according to the process flow (thus creating an iterative hyper-cycle). Successful innovation calls for multiple expertise to be persuaded in open and honest interaction, and assumes mutual interests to drive the group dynamics. Without creative but guided innovation work the ever-existing time constraints in collaborative R&D work would hinder success altogether, and new ideas would not even get a chance to come up.

In general, the combined Charrette and Futures Workshop methodology (details: ROADIDEA D5.1 2008) can successfully provide innovations for products and services as well as for organisation models for multi-stakeholder processes. This type of complex phenomenon needs methods that enable various experts on the fields concerned to interact and bring forward their tacit knowledge for common interest. (details: Keskinen & Aaltonen & Mitleton-Kelly 2003).

In particular, since ITS is a complex system it is necessary to use multidisciplinary methods for innovating futures ITS products and services and collaboration methods. The complexity of ITS is ever increasing in the wake of demands on more eco-efficient codes of conduct in transport stemming from global, and hence, European concerns on climate change.

The innovation process for ITS should be continued on a regular basis. However, the future innovation must still be more problem and goal-oriented and based on systematic observation of the trends, barriers, threats and drivers in the ITS development. This should assure that the state-of-the-art, the state-of-research and identified existing and upcoming problems are the triggers for innovation activities and solutions to burning problems.

We recommend the following actions to be taken:

- Use ROADIDEA innovation methodology for ITS and other complex services.
- Establish an ITS Innovation Taskforce within the European Commission. This would have the following tasks: 1) to watch and assess the development trends of road transport and ICT and 2) organise regular innovation seminars with distinguished ITS experts and other related topics to generate innovations for future ITS development and outlooks for Commission services' disposal.
- Utilise and contribute the work of the global futures think-tank Millennium Project as Project Node (details: www.millennium-project.org).

5.3 Fasten the slow development and deployment process

EU together with Member States and the active ITS organisations have been able via their various policies, research activities and citizen requirements to recognise the importance of transport system development and utilisation of intelligent transport systems (ITS) in their activities towards more a sustainable future. It has also became evident that the strategic policy objectives aiming at keeping Europe at the main edge of this development calls for a system concept accelerating innovation production, market creation, services production, citizen acceptance and political commitment. This same need for a new direction has not been identified only in Europe but also in the U.S. and other countries wishing to maintain a major impact on innovation based global markets.

Without a comprehensive concept and policy the deployment of ITS will be slow. This has been shown in Europe e.g. in the identification and implementation of Europe-wide systems having a remarkable and proven effect on the main transport policy objectives (e.g. eCall). Many major initiatives by the European Commission and industry have been launched but no radical changes in the uptake and markets of ITS have been seen before coordinating the efforts with MoU's and stronger tools. This same observation is seen in many Member States with missing political commitment and real trust in the private sector and companies. Organisations seem to be more waiting for opportunities to be brought out than to create opportunities by their own efforts. The recent major initiatives can also be viewed against the business strategy philosophies and the future - we cannot predict the future but we have to try to make it.

The recent developments aiming towards European ITS deployment and uptake are very welcome. The major players have to play together but they have also to adapt their own playing according also to the other relevant players e.g. discussing very clearly, openly and practically the goals and milestones with real commitment to be able to create real trust among the major players. In Europe these instruments seem to be the ITS Action Plan, ITS directive, and e.g. the ELSA initiative. Hopefully, the adopted European mechanism of cooperation with the Member States is based on the fact that fostering deployment is almost totally dependent on national commitment and activities although a common European policy and collaboration are of major importance.

EU Commission has defined the general problems of ITS deployment as:

- high number of mature applications available because of fast technical development are not, however, in effective use
- fragmented and uncoordinated deployment
- little continuity of services
- low degree of intermodality

producing a patchwork of national, regional and local solutions (Ferreira 2010).

The identified need for redirections of a common ITS strategy and policy is promising with regard to ITS deployment. We have proposed many main necessary actions that are summarised in ROADIDEA conclusions e.g. in the Road Map (ROADIDEA 2010c). Data and data quality have been some of the action areas needing urgent improvements. The ITS Action Plan and Directive have stressed the idea of defining free safety related information for all travellers opening the gates effectively for service development and focusing e.g. on: greater cooperation as PPP, fair and transparent access to public sector information, increased data quality, multimodal cooperation, and cross-border exchange

The ROADIDEA summary of necessary actions include of course improvements of business models, but it is still very clear that the function and effects of ITS measures have to be summarised, and made available for political and other decision makers and citizens in a tangible manner. This is because no deep understanding of ITS and its potential has been achieved so far and the deployment task with awareness building should be a continuous effort. In ROADIDEA we have also confronted the problems of privacy and security issues. One cannot stress their importance too much because we continuously face, also in media, the debate about privacy and security and this makes a barrier to many modern technology utilisations introducing delays and other problems on services development.

