Transport Research Knowledge Centre

INTELLIGENT TRANSPORT SYSTEMS THEMATIC RESEARCH SUMMARY

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Thematic Research Summary

Intelligent Transport Systems

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Abbreviations and acronyms used

ACARE	Advisory Council for Aeronautics Research in Europe
ACEA	Association des Constructeurs Européens d'Automobiles (European Automobile Manufacturers' Association)
ADAS	Advanced Driver Assistance Systems
ADS-B	Automatic Dependent Surveillance - Broadcast
AIS	Automatic Identification System
AS	Airborne Surveillance
ASAS	Airborne Separation Assistance System
ASAS-TN	European Airspace
ATC	Air Traffic Control
ATM	Air Traffic Management
ATS	Air Transport System
CCTV	Closed Circuit Television
CEN	European Committee for Standardization
CEPT	Common Effective Preferential Tariff
CUPID	Completely Universal Processor I/O Design
DAB	Digital Audio Broadcasting
DGTREN	Directorate General Transport and Energy
DMB	Digital Multimedia Broadcasting
DSRC	Dedicated Short Range Communication
DVB	Digital Video Broadcast(ing)
EATMS	European Air Traffic Management System
EC	European Commission
ECDG	eCall Driving Group
ECUs	Electronic Control Units
EGNOS	European Geostationary Navigation Overlay Service
EIM	Enterprise Information Management
ERA	European Research Area

ERFA	European Rail Freight Association
ERRAC	Strategic Rail Research Agenda
ERTMS	European Rail Traffic Management System
ESoP	European Statement of Principles
ETC	Electronic Toll Collection
ETCS	European Train Control System
ETSI	European Telecommunications Standards Institute
EU	European Union
EVC	Enhanced Video Connector
FAA	Federal Aviation Administration (US government)
FERRMED	Rail Freight Competitiveness in Europe
FIA	Futures Industry Association
FP5	Fifth Framework Programme
FP6	Sixth Framework Programme
FSD	Full Set of Data
FWF	Firewall Forward
GDP	Gross Domestic Product
GIS	Geographic Information System
GNSS	Global Navigation Satellite System
GPRS	General Packet Radio Service
GPS	Global Positioning System
GS	Ground Surveillance
GSM	Global System for Mobile Communications (cellular phone technology)
GVC	Galileo Vehicle Company
HLTCs	High-Level Target Concepts
HMI	Human Machine Interface
ICC	Intelligent Cruise Control
ICT	Information and Communication Technologies
IP	Internet Protocol

ISA	Intelligent Speed Adaptation
ISO	International Organization for Standardization
ITS	Intelligent Transport Systems
ITU	International Telecommunication Union
IVSS	Intelligent Vehicle Safety Systems
MAS	Multi Agent System
Mitre	Missile Test and Readiness Equipment
MOS	Maritime Operational Services
MSD	Minimum Set of Data
NASA	National Aeronautics and Space Administration (USA)
OBE	On-Board Equipment
OECD	Organisation for Economic Co-operation and Development
OEMs	Order Entry Management System
OPRC	Oil Pollution Preparedness Response and Co-operation
OTA	Office of Technology Assessment
PA	Public Authorities
PAA	Personal Assistant Agent
PDA	Personal Digital Assistant
PPP	Public Private Partnership
PSAP	Public-safety Answering Point
PT	Public Transport
R&D	Research & Development
RDS-TMC	Radio Data System - Traffic Message Channel
RFF	Ready For Ferry
RSE	Roadside Equipment
RTD	Research and Technological Development
RTTI	Real-Time Traffic and Travel Information
SAR	Search and Rescue
S-DB	Satellite Digital Broadcast

SME	Small and Medium Enterprises
SP	Service Providers
SRA	Strategic Research Agenda
SRA	Strategic Research Agenda
TEN	Trans-European Networks
TISA	Traveler Information Services Association
TMA	Transport Mode Agent
TMC	Traffic Message Channel
TPEG	Transport Protocol Expert Group
TRKC	Transport Research Knowledge Centre
TRS	Thematic Research Summary
UIP	International Union of Private Wagons
UIRR	International Union of Combined Road-Rail Transport Companies
UMTS	Universal Mobile Telecommunications System
VIN	Vehicle Identification Number
VMF	Variable Message Format
VMS	Vessel Monitoring System
VTM	Vessel Traffic Management
VTS	Vessel Traffic Services
WAP	Wireless Application Protocol
WRC	World Radiocommunication Conference

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Foreword

This paper has been produced as a part of the activities of the TRKC (Transport Research Knowledge Centre) project of the Sixth Framework Programme..

The role of TRKC, as its predecessor project EXTR@Web, is to collect, structure, analyse and disseminate transport research results. It covers EU-supported research, as well as research financed nationally in the European Research Area (ERA) and selected global RTD programmes. The main dissemination tool, used by TRKC, is the public web portal at www.transport-research.info.

The approach to dissemination of results of the research projects, adopted by the TRKC team, includes the following three levels of analysis:

- **Project Analysis**, which provides, project by project, information on research background, objectives, results, technical and policy implications;
- **Thematic Analysis**, which pools findings of research projects according to a classification scheme based on into thirty themes, fixed for the life time of the TRKC project; the product of this analysis activity is the set of **Thematic Research Summaries** (**TRS**); the present document belongs to this set;
- **Policy Analysis**, which pools findings of research projects according to combinations of themes based on ad-hoc policy priorities, which are agreed with DGTREN of the European Commission and the representative group of research users.

The present Thematic Research Summary deals with Intelligent Transport Systems (ITS). The aim is to provide the reader with a structured guide to the results of research projects carried out mainly in the European Research Area (ERA). The paper is intended for policy makers at the European, national and local levels, as well as interested readers from other stakeholders and from the academic and research communities.

Disclaimer

The analysis in this paper is under responsibility of the TRKC project team; it does not represent the official viewpoint of the European Commission; it has not been approved by the coordinators of the research projects reviewed.

Executive summary

This paper has been produced as part of the activities of the TRKC (Transport Research Knowledge Centre) project of the Sixth Framework Programme. The role of TRKC, as its predecessor project EXTR@Web, is to collect, structure, analyse and disseminate transport research results. TRKC provides comprehensive coverage of transport research in EU programmes as well as key research activities at national level within the European Research Area and selected global programmes.

The paper is one of the thematic research summaries (TRS). The TRSs aim at providing a synthesis of research results and policy implications from completed projects. Each TRS deals with a theme according to the classification, which the TRKC project has adopted. The theme of this TRS is Intelligent Transport Systems (ITS).

The first part of the paper includes a brief analysis of the scope of the theme, and a policy review where the main policy developments at EU level are summarised.

The ITS theme deals with several combinations of communication, computer and control technology developed and applied in the domain of transport to improve system performance, transport safety, efficiency, productivity, and level of service, environmental impacts, energy consumption, and mobility. ITS refers to efforts to add Information and Communications Technology (ICT) to transport infrastructure, vehicles and transport/traffic management in an effort to manage factors that typically are at odds with each other, such as vehicles, loads, and routes to improve safety and reduce vehicle wear, transportation times, and fuel consumption.

Policy developments at EU level have traditionally been related to: the promotion of intermodality and interoperability, with particular regard to traffic management systems; the development of the Trans-European network infrastructure; legislative initiatives to open market of transport services to competition; and infrastructure charging as a means to achieve better modal balance.

The second part of this paper includes a synthesis of the main findings and policy implications from research projects and is concluded with an overview of the implications for further research. The research projects synthesised are EU-funded projects from the Fifth and the Sixth Framework Programmes that have results publicly available. Projects that had been reviewed in the related paper produced within the predecessor project EXTR@Web are briefly summarised. This latter paper also included a selection of nationally funded projects.

Six sub-themes are considered in the synthesis. The following are the main achievements.

In the sub-theme concerning **road traffic management and control:**

- RTTI (Real-time Traffic and Travel Information) is the first area of a new generation of telematics services for drivers and other travellers to achieve appreciable success. Currently, this is due to the fast-growing implementation of services and products based primarily on existing RDS-TMC broadcast technology.

In the sub-theme **air traffic management and control:**

- An operational concept validation methodology has been developed, which makes the concept validation in ATM (Air Traffic Management) R&D projects easier, facilitating earlier and more consistent evaluation of the fitness for purpose and adequacy of the concept, both for stakeholders and project managers, allowing adjustment to take place at an earlier stage, and making comparisons among different projects possible and significant;
- Significant progress in the global definition, harmonisation, and validation of ASAS (Airborne Separation Assistance System) and ADS-B (Automatic Dependent Surveillance – Broadcast) applications on ground surveillance (GS) and airborne surveillance (AS) has been achieved.

In the sub-theme concerning **maritime traffic management and control:**

- A Maritime Operational Services (MOS) concept, which integrates several maritime operational services (such as Vessel Traffic Management – VTM and Search and Rescue – SAR) to enhance efficiency of maritime transport, has been developed.

In the sub-theme **safety and emergency systems**:

- Generation of the knowledge and development of methodologies and human-machine interface technologies required for safe and efficient integration of ADAS, IVSS (Intelligent Vehicle Safety Systems) and nomad devices into the driving environment;
- Developing, testing and validating common specifications for the vehicle emergency call at all levels in the vehicle emergency call chain and to investigate the technical, organisational and business structure for Europe-wide take-up of the solution.

In the sub-theme **satellite based technologies**:

- Investigation of conceptual and technical issues concerning the technical feasibility of using DAB satellite, terrestrial cellular communications (GSM, GPRS) capabilities for the provision of integrated navigation and fleet-management services;
- Investigation of conceptual and technical issues concerning the ITS industry aimed at supporting intermodal transport;
- A need for intelligent and personalised info-mobility services, covering the whole travel chain and being Europe-wide and flexible.

In the sub-theme **ITS architecture**:

- Increasing importance of ITS to be fully compatible, not only within a single country, but also at the international level;
- Provision of guidelines for the planning, design or implementation of ITS application.

In the sub-theme **cross border cooperation**:

- Activities contribute to the goal of the focusing on rail in a pan-European dimension;
- Implementing the ERRAC Strategic Rail Research Agenda 2020 by capturing the threefold increase in freight volumes by 2020;
- Harmonisation and integration of development of the telematics infrastructure for traffic management systems and traffic information services, and interoperable systems of automatic tools applicable in European countries.

In the sub-theme **electronic fee collection (EFC)**:

- Definitions of the framework for an interoperable European EFC service for road tolls and charges based on a central account;
- Issue of having on-board equipment and an associated contract that enables them to travel through all concession areas.

1. Introduction

This paper provides a structured review of the research relating to Intelligent Transport Systems, carried out in transport research projects throughout the European Research Area (ERA). The theme "Intelligent Transport Systems" is one of the thirty themes in the classification scheme adopted by the TRKC project. The scheme, and the ITS position in it, is shown in the table below.

Table 1. The classification scheme adopted in TRKC

Sectors
• passenger transport • freight transport
Geographic
• urban transport • rural transport • regional transport • long-distance transport • EU accession issues
Modes
• air transport • rail transport • road transport including walking and cycling • waterborne transport • innovative modes • intermodal freight transport
Sustainability policy objectives
• economic aspects • efficiency • equity and accessibility • environmental aspects • user aspects • safety and security
Tools
• decision support tools • financing tools • information and awareness • infrastructure provision including TENs • integration and policy development • **Intelligent Transport Systems (ITS)** • regulation/deregulation • land-use planning • transport management • pricing and taxation • vehicle technology

The scheme has been adopted to enable search facilities in the TRKC portal, and to ensure comprehensive coverage of research results and appropriate policy analysis in the

Thematic Research Summaries (TRS). Definitions for each theme are found on the TRKC portal at www.transport-research.info/web/projects/transport_themes.cfm.

In the predecessor EXTR@Web project, TRSs were produced for 28 out of the thirty themes (resulting from merging of some themes into a single TRS). The TRKC project is producing first versions of TRS for a sub-set of themes for which a critical mass of results from projects is available by July 2008 (including this one on ITS). Final versions of TRSs for the full set of themes are planned for production in December 2009.

A large number of research projects have dealt with the theme addressed by this paper and the nature of the TRKC's classification scheme is that all overlap with at least one other theme, and in many cases several themes. The thematic research summary "Intelligent Transport Systems (ITS)" produced in the predecessor project EXTR@Web (EXTR@Web, 2006), had reviewed research from European projects belonging to the Fifth Framework Programme (FP5) and national projects. The paper here adds new projects to the analysis reported on in that paper. The new projects are mainly European projects from FP5 and FP6.

The research reviewed in this paper does not represent the entire range of research dealing with ITS carried out in Europe. The paper focuses on research from those projects, which have prepared documentation on their results available to the TRKC team after the issue of the EXTR@Web paper (EXTR@Web, 2006). A summary of the research, reported on in the EXTR@Web paper, is also included to make the reader aware of a more complete range of research, which has dealt with the theme.

