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Overview of Intelligent Transport Systems (ITS) developments in and across transport modes

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Editors Note

This document was prepared by experts of the Hellenic Institute of Transport for the Joint Research Centre in 2011 for a two-fold purpose:

A) As a main input for the preparation of the **Scientific Assessment of transport technologies**, which was a part of a new Commission initiative, the **Strategic Transport Technologies Plan (STTP)**[1]. The STTP was designed as a follow-up of the Transport White Paper (TWP)[2]. The TWP set out to remove major barriers and bottlenecks in key areas across the fields of: transport infrastructure and investment, innovation and the internal market. The aim is to create a Single European Transport Area with more competition and a fully integrated transport network which links the different modes and allows for a profound shift in transport patterns for passengers and freight. To this purpose, the Transport WP puts forward 40 concrete initiatives for the next decade, including technological as well as non-technological measures. The Strategic Transport Technology Plan (STTP), addressing the technology pillar of the White Paper, is hence designed to contribute to these objectives in the mid-term, through stimulating research and innovation in some strategic technological areas in the field of transport. The use of Intelligent Transport Systems within modes and across modes has been identified early on as of the main issues within the STTP.

B) As a coherent description of the actual state of play in the field, in order to assist the JRC in identifying its potential role in the development, standardisation and deployment of ITS in Europe. For the JRC, it was important to identify potential areas in which the other Directorate Generals (INFSO, MOVE, etc) were in need of technical and scientific support.

This report, attempts to give a concise, yet complete overview of the ITS developments in the field of transport (and across all modes) during the last years, with emphasis on the European situation. Some hints on international developments are also given where appropriate. It should be noted, that this report focuses primarily on the technological developments and does not attempt to shed light in the complex issue of economics and competitiveness in this field. We hope that this can serve as a quick reference for anyone wishing to understand the general picture in this field within a few pages.

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[1] For updates on the STTP: http://ec.europa.eu/transport/research/sttp/sttp_en.htm

[2] "White Paper. Roadmap to a Single European Transport Area – Towards a competitive and resource efficient transport system", COM(2011)144 final of 28 March 2011. Available at http://ec.europa.eu/transport/strategies/2011_white_paper_en.html

Introduction

The term "*Intelligent Transport Systems*" or "*ITS*" is used to define the use of *Information and Communication Technologies* (or *ICT*) in the field of transport, to create real time flow of information and data in order to enable more "intelligent" use of infrastructures and vehicles and to enhance the management of traffic and mobility. The vision for ITS, as stated by ERTICO[3], is one of **"*intelligent mobility towards fully informed people, zero accidents, zero delays, with reduced impact on the environment, where services are affordable and seamless, with privacy respected and security provided*"**.

ITS is being identified as a domain of high potential to tackle the many challenges facing the Transport sector both within each of the modes and (most importantly) in creating interfaces and integration across the modes. In fact, besides infrastructure, the ITS is considered as the single most important "factor" that can be used to effect cooperation among the various modes of transport and create a seamless transportation system across Europe. Today, there is also an important and numerous stakeholder community[4] which is either providing or utilising ITS applications and services and the sector provides for a substantial contribution to economic and social development.

Deployment of ITS systems and services has so far been largely "unimodal" in scope and extent leaving the wider "cross modal" application of current systems behind, and further development to be sought for in the future. Also, the development and application of unimodal ITS applications, is seen by many as still incomplete and not widespread enough to cover in a comprehensive way the totality of potential applications and market uptake. Achieving "critical mass" for self sufficiency and sustainability of integrated ITS applications is currently still a goal to be achieved in many cases.

Efforts to enhance the proliferation of ITS at National and EU level have been intensified in the last decade or so through both legislative and technical development measures. The earliest "institutional" efforts to promote ITS in Europe came in the early 90's[5]. Since then, gradually and steadily, ITS systems and applications are continuously being developed and implemented in Europe and throughout the developed world. In 2008 the Commission issued a Communication on an **"*Action Plan for the Deployment of Intelligent Transport Systems in Europe*"**[6] . It has called for an assessment of the policy priorities, the choice of generic ITS components to be shared or re-used, and agreement on a clear timetable for implementation under the following 6 "Action areas":

- Optimal use of road, traffic and travel data;
- Continuity of traffic and freight management ITS services on European transport corridors and in conurbations;
- Road safety and security;

[3] http://www.ertico.com/about-ertico-weare/

[4] Suffice to mention here, as the most pronounced proponents of this "ITS stakeholder community", the three ITS promoting "umbrella" Organizations: ERTICO or ITS-Europe, ITS-America, and ITS-Japan.

[5] Council Resolutions: 94/C 309/01, of 24 October 1994, on telematics in the transport sector, the Commission communication, and of 4 November 1994, on telematics in the transport sector and Council resolution 95/C 264/01, and of 28 September 1995, on the deployment of telematics in the road transport sector.

[6] Commission Communication, of 16 December 2008, "Action Plan for the Deployment of Intelligent Transport Systems in Europe".

- Integration of the vehicle into the transport infrastructure;
- Data security and protection, and liability issues;
- European ITS cooperation and coordination.

In 2010, the *Directive* 2010/40/EU of the European Parliament and of the Council[7], issued on 7 July 2010, provided the necessary framework for the development and use of specifications and standards necessary to provide for interoperability, compatibility and continuity for the deployment and operational use of ITS.

In the 2010 Directive the following *priority areas* are delineated for the development and use of specifications and standards to provide interoperability, compatibility and continuity for the deployment and operational use of ITS:

- Optimal use of road, traffic and travel data,
- Continuity of traffic and freight management ITS services,
- Road safety and security applications,
- Linking the vehicle with the transport infrastructure.

Within these priority areas a number of *priority actions* for the development and use of ITS specifications and standards, are set as follows:

- Provision of EU-wide multimodal travel information services;
- Provision of EU-wide real-time traffic information services;
- Data and procedures for the provision, where possible, of road safety related minimum universal traffic information free of charge to users;
- Harmonised provision for an interoperable EU-wide e-Call;
- Provision of information services for safe and secure parking places for trucks and commercial vehicles;

Through its legislative actions, and especially the ITS Directive, the EU is aiming at bringing a European wide coverage of interoperable ITS services[8] giving priority in defining and developing:

- Common European ITS specifications (functional, technical, organizational, service provision) based on interoperability and open, public standards,
- EU-wide multimodal travel information services,
- EU-wide real-time traffic information services,
- Road safety related services such as the harmonised, interoperable EU-wide e-Call, information services for safe and secure freight transport operation, etc.

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[7] See http://ec.europa.eu/transport/its/road/action_plan_en.htm

[8] DG MOVE Workshop on Traffic and Travel Information – 21 June 2010

For the purposes of this report the various ITS systems, of relevance to both uni- or multi- modal transport operation, are considered under one – or more - of the following *8 areas of ITS application*:

- *Traffic and Travel Information*
- *Traffic and Public Transport Management*
- *Navigation services*
- *Smart ticketing and fee collection*
- *Transport safety and security*
- *Freight Transport and Logistics* (including *Urban Logistics*)
- *Intelligent mobility and co-modality services*
- *Environmental and energy efficiency* (including Electro mobility).

ERTICO has suggested a broader classification into 4 areas, but we will stick to the 8 ones above. The ERTICO classification for ITS is:

- Cooperative Mobility : connected vehicles and infrastructure
- Safe Mobility : providing safe transport operation
- Eco Mobility : reduced impact on energy consumption and the environment
- Info Mobility : real time information for travellers.

In the following, an account of the current technological as well as policy / legislative developments in each of the *above 8 areas of ITS application* is provided within the scope of the scientific assessment of the sector.

ITS for Traffic and Travel Information (TTI)

Traffic and Travel Information (TTI) technologies, systems, and legislating provisions aiming at providing real time information to the travellers, were of the first components of ITS to be developed and promoted commercially. TTI, features significantly in the EU's ITS Action Plan, the ITS Directive and the CEN-ETSI response to Mandate M/453 on Co-operative Systems Standardization. The ultimate scope and goal of TTI systems is to: *provide continuous and reliable traffic and travel data and information of relevance to all modes and networks through universal access to such information and data exchange (across regions and borders), enabled by feasible business models*.