It is also a fact both on EU and on national level that cooperation with public and private sector has to be fostered. Public sector needs, offers, supports and masters usually traffic services or some of the key elements in the service chain. Therefore, the public sector is a key stakeholder but it can not develop nor deploy ITS alone, nor without understanding the meaning of innovation in the networked world.

The key players in the public sector are the national, regional and local road authorities, which together with toll-road operators continue to equip their roads with Intelligent Transport Services related ICT and service infrastructures including both roadside and back office software and hardware. The road authorities and operators have to deal with ITS having a totally different lifecycle than traditional road infrastructure, as well as cost structure, where the operation and maintenance of ITS may be relatively much more expensive than for traditional infrastructure investments. Procurement strategies play a vital role, and new procurement practices are likely to emerge to account for the specific properties of ITS deployment as well as to fully utilise the innovation potential of the private sector. The procurement strategies and practices must be renewed in all fields of the public sector as this renewal concerns also general national and European legislation on procurement.

When reflecting the experiences gained in ROADIDEA project we support the directions based on e.g. ITS Action Plan, Directive and ELSA Task-Force report and recommend the following actions:

- Pay a lot more attention on data availability and quality as well as and optimal use of data in service development.
- Fasten the European deployment processes to be able to introduce effective Pan-European, standardised services as eCall.
- Strengthen European and national ITS coordination in service development and deployment.
- Introduce effective tools to support PPP cooperation and pro-innovation procurement in ITS service network and viable business model development, including the planning of changes required in procurement legislation.

5.4 Improve availability of data and deployment of necessary models

Barriers of data remain also very relevant. The ROADIDEA analysis revealed that access to necessary data is the key barrier of new service innovations. In the analysis of mobile business related pilots, the main challenges recognised were in three main categories: data quality, pricing/ willingness to pay and mobile handsets application version control. Data quality is a problem in a case like the Pulp Friction pilot, where the source data provider actively develops the data and modelling. In a case where the data is acquired from a public source without contractual commitments (such as e.g. SLA=service level agreement) no further guarantees for the data can be given by the service provider. Nomadic device or more generally hardware version control is always a challenge when the service is an application and not web service.

The ROADIDEA project has shown that models for traffic and weather can be used for increasing the information about present and forecasted weather related driving conditions. By using road weather data as well as traffic data - models have been developed to increase the possibility for valuable information to maintenance people as well as the drivers. ROADIDEA has developed models for:

- Data filtering
- Traffic flow
- Weather/traffic flow
- Road conditions – pulp friction: presented as pilot and a close to the market product
- Fog – combining satellite data and ground observations: presented as pilot and a close to the market product.

There are several ways which could be used for deployment and increased use of these models. One of the most important issues is to establish a data set of relevant data which can be used to force the models and also for research and further development of the data. The availability of data is also identified as a serious bottle neck for future deployment and implementation in EU. It is recommended to start a European initiative to establish a European-wide Transport Data Portal, using the Clarus initiative and data system by the US Federal Highway Administration as a benchmark. Details of these initiatives are available in the ROADIDEA D1.9 Road Map and the ROADIDEA-INCO Final Report (ROADIDEA 2010c and ROADIDEA-INCO 2010).

The ROADIDEA results are published as open reports on the ROADIDEA web-site so the results are available for further research and/or implementation.

The second important issue concerning the deployment is to identify relevant distribution channels for the services. If the services are provided as stand-alone applications or even as web services, reachability of the end-users is quite limited. However, there exist several services that the potential end-users already use actively:

- Car navigation services and devices, end-users consist of the drivers
- On board units and information devices, end-users consist of the road maintenance crew or other professional drivers
- Weather information services, end-users consist of the drivers and professionals such as climatologists.

We recommend the following actions to be taken:

- Establish a body in EU or mandate some other relevant organisation which will have as its mission to handle the European road weather and traffic data issue by starting an initiative for the creation of a European-wide Transport Data Portal.
- The Data Portal should contain in its first phase the minimum data necessary for the safety of European transport, i.e. information on road weather conditions, accidents and other disturbances in the transport system. The US Clarus system should be used as a model for the platform architecture.
- Other goals of this body should be to create a common European data standard and also to facilitate running or developing models for all companies, organizations, persons etc. requiring such data.