The paper is organised as follows. Sections 2 and 3 set the scene. **Section 2** includes a brief analysis of the scope of the theme. **Section 3** provides an overview of the policy priorities at EU level, which underpin the research objectives. The sources for this section are principally European Commission documents, which have set the policy agenda such as white papers, green papers, and communications.

Section 4 reports on the results from specific research projects. The section is structured according to sub-themes to make the broad area of research, which has dealt with ITS, more manageable. For each sub-theme, the research objectives and findings are reported on. A special focus is given to the policy implications of research results. **Section 4** is concluded with an overview of the gaps and topics for future research, which could be identified by the projects. Sources for Section 4 are documents available from the projects and reporting on achievements, essentially the project final reports and selected deliverables.

The sub-themes covered in Section 4 are:

- sub-theme 1: road traffic management and control;
- sub-theme 2: air traffic management and control;
- sub-theme 3: maritime traffic management and control;
- sub-theme 4: safety and emergency systems;
- sub-theme 5: satellite based technologies;
- sub-theme 6: ITS architecture;
- sub-theme 7: cross border cooperation;
- sub-theme 8: electronic fee collection.

The **Annex** 1 includes the list of the research projects that have been reviewed in the paper. Links to the projects' websites are included. In several cases these websites make the project documentation available to the public. This may include final reports and project deliverables.

2. Scope of the theme "ITS"

Intelligent Transport Systems (ITS) comprise several combinations of communication, computer and control technology developed and applied in the domain of transport to improve system performance, transport safety, efficiency, productivity, and level of service, environmental impacts, energy consumption, and mobility. In certain cases, ITS are known as Transport Telematics Applications that play particularly vital roles in ensuring mobility for all and meeting demand in increasingly competitive markets.

Intelligent Transport Systems represent the next step in the evolution of the entire transportation system. These technologies include the latest in computer, electronic, communication and safety systems.

ITS can be applied to vast transportation infrastructure of highways, streets, bridges, tunnels, railways, port and airport infrastructure, as well as to a growing number of vehicles, including cars, buses, trucks and trains, as well as aircraft and waterborne vessels. They can be used both for passenger and freight transport. These Information and Communications Technologies (ICT) provide the means to improve service quality, safety and management of transport systems.

ITS apply to all transport modes and can facilitate their interlinking (co-modality). Typical applications include (multi-modal) pre-trip planners, combined public transport ticket dispensers or River Information and Air Traffic Control Systems. Examples in road transport are dynamic traffic management with variable speed limits, Parking Guidance & Reservation, Intelligent Navigation Devices and (Advanced) Driver Assistance Systems (ADAS) like Electronic Stability Control or Lane Departure Warning Systems, and Electronic Fee (or Toll) Collection (EFC / ETC).

Interest in ITS comes from the problems caused by traffic congestion and from a possible synergy of new information technology for simulation, real-time control, and communications networks. Traffic congestion has been increasing worldwide as a result of increased motorisation, urbanisation, population and economy growth, and changes in population density. Congestion reduces efficiency of transportation infrastructure and increases travel time, air pollution, and fuel consumption, which also lead to increased costs.

Intelligent transportation systems vary in technologies applied, from basic management

systems such as car navigation; traffic signal control systems; container management systems; variable message signs; enforcement systems to monitoring applications, such as security CCTV systems; and to more advanced applications that integrate live data and feedback from a number of other sources, such as parking guidance and information systems; weather information; (Bridge Detection Systems). Additionally, predictive techniques are being developed in order to allow advanced modelling and comparison with historical baseline data.

The ITS applications fields of use can be classified by transport modes (road, rail, air, pipeline, maritime, inland waterway, ports, and intermodal chains), by transport types (passenger, freight) and by transport ranges (urban, regional, interregional, corridor, Trans-European).

3. Policy context

3.1 First steps of the Common Transport Policy

One of the main pillars of the European transport policy is to stimulate technological innovation in order to address transport problems. Recent ITS activities also focus on satellite navigation, with a view to optimising traffic management, whether surface, waterborne or aerial.

An important contribution to the common transport policy was the first White Paper on this theme, published in December 1992 “The Future Development of the Common Transport Policy” (COM(92)0494).

In 1998, the European Commission in the paper entitled “Sustainable Mobility: Perspectives for the Future” settled the priorities for the period, following the Action Programme for 1995 to 2000, aiming to increase quality of transport systems. Among the several priorities, the issues of Intelligent Transport Systems were clearly addressed.

3.2 White Paper

In September 2001, the “European transport policy for 2010: time to decide” White Paper recognising the growing importance of transport in modern economies, identified several policy objectives aiming to achieve better efficiency in transport systems by implementation of ITS.

- The European transport system has to overcome several major challenges in order to play its full role in satisfying the mobility needs of the European economy and society:
- Road traffic congestion is estimated to affect 10 % of the road network, and yearly costs amount to 0.9-1.5 % of the EU GDP.
- Road transport accounts for 72 % of all transport-related CO2 emissions, which increased by 32 % (1990-2005).
- Whilst road fatalities are falling (-24 % since 2000 in EU27) their number (42 953 fatalities in 2006) is still 6 000 above the intended target of a 50 % reduction in fatalities in the period 2001-2010.

These challenges are even more pressing with forecasted growth rates of 50 % for freight transport and 35 % for passenger transport in the period from 2000 to 2020. The main policy objectives arising from these challenges are for transport and travel to become:

- Cleaner,
- More efficient, including energy efficient,
- Safer and more secure.

It is however clear, that conventional approaches such as the development of new infrastructure, will not give the necessary results in the timescales required by the magnitude of these challenges. Innovative solutions are clearly needed if we are to achieve the rapid progress demanded by the urgency of the problems at hand. It is high time for Intelligent Transport Systems to play their due role in enabling tangible results to emerge.

Intermodality is of fundamental importance for developing competitive alternatives to road transport. Although there have been a few achievements in the freight domain, such as intermodal freight trains, containerisation and improvement of links to ports, a much greater effort is required to ensure fuller integration of the modes offering considerable potential transport capacity by intelligent transport systems. The same applies to multimodal passenger journeys, where ITS needs to help overcome issues like lack of information (or sometimes too much information which is difficult for the user to comprehend and select the best option), complexity of through booking and payment, and lack of reliability of connections between transport modes and operators.

Intelligent mobility solutions and transport demand management based on smart charging will alleviate congestion, but new or improved infrastructure will also be needed. In the longer run, there is no reason why aircrafts should have sophisticated communication, navigation and automation, and not ships, trains or cars. New technologies, coming to market, will allow improved real-time management of traffic movements and capacity use. Investment in viable alternatives to congested road corridors can support intelligent solutions involving co-modal logistic chains, which optimise the use of transport infrastructure within and across different modes. This includes transalpine tunnels, rail corridors and intermodal nodes for rail, sea and air transport.

3.3 ITS Action Plan

The ITS Action Plan for road transport, published by the European Commission in December 2008 (CEC, 2008c), has adopted a number of targeted measures and a proposal for a Directive laying down the framework for their implementation (CEC, 2008d). ITS can significantly contribute to a cleaner, safer and more efficient road transport system. The main goal is to speed up a market penetration of rather mature ITS applications and services in Europe.

Actions in this plan include greener transport, decreasing congestion and reducing energy consumption, improving road safety & security, improving mobility for citizens and transport logistics.

The main aims of greener transport are reduced congestion and energy consumption through optimisation of the infrastructure use and interaction of modes, to lower congestion on EU freight corridors and in cities and to enhance modal shift.

The road mode is the main focus of actions to improve safety, being the mode which produces the greatest number of accidents and deaths, and there is also a focus on commercial transport operations.

Improving mobility for the citizen and transport logistics involves providing more reliable Real-time Traffic and Travel Information (RTTI) in a safe way and improving the efficiency of logistics chains.

Main policy actions are as follows:

1. Optimising use of infrastructure/better traffic management & interaction of modes.

2. Reducing congestion freight corridors/in cities - developing European solutions for flexible demand management.

3. Enhancing the use of environmentally friendly & energy efficient transport solutions.

4. Improving safety / security of commercial transport operations – 'social' regulations, dangerous goods.

5. Improve road safety.

6. Providing more reliable RTTI.

7. Improving the efficiency of logistics chains.

The action plan also focuses on vertical areas below.

1. Synergies by combining applications and services in the area of commercial and private transport.

2. Framework for optimised use of latest road data, access to data and provision of traffic Info.

3. Data security, protection of individual's data and liability.

4. Strengthening public authorities' capability in ITS.

5. Framework for programme coordination.

6. Demonstrating the case for ITS.

3.4 i2010 Intelligent Car Initiative

The use of information and communication technologies (ICT) in building intelligent cars can contribute towards increasing road safety by these elements:

- Making transport systems more efficient;
- Using fuel more efficiently; helping drivers to prevent or avoid accidents;
- Providing drivers with real-time information about the road network in order to avoid congestion;
- Enabling drivers to optimise journeys.

More specifically, studies have shown that the use of ICT could enable the number of accidents in the European Union (EU) to be reduced considerably. For example, 1 500 accidents a year could be avoided if 0.6% of vehicles were equipped with systems helping them to stay in lane or to overtake.

The European Commission has identified a number of barriers to the deployment of this potentially life-saving technology. In February 2006, therefore, the Commission launched the "Intelligent Car Initiative", to remove bottlenecks in rolling out intelligent systems and to speed the development of smarter, safer and cleaner transport for Europe.

The Intelligent Car Initiative will accelerate the deployment of intelligent vehicle systems in European and international markets, using a mix of policy, research and communications instruments to:

- Ensure interoperability across different EU countries and harmonise technical solutions through a comprehensive European approach;
- Support ICT-based research and development in the area of transport and facilitate the take-up and use of research results;
- Raise awareness of the potential benefits of ICT-based solutions among consumers and decision-makers.

3.5 SESAR

The SESAR system is the EU's response to the problem of Air Traffic Control in international corridors. The European Council identified the project in 2005 as one of the "projects of common interest" for infrastructure to be implemented. SESAR is the technological element of the Single European Sky, adopted in March 2004, which lays down a clear organisation and establishes cross-border blocks of airspace. With these blocks, routes and airspace structures are no longer defined in accordance with borders but in accordance with the operational reality of traffic.

- The implementation of SESAR has required several stages. Given the differences between the various air traffic control systems in Europe and the diverse nature of the fleet currently in service, a transitional period was necessary. The implementation of SESAR therefore is being carried out in three phases: A definition phase (2005-2007), in which the air traffic modernisation plan (or "ATM Master Plan") was carried out, dealing with the different technological stages, priorities and timetables;
- A development phase (2008-2013) will make it possible to develop the basic technologies which will underpin the new generation of systems;
- A deployment phase (2014-2020), which will see the large-scale installation of the new systems and the widespread implementation of the related functions. In the view of the Commission, the new system will triple capacity in comparison to the current situation, with safety increased tenfold and unitary operating costs far lower than current levels.

3.6 Other specific initiatives

In the logistics and freight transport area, the recent Freight Transport Logistics Action Plan (CEC, 2007a) has focused on the application of ICT (Information and Communication Technologies) for the development of e-freight and in particular of “internet for cargo”, on the identification of operational, infrastructure and administrative bottlenecks, on vehicle dimensions and loading standards.

In the telematics technologies area, the European global satellite system (Galileo) for location and timing is under development.

In the traffic management area, the focus has been on technical interoperability of telematics infrastructure and devices: electronic fee collection for road transport; the

development of European Air Traffic Management System (EATMS) for a single European sky within the SESAR programme; the development of the European Rail Traffic Management System (ERTMS); the development of Vessel Traffic Management and Information Systems (VTMIS) and River Information Services (RIS) systems.

In the local and regional passenger transport area, a major initiative has been the promotion of a Citizens' Network for the development of high quality collective transport of all kinds, including appropriate interfaces for the car user (CEC, 1995b; CEC, 1998b).

4. Research findings

4.1 Introduction

The research synthesised in this paper, deals with six sub-themes, as shown in the figure below. Each sub-theme is a domain for policy action. Actions in these domains have the potential to improve intelligent transport systems.

The first sub-theme deals with **road traffic management and control**. This topic includes cooperative systems and technologies, traffic information, efficiency of traffic management. Cooperative systems, based on vehicle-to-vehicle and vehicle-to-infrastructure communications, directly relate to the efficiency and traffic management and congestion management. Traffic information is focusing on implementation of services and products based primarily on existing RDS-TMC broadcast technology, TMC and TPEG upgrade static navigation to real-time, i.e. dynamic route guidance, or “electronic traffic avoidance”.