TTI is thus about the collection, processing, transmitting, and optimal use of Traffic and Travel data for regional, National, and EU-wide real-time travel information, and its provision (a minimum of which should be free) to users of such information thus enabling the development of diverse commercial value added services. In assessing the scientific and developmental potential of TTI technologies and services, there are four main issues to be considered, i.e. the:

- Legal framework for the provision of TTI,
- Technical standards used and the interoperability of these standards,
- Business models used for the provision of these data, and
- Extent to which the travellers themselves (i.e. the "demand") are reacting to TTI provision.

The *legal framework* for TTI services is the legislation referring to ITS, which has been gradually put in place at European level in the last decade or so. The major element of this framework is the Directive 2010/40/EU of the European Parliament and of the Council, which sets the scene for further legislative action on behalf of the member states. In fact this Directive establishes a framework in support of the coordinated and coherent deployment and use of Intelligent Transport Systems (ITS) within the Union, in particular across the borders between the Member States, and sets out the general conditions necessary for this purpose. It provides for the development of specifications for actions within the priority areas, as well as for the development, where appropriate, of the necessary standards. In turn, Member States have to ensure that the processing of personal data in the context of the operation of ITS applications and services is carried out in accordance with Union rules protecting fundamental rights and freedoms of individuals (as contemplated in Directive 95/46/EC and Directive 2002/58/EC) and they (Member States) must ensure through their legislation that personal data are protected against misuse, including unlawful access, alteration or loss, etc. Of interest is also the provision of the ITS Directive that Member States should submit to the Commission by 27 August 2011 a report on their national activities and projects regarding the priority areas, and by 27 August 2012 information on national ITS actions envisaged over the following five year period.

Furthermore, in accordance with the advisory procedure referred to in the Directive, the Commission adopted a working program, in February 2011, which includes objectives and dates for its implementation every year and proposes the necessary adaptations.

In spite of the progress made during the decade 2000, the European *legislating framework* for TTI services is still in the making especially at the level of the individual EU member states, where relevant provisions either pre-existed the EU Directive and need harmonisation, or did not exist at all. For instance, a crucial field for legislative harmonisation concerns the multitude of legal provisions in the area of re-use of public sector information. National legislations vary as regards the provision of such data free of charge and the degree to which they ensure that their provision is fair, transparent, and non discriminatory. For example in the UK there is free access and re-use, including traffic and public transport information, in Germany the model contracts foresee the sale of traffic data from federal traffic control centres and from local authorities to ITS service providers and manufacturers, while in Greece these data are for sale too, with no other legal provisions, and so on.

As regards the *technical standards* used for the transfer of traffic and travel information and data, the last decade has seen the development of a number of TTI standards and a, relatively modest, attempt to create interoperability among these standards. The most known examples of TTI standards in Europe today, are the:

- DATEX I and DATEX II (there is an EU initiative to extend DATEX to all actors in the traffic and travel information sector – the *EasyWay* programme. The standardiser for DATEX II is CEN/TC 278 Working Group 8);
- CORBA − Common Object Request Broker Architecture;
- OTAP − Open Travel Data Access Protocol;
- TPEG − *Transport Protocol Experts Group* (T-peg) - developed by TISA[9] as the successor to the current RDS TMC traffic information protocol. The standardisers for the T-peg protocol is CEN/TC 278 WG 4 and ISO/TC 204 WG10;
- RDS-TMC− Radio Data System-Traffic Message Channel.

There are several others too (ALERT C, CAM, DENM, and so on).

These standards have reached a considerable degree of maturity, having also already considerable communities of interest and development (within their creating bodies and procedures e.g. in the ISO/TC204 WG10, CEN/TC278 WG4, CEN/TC278 WG8, ETSI TC ITS WG1).

As regards *interoperability* of these standards (also called "*Alignment*") the progress has been rather slow so far. An MoU between EasyWay and TISA focusing on the DATEX II => TPEG exchange has been worked out, and a first demonstrator planned[10]. The interoperability work may require some level of reworking of the standards, or definition of standardised mappings but the overwhelming need is for eventually establishing a single common data dictionary/registry for TTI data.

Expected future standardisation work is foreseen in areas such as:

- Event Driven Road Hazard Warning
- Traffic Management data (e.g. Lack of harmonisation of the management of TMC location tables)
- Cooperative Traveller Assistance.

[9] TISA: Traveller Information Services Association is a market-driven membership association with worldwide scope, established as a not for-profit company focused on proactive implementation of traffic and travel information services and products based on existing standards, including primarily RDS-TMC and TPEG technologies.

[10] In connection to the ITS Europe Congress in Lyon (6- 9 June, 2011)

As regards the *business models* used for the provision of TTI, the current cycle of Service Value Chain for the provision of TTI services is depicted diagrammatically below:

The current most common models of business structures for the provision of ITS / TTI services, are based on public – private partnership arrangements that normally provide for outsourcing the data collection and storage to commercial contractors, distribution of these data to service providers who provide high quality travel information to the public. The Dutch NDW organisation (National data warehouse for traffic information) established in 2007, with its data base opened in July 6th 2009, is a good example of a European PPP business model for TTI services. It is a collaborative venture between 15 authorities to collect, process, store and distribute traffic data.

This data base consists of:

- Traffic information
- Current information about the situation on the roads e.g. traffic intensity, journey time, spot speeds
- Status information
- Information about the operational condition of the roads e.g. road works, reports of congestions and incidents
- Status of peak lanes and bridges, operations scenarios
- Historical data.

The NDW outsources data collection and storage to commercial contractors. The data ownership lies with the joint authorities who participate to the NDW. The data are distributed to service providers (connection fee € 6000 per year) who develop and provide the final user services. The investment model of NDW involves payment for the NDW expenses as well as for the organisation and exploitation database, by the participating (local) governments, each relevant party pays for data collection on own road network while the end user service providing partners get all data from (and pay) NDW.

Data for TTI services are growing in availability due to:

- Technological progress (a most notable trend is the collection of data through the so called "*collaborative*" model where each vehicle on the network becomes information gatherer and transmitter),
- Diversification of data sources,
- Better data organisation and management,
- Re-using of public sector information and data[11], and
- Existence of many commercial and business structures active in this field.

[11] Directive 2003/98/EC of the European parliament and of the council of 17 November 2003 on the re-use of public sector information

On the "*demand*" side i.e. the number of users and the way the users of TTI react, a number of issues remain to be addressed:

- How does the customer use the TTI,
- How much information can be digested,
- What is the link between information and behaviour (habits, uncertainty, imperfect information, costs of adjustment etc.),
- What is the best format and timing for the information,
- Which are the preferred information dissemination channels,
- What is the willingness-to-pay.

In conclusion, the sector of TTI/ITS in Europe although quite advanced, is still in the process of shaping, technically, organisationally, legally. The last decade has seen a marked progress in many areas but it is estimated that it will take at least another decade (this current one) before all the related issues are solved in order to have pan-European interoperable TTI services across the modes that display:

- High quality of data especially with multimodal content, and coded using the same or well harmonised and interoperable standards.
- Organisational systems ensuring fair and transparent availability of data.
- Smooth private or private-public co-operation based on sound business models.
- Full cross-border data exchange and utilisation fully available to all users (irrespective of language or other barriers).
- Fully harmonised location tables across Europe.

The above relate primarily to Europe. In other world regions, the development of TTI/ITS services is also progressing fast although at differing levels and speeds. In Japan, for example, TTI services are considered as being ahead of those in Europe, and the US. In Japan the fully "collaborative" model for data collection, through the VICS platform, has been implemented several years ago and there is a host of other applications operating on sound business models.