5.5 Develop viable business models

There is an aspiration for new business models of transport information services which are not as dependent of public funding as many traditional services. Different funding sources, like advertising, sponsoring, different types of end user payments, like monthly fees, pay-per-use or micro-payments from service applications and public-private partnership have been tested. However, there is so far not sufficiently sound experience of the sustainability of the new models along time.

A review of European transport information services (ROADIDEA D7.1) showed that many current services have not only one financing mode but several sources of financing. Their business models can be categorized according to the necessity and value / impact level (society / transport business/ private users). Services necessary for the society, the so called "must-have" services (e.g. affecting safety or environment) are financed mainly by public funding, even if part of the income may come e.g. from advertising . "Nice-to-have" services (affecting e.g. traveller convenience or timing) typically require private funding from service end users or different types of sponsors, like associations, local authorities, insurance companies or advertisers. For this type also public-private partnership solutions have been developed, to share the investment and risks. Some of the services were considered to belong to the group of "must-be-profitable" services with low societal impact but interesting for the users or important for the sponsors. For these, private funding is expected.

All the ROADIDEA pilots made an analysis of their value and benefit, potential users, and other stakeholders and identified several types of potential financing models, from user payments (monthly or pay per use, including micro-payments), advertising, sponsors (like insurance companies or associations) to public funding. No pilot envisaged to survive with only one source of financing; instead a mix of different funding types were proposed. Additionally, some of the pilots were expected to be more competitive not as such but integrated with other services. For example, pulp friction is expected to become part of Media Mobile Nordic's (previously Destia) "Premium" transport information services.

We recommend the following actions to be taken:

- Create *a multi-service environment, service portfolios or service networks* by linking together different transport information services or incorporating the transport information services with other "real-world" services or social media. The multi-service environment with both mandatory, regulated and optional services or services from a different field improve the visibility of the services and thus increase the awareness of potential users of all the services available. The mandatory services increase the number of users in the environment and thus also bring more potential users for the optional or value-added services. On the other hand, the multi-service environment requires development of practices for creating, operating and managing service networks of different actors, including data & information providers, communication providers, service brokers etc.
- Development towards a Pan-European service system requires that the services are available also when crossing the borders. From the user point, it is recommendable that *the business model for the user remains the same as much*

as possible; in minimum the user is made aware how the invoicing changes when crossing the borders.

- When developing new services, *focus on users as early as possible*. Take into account the user interests and behaviour, concerns for privacy and security, user capabilities and readiness, including the need for different languages. Understand the real added value for users. The users could be involved in the development (co-creation) using different methods, like key users, social media campaigns etc.
- *Monitor the successes, failures, trends and challenges of new business models in* European transport information services. Link this activity with the ITS innovation taskforce, European Innovation Platform(s) or other collaboration forums to share information and learn from experience.

5.6 Enhance use of standardised technology

The inevitable change from the centrally controlled top-down Traffic and Mobility Management ecosystem into the heterogeneous and fragmented autonomous Mobility ecosystem is going on right now and this process will continue in an even faster pace. In the future, the mobility services are on-line and available to the users everywhere in their daily life. People are aware of any incidents and other disturbances on their planned journeys before and during their trips, and they are able to make informed decisions concerning their journeys and use of time.

Technology development is the foundation of the modern service production. The utilisation of new innovations in this field is a continuous process, which also suffers from a chicken and egg type of a problem concerning when is the time to implement ideas, and when the technology is mature enough? When committing into large systems, the owners have to make long term investments and start to live with operating and maintaining the implemented systems. If no standardised solutions are available there is a great business risk both for the buyer and the provider.

The hot topics now deal with the open platforms (in pockets, at homes and offices, in vehicles) and the new Internet behind all different applications (which are sensing, controlling, guiding, aiding and entertaining) merged and working together. Information and communication technology is becoming smarter, smaller and faster and at the same time, society is progressively becoming more closely connected. Internet and cloud computing supported services are entering a new phase of mass deployment. This is a challenge especially for public authorities to identify their optimal role in this fast development of a multitude of mobility aiding services and open platforms.

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 (Britschgi et al. 2009): (1) Islands of technology, (2) Data pool model, (3) Vertical integration and (4) Decentralised networked world. Today, it is not possible to define which of these developments will be in main line or is it a mixture of several as usual for these kinds of major trends, but in a fast developing technology environment, also completely new directions may evolve.