The second sub-theme relates to **air traffic management and control**. This topic include development of validation concepts and methodology, which makes the concept validation in ATM (Air Traffic Management) R&D projects easier, facilitating earlier and more consistent evaluation of the fitness for purpose and adequacy of the concept, both for stakeholders and project managers, allowing adjustment to take place at an earlier stage, and making comparisons among different projects possible and significant. Focus of ground surveillance (GS) and airborne surveillance (AS) has been achieved.

In the third sub-theme, concerning **maritime traffic management and control**, a Maritime Operational Services (MOS) concept, which integrates several maritime operational services (such as Vessel Traffic Management – VTM and Search and Rescue – SAR) to enhance efficiency of maritime transport, has been developed.

The fourth sub-theme relates to **safety and emergency systems**. The focus is on development and use of Intelligent Vehicle Safety Systems (IVSS) that utilise information & communication technologies to increase road safety and to reduce the number of accidents on European roads. The use of in-vehicle emergency call (eCall) to deploy emergency assistance to the number of road accidents by improving the notification of accidents, speeds up the emergency service.

The fifth sub-theme deals with **satellite based technologies**. Galileo and EGNOS, European satellite navigation systems, among others enable the possibility of using satellite positioning in crucial 'safety-of-life' transport applications, including aviation. They focus on the dual frequencies as a standard, which is unprecedented for a publicly available system. The theme deals with the integration between different communication technologies, allowing to take full advantage of their individual potential and overcoming their limitations.

The sixth sub-theme relates to a growing number of European countries that are now adopting the Framework Architecture as the basis for their national **ITS architectures**. This brings a growing use of advanced telematic technologies into modern transport systems, their increasing complexity and the importance of ensuring integration and interoperability between systems. The purpose is to provide guidelines for the planning, design or implementation of ITS application. ITS architectures usually come in very different forms and levels; they are based on the European framework. They range from specific structures, such as the layout of a communication system or the design principles for an individual ITS element, to high-level concepts representing the underlying framework of a whole project.

The seventh sub-theme relates to fostering **cross-border coordination** of strategies, systems and services (e.g. Traffic Management Plans), optimisation of the road capacity use by implementing innovative cross-border ITS applications. Issues of relevance include the enhancement of the attractiveness of sustainable modes – rail and maritime above all, in order to lower traffic on congested roads – and the development of intermodality in freight transport.

The eighth sub-theme deals with convergence of interoperable **electronic fee collection** systems to facilitate traffic flow and the payment of fees, in particular for subscribers, heavy goods vehicles (HGVs) and long distance coaches. Electronic Fee Collection (EFC)[1] systems offer the possibility of charging road vehicles in a more flexible way. Such systems have to be interoperable across national borders to avoid creating new obstacles to traffic flow in Europe. Existing motorway EFC systems make use of Dedicated Short Range Communication (DSRC) between fixed roadside equipment and vehicles. Another type of system is based on satellite location (Global Navigation Satellite System -GNSS) and mobile telephone technology (GSM).

[1] Or Electronic Toll Collection (ETC), when applied to road traffic, as EFC can also cover payment for other types of services.

The overview of the specific sub-themes is given in the following table.

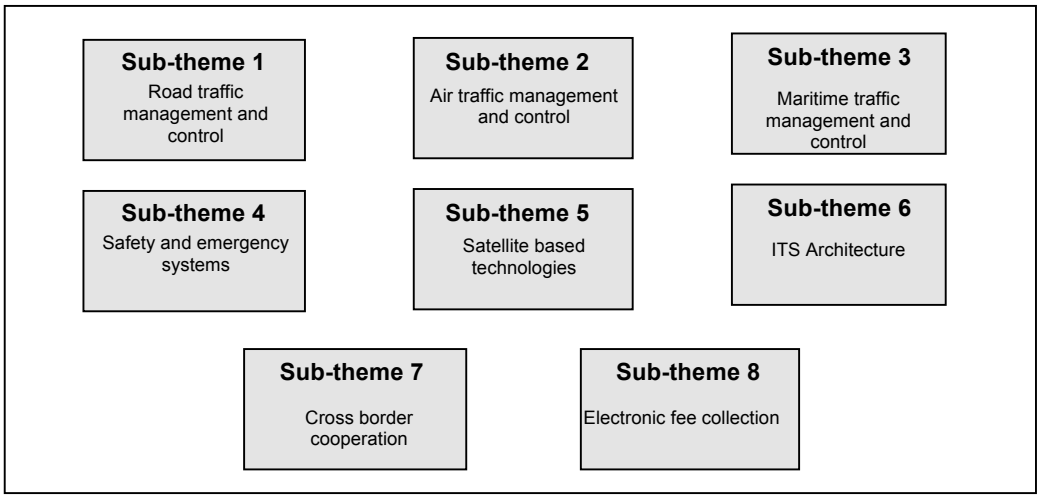

Table 2 below shows the EU-funded projects, which have dealt with each of the sub-theme. Further details of projects listed in this table are given in the Annex. The Table includes:

- projects which had been synthesised in the EXTR@web TRS and which are briefly summarised in the background of the following sub-sections;
- completed projects which are synthesised in this TRS and for which the following sub-sections report on research objectives, research results, policy implications and implications for further research;
- projects which are still on-going or which, although completed, have not yet made results publicly available.

Table 2. Projects relevant to the theme

Sub-theme	Contributing projects
1. Road traffic management and control	Projects covered in this paper: RoadCast; CONNECT; AGORA Projects covered in EXTR@Web paper: DENSETRAFFIC; EYE IN THE SKY; SMARTNETS; RESPONSE 2; TASKU (FI); COMPOSE Other EU projects for which the TRKC project has not yet received results: CIVITAS CATALIST; eMOTION; REDUCE; HEAVYROUTE; HOST; RAILCOM; SAFE-RAIL
2. Air traffic management and control	Projects covered in this paper: SUPER-HIGHWAY Projects covered in EXTR@Web paper: THEATRE; ADAMANT Other EU projects for which the TRKC project has not yet received results: CAATS II; Episode 3; iFLY; NEWSKY; IFATS; AIRNET; OPTAG; SWIM-SUIT; ATENAA, AIRNET
3. Maritime traffic management and control	Projects covered in this paper: MARNIS Projects covered in EXTR@Web paper: INDRIS Other EU projects for which the TRKC project has not yet received results: OPTINAV
4. Safety and emergency systems	Projects covered in this paper: AIDE; HUMANIST; APROSYS; ESCOPE; PREVENT; E-MERGE Projects covered in EXTR@Web paper: APOLLO; ADVISORS; BOJCAS; CHAMELEON; SAFET; SAMNET; SEAM; SUNFLOWER Other EU projects for which the TRKC project has not yet received results: IN-SAFETY; REACT; SAFEDMI; ASSTAR; EUDDPLUS, SAFE-AIRPORT
5. Satellite based technologies	Projects covered in this paper: RELY; Egnos; IM@GINE IT; GEMINUS; HIGHWAY Projects covered in EXTR@Web paper: GADEROS; GALA; GALLANT; GENESIS Other EU projects for which the TRKC project has not yet received results: HEAVYROUTE; ASPASIA
6. ITS architecture	Projects covered in this paper: EASIS; FRAME-S; FRAME-NET Projects covered in EXTR@Web paper: FRAME-S; FRAME-NET Other EU projects for which the TRKC project has not

Sub-theme	Contributing projects
	yet received results: None
7. Cross border cooperation systems	Projects covered in this paper: FREIGHTWISE; NEW OPERA Projects covered in EXTR@Web paper: ESCUGIBRI; NAUPLIOS; NOPSEURA; S240B; SAMRAIL; SIMTAG; THEMES; CITY FREIGHT; CONPASS; e-THEMATIC; GIFTS; HISPEEDMIX; IDIOMA; ISHTAR; ROLLING SHELF Other EU projects for which the TRKC project has not yet received results: KITE; CREAM; SIMBA; RAILCOM; EDIP
8. Electronic fee collection	Projects covered in this paper: PROGRESS; INTRO; CARDME Projects covered in EXTR@Web paper: TRACE;TRAFFIC Other EU projects for which the TRKC project has not yet received results: CEASAR

4.2 Sub-theme 1: Road traffic management and control

4.2.1 Background

Research reviewed in the related EXTR@Web paper (EXTR@Web, 2006) which addressed this sub-theme covered the creation of new technologies that, when applied to transport systems, can in some way allow better conditions in order to increase safety, intermodality and allow more efficient use of transport infrastructure.

The development of technologies can also contribute to the development of new services, helping to improve mobility, transport management, quality and efficiency of transport using different communication technologies and protocols such as, for example, Wireless Application Protocol (WAP).

4.2.2 Research objectives

Research objectives focused on the development and validation of traffic management systems for road transport.

Researchers in this field focused mostly on Real-time traffic and travel information (RTTI) that can contribute greatly to safety as well as on facilitating access to public sector data and enable the private and public sectors to cooperate in the service provision.

RTTI is the first area of a new generation of telematics services for drivers and other travellers to achieve appreciable success. Currently, this is due to the fast-growing implementation of services and products based primarily on existing RDS-TMC/GSM broadcast technology. By delivering traffic data messages promptly to a suitable in-vehicle terminal, TMC and TPEG upgrade static navigation to real-time, i.e. dynamic route guidance, or “electronic traffic avoidance” while giving safety benefits by alerting drivers to accidents, congestion and hazardous driving conditions.

Floating Vehicle Data, ‘Floating Phone Data’ (GSM network-based telephone location) and other advanced data collection techniques are now being used to support high quality TMC services. Public/private partnerships help increase the use of these techniques (CONNECT 2005).

4.2.3 Research results

Research focused mainly on traveller information services. RDS-TMC receiver deployment has reached mass-market status thanks to its relationship with navigation systems, particularly the booming Personal Navigation Device market.

The Traveller Information Services Association (TISA) was founded on the basis of TPEG project. This project aimed to develop a new and open international standard for broadcasting language independent and multimodal traffic and travel information. It covers all modes such as road, bus, train, ferry, air traffic and may be distributed over a wide range of digital media (Digital radio/DAB, Internet, DVB, etc).

The major objective of this project was to test and validate the TPEG data stream on the DAB broadcast network and the Internet with specifically developed TPEG software decoders from the Consumer Electronics industry that would permit to test the wide range of TPEG functionalities specified in the European pre-standards of CEN TC 278.

The Traveller Information Services Association (TISA) continues to support wider use of RDS-TMC through assistance for new and existing EU Member States and organisations. It offers:

- Advice on all aspects of setting up TMC services
- Harmonisation, standardisation and quality assurance, e.g. certification of Location Tables
- Development work to implement new features to improve services.
- Development work on advanced TPEG services for digital bearers such as DAB, DVB and DMB (CONNECT 2005).

Traffic management is inherently connected with traffic flow management. Capacity bottlenecks in the road network limit the capacity of the adjacent sections. A frequent cause for such capacity bottlenecks in the major road network are lane drop offs in the context of construction sites. On Austrian motorways, capacity bottlenecks caused by construction sites are concentrated to the summer, when the traffic volume rises by reasons of holiday traffic, in addition to the common level. These arrays are designed as merging segments, where vehicles change from the off dropping to the remaining lanes. These manoeuvres cause discontinuity in the traffic flow, so that the capacity of a merging section is lower than the one of a basic freeway lane.

Experience shows that traffic overloads cause unstable conditions of the traffic flow, which clearly reduce the capacity and also result in a decrease of traffic safety; suitable traffic management and information measures can increase the capacity; compliance

suffers from discrepancies between posted information and the actual traffic situation (RoadCast, 2004).

The use of higher-bandwidth communication media (such as terrestrial or satellite DAB) and the results of research initiatives such as AGORA project contributed to further development of space syntax methodologies and to integration of live data with GIS to model the changes in use of space by citizens in city districts and urban corridors. The project investigated how space and movement interact with other characteristics of the urban environment (pioneering on-the-fly location referencing) and TPEG (new protocols extending the message set and supported applications) can help broaden the capability for future RTTI services (AGORA 2005).

The most important findings from the research activities in telematics system for weather forecast and information systems field are:

- A speed limit of 60 km/h can maintain flowing traffic conditions slightly longer than a speed limit of 80 km/h.
- A speed funnel can delay the beginning of congestion distinctly. Therefore it is appropriate to survey the application of a speed funnel in an on-road test.
- In case of flowing traffic with higher speeds it is favourable that drivers change lane previous to the lane drop. So a longer area (some 100 meters) can be used for merging and drivers can find a sufficient gap by moderating speed positively.

Under congested conditions the highest capacity can be obtained if the ending lane is used until its very end. Alternate merging affects the capacity advantageously. On the basis of these findings an information system was developed, which consists of different signals, sensors and a control unit. For a high effectiveness of the information transmission different embodiments and texts should be put to an on-road test.