In the US too, there is a multitude of TTI provision instruments and business ventures, while the development of TTI systems followed a largely commercially-led innovation boom. In the US for example the following is an example of major TTI provision sites and organisations:

<u>National Information Links:</u>

- National Traffic and Road Closure Information (FHWA)
- Weather/Road Conditions Related:
- AccuWeather Weather Headlines
- Intellicast Highway Conditions
- National Weather Service
- National Weather Service Interactive Weather Information Network
- Safe Travel USA - Weather and Road Conditions for the Upper Midwest
- Travel Cities Weather

- Weather Channel Travel Weather
- Traffic Conditions Information:
- AccuTraffic - Traffic Information for States
- Beat the Traffic Information for Various US Cities
- Iteris Real-Time Traffic Information - Maps and Times - for Various US Cities
- MSN Traffic Reports
- SmarTraveler - Traffic Information for Various Major US Cities
- Smart-Traveler Information for Various US Cities
- Total Traffic Network - Traffic Information for US Cities
- Traffic.com - Traffic Information for US Cities
- TrafficLand.com - Traffic Cameras for US and other Cities
- TravelForecast.com - United States Road and Traffic Conditions
- Regional Information Links:
    - I-95 Corridor Coalition Traveler Information
    - I-95 SafeTrip-21 Long Distance Trip Planning Web Site (from I-95 Coalition)
    - I-95 Travelers Alert (from Starsystems)

State Departments of Transportation:

- All State DOTs have TTI provision sites and services.

A late entrant, China, enters the picture with the Chinese government committed to investing a large amount of money during the coming years into TTI provision and the ITS market in general. China is likely to adopt its own unique approach for TTI/ITS development that draws on the strengths and lessons learnt in other markets but taking into account the unique characteristics of traffic problems in China.

ITS for Traffic and Public Transport Management

The development and deployment of ITS to improve traffic management in urban and interurban transport networks is also a prime field of ITS applications. In the road transport field, where the first ITS management applications were developed, the following are typical applications extensively deployed today:

- Intelligent traffic signal control,
- Incident detection and management,
- Priority to specific types of vehicles such as emergency, and public transport vehicles,
- Intelligent lane control,
- Speed limits enforcement,
- Longer distance diversions re-routing,
- Data collection (including floating car data and other methods).

Road traffic control systems are considered as the backbone of Intelligent Transport Systems, in the sense of large-scale, area-wide system implementations, dealing with large amounts of traffic (and other) data stored and processed in real-time from various sources/detectors, with the use of advanced traffic models, prediction algorithms and management strategies able to respond in real-time to the prevailing traffic conditions. Some significant advances for the next generation of traffic management systems within large-scale implementation of ITS, are: traffic predictive control methods and intelligent network control strategies based on certain prevailing criteria such as minimisation of overall travel times, or minimisation of environmental impacts, etc.

Research into ITS for road traffic management has been supported in the EU since the 1980s, but more rigorously from the mid 1990s with the Euro-Regional projects, to improve traffic management and user services, focusing in cross-border corridors. At the same time, projects under the CIVITAS initiative implemented and shared urban transport and traffic solutions, also involving traffic signal management, priority of public transport, and more recently the comprehensive mobility management approach. The main push however, for the development of comprehensive traffic management ITS applications, came with the TEMPO programme (2001-2006), where seven major projects involving ITS enabled road traffic management, took place: ARTS, CENTRICO, CONNECT, CORVETTE, SERTI, STREETWISE and VIKING[12]. Also, and following these projects, the EASYWAY[13] initiative was established, involving 21 member states, and aiming to enhance the use and efficiency of ITS in order to decrease (until 2020):

- traffic fatalities by 25 %
- traffic congestion by 25 %
- CO2 emissions by 10 %.

Concurrent with road traffic management, there are ITS related systems developed for the management of Public Transport Networks (primarily in urban areas). Here, the applications include:

- Real time public transport information,

[12] http://ec.europa.eu/transport/its/road/deployment_en.htm

[13] http://www.easyway-its.eu

- Automatic Vehicle Identification and real time information to the bus or train stops,
- Priority for buses and other road public transport vehicles at intersections,
- Flexible bus lane control (to allow utilization of the bus lanes by other types of vehicles too), etc.

Public transport fleet management using “cooperative” systems (see following sections) is also expected to be fully developed in the near future although it will take longer than application of the same systems in private vehicle fleets. This longer take up for public transport vehicles is the consequence of the longer time between stock-turnover in public transport as compared to private fleets.

In the rail transport domain, the development and deployment of the *European Rail Traffic Management System* (ERTMS), encompassing the *European Train Control System* (ETCS) and the *Global System for Mobile communications in Railways* (GSM-R), unified signalling and train speed control in Europe, enabling interoperability throughout the European Rail Network.

In the waterborne transport, *Vessel Traffic Management Systems* (VTMS) are in place in almost all major EU maritime regions especially near major ports. The EU proposed ITS enabled *e-Maritime initiative* (one of a number of such EU e-initiatives such as: e-Government; e-Administrations; e-Commission; e-Business, etc) will develop an integrated ITS based information management system for identification, monitoring, tracking and reporting of sea vessels. The *e-maritime* framework can be understood as consisting of three major elements (see Figure 1):

1. The *e-Maritime Strategic Framework* which will describe the key stakeholder requirements and how these could be achieved through appropriate processes, standards and policies in specified time windows taking into account legal, technology, human factors issues and ongoing developments particularly associated with the SSN[14], e-customs, security and environment initiatives.
2. The *e-Maritime Support Platform* which will facilitate the development and deployment of e-Maritime applications exploiting the latest ICT developments particularly e-maritime related technologies (communications, surveillance, system networks) and software engineering (on interoperability and integration of data and services). It will consist of the “tools” to support the dynamic integration of e-Maritime applications with SSN and other EU Platforms such as e-Customs and to provide EU level value added information services from statistical and other analytical services.
3. Finally, the *e-Maritime Reference Applications* part will provide applications to demonstrate the potential benefits of e-Maritime in real life situations involving administrations and businesses across Europe.

[14] Space Surveillance Network

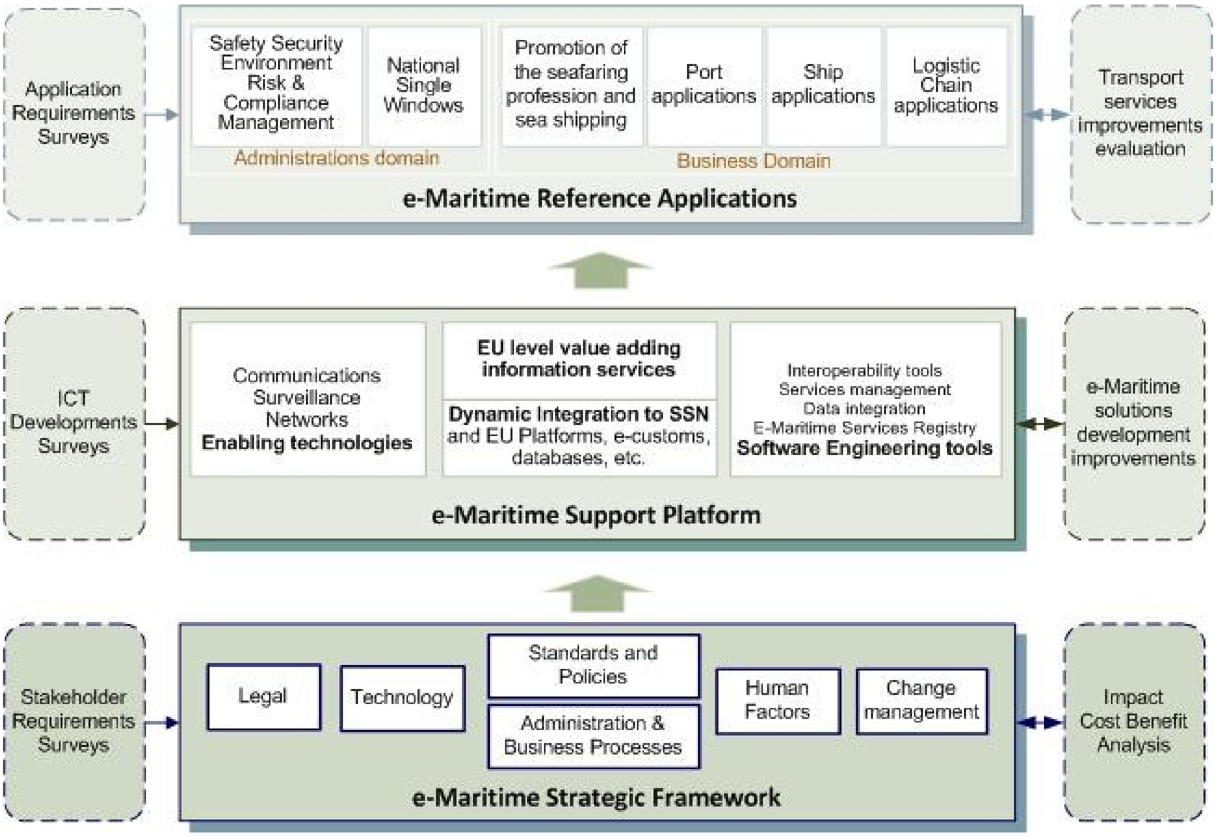

Figure 1: The e-maritime framework for ITS enhanced maritime management

(source: DG MOVE, Maritime Policy Unit)

In the air transport sector, the various Air Traffic Control (ATC) systems, that are to be integrated through the *Single European Sky* policy, and the various interoperability advances particularly in creating cross-border blocks of airspace are the most advanced examples of ITS based, traffic management systems. In 2007, the EU established a joint undertaking to develop SESAR (*Single European Sky ATM Research*), the *Air Traffic Management* (ATM) Master Plan for Europe and the development of the new generation of ATM. The same year an Action Plan for Airport Capacity, Efficiency and Safety in Europe was adopted, proposing better use of airports capacity, promoting co-modality and improving environmental and safety aspects at airports.