ROADIDEA has worked on pilot applications which were mainly located at the proof-of-concept level in geographically limited regions and with limited user sets. However, for example the road weather related pilots (pulp friction, for warning, rainfall warning) have also the potential for up-scaling and dissemination on the European level. The applications as such are quite new, and there is the potential for the pilot owners to set a standard on European level in the respective field. Of course, the applications were developed primarily to fulfil the user needs of the pilot owners in ROADIDEA, but as soon as the application has to be geographically up-scaled/ disseminated away from the technology islands (e.g. to European level) there will be a need for agreements and – finally - standards in the respective fields.

ROADIDEA studied the international standardisation activities in the field of ITS mainly in order to obtain an overview of the different initiatives and to identify the further needs for standardisation. This included also interviews with CEN/ISO standardisation experts. The intention was to provide the background for service concept development in ROADIDEA. Some of the major conclusions on necessary standardisation work and the challenges for standardisation in the field of ITS are listed hereafter:

- Standards need to be created to enable ITS services to be delivered everywhere, all of the time. A good example for a standard which supports this idea is the CALM standard which specifies the communication for the future co-operative systems. Co-operative systems will have to be supported in every country, by all vehicles, infrastructure components and communication systems. This and other standards needs completed as soon as possible. This will allow for a situation where the service level is the same, independently for the geographical coverage. The same is true for disseminating ROADIDEA pilots.
- The creation of standards must not prevent innovation. However, once something has been innovated and developed, there may be a need for new standards to support its use. This can be difficult because often the results of innovation are clouded with IPR issues, which make creating true national or international standards difficult. To counter this, more work needs to be done to educate the senior people within ITS related organisations that the introduction of standards should be seen as a benefit and not a threat.
- There must be more co-operation between the Standards Development Organisations (SDO's, e.g. CEN, ETSI, CENELEC, ISO, SAE, IEEE) so that there is no duplication of coverage between the standards each of them produce.
- Most ITS standards need to be intended for international use and should not be developed with national or even regions in mind, unless there are very compelling reasons for creating national, or regional standards. The reason for making standards international is to try and ensure commonality in the use of components across the world, which will drive down their cost. A good example of this is the co-operation between CEN and ISO on ITS standards, which means that regardless of whether the development of a particular standard is led by CEN or ISO, it applies to both Europe and the rest of the world. This type of co-operation needs to be extended to other bodies such as SAE and IEEE to ensure that all of their ITS related standards are truly international.
- More needs to be done to ensure that standards are used and that conformance to them is a necessary pre-requisite of a tender for product and/or service supply being successful. At the moment the use of standards for ITS is mostly voluntary, but if we are going to maximise the benefits they can provide then their use has

to become required, even if this means legislation at national and/or regional level.

- Standards need to be brought into the HMI domain, even if it is only to standardise the symbols that are used to access ITS services. But the switch by a user from using a device from one manufacturer to using a device provided by a competitor should be an easy task. This will be particularly important for ITS services that are to be available from vehicles and/or mobile devices, where there are many active competing suppliers.

We recommend the following actions to be taken:

- *Develop an optimal deployment path for the service in question.* In practise, this means management of transition from a proof-of-concept or a prototype service to a service with sustainable funding model contributing to the goals set for the specific service. For example, starting the deployment with a business-to-business service may be an option worth considering when launching a service directly to consumer market looks too ambitious goal or is otherwise not practicable. It is also recommended that the deployment of a new service is started in geographically limited regions such as urban areas, other regions or transport corridors with significant traffic problems and large enough number of potential users to demonstrate its potential in tangible terms.
- When the idea and pilot development has left the proof-of-concept phase, the system developers should seriously take into account adopting standards wherever possible but also necessary in up-scaling and disseminating the product. Therefore, the relevant technical standards should be identified and studied at an early stage.
- Having in mind the ongoing standardisation activities, the system developers should be open for identifying the needs for standardisation. These could be fed in the work of standardisation bodies.
- There is a clear need for establishment of an ITS Innovation Taskforce. This taskforce should: a) have strong background on the ITS standardisation on European and international level in order to be able to combine innovations and existing standards as well as to identify and trigger new standardisation activities, b) have a good overview of the work in the different Standard Development Organisations relevant for ITS and c) provide guidance for innovators on which standards to consider in order to enable international applications which can be available everywhere at all times.
- The use of a common system architecture should be considered for each ITS application. If the application is only used on national or local level, the national architecture of the specific country might be the choice. If the application has the potential for European level deployment, the EITSFA (European Intelligent Transport Systems Framework Architecture) is the architecture, which should probably be chosen. Service-oriented architectures usually suffice, when the harmonisation of interfaces between different service parts and functions is sufficient for interoperability.