In a next step the proposed system should be assigned to and tested at sites with long-term lane drops and expanded by a dynamic speed funnel. The results of the feasibility study shall be extended in several ways:

- The form of information transfer and its control is specified and will be tested on-road.
- The application shall be extended to other highway sections with lane drops. This allows more expensive measures.
- The quantitative evaluation of the effects shall be extended by pollutant emission and traffic safety.

This optimisation affects the increase of capacity, reduces loss of time of the vehicle occupants and causes a homogenisation of the traffic flow, which causes an increase of traffic safety. (RoadCast, 2004)

4.2.4 Policy implications

The first service trials using TPEG-based technology, started in the end of 2006, formed an important step in bringing this new technology closer to market. The first limited commercial services began to broadcast in the UK in the end of 2008. Actions proposed by the RTTI recommendations were supported by several recent European projects:

- The CONNECT Euro-Regional project which (among other activities) supported the introduction of TMC in selected new EU Member States.
- Mobile info (German industry-led but wider applicability) developed TPEG-based RTTI service supporting dynamic navigation. The project delivered its output to TISA to support wider standardization and deployment work.
- TISA (Traveller Information Services Association), a non-profit organisation hosted by ERTICO and formed in order to leverage synergies of TMC and TPEG forums and technologies for a coordinated market development:
    - working on development and standardisation of new features for TMC, following requests from industry and public authorities, on an ongoing basis;
    - working on development and standardization of TPEG (Transport Protocol Expert Group) framework and travel information applications using digital bearers.

The RTTI Working Group, following the EC's Recommendation on the deployment of traffic and travel services in Europe (in 2001), has provided further analysis and recommendations for accelerating the take-up of the measures for accessing the public sector data, enabling the establishment of public-private partnerships, and the provision of reliable, high-quality RTTI services in Europe. The WG has produced a technical and economic model for implementation of RTTI services. It recognised that the only viable short-term solution is RDS/TMC, while other technologies will offer higher quality services in the future.

The RTTI WG ended its work in 2005. Among the recommendations to Member States:

- An agreement on an implementation strategy for the extension of RTTI services working to European standards is needed;
- Support the TMC Forum is encouraged;
- There should be a minimum quality for public services;
- Clear guidelines for the private sector should be published on the conditions for establishing private data collection networks for commercial vehicles;
- The frequency spectrum and broadcast capacity should be made available in the near future and support the development of future advanced digital services.

Since then, further development in the field of RTTI has taken place but the issues

regarding implementation, recommended measures and further roll-out remain open.

TISA is engaged in coordinating and supporting these actions among public and commercial stakeholders. Member State support for digital broadcast deployment is critical for widespread implementation of advanced services using TPEG to deliver a wide range of high quality RTTI and other traveller information services (E-Safety recommendations 2008).

4.3 Sub-theme 2: Air traffic management and control

4.3.1 Background

Research reviewed in the related EXTR@Web paper (EXTR@Web, 2006) which addressed this sub-theme is focused on air traffic control and safety systems. The main topics were Navigation and Surveillance (CNS) / Air Traffic Management (ATM) systems, Advanced Surface Movement Guidance and Control (A-SMGCS), Data and Voice Communications, Automatic Dependent Surveillance (ADS), Future Airborne-Ground Integration in ATM and GNSS.

4.3.2 Research objectives

Research objectives focused on the development and validation of traffic management systems for air transport (ATM) and marine transport.

Objectives included the development of strategies for improving the operational capability and safety of aircrafts in the air transport system. Current systems' capacity of managing the airspace is principally limited by the controller workload associated with monitoring and controlling aircraft separation. Airborne separation assistance system (ASAS) can reduce the controller workload, while automatic dependent surveillance-broadcast (ADS-B) supports improved use of airspace, reduced ceiling/visibility restrictions, improved surface surveillance, and enhanced safety. Consequently, research has created a thematic network to accelerate the application of ASAS/ADS-B operations in the European Airspace (ASAS-TN) with a view of increasing airspace capacity and, at the same time, maintaining or increasing safety. In order to improve efficiency in air traffic management, a research objective was to develop innovative concepts of the operational framework of the present airspace structure. To this aim, a set of Operational Concept Scenarios was developed and validated which ensures safer and more frequent flights along a Super-Highway. Three essential aspects have been considered: decreasing workload, improving the situational awareness and ensuring on time performance.

Impacts on capacity, efficiency and environment have been investigated, as well as economic aspects. The performance targets were mainly concerned with operational improvements and the user benefits (SUPERHIGHWAY, 2008).

4.3.3 Research results

Research led to significant progress in the global definition, harmonization, and validation of ASAS and ADS-B applications on ground surveillance (GS) and airborne surveillance (AS). Operational airborne and ground user needs for ADS-B were considered and the operational and technical standards required for the early implementation of ADS-B applications were developed (ASAS-TN).

GS applications consisted in:

- ATC surveillance for en-route airspace;
- ATC surveillance in terminal areas;
- ATC surveillance in non-radar areas;
- Airport surface surveillance;
- Aircraft derived data for ground tools.

AS applications categories included:

- Airborne traffic situational awareness for improving safety and efficiency;
- Airborne spacing and airborne separation for improving capacity and flexibility.

The ASAS-TN thematic network has proved to be a valuable tool for progressing ASAS and ADS-B. As an open forum for discussion it has acted as a catalyst in the understanding and acceptance of these new ideas, and has significantly contributed to international scientific and technological cooperation, with representatives from the USA (FAA, Mitre, NASA and Boeing) Australia and Japan.

Research has also defined and described two scenarios in compliance with the airspace organization described by the SESAR operational concept (SUPERHIGHWAY, 2008). The first scenario dealt with the optimization of the current airspace and route structure. Main changes are in the direction of closely spaced parallel lanes in the upper airspace that increase the currently available capacity. The design principles of this Scenario have been applied using fast time and real time simulations to highly loaded airspace routes in Europe[9] in order to evaluate the Super-Highway in terms of acceptability, safety, efficiency and capacity of procedures in handling air traffic in a Super-Highway operational environment. The second Scenario describes a pan-European approach to the design of a network of highways in European airspace.

The development of these two scenarios permitted the assessment of the following objectives for improving air traffic (SUPERHIGHWAY, 2008).

- Increase in capacity in terms of traffic rate during peak hours and traffic rate per annum; this could be met by decreasing the air traffic controller workload by around 30%.
- Increase in efficiency by reducing the delays.
- Reduction in the number of conflicts by using layered planning functions.
- ATCo perception regarding hazards and safety occurrences, through the analysis of the number and severity of potential conflicts situations.
- Improvement of planned flight times, and preservation of natural resources by decreasing the workload per aircraft, improving the situational awareness and ensuring on time performance. Also fuel consumption resulted from simulations (SUPERHIGHWAY, 2008).

4.3.4 Policy implications

Although in recent times ASAS and ADS-B applications have gained international recognition and positive progress towards acceptance has been made, there are still many issues to be addressed. Research showed that efforts should be devoted to (ASAS-TN).

- Make ASAS and ADS-B applications an integral part of the European ATM Master Plan, because it has been demonstrated that they have the potential to enhance the ATM system in the areas of safety, capacity, flexibility, efficiency and environment;
- Conduct operational trials in Europe involving revenue flight, including in-situ certification and operational approval of the applications;
- Study ASAS application as an integral part of the ATM system, in order to identify synergies with other new concept elements for maximizing benefits;
- Involve stakeholders in ASAS-TN2 activities to ensure a common understanding (Global stakeholder participation has been excellent during the project, but an increased participation of aircraft operators, particularly the airlines, and airport operators would be very beneficial.

4.4 Sub-theme 3: Maritime traffic management and control

4.4.1 Background

Research reviewed in the related EXTR@Web paper (EXTR@Web, 2006) which addressed this sub-theme covered the creation of waterborne transport telematics: Vessel Traffic Management and Information Systems (VTMIS), Integrated Ship Control (ISC), Electronic Chart Display & Information Systems (ECDIS), International Safety Management, International Safety Management Code's Implementation Tools, Maritime "Black Boxes", Cargo Information Systems, River Information Systems (RIS), etc.

4.4.2 Research objectives

A cluster of research objectives concerned the enhancement of the efficiency of maritime transport. In particular, a contribution was made to the e-Maritime concept by encouraging a systematic use of modern localisation and telecommunication techniques for all operators in the maritime sector. The focus was not only on allowing easier communication between ship and shore, but also on allowing better compliance with the wide-ranging legislation governing the sector (MarNIS). This research was motivated by the fact that even if Vessel Traffic Management (VTM), including Vessel Traffic Services (VTS) and coastal Automatic Identification System (AIS), has already achieved a significant development at local and regional level, further development and integration is required in order to develop an operational system at European level.

4.4.3 Research results

Research in MarNIS has developed the Maritime Operational Services (MOS) concept (its implementation is planned between 2012 and 2020). The MOS concept integrates several maritime operational services (such as Vessel Traffic Management - VTM, Search and Rescue – SAR, and Oil Pollution Preparedness Response and Co-operation – OPRC), which in several Member States are currently separate, and managed by different staff and resources under different institutions or ministries.

The MOS concept coordinates these services virtually, sharing information and data, using new and emerging technologies, and adopting a functional architecture, which is independent of technology.

The MOS concept can overlay real-time web-mapped (geo-spatial) information to help mitigate the risks and to mobilise emergency response resources. Web-mapped data may include real-time weather and hydrological information. Drift models can be run and visualised as a layer on the traffic image display to predict the movement of an oil slick, containers or passengers overboard (MarNIS).

4.4.4 Policy implications

The MOS concept will potentially affect the tasks and responsibilities of various authorities related to maritime transport and traffic, including not only maritime safety but also related to enforcement authorities such as customs and immigration. A European Maritime Directive, describing the legal structure, is recommended (partly developed during the

project) in order to clarify and support the interaction between all authorities and actors involved. While respecting the principle of subsidiarity, a general Directive on maritime transport and traffic will also provide uniform and transparent responsibilities for competent authorities (MarNIS).

4.5 Sub-theme 4: Safety and emergency systems

4.5.1 Background

Research reviewed in the related EXTR@Web paper (EXTR@Web, 2006) in this sub-theme, covered the creation of technologies, new developments that demonstrated the feasibility of technologies in several fields, such as using computer vision to detect unusual human behaviour (thus improving safety).

These developments enable, among others, to respond to incidents faster; better guidance; collision avoidance; better energy utilisation, and improved fleet management. The emergency call is a high priority area within the European Commission. The use of in-vehicle emergency call (eCall) to deploy emergency assistance will save lives and reduce the social burden of road accidents by improving the notification of such accidents, speeding up the emergency service response and lowering the subsequent effects on fatalities, severity of injuries and traffic flows.

4.5.2 Research objectives

The general objective of research in this field is to generate the knowledge and develop methodologies and human-machine interface technologies required for safe and efficient integration of ADAS, IVIS and nomad devices into the driving environment. Main objectives:

- To maximise the efficiency, and hence the safety benefits, of advanced driver assistance systems;
- To minimise the level of workload and distraction imposed by in-vehicle information systems and nomad devices;
- To enable the potential benefits of new in-vehicle technologies and nomad devices in terms of mobility and comfort.

Specifically, the goal of the AIDE Integrated Project was to design, develop and validate a generic Adaptive Integrated Driver-vehicle Interface (AIDE 2008).

- Maximises the efficiency of individual and combined advanced driver assistance systems by means of innovative, integrated and adaptive, human-machine interface concepts that prevent negative behavioural effects (e.g. under-load, over-reliance and

safety margin compensation). It also maximises positive effects (e.g. enhanced situational awareness), thereby enhancing the safety benefits of these systems. AIDE should demonstrate significantly enhanced safety benefits compared to existing solutions;

- Reduces the level of workload and distraction related to the interaction with individual and combined in-vehicle information and nomad devices, thereby reducing the number of road accidents. AIDE should demonstrate a significant reduction in the imposed workload and distraction compared to existing solutions;
- Enables the potential benefits of new in-vehicle technologies and nomad devices in terms of mobility and comfort, without compromising safety.

Researchers paid much attention to immunity problems that, until now, had been limited to the qualitative assessment of susceptibility problems, without taking into account the impact of new technologies on one side, and forgetting that vehicles are becoming increasingly full of communication equipment that transmits high power levels in wider frequency ranges on the other. In addition, new electronic technologies aim to design embedded controllers with stronger and more sophisticated system.

One of the main research objective areas was a wide range of Advanced Driver Assistance Systems (ADAS) for enhancing the driver's perception, interpretation and reaction in critical traffic situations and/or partly automating the driver's task in order to reduce his/her workload. The safety potential of these systems is foreseen in a great extent determined by their interaction with the driver (AIDE 2008).