In summary, the major technological systems and technologies related to ITS in the traffic management field, are presented by mode below:

- *Road traffic management and control:*
  - Cooperative systems and technologies (V2V, V2I);
  - Real Time Traffic and Travel Information services supporting traffic management (RTTI)[15];
  - Traffic management systems including emergency management;
  - Implementation and use of of RDS-TMC/GSM broadcast technology;
  - TMC and TPEG[16]-TISA[17] real-time navigation and Floating Vehicle Data collection[18];

[15] Several recent European projects support the actions proposed by the RTTI recommendations (CONNECT Euro-Regional (TMC), Mobile Info (TPEG), TISA (TMC and TPEG)).

  - Public transport integration systems.
- *Air traffic management and control*:
  - Unified Air Traffic Management for Europe (SESAR);
  - Airborne Separation Assistance System (ASAS);
  - Automatic Dependent Surveillance – Broadcast (ADS-B) and applications on ground and airborne surveillance (GS-AS)[19].
- *Maritime traffic management and control*:
  - Maritime Operational Systems (MOS)[20];
  - Vessel Traffic Management and Information Systems (VTIMS)[21];
  - Integrated Ship Control (ISC);
  - Electronic Chart Display & Information System (ECDIS);
  - River Information Systems (RIS).
- *Rail network management*:
  - ERTMS (European Rail Traffic Management System);
  - European Train Control System (ETCS);
  - Global System for Mobile communications Railway (GSM-R).

As regards the future, and since most of the above mentioned ITS based traffic management systems, are today unimodal i.e. developed and implemented within one transport mode, the most "transformative" future development is expected to be in the development of cross-modal

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[16] The first service trials using TPEG-based technology started in 2006. The first commercial services began to broadcast in the UK in 2008.

[17] The *Traveller Information Services Association* (TISA), a non profit organization hosted by ERTICO founded in the basis of the TPEG project, aims to develop a new and open international standards for broadcasting language and multimodal traffic and travel information, covering all modes and offering:

1. Advice on all aspects of setting up TMC services
2. Harmonisation, standardization and quality assurance
3. Development work to implement new features to improve services
4. Development work on advanced TPEG services for digital bearers

[18] Public/private partnerships must be established for increasing the use of these techniques.

[19] GS (Ground surveillance) applications consist in:

1. ATC surveillance for en-route airspace, in terminal areas and in non-radar areas
2. Airport surface surveillance
3. Aircraft derived data for ground tools

AS (Airborne surveillance) applications include:

1. Airborne traffic situational awareness for improving safety and efficiency
2. Airborne spacing and airborne separation for improving capacity and flexibility

[20] Developed in the MarNIs project, implementation planned between 2012 and 2020). The MOS (Motorways of the Seas) concept integrates Vessel Traffic Management (VTM), Search and Rescue (SAR) and Pollution Preparedness Response and Co-operation (OPRC), coordinating these services virtually and sharing information for overlaying real-time web-mapped (geo-spatial) information to help mitigate risks.

[21] Including Vessel Traffic Services (VTS) and coastal Automatic Identification Systems (AIS)

traffic management systems i.e. systems that optimise traffic management across two or more modes, towards the achievement of the so called co-modality (cooperative modality).

Such cross-modal systems would: a) exchange real time information and data between the traffic management centres of two or more modes, b) analyse and compare the traffic conditions in the two (or more) networks, and c) provide optimisation of traffic flow in all networks based on the conditions at the integrated system (e.g. arrange the traffic signals on the road network to handle the demand caused by an arrival of a RO-RO vessel at a port, or harmonise traffic management with freight transport management especially in urban areas).

Also, for the future, a move towards greater coordination between information services and network management tools is expected. This will allow for a more intelligent operational decision support in the management of transport networks. Navigation systems are expected to be used for this purpose, through public private cooperation between network managers and service providers.

ITS for Navigation Services

The modern history of ITS in navigation services goes back to early 60's, when the US Federal Highway Association developed the *Electronic Route Guidance System* (ERGS), which aimed to provide route guidance to road vehicles , consisting of on-board devices and proximity beacons installed at the roadside. The Japanese *Comprehensive Automobile Traffic Control System* (CACS) was developed by the late 70's, utilizing vehicle motion detection, roadside equipment and a central data processing core. A few years later, two European systems, similar to ERGS and CACS were developed. These were the: *Autoguide* in the UK and the *ALI-SCOUT* in Germany, known also as EUROSCOUT or LISB. In *Autoguide*, the vehicle positioning was achieved through beacons installed on the roadside, while routing was computed with real-time traffic data coming from both other vehicles and from a control centre. *ALI-SCOUT* was developed around a similar concept, as the one of Autoguide.

The entrance of satellite navigation technologies enabled the development of a new generation of navigation systems first in the U.S. and Canada. Examples of initial experimental implementations include the systems ADVANCE, Travtek and Travelguide. *ADVANCE* used GPS positioning technologies together with bi-directional dedicated radio communications with a Traffic Information Centre, in order to send and receive real-time traffic data. A pilot implementation of *ADVANCE* took place first in Chicago. *Travtek* offered real-time traffic information, route guidance and navigation and was tested in Orlando, US. *Travelguide* was a portable device, which provided, in addition to the above, public transport related real-time information.

Following the development of such 'centralized' systems, the further advances of GPS technologies during the 90s resulted in the development of 'autonomous' navigation devices. Nowadays, such devices tend to take over the respective market share of the previous 'centralized' systems.

Navigation services, in general, include technologies related to the identification of the position of a vehicle or load unit (positioning) and providing instructions as to the optimal route to one's destination. The basic components that comprise a modern navigation system is shown in Figure 2[22]. The scope and content of each of the components is self evident from its name.

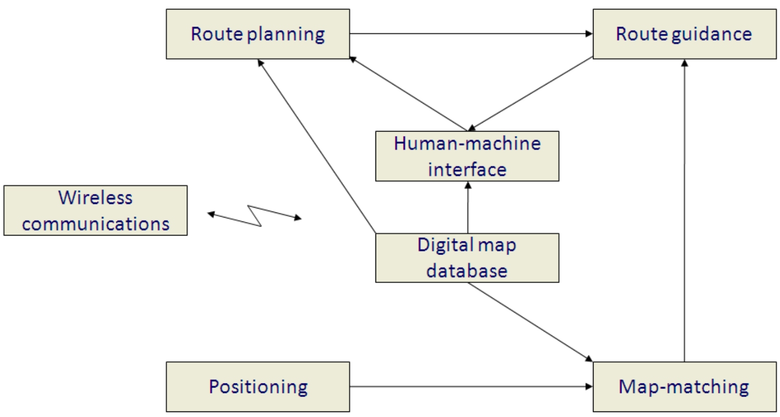

Figure 2: Basic components of a "navigation" system

[22] Taken from Zhao, Y. (1997), "Vehicle location and navigation systems", Artec House Inc., Norwood, MA, USA.

The positioning part of navigation services is handled through one of the existing GPS positioning systems. The European Galileo satellite navigation system is expected to be operational by 2013 and will provide a highly accurate, guaranteed global positioning service under civilian control. It will be inter-operable with both GPS and GLONASS which are the other two existing global satellite navigation systems.