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Appendix 1.TEMPO 2007

The main targets of impacts and related indicators for different ITS functions (Tarry et al. 2007)

		TARGET OF IMPACTS						MAIN INDICATORS						
No.	ITS function	Transport demand	Travel timing	Mode choice	Route choice	Vehicle, traffic behaviour	Transport system man/dev	Network and its costs	Fleet and its costs	Accessibility	Time and its predictability	Traffic safety	Noise, emissions, energy	Valuations, comfort
1.	**INFORMATION SERVICES (INF)**													
INF1	Information on alternative transport modes													
INF2	Information on traffic fluency, incidents and road works													
INF3	Information on weather and road surface condition													
INF4	Information on routes and (travel) services													
INF5	Information on presently available parking places													
INF6	Information services for public transport users													
2.	**DEMAND MANAGEMENT (DEM)**													
DEM1	Park-and-ride system operation													
DEM2	Demand responsive public transport													
DEM3	Combining trips													
DEM4	Car pooling													
DEM5	Introducing general road tolls													
DEM6	Introducing congestion pricing or area tolls													
DEM7	Access control													
DEM8	Public transport payment system													
DEM9	Integrated payment system (several services)													

3.	**TRAFFIC CONTROL (C)**													
C1	Junction and link control using traffic signals													
C2	Network control using traffic signals													
C3	Traffic signal priority functions													
C4	Local warnings with variable message signs (VMS)													
C5	Condition controlled variable speed limit													
C6	Direction to alternative routes													
C7	Control of lane use													
4.	**FLEET & TRANSPORT MANAGEMENT (F)**													
F1	Public transport fleet management													
F2	Goods transport fleet management													
F3	Hazardous goods transport management													
F4	Freight management													
F5	Maintenance fleet and operations management													
5.	**INCIDENT MANAGEMENT (INC)**													
INC1	Private transport incident detection													
INC2	Private transport incident management													
INC3	Public transport incident detection													
INC4	Public transport incident management													
6.	**DRIVER SUPPORT FUNCTIONS (DRI)**													
DRI1	Autonomous cruise control													
DRI2	Intelligent Speed Adaptation													
DRI3	Instructions on safe following distance													
DRI4	Automatic maintaining of safe following distance													
DRI5	Collision avoidance (incl. Vulnerable road users and animals)													
DRI6	Lane keeping support													
DRI7	Vision enhancement													
DRI8	Driver condition monitoring													
DRI9	Navigation and route guidance													
DRI10	Emergency services													

7.	ENFORCEMENT SYSTEMS (E)													
E1	Automatic speed enforcement													
E2	Automatic enforcement of signal compliance (red light running)													
E3	Monitoring of hazardous goods transportation													
E4	Load weight enforcement (WIM)													
E5	Automatic lane use enforcement													

Note: For monitoring, information management and traffic management/information centre operator support systems, the impacts will depend on the user services utilising these systems.

Appendix 2. EU Commission 2007

Effects of different ITS applications on EU policy objectives.