Research focused on developing, testing and validating common specifications for the vehicle emergency call at all levels in the vehicle emergency call chain and to investigate the technical, organisational and business structure for Europe-wide take-up of the solution (E-MERGE 2004).

The main objective in this research area was to design eCall as an emergency call either generated manually by vehicle occupants or automatically via activation of in-vehicle sensors when an accident occurs. When activated, the in-vehicle eCall system establishes a 112-voice connection directly with the relevant PSAP (Public Safety Answering Point), which is a public authority or a private eCall centre that operates under the regulation and/or authorization of a public body.

4.5.3 Research results

Convergence on a methodology is gradually being achieved, mainly by the AIDE (developing a driver workload manager) project. Valid, easily applicable, and reliable procedures have become available as a result of recommendations. Moreover, these workload assessment procedures can be combined with actual driver behaviour parameters to yield an overall estimate of accident risk effects (i.e., reductions) that the

system would exercise. HUMANIST has proposed an overall assessment framework.

- Standardisation work has already been carried out in the relevant ISO standardisation group on assessing visual load and interruptability with the occlusion technique (ISO 16673 - Road vehicles — Ergonomic aspects of transport information and control systems — Occlusion method to assess visual demand due to the use of in-vehicle systems). It achieved good consensus and has been published as a full ISO standard. The possibility of a standardised "reference task" is under active consideration which could also assist reliability of assessment. Currently, another method is being standardised (Lane Change Test) that allows measuring the effect of driver distraction caused by in-vehicle information and communication systems on driving performance. Some vehicle manufacturers (E.g. Volvo, Renault) already offer systems that modify system outputs to the driver depending on traffic situations.
- Workload cannot be measured directly and is actively managed by the driver while driving; it would be the most difficult parameter for certification. As the installation of displays and controls is already subject to rules and regulations for integrated systems in order to avoid a compromised view and passive safety, certification should equally address the aspect of installation for nomadic devices and aftermarket systems.
- Some necessary components of workload assessment are being developed; a testing and certification methodology with a good scientific basis and a broad consensus has yet to be established.

The APROSYS project developed critical technologies to improve passive safety. Their goal was to see a reduction in road deaths. The following achievements of the project can help reach this goal:

- Development of new injury criteria;
- New mathematical models of the human body;
- A worldwide, harmonised, small female crash-test dummy for side impact testing;
- Development of knowledge and tools for design, implementation and evaluation of intelligent safety systems;
- Enhanced virtual testing technologies; and
- Test methods and advanced protection systems for injury reduction (APROSYS 2007).

The introduction of new safety functions may induce long term changes in driver behaviour. This type of behavioural change, often referred to as behavioural adaptation, may affect the actual (as compared to the expected) safety benefits of a safety measure, both positively and negatively. In the case of Electronic Stability Control, these behavioural changes did not take place, since the safety benefit is and remains very high (AIDE 2008).

There were also Intelligent Speed Management (ISM) systems on driving behaviour researched. A wide range of systems that target speeding have been introduced already more than 15 years ago and are frequently referred to as intelligent speed adaptation

(ISA) or speed limiter, intelligent cruise control (ICC) and so on, which are a further development of cruise control devices.

The operation of ISA is as follows: the system monitors vehicle speed and if it exceeds (or is detected to exceed) a threshold limit, which is related to the prevailing speed limit, the systems triggers specific actions. These actions depend on the system functionality in terms of its Human Machine Interface (HMI); and ISA can be informative, warning and intervening/mandatory. Information of the prevailing speed limit is being provided to the user usually through an in-vehicle screen (informative function) or auditory. A warning indicating that the speed limit is exceeded is being transmitted, in the case of the warning system, which can be auditory, visual or tactile. Last, the intervening function does not allow the driver to exceed the speed limit.

There are three types of system in relation to the set threshold speed. The threshold speed can be fixed, variable or dynamic. Fixed speed limits are the posted speed limits, variable also include specific places such as pedestrian crossings etc. Where there are permanent speed limits and dynamic speed limits involve temporary limits due to adverse weather conditions, school areas at start and end of school day etc (HUMANIST 2008).

The deployment of the in-vehicle emergency call (eCall) is a priority both for the industry and the public sector. In cases, where a vehicle is involved in an accident, an eCall can be initiated automatically or manually, and accurate vehicle location and additional safety related information can be passed to the Public Service Answering Point (PSAP). Such information significantly cuts the emergency response times, which in return can save lives and reduce the consequences of serious injuries (E-MERGE 2004).

4.5.4 Policy implications

To reduce the risks associated with the new in-car information, entertainment and safety systems, the EU published in 1999 a European Statement of Principles (ESoP) for Information and Communication Systems. The eSafety Forum established the HMI Working Group in February 2003 to address these issues.

- The EC has acted on one of the recommendations and formed an Expert Group to update the ESoP on HMI. A new version of the ESoP was drafted, taking into account national experiences and industry best practices along with Recommendations on Safe Use and Implementation Recommendations. These three documents were reviewed prior to being sent to the EU Member States, the European Parliament and the European Council and were published as an official EC Recommendation on 6 February 2007.
- The recommendations foresee a close cooperation with the Member States for both the dissemination of the principles and the possible transposition into national legislation, promotion of good HMI principles as an incentive for innovation and competitiveness for the European industry and for affordable and user friendly

products for the citizen, the signature of voluntary agreements, and standardisation activities.

Against the background of the publication of the update of the "European Statement of Principles on Human Machine Interface" on 2 February 2007, the June 2007 eSafety Conference in Berlin addressed the implementation and update of this EU Recommendation and reached the following conclusions: There are several ways for ensuring that the update of the ESoP is complied with and implemented. Voluntary self-commitments by the addressees of this EU recommendation (stakeholders) are, in principle, the preferred option compared to regulations or consumer protection requirements.

The eCall Driving Group (ECDG) initially agreed on a roadmap that should enable eCall to become a standard option in new vehicles type-approved after 1 September 2010 (Model Year 2011). Due to delays related to standardisation and data transport protocols with still unclear timing as well as an industry lead time of three years to develop and integrate such systems the automotive industry is no longer in a position to accept the above timing but need to insists that eCall can only be made available as a standard option three years after all standardisation and specification work is finalised and approved. It now seems that this standardisation work might be finalised in the course of 2009.

The progress towards full deployment of eCall includes many steps for which deadlines have been set but revised now for the second time:

- All key stakeholders should sign the eCall Memorandum of Understanding.
- Full standardization incl. agreement on transport and communication protocols by the end of 2008 (decision taken by ETSI in December 2008 but details still to be worked out until probably March 2009). Operating requirements for public eCall currently in ballot process, which could last until May 2009. Operating requirements for Third Party eCall Services is still under development, no short-term solution is expected.
- VIN Decoder project was expected to have been finalised by the end of 2008
- Full-scale field tests to be performed. All Member States ready to start to upgrade their PSAPs by the end of 2008. Full deployment should be ready 2 years after all specifications and standards are finalised and approved.

On 23 November 2006, the Commission adopted its third Communication on "Bringing eCall back on track". It presents an updated eCall Road Map and two actions that are crucial for making eCall a reality:

1. Member States have been given clear actions with deadlines for solving the remaining legal, technical and socio-economic issues and proceeding with the necessary 112, E112 and eCall infrastructures.

2. Industry was asked to renew its commitment to eCall. The EC has also started and finalised negotiations with the associations of the automotive industry on a voluntary

agreement for introducing eCall devices into vehicles (standard option for new type-approved vehicles after a certain cut-off date).

A few PSAP Expert meetings that took place concluded that the EC will take action in collaboration with the vehicle manufacturers to promote a harmonised Vehicle Identification Number (VIN) and the development of a VIN decoder suitable for PSAPs operation. The EC has transmitted the PSAP consensus on the MSD data to the CEN TC278 WG15 chair. A VIN Decoder software was developed by YGOMI but there are still issues with historic data (not all vehicle manufacturers contributed equally) and how to update the information in the future.

CEN TC278 WG15 reported that the CEN Plenary requested standardisation of the other eCall operational requirements, and not only the MSD content (eSafety Support 2008).

4.6 Sub-theme 5: Satellite based technologies

4.6.1 Background

Research reviewed in the related EXTR@Web paper (EXTR@Web, 2006) has addressed the utilisation of GALILEO satellite system. To achieve the purpose of discovering what can be done to increase the share of the global satellite navigation market, it was necessary to find references among the projects research objectives.

Effort is also being put in the contacts with organisations, companies and authorities to discuss GALILEO. This allowed to obtain inputs, attention and opinions concerning what can be done to take full advantage of this satellite system and other information helping to create the legal, regulatory and institutional framework that will ensure Galileo's success.

Insights have been provided on:

- Raising awareness and social acceptances of a new development;
- The European Radio Navigation Policy;
- The GALILEO satellite system and guidelines for the evaluation of ITS projects impacts.

Using Galileo, one can determine the position or location of any moving/stationary object such as a vehicle, container, etc. to within a meter using an individual receiver. The system also provides services across various sectors such as road, maritime and rail transportation, public works, social services, rescue and search activities, judicial system and custom services and recreation. The system is expected to be functional by 2010. Over the years, several countries have become part of the project, including China, India, Israel, Morocco, Ukraine, South Korea, and Saudi Arabia.

(http://ec.europa.eu/transport/galileo).

The integration of different communication technologies allows to take full advantage of their individual potential and to overcome of their limitations. Some of those communication technologies are DAB (Digital Audio Broadcasting), GSM (Global System for Mobile Communications), UMTS (Universal Mobile Telecommunication System) and GNSS.

4.6.2 Research objectives

Research has investigated conceptual and technical issues concerning the technical feasibility of using DAB satellite, terrestrial cellular communications (GSM, GPRS) capabilities for the provision of integrated navigation and fleet-management services.

Objectives include conceptual and technical issues concerning the technical feasibility of using DAB satellite, terrestrial cellular communications (GSM, GPRS) and EGNOS capabilities for the provision of integrated navigation and fleet-management services. To achieve this, the project integrates satellite audio and data broadcast, cellular technologies, EGNOS and Wireless Navigation technology capabilities into one prototype receiver (RELY 2002).

Development of understanding of user requirements through validation obtained a view on market size and willingness to pay in markets, developed legal views on the feasibility of certain differentiators (e.g. service guarantees/liability) and the optimal structure of the Galileo Vehicle Company (GVC) to make it attractive to private investors and their backers (GEMINUS 2001).

Research has investigated conceptual and technical issues concerning the ITS industry supporting, or supposed to support, the intermodal transport. Personal end user profiles, differences in culture/language and user interface preferences are rarely taken into consideration. Objectives were also addressed to intelligent and personalised info-mobility services, covering the whole travel chain and being Europe-wide and flexible (IM@GINE 2006).

4.6.3 Research results

Research led to significant progress in validation of a fully integrated EGNOS and Satellite Digital Broadcast (S-DB) hardware and services in an in-vehicle environment; in integration S-DB, GSM and EGNOS features into one platform suitable for the provision of navigation and fleet services. Applications consisted in:

- Providing new means for improving data reception compared to current systems to ensure better service availability, especially in urban canyons, tunnels;

- Demonstration of wireless navigation and fleet-management services provided via S-DB and integrating EGNOS positioning;
- Assessment of commercial viability of the service concept for the European market;
- Paving the way towards the deployment of Galileo and to proposing EGNOS-GALILEO roadmap;
- Paving the way towards the deployment of S-DB.

The Galileo thematic network has proved to be a valuable tool for improving:

- Feasibility of integration of a GNSS locator for interoperability with the ETCS On-Board;
- Development of a Common Test Bed;
- Feasibility of the application of a GNSS locator to support a Traffic Monitoring Centre.

The technical achievements are:

- Providing the Requirements Specifications for the software qualification tools;
- The data content, structures and qualification criteria of DigitalRoute Maps, including the update of software procedure specifications;
- Contribution to the technological development of GNSS Locators and of Safety Qualifiers;
- Requirements Specification for test, verification and evaluation procedures applicable to validations according to EU standards specification relevant to railway safety and under the frame of ERTMS/ETCS Interoperability Directive.

The value net framework identifies each participant that contributes to customer value (i.e. players in the game) and maps their interdependencies to understand who is adding value and how. Mapping the interdependencies also provides a baseline for understanding value creation strategies (Midterm Evaluation of the Galileo project, 2008).

Through the combination of smart real-time maps, UMTS 3G mobile technology, positioning systems and intelligent agent technology, 2D/3D spatial tools and speech synthesis/voice recognition interfaces is providing European car drivers and pedestrians with eSafety services, necessary interaction with multimedia (text, audio, images, real-time video, voice/graphics) and value-added location-based services (IM@GINE 2006).