Different types of navigation devices are used and these can be categorized as follows[23]:

- Dedicated navigation units integrated into the vehicle (by the vehicle manufacturer or Original Equipment Manufacturer – OEM);
- In-vehicle entertainment devices having navigation facilities installed as an accessory or replacement of a conventional function (e.g. radio, CD, tape);
- Dedicated after-market devices that are permanently installed in the vehicle;
- Dedicated free standing after-market devices that can be temporarily installed in the vehicle;
- Personal digital assistants (PDAs) with suitable software and connection to a satellite navigation receiver;
- Mobile phones with navigation functions;
- Mobile data terminals.

An important feature of ITS navigation systems is the coupling of navigation services with real-time traffic data (invariably enhanced with historical data sets and short term traffic prediction) so as to provide route guidance based on real time traffic conditions.

So far, ITS navigation services have relied largely on the advances occurred in communication technologies and mobile cellular networks in particular. The 3G communications protocol and the spread of wireless internet technologies have contributed to the possibilities for exchanging larger amounts of traffic related data, in real- or near real-time, at affordable cost levels. However, still, navigation services depending on pure real-time data are rather expensive, because of the costs of keeping permanent (or almost permanent) communication channels open for the transfer of traffic data through a mobile telecommunications operator. For this reason, navigation services currently depend to a large degree on historical traffic data and traffic profiles, with minimum real-time data exchange and mainly focusing on incidents, i.e. accidents or other traffic-disturbing events. Such small-sized data sets are usually communicated through less expensive channels, such as the RDS-TMC.

Each company providing navigation services utilizes proprietary data sets, and uses common exchange and communication protocols. Traffic data sources used for the provision of real-time services are sometimes beyond the usual traffic data warehouses (e.g. traffic management centres) due to the cost of real-time data and may include the tracing of the navigation devices, so as to extract traffic related information in real-time based on the users en-route.

A highly interesting project has been completed recently in the U.S., with the cooperation of UC (University of California) at Berkeley and Nokia, aiming to contribute to real-time navigation

[23] Wood, K., Maxwell, A., Stevens, A. and Thompson, S. (2006), "Routing assessment of dynamic route guidance systems", TRL Report No PPR093.

services and to identify ways for anonymous data handling through the use of smart phones as both sensors (traffic data collectors) and service provision devices[24].

Advances, based on recent research, in the field of navigation services for road transport[25] include:

- Provision of highly accurate navigation, aiming to monitor and assist drivers' manoeuvring by providing information at the lane level;
- Micro-routing, i.e. the provision of highly detailed route guidance information, which includes information aids for the surrounding environment;
- Strategic routing, i.e. enhanced routing functionalities that take into account some pre-defined strategies;
- Receiving of alerts and/or notifications related to road safety directly from other vehicles (vehicle to vehicle - V2V);
- Receiving of information related to signal timing when approaching signalized intersections, with appropriate instructions regarding the optimal speed of the vehicle, so as to reach the intersection when signals turn green (infrastructure to vehicle - I2V);
- Public transport fleet and schedule management systems, which are components of public transport fleet management and information provision centres.

The future of navigation will see developments towards the personalized information provision, environmentally aware routing and navigation services to assist travellers in understanding the environmental implications of different travel choices and provide advice for greener choices[26]. Also, providing optimal routing strategies, as opposed to today's routing suggestions, for routes with the lowest degree of travel time uncertainty. Reliability of predictions will be a major challenge for the development of such systems, especially in the presence of increasing market penetration rates and competitive markets for the provision of information. Such systems will be also expected to deliver optimal routing strategies in case of non-recurrent congestion e.g. accidents or adverse weather conditions as well as to be integrated in centralized systems for the management of emergences.

In materialising the above advances, developments are due in the core-component of navigation and routing of navigation systems, i.e. the algorithms that silently work underneath. In developing these "third generation" of algorithms that will be especially useful for the new navigation services of the future, and with low computational capability requirements, use will be made of advanced mathematical tools such as the *contraction hierarchies* method[27], or the representation of travel strategies as dynamic network *hyperpaths*,[28] which have traditionally been applied in path choice models for urban transit systems in cases with high frequency and/or low regularity.

Some behavioural issues related to the users' perception and response to navigation devices, are also of interest here, but are not examined as they do not fall under the scope of this work.

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[24] The Mobile Millennium project. http://traffic.berkeley.edu/

[25] The cooperative mobility research framework projects: CVIS, SAFESPOT and COOPERS

[26] e.g. the Commute Greener i-phone application of Volvo

[27] H. Bast, S. Funke, P. Sanders, D. Schultes. Fast Routing in Road Networks with Transit Nodes. - Science, Vol. 316. no. 5824, p. 566, 27. April 2007.

[28] Trozzi V., Bell M.G.H. Gentile G., Hosseinloo S.H. (2010) Dynamic hyperpaths in transit networks: the stop model with online information, in Proceedings of the 5th IMA Conference on Mathematics in Transportation, London, UK.

ITS for Smart Ticketing and Pricing

ITS technologies and services for the collection of fees in the field of transport have been developed in the last 20 years starting with toll collection systems, and more recently the pricing of transport, according to certain criteria (e.g. emissions). A separate section of this area is the "smart ticketing" systems i.e. ITS enabled ways to pay the tickets in public transport or other transport services.

There is a long number of policy decisions, standardization and legislative steps that create the current landscape in this area. The principles of the infrastructure charging were presented in the Green Paper "*Towards Fair and Efficient Pricing in Transport*" and the White Paper "*Fair Payment for Infrastructure Use: a Phase Approach to a Common Transport Infrastructure Charging Framework in the EU*". In 1999, the Eurovignette proposed the charge of HGVs[29] for the use of certain roads, applying the concept of "user pays" and allowing the recuperation of construction costs, maintenance and operation of roads by the member States. In 2003, a new EU Directive amending the Eurovignette changed the notion of the tolling system, into the more comprehensive concept of the of the "polluter pays" introducing distance travelled, accident and environmental costs, congestion levels by time period, local population density, vehicle emission classes, and other such parameters into the whole tolling concept. "External" costs were included in the calculation of road tolls with the Directive 2006/38. In 2008, the European Commission proposed the "smart pricing" of transport according to vehicle emissions or congestion levels, under a constraint of revenue neutrality. Different infrastructure charges, fees and taxes across Europe result in different transport prices and distortion in competition (i.e. prices do not reflect real costs). In the rail transport system, Directive 2001/14, based on the marginal social cost principle, was added to the amending Directives for air pollution and noise pollution caused by traffic.

The 2009 Commission's *Communication on sustainable future for transport* further detailed the proposed internalization of the "external" costs that were introduced with the Directive 2006/38, while the 2009 *Action Plan on Urban Mobility* proposed the use of ITS tools for obtaining pricing solutions, including two actions related to the use of ITS for the smart pricing of infrastructures. The first action aimed at the information exchange on urban pricing schemes in the EU (aiming at the inclusion of the input obtained in consultation processes, scheme designs, information provision to citizens, public acceptance, operating costs/revenues and technological/environmental impacts). The second action aimed at the application of ITS technologies on urban mobility to complement the ITS Action Plan, e. g. electronic ticketing and payment, improving the interoperability of ticketing and payment systems across services and transport modes (using smart cards in urban transport with focus on airports and rail stations). .

Electronic Fee Collection (EFC) systems offer the possibility of "smart" charging for the use of transport infrastructure (mainly roads) following the pricing policies established in the different EU Directives as mentioned above. This is also called "*smart pricing*" as opposed to smart ticketing which refers to the collection of fares in a public transport system. According to the stakeholders' hearings, held within the STTP exercise, *smart pricing* will be a market where the infrastructure managers, together with the vehicles industry, and the ITS providers, will co-operate in order to produce a (road or other mode) service and provide it at a certain price to the "consumers" with one given technology or with harmonised technologies.

[29] Heavy Goods Vehicles

In the provision of such a service the market of the infrastructure managers will have synergies, while the markets of the ITS providers will mostly have competing forces.