EU Policy Objectives →	Transport Efficiency							Safety and Security				Environment and Climate Change		Economy				Accessibility	Internalisation of External Costs
Sub-Objectives → / ITS Applications ↓	Congestion Reduction	Inter-urban corridors	Urban mobility	Sensitive areas	Freight transport (incl. cross-border formalities)	Collective transport	Intermodality	Road safety	Hazardous goods	Freight transport security	Public transport security	Environmental impact	Energy efficiency	Internal Market	Peripheral states	Auto industry	Telecoms & ITS industry		
Network operations																			
Cross-border traffic control centre inter-connections	•••	•••	•	•••	••	•	•	•	••	•	•	•		••	•		•		
Near-term traffic predictions and weather forecasts	•••	•••	•••	•••	••	•	•	•••	•			••		•	•			••	
Wide area seamless traffic management (incl. cross-border)	•••	•••	••	•••	••	••	•	•	••			••	••	•	••		•		
Event and emergency planning and incident response	•••	•••	•••	•••	•••	••		•••	•••	•••	•••	•••	•	•	•			••	
Fast alert system (black spots)	•••	•••	••	•••	•••	•••	•	•••	•••	•	•	•••		•	•			•	
Real-time traffic & event databases	•••	•••	•••	•••	•••	•••	••		••	•	•	••	•	••				••	
Travel demand management	•••	•••	•••	•••	•	••	•••					•••	••	••	•		•	••	
Network performance measures & data archive	•••	•••	•••	•	•••	•••	•••					•••	•	••	••		•		
Public transport priority (on *intersections)*	••	•	•••	••		•••	••	•			•	••	••				•	••	
Traffic & Travel Information																			
(Dynamic) Navigation & digital maps	•••	•••	•••	•••	•••	••	••	•	•••	••		••	••	••	•••	•••	•••	•••	
Real-time road traffic information (pre-trip / on-trip)	•••	•••	••	••	•••	•	•	•	•	••		•	••	•	•		••	•	
Parking information	••	•	•••		••							•	•			•			
Real-time public transport information (pre-trip, on-trip)	••	•••	•••	•••		•••	••	•			•	••	•					•••	
Multi-modal journey planning	•••	•••	•••	••	•	•••	•••	•				••	•		•			•••	
Electronic Payment																			
Electronic Fee Collection																			
‣ Electronic toll payment	•	•••		•	••	•						•	•	•			•		
‣ Lorry tolling & charging	•••	•••		•••	•••		•		•	•		•••	••	••					•••
‣ Congestion charging	•••		••	••	••	•••	•••	•				•••	•••					•••	•••
‣ Value pricing (for priority)	•••	•	•			•	•					•	•						••
Public transport payment and ticketing			•••			•••	•••					•					••		
Parking ~~payment~~ *Management*	••	•	•••	••			••	••				••	••			••	••	•	••
Public transport operations																			
Vehicle location, timetables and reliability	••		•••			•••	•••				•••		•				•	•	
Demand responsive public transport			•			•••	••	•				•	••		••		•	•••	
eCommerce B2B / B2C																			
Mobile communication & location-based added-value services		••	••	•	•••	•	•			•	•	•	•	•		•••	•••	••	
Commercial vehicle operations (freight)																			
Intelligent logistics , timetables and reliability	••	••	•••		•••	•••	•••		•••	•••	••	•	••	•••	•••		•		
Electronic manifest & customs clearance							•••			•				•••	••				
Lorry routes & truck navigation	••	•••	•	•••	•••		•••	•	•••	••		•••	••	••	•				
Truck stop, loading bay & truck parking real-time information	•••		•	•••	•••		•••		•••	•		•••	•••	••					
Sensitive goods cargo tracking and management		•••		•••	•••		•	•	•••	•••		•••		•	•				
Hazardous materials security and incident response		•••		••	•••			•••	•••	•••		•••							
On-board safety and security monitoring					•••					•••									
Advanced Safety Systems																			
Emergency call systems	•							•••	•••		•••					•••	•••	•••	
In-vehicle HMI *(impact on driver)*	•							•••								•••		•••	
Speed warning	•	•	•••	••				•••					•			•••		•••	
Longitudinal collision avoidance								•••								•••			
Lateral collision avoidance								•••								•••			
Vision enhancement								•••								•••		•••	
Pre-crash restraint systems								•••								•••			
Co-operative vehicle-to–vehicle (v2v) systems	•••	•••			•••			•••								•••	•••		
Co-operative vehicle-to–infrastructure (v2i) systems	•••	•••			••	•••		•••								•••	•••		
Crash avoidance at intersections	•••							•••								•••	•••	•••	
Electronic Stability Control	•							•••					•			••			
Lane keeping/warning systems	•	•						••								••	•		
Tyre pressure monitoring	•							••				••	••			••	•		
Emergency management																			
Emergency notification and personal security	•	•	•		•••	••		•	••	•••	•••								
Emergency services vehicle management	•	••	•	•		•		•••										•	
Disaster response and evacuation		••	••															•	
Enforcement systems																			
Emissions testing & control		••	••	••	•							•••	•••	••				•••	
Speed enforcement	••	••	••	•	••	•		•••				••	••					••	
Non-payment of fees and charges			•••											••			•		
Unlicensed vehicles / drivers					•			•••						••					
Over-loading enforcement					••			•	•			••		••					
Drivers' hours enforcement					•••			•••						••					
Road worthiness enforcement	•							••				••	••			••			

Legend: • slight impact •• considerable impact ••• very important impact