Research was focused on integration of safety scenario, the role of digital maps was central: smart, querable. Maps area bringing up-to-date information enriched with safety relevant data to the car. Maps should help drivers to face critical driving situation resulting from road topography, e.g., by delaying incoming phone calls or triggering safety mechanisms based on map information like the radius of the curve ahead or speed limits or data like an accident ahead. In addition to decreasing the probability for accidents and minimizing potential damage to drivers and property, Services are more cost-effective, efficient (saving time to customers) and informative (e.g., better informing travellers who can have difficulty discovering what is available or being offered in an area they arrive) (HIGHWAY 2007).

Research has identified the main outcomes listed and shortly described hereafter:

- Multi Agent System (MAS) for e-Market Place (including bluetooth agent, events handler agent and personalization algorithm of HIT);
- Interface Agent. The interface agent provides credentials to personal assistant agents (PAAs);
- Personal Assistant Agent (PAA) nomad device retains a user profile and learns about the user habits, as to what points of interest the user prefers to see around him/her and which travel chain is best for him/her in multi-modal trip planning;
- Nomad device Transport Mode Agent. The TMA monitors a user's route and based on data regarding his/her position coming through GPS and a logical positioning method it can follow the user's progress in his/her route plan and can report any change in transport type or if he/she follows his/her trip while he/she is moving. Also, it can notify the user about relevant information for his/her current segment;
- HMI design. Specification and development of a multi-device HMI (PDA, mobile phone) for the application;
- Smartphone Device Booking Application;
- Server side interface to booking systems;
- Smartphone Off Board navigation application. Maps and routes are downloaded dynamically from the MMS navigation server and are updated to the current traffic situation and to the latest TeleAtlas cartography version.

The system sends up-to-the-minute information on driving conditions, accidents, traffic jams and road works to drivers' in-car devices and/or mobile phones.

The driver can also receive suggestions of alternative, safer courses to follow, accompanied by the same up-to-date information service, meaning that road-users are aware of the obstacles on their paths and are thus less likely to be involved in accidents. The system works by integrating smart real-time maps, modern mobile phone technology, positioning systems, 2D/3D spatial tools and speech/voice recognition interfaces (IM@GINE IT 2006).

Before setting off on a journey, the driver sends the coordinates of his or her location and destination via the Global Positioning System (GPS). The service then fetches an up-to-date map of the route with road conditions, accidents, and traffic jams and road works information superimposed. The GPS then relays information between the driver and the service, which will provide up-to-date map and traffic lane information at intervals of 5 to 10 minutes for the remaining part of the journey.

In addition to supplying information such as road obstacles and traffic jams from its Tele Atlas database, the system will also provide information on the likelihood of a sudden

deterioration in driving conditions due to changing weather conditions (HIGHWAY 2007).

4.6.4 Policy implications

The projects participated in development of Commission policies relating to both satellite and terrestrial application and notably contributed to Commission support of position papers, Commission decisions, action plans and standardisation (e.g. Convergence issues, Euro-communications Act). This support takes the form of a participation in bilateral and multilateral working groups on matters relating to spectrum issues (ETSI, ITU, WRC) including European delegations at regional and international conferences.

The Galileo project is supporting and contributing to the fulfilment of the objectives of the following key EU policies/strategies:

- The Lisbon Strategy;
- Sustainable Development strategy;
- The Transport Policy and the Space Policy.

The EU's Sustainable Development Strategy 2005-2010 aims to bring about a high level of environmental protection, social equity and cohesion, economic prosperity and active promotion of sustainable development worldwide. Given the inter-linkages between Sustainable Development Strategy and the Lisbon strategy, it is not surprising that Galileo also supports several actions proposed by the Commission in its reviewed strategy for Sustainable Development.

In addition to the growth and jobs issues described under the Lisbon Strategy Galileo also provides benefits in the transport sector and innovations within satellite technology are directly mentioned among the actions related to sustainable transport. Also Galileo will be a useful tool for environmental monitoring of risk reduction (ex. transport of dangerous goods) besides having potential for regional development in third countries (e.g. expansion of Egnos to Africa).

Numerous applications and uses of Galileo have directly beneficial impacts to sustainable development in following areas: agriculture and fishery (precision, monitoring etc.), energy sector (energy infrastructure, power distribution etc.), improvement of maritime and rail navigation.

It is assessed that depending on usage Galileo can have a high contribution to Sustainable Development, not only in the EU, but globally (Midterm Evaluation of the Galileo project 2006).

After the development of the main services and modules, but mainly following the Pilots' results, the need for new guidelines and standards emerged and these have been proposed. Furthermore, the proposed standards are to be distinguished if they are to be

introduced as new ones (in the respective standardization body), or if they are correlated to an existing standard, thus a modification of the respective standard is needed.

Inputs to the Green Paper were due to March 2008. Stakeholders' response to this Green Paper will contribute to the development of a strategic action plan, defined by the Commission as "a European urban mobility strategy that lives up to people's expectations" (HIGHWAY 2007).

4.7 Sub-theme 6: ITS Architecture

4.7.1 Background

Research reviewed in the paper on ITS produced within EXTR@Web (EXTR@Web, 2006) addressed the issue of multimodality, also considered as an objective in the ITS architecture and traffic monitoring applications.

The purpose of ITS architecture is to provide guidelines for the planning, design or implementation of ITS application. ITS architectures come in very different forms and levels. They range from specific structures, such as the layout of a communication system or the design principles for an individual ITS element, to high-level concepts representing the underlying framework of a whole project.

The Framework Architecture was developed by the KAREN project in response to the need for a single reference platform in Europe, which would provide a basis for the development of ITS products and services. A number of national authorities have started to develop their own national ITS framework architectures since, and are adapting KAREN to their own needs. FRAME-NET plays an important role in providing technical guidance, and overall co-ordination to ensure coherence at the European level (FRAME-NET 2004).

4.7.2 Research objectives

The existence of ITS system architectures has become increasingly necessary because Intelligent Transport Systems themselves are rapidly becoming more and more complex. Intelligent Transport Systems frequently span several transport means (e.g. private and public transport) and are provided in many locations (on board vehicles, at the roadside, at home, at the office, or through mobile devices). It is also increasingly important that they should be fully compatible, not only within a single country, but also at the international level as well. "Architecture" in its broadest sense defines the top-level structure of a system, providing a strategic framework that enables the possibility of

multiple designs. It may include both technical and organisational aspects. By establishing ITS architectures, it is possible to achieve the harmonious integration of systems by defining standards, norms and practices. It also ensures the solution of issues such as stakeholder relationships and responsibilities for communications infrastructure provision.

The use of ITS architecture also makes it possible to highlight any problems that arise from the refinement and modification of the services that are being provided. The architecture can then become a "tool" that enables these problems to be addressed and resolved (www.frame-online.net/).

The aim of this Thematic Network is to provide a focal point for confrontation and co-ordination of ITS architecture-related activities in the whole Europe.

Another possible – and necessary - application of ITS architecture consists in making Integrated Safety Systems (ISS) a powerful, highly dependable in-vehicle electronic architecture – concerning both hardware and software. Those elements, which are not competition-relevant for OEMs and suppliers, must be standardised to achieve an improvement in system quality with shorter development times and lower system costs. One major part of this expected electronic architecture is the software architecture upon which the Integrated Safety Systems shall be executed.

Integrated Safety Systems have demanding requirements in terms of dependability; especially regarding the dependability attributes of safety, reliability, availability and security. Moreover, achieving system dependability in a predictable and assessable way will be significantly harder for integrated safety systems than for traditional safety critical vehicle subsystems. There are three reasons for this: criticality of software, complexity and responsibility.

While the transition towards complex safety critical software-based systems has already taken place in other industry (e.g. avionics), the approaches followed there for achieving system dependability are not transferable to the automotive industry without modification due to different constraints concerning volumes, variability, and cost (EASIS 2006).

Intelligent Transport System Architecture will need to cover the technical aspects (functions, physical systems, and communications between them), plus related organisational, legal and business issues.

4.7.3 Research results

ITS Architectures can be created at national, regional or city level, or relate to specific sectors or services. They help to ensure that the resulting ITS deployment:

- Can be planned in a logical manner;
- Integrates successfully with other systems;

- Meets the desired performance levels;
- Has the desired behaviour;
- Is easy to manage;
- Is easy to maintain;
- Is easy to extend;
- Satisfies the expectations of the users.

One of the main elements of ITS Architecture is the list of Stakeholder Aspirations. These consist of the high-level objectives and requirements of all those involved in the ITS deployment. These Aspirations are then converted into simple statements often called the User Needs. In addition, an ITS Architecture normally includes:

- An Overview (or Conceptual Model) – a top-level diagram that shows the whole system and explains how it works;
- A Functional (or Logical) Architecture (or Viewpoint) – a series of diagrams and specifications that show the functions or processes needed in order to satisfy the User Needs;
- A Physical Architecture (or Viewpoint) – a series of diagrams and specifications for the physical components and their locations for a particular deployment;
- A Communication Architecture (or Viewpoint) – an analysis of the communications requirements of the links needed between the locations shown in the Physical Architecture.

With the spread of ITS, more and more countries throughout the world are creating their own National or Regional ITS Architectures.

The results of EASIS project include other examples of the creation of ITS architecture.

- A platform for software-based functionality in vehicle electronic systems has been defined, providing common services upon which future applications can be built;
- A vehicle on-board electronic hardware infrastructure which supports the requirements of integrated safety systems in a cost effective manner has been specified;
- Methods and techniques for handling critical dependability-related parts of the development lifecycle have been analyzed, adapted, extended and defined;
- An engineering process and a suitable tool chain have been defined, enabling the application of integrated safety systems. The results are validated by two different domain overlapping demonstrators;
- To prove the gateway and firewall capabilities of the architecture, a telematics gateway is realised;

Current standardisation activities (namely the ISO WD 26262) reveal the need for a suitable automotive electronics dependability methodology (EASIS 2006).

4.7.4 Policy implications

The FRAME FORUM has been established as a logical result of ITS architecture related projects, funded by EU. It consists of a group of organisations who have taken responsibility for promoting the use of the European ITS Framework Architecture and guiding its future development. Membership is open to any public or private organisation interested in ITS architectures.

The European ITS Framework Architecture (developed by the KAREN project and extended in the FRAME project) is designed to provide a flexible high level 'framework' that individual countries can tailor to their own requirements. National ITS Architecture projects based on the European ITS Framework Architecture, such as ACTIF (France), ARTIST (Italy), TTS-A (Austria) and TEAM (Czech Republic), therefore have a common approach and methodology, but each has been able to focus on the aspects of local importance and develop them in greater detail.

The ability to integrate systems greatly increases their potential. By complying with the European ITS Framework Architecture, not only will applications work together, but they can also be made inter-operable at a European level, which is a feature of growing importance. Inter-operability encompasses the technical, operational and organisational aspects, and implies the harmonious and complementary functioning of the overall system.

The most important standards for transportation and safety relevant electronic systems are:

- IEC 61508 as the common standard for safety of electronic and software systems. IEC 61508 is a "generic" standard. This means that it suggests itself as a generic framework based on which application sector specific specializations can be derived and supplemented. In examining this claim with respect to the automotive sector – specifically for electronically enabled software intensive integrated safety systems (ISS) - the following issues surfaced.
- IEC 61508 authors expected its generic framework to hold at least for basic principles and terminology. However, the scale for the required safety integrity levels needs adaptation for the automobile sector, per provisions in IEC 61508.
- Currently this adaptation activity is performed by ISO TC22/SC3/WG16, which is evolving a working draft of the ISO 26262 standard. As stated in its introduction, it "sets out the automotive approach for all safety lifecycle activities for safety relevant systems comprised of electrical and/or electronic components".

Certain aspects of these standards may be worthy to have a closer look at even though

there is no direct link to the automotive area (EASIS, 2006).

4.8 Sub-theme 7: Cross border cooperation systems

4.8.1 Background

Research reviewed in the paper on "Intelligent Transport Services" produced within EXTR@Web (EXTR@Web, 2006) addressed the development of the trans-European road network.

The rapid development of ICT is increasing and facilitating communication on a technical level, but there are a number of additional aspects, which have to be addressed if the communication along the intermodal chain is to be efficient. One is the need for common definitions and a common architecture; another is the more complex issue of rules for co-operation between the partners in the chain. The lack of common definitions, data dictionaries and architectures is well known, but there are also wider problems related to the applicability, scope, and commercial acceptance of standardisation efforts.

4.8.2 Research objectives

In this field, research objectives include the harmonised and integrated development of the telematics infrastructure for traffic management systems and traffic information services, and the interoperable systems of automatic tools to apply in European countries.