Interoperability is the crucial element, still to be achieved, for such systems. This is to be achieved by:

- Technical interoperability (on-board equipment);
- Procedural interoperability (contractual agreements);
- Treatment of non-equipped users;
- Protection of personal data.

Technical and procedural interoperability is a key issue for a successful implementation of smart pricing in Europe, especially at tolls. An example of such interoperability is the E-ZPass tag used in toll roads, bridges and tunnels in fourteen states along the USA. In the EU, specifications have been made in the Directive on ***Interoperable Electronic Road Toll Systems in Europe***. Directive 2004/52/EC had set the framework for a *European Electronic Toll Service (EETS).* The detailed definition of the EETS, including technical, procedural and legal issues and a schedule for implementation, has been set in a European Commission Decision adopted in October 2009.

The EFC Directive 2004/52/EC on the interoperability of electronic road toll systems, standardized[30] the European toll collection system deployed after 1 January 2007. Based on this, a high level architecture (based on DSRC[31] and GNSS[32] technologies and the CESARE III[33]) for road charging interoperability was demonstrated towards the end of last decade in collaboration with the standardisation committees CEN and ISO, the ASECAP[34] tolling operators, and the so called "Stockholm Group" (the members of the "Stockholm Group" are the five countries, interested in a common approach to Electronic Fee Collection: Belgium, Germany, Sweden, Switzerland, UK). The system allowed any user to access a European Electronic Toll Service (EETS) anywhere in Europe using the correct on-board equipment (OBE). Despite all these efforts, seamless interoperability of EFC systems across Europe is still not reached and it will probably take the most of the current decade before it is realized.

Of similar characteristics with the toll collection but different in magnitude and sophistication are the systems for fee collection over a larger area used for road pricing. Such systems have now being installed in many European countries over the last decade, e.g. Norway (Bergen, 1986;

[30] ETC systems must support at least one of the following technologies:

1. Satellite positioning
2. Mobile communications using GSM-GPRS or the 5.8 GHz microwave technology

[31] Short range communications

[32] Global navigation satellite system

[33] CESARE (*Common Electronic Fee Collection System for an ASECAP Road Tolling European Service*) is a project developed so far in three phases (I, II and III) whose objective is to specify, design, develop, promote and implement a common interoperable Electronic Fee Collection System on European toll roads (source: www.asecap.com).

[34] ASECAP (*Association Européenne des Concessionaires d'Autoroutes et d'Ourages à Péage* - European Association with tolled Motorways, Bridges and Tunnels) is a European Organisation whose mission is "to promote toll as the most efficient tool to finance the construction, operation and maintenance of motorways and other major road infrastructures" (source: www.asecap.com).

Oslo, 1990 and Trondheim 1991), Rome in 2001, London in 2003 (extended in 2007), Valletta (Malta) in 2007, Stockholm in 2006-2007, Milan in 2008[35]. The pricing strategies differ with respect to the geographic coverage of the road pricing, and can be distinguished in:

- Area pricing (within an area)
- Cordon pricing (for accessing an area)
- Facility pricing (on individual facilities such as freeways)
- Network pricing (on freeway systems).

The most common ITS technologies used for smart pricing, tolls or area wide, are:

- Automated vehicle identification technologies (using barcodes[36], RFID[37], plate recognition[38], GPS[39]);
- Automated vehicle classification (using video cameras, sensors, or storing the vehicle class in the customer record);
- Transaction processing (prepaid or postpaid systems);
- Violation enforcement (physical barrier, plate recognition, police at toll gates, etc).

Coming to the field of ITS applications for *smart ticketing,* we note that these require a different set of technologies. Here smartcards are the main technology used. Standards for Transport Smartcards have recently being developed and the EU Directive (2009/110/EC) has changed definitions and introduced various terms to ensure interoperability of smart ticketing. Inspite the efforts (e.g. a recent FP6 research project called *Interoperable Fare Management* (IFM) has aimed to ensure cross-border interoperability of Transport Smartcards and developed a roadmap towards the implementation of the electronic ticketing in Europe where customers use their Smartcards outside their home network, and transport authorities can build new systems using standardizations as commented above) smart ticketing interoperability is far from being realised.

In concluding, the ITS enabled *smart ticketing* and *pricing* in the field of transport, is here already but it is expected to be the standard rule in the future urban and interurban networks, within the coming decade.

In addition, there is a trend towards the integration of payment systems for (transport) services and charges. The challenge still is to implement interoperable interfaces between payment systems that could be provided by a single platform (interoperability) and could rely on various means such as credit cards, mobile phone payments and integrated transport ticketing solutions.

[35] The Ecopass program provides free access to low-emission vehicles.

[36] Optical systems proved to have poor reading reliability

[37] Via Dedicated Short Range Communications (DSRC), proved excellent accuracy, but with a high cost

[38] Used in the Toronto Electronic Toll Route

[39] Used in the truck tolling system in Germany

ITS for Safety and Security

Safety and security enjoy full priority in the transport policies of both the EU and its individual Member States. In the EU, 97% of all transport fatalities are caused by road transport and thus road safety enjoys full priority in the ITS applications. A typical safety-oriented ITS application would give drivers information that would help them avoid an accident or in some cases provide information that would mitigate the consequences of an accident . Determining what ITS applications might best reduce accidents and their severity, requires a framework in which to link the effects of ITS applications to the causes of accidents.

Such framework would be based on consideration of the three main pillars: The driver, the vehicle and the traffic environment. The optimal ITS for safety applications are those with combined effects to all three of these contributors as well as those that build upon the strengths and interactions between each combined environment.

The ITS technologies and systems for transport safety are therefore distinguished in:

- "*Autonomous*" solutions (i.e. systems that are unilaterally concerned with only the infrastructure, the driver, or the vehicle), and the
- "*Co-operative*" solutions (i.e. systems that rely on the cooperation between two or more pillars e.g. Vehicle to Vehicle - V2V – or Infrastructure to Vehicle - I2V – etc).

Furthermore, and depending on the way that the specific ITS application is contributing to safety, the corresponding systems are categorized as ***Passive*** or ***Active Safety*** Systems according to whether they are passively preventing and protecting in case of an accident occurs, or pro-actively i.e. assisting the driver to achieve the desired levels of safety. The so called *Advanced Driver Assistance Systems (ADAS)* and the *Advanced Rider Assistance Systems (ARAS*[40]*)* are, for example, ITS based *active - cooperative* safety systems.

There are many examples of ITS cooperative – active or passive - systems. We indicatively mention a number of them below not as an exhaustive list but as an indication of the multitude of systems developed and the potential of the ITS sector in this field:

- Advanced Driver Assistance:
  - Speed adaptation (V2I and I2Vcommunication);
  - Reversible lanes due to traffic flow (V2I and I2V);
  - Local danger / hazard warning (V2V);
  - Post crash warning (V2V);
  - Vehicle lateral and rear area monitoring (LRM);
  - Lane Departure Warning/lane keeping (LDWS);
  - Collision Avoidance Systems (CAS), including lane change support, and others;
  - Longitudinal control systems: Cruise Control and Advanced Cruise Control (ACC);
  - Collision Warning and Avoidance (CWS/CAS);
  - Intelligent Speed Adaptation (ISA);
  - Night vision enhancement;

[40] For Powered-Two-Wheelers (PTW) such as motorcycles.

    - Object detection;
    - Pedestrian and other Vulnerable Road Users (VRU) protection[41]: These applications aim to mainly provide guidance, and other information (e.g. about the existence of special access facilities) for VRUs and have been in development since the mid 90s.
- Advanced Rider Assistance
    - Frontal Collision Warning;
    - Speed Alert Curve;
    - Warning Intersection support;
    - Lane Change Support;
    - Advanced Rider Assistance Systems – HMI;
    - Vibrating Glove;
    - Smart Helmet;
    - Vibrating Seat;
    - N&RG Display;
    - Blind spot warning mirror.
- Road Intersection safety
    - Cooperative collision warning at intersections;
    - Integrated intelligent intersection safety system[42];
    - Other intersection safety features[43].

Cooperative systems have been and are being demonstrated in various EU funded projects (e.g. CVIS, Coopers, FREILOT, SMARTFREIGHT etc.) and through Field Operational Tests in real-life environments. These include intersection management and control and fleet management with real-time loading and delivery space booking, or routing applications (for freight and other), parking information, etc.