In particular, research activities contribute to invert the declining trend of EU railways by:

- Setting sound methodologies for the distribution of traffic flows over railway networks;
- Precisely localising traffic flows in the European area so as to give development forecasts;
- Providing a sound analysis of transport demand and supply over railway networks;
- Establishing simulation and modelling tools of traffic flows on medium and long-term perspectives;
- Providing an efficient decision-making tool;
- Allowing for the introduction of the concept of dedicated rail freight networks backed by a sound socio-economic and environmental assessment.

The achievement of these objectives should provide the market with:

- Significant increase of speed on the main European corridors of up to 100 %; present measurements made on railway networks (RFF) show, that the most critical point is the time lost on nodes to leave priority to passengers trains rather then the speed of the freight train;

- Increase in reliability and consistency of rail services competitive with those offered by road;
- Important reduction of cost due to increasing rotation of rolling stock, increase of "effective" driving hours of drivers and possible increase in length of trains: these are expected to lead a reduction from 30% up to 50% of operating costs;
- Very significant increase in rail network capacity due to more homogenous speed of the trains, pointing at bottlenecks which have to be removed.

Better combined utilisation of new infrastructure for High Speed Train and former rail lines, leading to an improved combination of lines dedicated respectively to freight or to passengers, avoids conflicts between type and traffic (NEW OPERA 2008).

4.8.3 Research results

Research results are covering framework architecture, a set of common definitions and solutions, which shall provide:

- Easy message exchange between the partners in the intermodal chain;
- Mechanisms for automating intermodal transport management decisions based on business rules;
- Enabling technology for efficient exchange of schedule information which can develop into automated mechanisms for establishing new chains in an established “virtual transport network”;
- Integration of intermodal planning systems with the commercial environment;
- Interfaces to traffic management systems for shipment planning and incident management.

Research results cover other types of measures for promoting efficient ICT solutions, e.g., regarding the contractual relations between the parties and solutions to inspire trust between the parties (FREIGHTWISE 2008).

Research results addressed in the following dimensions have been produced for the improvement of intermodal transport for the EU Member States:

- New operating and technical systems/aspects. This dimension addressed all technological aspects, both hardware and software. The issue of longer and heavier trains has been developed together with the signalling and management systems necessary for allowing the increased measures to be adopted. A variety of other management and bureaucratic barriers preventing the rail system from being one uniform rail space in Europe have been addressed. The free cross border rail circulation is still in its infancy. A lot of conflicts interfering with optimisation are still in existence. A showcase corridor has been taken as example for its complexity. The training and new operating rules dealt with harmonisation principles and the need of operating on a recognised and accepted sets of guidelines assuming the value of

contract between partners. The interoperability dimension has been elaborated with particular attention to the ERTMS level 1, 2, 3 cost effectiveness assessment.

4.8.4 Policy implications

An integrated government policy for improving efficiency of intermodal freight must give at least as much attention to regulatory and operations issues as to infrastructure needs. (FREIGHTWISE 2007).

Research managed to achieve a high degree of acceptability in terms of its project innovations, discoveries and strategic approach throughout the European rail establishment. CER and UIC cooperated actively with project having perceived that its market driven approach was instrumental to rail freight rejuvenation and to the creation of a new rail freight economy. Such economy must be open to competition and must rely on a new marketing approach from the authorities. Particular appreciation has been received by NEWOPERA from EIM, ERFA, UIRR, UIP, Rail Freight Group, FERRMED and many others. In particular a cooperation agreement for accessing each other's documents and discoveries has been signed with UIC in the common interests and for improving data consistency of Developing Infrastructure use and Operating Models for Intermodal Shift. Other projects pursued this policy of seeking to cooperate with whoever is interested in improving rail freight mobility.

Defined activities contribute to invert the EU railways declining trend by:

- Setting sound methodologies for traffic flows distribution over the railways network;
- Localising traffic flows in the EU area producing development forecasts;
- Providing transport supply and demand analysis over the rail network;
- Establishing traffic flows simulation and modelling tools on medium and long-term perspectives;
- Providing an efficient decision-making tool;
- Allowing the introduction of rail freight dedicated network concept backed by a sound socio-economic and environmental assessment.

4.9 Sub-theme 8: Electronic fee collection

4.9.1 Background

Research reviewed in the paper on Intelligent Transport Systems produced within EXTR@Web (EXTR@Web, 2006) addressed the development of urban and regional transport systems with detailed focus on the increase in mobility through more efficient management of the traffic flows, better intermodal systems and the application of new vehicles (with some innovative technologies). The development of new fare collection systems and terminals for public transports relates to this.

4.9.2 Research objectives

Research was focused mainly on definitions of the framework for an interoperable European EFC service based on central account. This service is intended for use in addition to existing local EFC services. Users who want to have the convenience of an interoperable service are offered the option to have on-board equipment and an associated contract that enables them to travel through all concession areas.

Within the framework of the project, the cities chose to test different systems and technical solutions. Within the Swedish part of research activities, a largely complete road pricing system has been created and tested.

Demonstrations and evaluations of the effectiveness and acceptance of integrated urban transport pricing schemes has been tested to achieve transport goals and raise revenue.

Focusing on 6 main goals approached purpose of research activities:

- To provide effective co-ordination between the demonstration sites, and with the thematic network;
- To develop and demonstrate integrated urban transport pricing schemes, based on the concept of marginal-cost pricing, in real urban situations;
- To develop and assess the political, economic and social framework required for the implementation of urban transport pricing;
- To evaluate the impact and effectiveness of these demonstrations;
- To develop material for dissemination of the demonstration and evaluation results at the local and national level, and at the European level (PROGRESS 2004).

4.9.3 Research results

Impacts and results of EFC related scientific research have been summarised into the following fields and functions:

The following functions have been foreseen for interoperable EFC:

- Information - the User is informed about the transport service, the payment service and the payment method related to the payment service;
- Purchase - the User purchases the Service Rights, getting a contract and the payment medium to be used as part of the payment method;
- Charging by Operator - The User benefits from the local Transport Service and is charged for that by his "home" Operator. This is the normal procedure with no relevance to interoperability;
- Payment - The User pays for the Service (either before or after consumption of the transport service);
- Settlement - Operator claims and receives payment from different operator for the consumption of his Transport Service by the User;
- Enforcement - The User is possibly enforced (in case that he is found as having violated the system) (CARDME 2001).

The detection and charging procedure comprises the following functions:

- Initialisation - The first step is to initiate the charging procedure by response of the OBE to a signal broadcasted by a DSRC beacon (or by indication of a virtual charging point in case of an autonomous system);
- Read Characteristics - In case of a DSRC system the vehicle characteristics to be used to determine the class could be read from the OBE;
- Measure characteristics - The vehicle characteristics to be used for the determination of the class could also be measured by the RSE;
- Vehicle Detection - In case of a measurement of characteristics the vehicle needs to be detected before;
- Determination of Class - The class to be applied for the determination of the fee will be based either on the claimed or the measured vehicle parameters;
- Determination of Fee - The due fee will be calculated on the basis of the determined class either on-board the vehicle (in the OBE) or by the RSE;
- Debit of Account - The fee determined is deducted from the User's charging account (either on-board or centrally) and the new balance is stored;
- Documentation - The complete charging transaction is documented (either on-board or centrally or both).

Additionally in some EFC systems the status of the OBE is permanently written to a log

file in order to allow for a clear distinction between system failure and user manipulation in case of malfunction.

The Charging Receipt is either stored in the OBE to be printed out later or stored centrally by the Operator to be sent to the User as part of an invoice or a statement.

The system tested in Gothenburg was based on the Internet, using GPS for positioning (satellites send coordinates to the car's computer system) and communicating via a cell phone system (PROGRESS 2004).

Although the system cannot be regarded as mature for introduction on a large scale, important experience can be identified. In the "Environmental" scenario the journeys by car decreased by almost 10 % per day, foremost the long journeys. Particularly with regard to journeys made in connection with work, there was a large move from cars to other means of transport. Most motorists in Gothenburg consider that road pricing is not justified today as the traffic does not imply any particular problem. In the "Congestion" scenario, where charging was imposed during the rush hour instead of during the whole day and night, there was a reduction in car traffic during the rush hour by about 15 %, because many drivers avoided the charges by travelling at a different time of day.

The Danish programme demonstrated that it is possible to develop a road pricing system which charges a kilometre rate based on time, place and distance driven. It also demonstrated that road pricing affected the driving pattern of the test drivers. The GPS-based system was widely understood and accepted, and a large proportion of road users in Denmark found variable taxes on car driving more acceptable than the fixed ones. However, payment, security and control functions were not considered at a level of detail that showed that such a scheme is practical. As these functions are vital to the feasibility of a road pricing system, there is a need for further technical development.

The Copenhagen trial demonstrated that road user charging does affect behaviour; it is not considered as another fixed cost, but as a marginal cost that drivers respond to. But the pricing level needs to be high if road users are to change behaviour. Hence the high km-based pricing level clearly made an impression on the participants. Even if they could not change behaviour, they had examined alternative travel options before rejecting these. The low km-based pricing level was in general not sufficiently high to change behaviour, although a few participants made some minor changes when it was easy. The km-based schemes were in general considered to be more fair than the cordon-based. About 50% of the test drivers in some way changed behaviour, and the main changes were:

- Choice of different (cheaper) route - mostly for non-commuting trips;
- Increased use of kiss-and-ride facilities (more passengers in the test cars);
- Changes in destination and time of day for non-commuting trips (PROGRESS 2004).

A general finding is that the drivers are ready to consider road pricing if petrol and vehicle

taxes were simultaneously reduced, or that public transport and air quality were improved. A condition, however, is that the revenues from road charging were returned to the traffic system. Integrity is often mentioned as a problem in the debate but the trial indicated that this problem is over-estimated.

4.9.4 Policy implications

The possible policy implications as well as the recommendation for future actions are summarised as follows.

Weak support for road pricing as an isolated measure: the recommendation is to present road pricing as part of a strategy, including other measures, to solve congestion. It is then also crucial in the consultations to communicate clearly.

- It is hard to find support for full-scale schemes: to implement full-scale road pricing schemes has been difficult from a political point of view. Instead of full-scale schemes, demonstration projects have therefore been carried out in some cities. A lesson learned is that this approach also provides experiences enabling cities to proceed with consultations leading to the development of a more appropriate full-scale road pricing scheme. A recommendation is therefore to consider running demonstration projects as a first step on the way towards the implementation of a full-scale road pricing scheme.
- Difficult to communicate scheme objectives: opposition to the road pricing schemes seems to be reduced after implementation, but road pricing is still very controversial. A lesson learned from the consultations carried out is the difficulty to communicate the scheme objectives and the discussion focuses often on the political process rather than whether the scheme will be able to meet its objectives. A recommendation is to put a lot of emphasis on providing information on the scheme objectives and its traffic effects: at this purpose it is also useful to present schemes as part of a strategy.
- Businesses in city centres are often against road pricing: commercial interests often seem to be against road pricing schemes, certainly before the scheme has been implemented. A recommendation is to communicate closely with businesses and stakeholders so that their fears and concerns can be mitigated before the implementation of any measures; a further proposal is to announce close monitoring of effects and the possibility for redesigning the charging system after a defined period of operation.
- Extensive communication is needed: it is important to give information to users after implementation to inform them about the scheme benefits. A recommendation is therefore to make a consultation plan early in the implementation process and to budget large resources for the information activities.
- Distance-based systems give higher flexibility for transportation policy: distance-based systems are flexible, they can be easily used to solve local congestion problems and GPS technology is well suited for such systems. In a transportation policy, where GPS technology is used, the road pricing can thus be used as more

fine-tuned instrument. On the other hand, this technology is not as mature as the others for road pricing and therefore may be difficult to use as transportation policy tool. A recommendation is to follow the development of GPS-based systems in order to decide when it can be a practical tool for road pricing in urban areas.

- Transportation policy must deal with social equity: different schemes have different effects on social equity. A recommendation is to analyse effects of road pricing together with other pricing tools such as costs for parking, public transport fares as well as Park and Ride (PROGRESS 2004).

Related acts:

- Communication from the Commission: Developing the trans-European transport network: Innovative funding solutions, Interoperability of electronic toll collection systems [COM (2003) 132 final].
- Proposal for a Directive of the European Parliament and of the Council on the widespread introduction and interoperability of electronic road toll systems in the Community [COM (2003) 132 final].

This proposal was announced in the White Paper on transport policy. Its purpose is to create a European electronic toll service so as to ensure the interoperability of toll systems in the internal market and to help with the formulation of infrastructure charging policies at the European level.

The service is based on the principle of "one contract per customer, one box per vehicle" and will serve to reduce congestion, improve traffic flow and limit cash transactions at toll stations.