The cooperative systems developed so far, and mentioned here, are however still not market ready in spite the fact that systems such as *Intelligent Speed Adaptation* (ISA), *Collision Avoidance* (CAS), and *Brake Assistance systems* (BAS) already exist in certain vehicle models. For these applications to have a real impact on road safety they must be universally enforced and employed, something that would require new telecommunication standards dedicated for such applications (such a standard was initiated among others by the CAR 2 CAR project) and wider market acceptance.

[41] 46% of road traffic fatalities in the European Union

[42] Such as were examined for example in FP6 project IRIS.

[43] Such as were examined for example in FP7 project SAFESPOT.

ITS for Freight Transport and Logistics

ITS for Freight Transport and Logistics is realized through a set of "intelligent" services, application programs and technologies for gathering, storing, analyzing, and providing access to cargo data to help users make better decisions. ITS contribute to the efficiency improvement of freight transport, by developing interoperable information services at national and global levels and building intelligent service applications on standardised data structures (e. g. the DATEX II) and exchange services.

The main application areas of ITS in the freight transport and logistics domain are the following:

- Development and implementation of the *next generation e-freight transport environment* known simply as "*e-freight*" (inducing individual cargo item intelligence and providing interaction with the "item" throughout the transport chain);
- *Freight Transport Management applications* (dealing with the management of the transport operation from order capture to payment and invoice control);
- *Fleet management applications* with the objective of optimising the utilisation and scheduling of a fleet of freight vehicles (or wagons, or vessels);
- *Management of special categories of freight* such as Dangerous goods
- *Terminal management* including access control, loading bay and parking zone management, etc.

The original EU ITS Action Plan[44] established a general framework for developing ITS in the freight Transport and Logistics sector. This general framework addressed the areas of: innovation (in freight transport), simplification of procedures, quality and efficiency of operations, environmental quality ("green" freight transport), and reshaping the legal framework for freight in Europe. The ITS Action Plan of 2008[45] goes to identify specific ITS services to be deployed in support of freight transport. Among the services specified in this Action Plan are the following:

- Cargo tracking and tracing (all modes);
- Electronic fee collection (this applies to road transport in general and is dealt separately);
- Systems for reducing delays of freight at railway networks;
- Efficient and clean urban freight transport deliveries (ITS solutions in this domain can provide coordination and consolidation of shippers and carriers for an environmentally friendly city logistics);
- Implementation of Single Window Platforms.

As regards the ITS technologies used for freight it can be said that all previously mentioned technologies in the other sectors are also used in the freight and logistics sector, but of specific interest are the following:

- Freight technologies for Heavy Goods Vehicles (HGV) routing, in order to drive them out of sensitive areas (often different from routing of Satellite Navigation which is designed without consideration of HGVs). This is of particular interest to urban areas and local

[44] COM(2007) 607 final, 18.10.2007.

[45] Action Plan for the Deployment of Intelligent Transport Systems in Europe, report COM(2008) 886 final

authorities as is also the following item.

- Enforcement of restrictions (e.g. parking, loading / unloading, entering restricted zones / streets, etc.).
- Online pre-trip planning, as well as in-vehicle routing based on the headquarters' planning and management requirements as well as on routing strategies designed by local authorities (rather than routes which may be based on shortest distance or shortest time guidance for HGVs).
- On-line tracking and tracing of individual cargo items throughout the transport chain, and provision of detailed information to the relevant stakeholders along these chains.
- Intelligent cargo applications (e-freight).

ITS for Intelligent Mobility and Co-modality Services

The term "intelligent mobility" refers to the provision of well analysed information based on real time data for the effective and sustainable planning, and execution of trip making and the management of the demand for such trips. Intelligent transport mobility refers not only to trips in urban agglomerations, but also to long distance trips and transport demand. The ways that the demand for transport can be handled effectively is referred to, as *mobility management* or mobility schemes.

All previously mentioned areas of ITS development can be thought of as also promoting intelligent mobility and mobility management as well as the notion of "co-modality" (cooperation between the modes). This is due to the fact that they invariably promote the:

- Free flow of traffic in the networks of all modes (urban and interurban areas);
- Greener transport through the intelligent management of fleets and distances travelled ;
- Smarter and in real time information provision for mobility;
- Better managed public transport systems and networks ;
- Safer and more secure transport through safer behavior, safer and more secure infrastructures and safer use of the vehicles.

The 2009 *Action Plan on Urban Mobility*[46] sets out the main ITS contributions to mobility and co-modality and sets a coherent framework for EU initiatives in this area. Twenty actions are proposed, in this Plan, which by and large rely (among other factors) on the existence and operation of ITS as an enabling factor. In parallel, some forms of cooperative mobility relying on mobile phones are progressively developing, largely independently from the vehicles and the transport infrastructure.

The twenty actions of the 2009 Action Plan are arranged in 6 themes as follows:

Theme 1: Promotion of integrated policies

- Action 1 — Accelerating the take-up of sustainable urban mobility plans
- Action 2 — Sustainable urban mobility and regional policy
- Action 3 — Transport for healthy urban environments

Theme 2: Focusing on citizens

- Action 4 — Platform on passenger rights in urban public transport
- Action 5 — Improving accessibility for persons with reduced mobility
- Action 6 — Improving travel information
- Action 7 — Access to green zones
- Action 8 — Campaigns on sustainable mobility behaviour
- Action 9 — Energy-efficient driving as part of driving education

[46] COM(2009) 490

Theme 3 — Greening urban transport

- Action 10 — Research and demonstration projects for lower and zero emission vehicles
- Action 11 — Internet guide on clean and energy-efficient vehicles
- Action 12 — Study on urban aspects of the internalisation of external costs
- Action 13 — Information exchange on urban pricing schemes

Theme 4 — Strengthening funding

- Action 14 — Optimising existing funding sources
- Action 15 — Analysing the needs for future funding

Theme 5 — Sharing experience and knowledge

- Action 16 — Upgrading data and statistics
- Action 17 — Setting up an urban mobility observatory
- Action 18 — Contributing to international dialogue and information exchange

Theme 6 — Optimising urban mobility

- Action 19 — Urban freight transport
- Action 20 — Intelligent transport systems (ITS) for urban mobility.

Relevant to the notion of intelligent mobility, the use of ITS for *clean mobility* is also discussed. As it was noted by the stakeholders' consultation[47] it is unlikely that any ITS measure alone will manage to reduce CO2 emissions considerably, but overall ITS can help to support reduction in emissions. Therefore, ITS measures for "clean mobility" need to be introduced within a coherent policy package including other measures (e.g. promotion of public transport and non-motorised modes, parking policy, etc.).

To achieve intelligent mobility at the "local" i.e. urban, level some of the key elements are:

- Integration of information on the local network (traffic conditions, infrastructure facilities, options, etc) to the daily information outlets used by trip makers;
- Integration of network management with information and infomobility services;
- Integration of payment and charging systems;
- Seamless interfaces between long and short distance networks, for freight and passenger transport.

The strategic coordination between traffic and travel information and network management is an important enabler of seamless mobility. In the case of the contribution of cooperative systems to seamless urban mobility, the market penetration rates differ depending on the applications under question. Some require a very large number of RSUs (roadside units) and equipped vehicles, whereas some do not. It is therefore likely that a step-by-step deployment will be made starting with applications on low penetration rate. Barriers in introducing ITS systems for urban mobility, are:

[47] In particular this section is utilizing the POLIS contribution to the STTP consultation.

- High investment costs;
- Legacy and integration issues;
- Uncertainty of market penetration rates;
- Legal and liability issues;
- Standardisation issues;
- Complex stakeholder interaction (particularly for cooperative systems).

ITS for Environmental and Energy Efficiency

The main objectives of ITS for energy efficiency are to help provide cleaner, more energy efficient and safer transport. In the 2008 Action Plan for the Deployment of ITS in Europe, it is clearly stated that ITS applications have an essential role to play in making the domain of transport more energy efficient.

The key energy-related actions for the deployment of ITS, are[48]:

- Optimization of the use of the infrastructure;
- More efficient traffic management and better interaction of modes;
- Reduction of congestion in freight corridors;
- Development of European solutions for flexible demand management;
- Enhancement of environmentally friendly & energy efficient transport solutions; and
- Improvement of the efficiency of logistic chains.

Most of the ITS application domains mentioned in the previous sections can influence positively the environmental and energy efficiency of transport systems.

Other, more directly relevant ITS applications to energy efficiency are the ones related to:

- Monitoring systems of the vehicles' maintenance and operating status, for fuel efficiency,
- Environmental route guidance, to avoid forecasted congestion,
- Environmentally sensitive journey planning,
- Eco-driving (environmentally sensitive driving),
- Better management and utilization of transport infrastructures including reducing empty runs of vehicles or containers, and many
- Other (see for example the EC Communication on the Greening of Transport[49]).

ITS has a critical role to play in the advancement and operation of electric cars and buses (either plug-in hybrids or fully electric), i.e. the so called ***electro-mobility*** through providing:

- Information on available charging points throughout the road network;
- Management of the supply of such points and helping to balance the electricity supply (electric grid integration);
- Integration of the electric cars into the traffic stream (especially in urban areas) mainly from the safety point of view.
- Monitoring of vehicles (in particular in public fleets),
- Management of parking and charging points,
- Provision of interfaces for the payment of electro-mobility related services and with the

[48] COM (2008) 886 "Communication from the Commission: Action Plan for the Deployment of Intelligent Transport Systems in Europe", see also: European Commission DG Energy and Transport (2009) "Intelligent Transport Systems Thematic Research Summary"

[49] COM (2008) 433 Final "Greening Transport"

grid.

It is likely that the deployment of ITS and electro-mobility will steer each other in a complementary way.

In relation to the use of ITS for energy efficiency it is worth mentioning here two EU co-funded research projects of the 7th Framework Programme. The first is the *Eco-Move*[50] project which aims to apply the latest V2I and V2V communication technologies so as to create an integrated solution comprising eco-driving support and eco-traffic management. The second is the project *FREILOT*[51], which aims to increase energy efficiency in road goods transport in urban areas. It considers systems for fleet management, the type of the delivery vehicles, freight driver assistance systems, etc and it demonstrates that up to 25% reduction of fuel consumption in the urban freight transport scene is feasible through measures based on ITS.

Even more recently, two projects were launched to develop the tools which are required to assess the impact of ICT/ITS measures upon greenhouse gas emissions:

- AMITRAN, which will develop a framework for the evaluation of the effects of ICT measures in traffic and transport on energy efficiency and CO2 emissions, with the ambition to build the foundations for a standardised assessment of future European ICT developments;
- ICT-EMISSIONS, which aims at developing a novel methodology to evaluate the impact of ICT-related measure on mobility, vehicle energy consumption and CO2 emissions of vehicle fleets at the local scale.

[50] http://www.ecomove-project.eu

[51] http://www.freilot.eu

Consolidation and Prioritization of ITS Technologies and Systems

In the previous sections, an account of the ITS sector, across all transport modes, was given in terms of both its main technological developments and the various EU transport policies and visions for the future. This “parallel” presentation was deliberate in order to delineate fully the sector and produce a “mapping” of its many applications and potential which depends not only on the technological aspects but also the regulatory and policy ones.

The main goal of ITS applications across the modes, which are currently in an important transition phase, is to translate the currently deployed “island” solutions - with very limited data exchange between networks and lack of interoperability - towards a comprehensive co-modal data exchange network and seamless mobility services, where people, goods and vehicles are continuously and ubiquitously connected receiving or sending useful data/information. Therefore, the most challenging task for the European Institutions in the immediate future will be to *establish a common vision, common goals, common roadmaps and a coherent long-term strategy to support deployment of the relevant services towards the above goal*[52] .Some priority issues emerge which can be summed as follows:

- Interoperable – integrated Traffic and Traveler Information systems across all modes;
- Cooperative Mobility systems and services especially in urban areas;
- Safety applications (e.g. like the pan-European application of the e-Call);
- Interoperability of road charging/tolling;
- ITS and electro-mobility;
- Freight and logistics management for safe, secure, and environmentally friendly freight transport especially in urban areas (e.g. parking of trucks);
- Public transport/multimodal traveller services.

The following issues will need particular attention in enabling an integrated ITS across the modes[53]:

- Communication bearers for ITS services,
- Data warehouses/data market places,
- Location referencing methods, and
- E-Freight applications across the modes.

The role of the EC is seen mainly as a facilitator for interoperability of ITS across the modes and as a promoter of reliable and efficient ITS services within and between modes for the benefit of the European citizen through:

- Assuring the availability of good quality of data at all levels,
- Quality assurance of the systems deployed,
- Interoperable standardisation, and

[52] Based on ERTICO’s contribution to the STTP stakeholders consultation.

[53] As prioritized by the ERTICO position paper, and other stakeholders’ position papers (POLIS, ERRAC)

- Promotion of research and innovation, taking care to address properly intellectual property rights and privacy issues.

Since the purpose of the STTP exercise is to consolidate and present the Transport sector in terms of a number of key technologies (among which the ones for the ITS) that are considered as crucial for the future application and success of the EU Transport policy, we consolidate here the key ITS technologies and / or systems that are bound to influence, and get influenced, by the Transport policies to be followed.

This can be done in terms of the following 9 ITS related Technological sectors that cut across (i.e. have applications in) all or almost all of the eight areas of ITS application mentioned above:

I. Traffic Data and travel information exchange (universal interoperable standards, sustainable business models):
   a. within one mode
   b. across modes and borders.

II. Route guidance / navigation systems:
   a. strategic (pre-defined strategies)
   b. micro
   c. personalized
   d. environmental and energy sensitive.

III. Intelligent real time traffic Management in:
   a. road
   b. rail
   c. maritime
   d. air transport
   e. across the modes.

IV. Management of urban public transport networks

V. Intelligent fee collection

VI. Cooperative systems (V2I, V2V) for :
   a. Advanced Driver Assistance (ADAS)
   b. Advanced Rider Assistance (ARAS)

VII. Intelligent Freight transport (urban and interurban)
   a. Universal e-freight environment integrated across modes
   b. Intelligent fleet and transport management systems
   c. Consolidated interoperable and universally available platforms for one-stop-shop freight transport info provision across all players.

VIII. Intelligent energy (eco-driving, environmental and energy traffic management, vehicle maintenance monitoring, etc)

IX. Sustainable mobility services (demand management, info-mobility, environmentally friendly modal choice, etc).

In concluding it can be stated that Governments on national, regional and local level must develop their strategic positions on ITS. Few of them have ITS strategies now. This is a potential barrier for the deployment and best use of ITS, also because it increases the risk, real and perceived, from the perspective of private parties.

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Title: Overview of Intelligent Transport Systems (ITS) developments in and across transport modes

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Abstract

This document was prepared by experts of the Hellenic Institute of Transport for the Joint Research Centre in 2011 for a two-fold purpose:
A) As a main input for the preparation of the Scientific Assessment of transport technologies, which was a part of a new Commission initiative, the Strategic Transport Technologies Plan (STTP) . The STTP was designed as a follow-up of the Transport White Paper (TWP) . The TWP set out to remove major barriers and bottlenecks in key areas across the fields of: transport infrastructure and investment, innovation and the internal market. The aim is to create a Single European Transport Area with more competition and a fully integrated transport network which links the different modes and allows for a profound shift in transport patterns for passengers and freight. To this purpose, the Transport WP puts forward 40 concrete initiatives for the next decade, including technological as well as non-technological measures. The Strategic Transport Technology Plan (STTP), addressing the technology pillar of the White Paper, is hence designed to contribute to these objectives in the mid-term, through stimulating research and innovation in some strategic technological areas in the field of transport. The use of Intelligent Transport Systems within modes and across modes has been identified early on as of the main issues within the STTP.
B) As a coherent description of the actual state of play in the field, in order to assist the JRC in identifying its potential role in the development, standardisation and deployment of ITS in Europe. For the JRC, it was important to identify potential areas in which the other Directorate Generals (INFSO, MOVE, etc) were in need of technical and scientific support.

This report, attempts to give a concise, yet complete overview of the ITS developments in the field of transport during the last years, with emphasis in the European situation. Some hints on international developments are also given where appropriate. It should be noted, that this report, focuses on the technological developments and does not attempt to shed light in the complex issue of economics and competitiveness in this field.

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