- Co-decision procedure (COD/2003/81)

4.10 Implications for further research

The information on implications for further research illustrated in this section has been collected from the projects reviewed in this report, and from European Strategic Research Agendas (SRA), developed by the European technology platforms[2] on Air Transport (ACARE, 2004), Rail Transport (ERRAC, 2007), Intermodal Transport (EIRAC, 2005), Waterborne Transport (Waterborne, 2006), and Road Transport (ERTRAC, 2004). The characteristics of a strategic research agenda for air transport (ACARE 2006) can be extended to the other technology platforms. A SRA:

- Sets a common background of information on the technology concerned for reference;
- Encourages the use of a common technology language and helps enterprises to identify research areas on which they should concentrate or collaborate;
- Provides a tool for monitoring progress and identifying which areas are not being covered;
- Helps enterprises to establish their own research programme, and to participate in forming new ones.

4.10.1 Summary of further research recommended by Strategic Research Agendas

Concerning road transport, the ERTRAC SRA has identified the following areas and topics for further research to improve efficiency of road traffic management and control (ERTRAC, 2004):

- Development of real-time traffic information systems, in combination with European digital road map database, including traffic restrictions, road condition data, and parking availability, to allow reliable travel time prediction and better route selection.
- Integration of intelligent transport management and infrastructure systems into broader networks (e.g. food distribution, energy, industrial production) to create more responsive multi-modal transport system capable of resisting and recovering from shocks.
- Development of robust indicators on freight transport efficiency, journey time reliability, and network efficiency.
- Development of applications of navigation and positioning systems for tracking the position of vehicles and for collecting real-time traffic information. Investigation of the

potential for improved and more accurate localisation in order to enable new functions such as parking slot identification, lane keeping, distance relative to other vehicles (platooning) based on vehicle-vehicle and vehicle-infrastructure communications combined with the GALILEO satellite system.

- Development of network level systems to support the transit of heavy vehicles. This should consider the issues of restrictions for bridges, tunnels, steep gradients and congested or environmentally sensitive areas. Real-time and seasonal effects will need to be examined to maximise the effectiveness of the system in all weather conditions.
- Development of solutions using new dynamic traffic management and infrastructure technologies in order to improve the use of the existing infrastructure and reduce bottlenecks.
- Investigation of systems for platooned trucks in dedicated lanes.
- Development of new technologies for cost effective traffic data collection on all networks (urban, rural, main roads and motorways) with improved performance over existing technologies. Communication with the navigation systems in the vehicles, Traffic Dialog Systems (TDS), Floating Car Data (FCD) and anonymous data transmission should be further developed. Mobile communication may enable the collection of data from distributed, moving vehicles in real time and could allow more comprehensive assessment of traffic effects.
- Development of measuring methods for congestion, travel time reliability, network performance monitoring and service level indicators.
- Development of real-time travel time prediction methods and increased reliability of short-term traffic forecasting models to improve information and management.
- Further research on the implementation and the assessment of new Information and Communication Technologies (ICT) and ITS technologies for application in road transport.
- Development of assessment tools for traffic management strategies, based on dynamic capacity optimisation models, taking into account dynamic lane allocation, tidal flows, two-way communication with the users, ICT and ITS, and electronic parking management services.
- Creation of dynamic, information led traffic management and control models utilising embedded information, real-time data transmitted from the vehicles (position, speed, origin, and destination), individual route planning, and access control to routes, lanes, and parking. More automation in traffic flow control should be developed.
- Development of methods for intelligent, dynamic lane allocation considering the effects of variable lanes and speed limits for different traffic flows, taking into consideration all types of private or public vehicles (trucks, cars, busses, two-wheelers).
- Improvement of the links between traffic control centres across Europe in order to enable traffic management on long stretches including alternative routes, incident management and congestion management.

- Development of methods for mobility and traffic management in case of special events, man-made and natural. Strategies based on risk evaluation should be developed.
- A better understanding of removing bottlenecks in order to provide the required capacity. Harmonised decision indicators and standards for the level of service of the road infrastructure for all road users have to be established.
- Pilot studies and validation projects for the practical installation of ICT and ITS, intelligent pavements enabling dynamic traffic management, allowing dynamic allocations of lanes, intelligent merging systems, speed control, guidance systems, and lane prioritising for collective transport, high occupancy and emergency vehicles. These pilot studies should include new technologies for electronic road markings, pavement surface colouring and dynamic lane barriers.
- The overall effectiveness of separate lanes for road operations should be evaluated, as well as the need for upgrading the secondary road network (safe alternative and escape routes).
- Further research on Automatic Vehicle Guidance (AVG) (in particular speed and distance management systems) is needed to evaluate its potential to increase road capacity.
- Evaluation of systems enabling platooned vehicles for safety and capacity increase.
- Research on interactive functions (vehicle-vehicle, vehicle-infrastructure) in support of methods to improve the capacity of the road infrastructure.
- Telematics communication systems must be developed for real-time information transmission between the infrastructure, vehicles, and individuals for:
    - Infrastructure monitoring, maintenance and operating activities;
    - Suitable management and operative processes for emergencies;
    - Improved safety and avoidance or reduction of congestion.

The SRRA (Strategic Rail Research Agenda) has also stressed the fact that efficiency can be increased by enhancing railway interoperability, through a continuous improvement of the conditions for operational and technical integration of the different national railway systems in the European Union and Accession Countries. More specifically, further research is needed to (ERRAC, 2007):

- Develop the use of new train control technologies such as ETCS (European Train Control System) level 3 to increase capacity;
- Develop specifications and hardware for a new generation of interlocking systems to facilitate the introduction of ERTMS (European Rail Traffic Management System);
- Development of new technologies for staff training and traffic management such as virtual reality and simulation tools;
- New methods and tools for train configuration management and for train/infrastructure interaction management;
- Availability of fleet management and train deployment information across Europe;

- New management techniques to enable more efficient use of infrastructure (e.g., through improved management and integrated long, medium and short distance clock-face rail services);
- Tools that can predict deterioration of both track and train as traffic levels increase, leading to scientifically based track access charges including classification of vehicles and track that reflect the damage inflicted on track and train.

The ACARE SRA has identified the following research needs for a highly time efficient air transport system (ACARE, 2004).

- Improvement of predictability within the ATM system. Time efficiency is strictly connected to high predictability. The main aspect to be considered is the coping with non-predictable events, especially weather and congestion. Unfortunately, weather will never become fully predictable, or manageable, but it is possible to mitigate its effects by organising the airspace dynamically in order to minimise its impact on traffic flows. In each airport, all weather landings/take-off equipment must be made mandatory, and pilots or controllers must be equipped with enhanced/synthetic vision systems. The congestion issue can be solved adopting a more rigid organisation of traffic, according to aircraft capability as well as aircraft operator's needs.
- The increase in predictability is likely to be based on a time and space (4D) trajectory. The "4D trajectory management system" must be supplemented by autonomous separation, in which aircrafts ensure on their own that they are appropriately separated one from another, for instance on express-ways or in low density airspace. In other zones "conventional" ATM, rendered highly efficient by the use of new technologies and automatic support to human controllers will be used. Dynamic Flow Management techniques would need to be integrated into possibly new Air Traffic Control (ATC) operational concepts through a consistent, end-to-end trajectory-based information management system. For example, the integrated (air/ground) 4D trajectory management system is ultra secured, in order to prevent any intrusion in the definition and negotiation of trajectories. Trajectories close to the airports are the most security sensitive, because of their proximity to cities and the ground. Secured trajectories should be therefore defined and strictly respected by the aircraft. Any deviation from the defined trajectory should be immediately detected, and given the ground proximity of the aircraft and the impossibility to launch interception actions, the ground system should take over the control of the aircraft in order to put it back on its planned trajectory.
- Improvement of the ATM operations by ensuring that all actors, ATM aircraft operators and airport operators, exchange information on the exact status of their operations dynamically.
- Development of models to optimise the efficiency of the whole operational ground.
- Flight / ground cycle (air and ground operation, aircraft/airport/ATM environment). Particular attention must be paid to the modelling of passenger and baggage flows (intermodal, in the airport, boarding).

The maritime sector must confront with the dramatically increasing amount of traffic in

European waters. As a consequence much stress was put by the WSRA on the development of excellent ICT support systems for managing waterborne traffic. Further research needs to include the development of Decision Support Systems and ICT-Efficient data models and algorithms for shore based traffic management systems. These must be developed, tested and implemented for large numbers of participants and high risk/dense traffic areas, as well as for port approaches and port call preparation. Man-machine interfaces will have to be improved and made simple to use (Waterborne, 2006).

Furthermore, next generation of automation, navigation and control systems of commercial vessels need to be substantially improved to significantly reduce the costs of hardware, installation, and maintenance. The key technology identified for this is “distributed control systems”, where one module can be equipped, tested and set into operation on its own and the completed modules can be commissioned in a few hours. Future navigation systems need to be proactive and must interact with shore based logistics management systems. They must be able to retrieve external data about weather systems and traffic patterns and integrate them with information on ocean currents and tides, and other conditions to set an optimum routing that minimises operating costs and maximises throughput in ports. The Galileo satellite navigation system will play a key role (Waterborne, 2006).

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6. Annex 1: List of EU-funded projects per sub-theme

Sub-theme 1: Road traffic management and control				
Project acronym	Project title	Programme	Project website	Coverage
AGORA	Cities for people	FP5 - IST - KA1 - Systems and services for the citizens		this paper
CIVITAS CATALIST	CIVITAS CATALIST	FP6 – SUSTDEV-2 - "Sustainable surface transport"	www.civitas-initiative.org/	if reports become available
COMPOSE	Composition Of Mobile Pre-trip On-trip Services	FP5 - IST - KA1 - Systems and services for the citizens	galileo.cs.telespazio.it/compose	EXTR@Web paper
CONNECT	Co-ordination and stimulation of innovative ITS activities in Central and Eastern European Countries	European - MIP - Multi-annual Indicative Programme	www.connect-project.orgv	this paper
DENSETRAFFIC	A Forward Looking Radar Sensor for Adaptive Cruise Control with Stop & Go and Cut In Situations Capabilities implemented using MMIC technologies.	FP5, KA 1		EXTR@Web paper
eMOTION	Europe-wide multi-modal on-trip traffic information	FP6 – SUSTDEV-2 - "Sustainable surface transport"		if reports become available

Sub-theme 1: Road traffic management and control				
Project acronym	Project title	Programme	Project website	Coverage
EYE IN THE SKY	New Services for (i) Fleet management and Customised Mobility Information plus (ii) Emergency Support for Crises during large-scale events, based on the use of low-altitude platforms and floating car data	FP6 – IST – KA1 “Systems and Services for the Citizen”	www.isky.gr	EXTR@Web paper
HEAVYROUTE	Intelligent Route Guidance of Heavy Vehicles	FP6-SUSTDEV-2 - Sustainable Surface Transport		if reports become available
HOST	Human Oriented Sustainable Transport mean	FP6-SUSTDEV-2 - Sustainable Surface Transport		if reports become available
RAILCOM	Electromagnetic Compatibility between Rolling Stock and Rail-infrastructure Encouraging European Interoperability	FP6-SUSTDEV-2 - Sustainable Surface Transport	www.railcom.info	if reports become available
REDUCE	Reduced Separation Minima	FP6 - AERO-1.4 "Increasing operational capacity and safety of the air transport system"		if reports become available
Response 2	Advanced Driver Assistance Systems: From Introduction Scenarios towards a Code of Practice for Development and Testing	FP6 – IST – KA1 “Systems and Services for the Citizen”	Http://response.adase2.net	EXTR@Web paper
RoadCast	Telematic system for weather forecast and information systems	National (Austria) I2 - Intelligent Infrastructure		this paper
SAFE-RAIL	Development of an Innovative	FP6-SUSTDEV-3 - Global	www.saferail-project.eu	if reports become

Sub-theme 1: Road traffic management and control				
Project acronym	Project title	Programme	Project website	Coverage
	Ground-Penetrating Radar System for Fast and Efficient Monitoring of Rail-Track Substructure Conditions	Change and Ecosystems		available
SMARTNETS	Signal Management in Real Time for Urban Traffic Networks	FP6 – IST – KA1 “Systems and Services for the Citizen”	www.smart-nets.napier.ac.uk	EXTR@Web paper
TASKU (FI)	Tracking and Tracing of Freight Transport	Project from Finland		EXTR@Web paper

Sub-theme 2: Air traffic management and control				
Project acronym	Project title	Programme	Project website	Coverage
ADAMANT	Airport Decision And Management network	FP5 - IST - KA1 - Systems and services for the citizens	adamant.elec.qmul.ac.uk	EXTR@Web paper
AIRNET	Airport Network for Mobiles, Surveillance and Alerting	FP6-IST - Information Society Technologies - Priority Thematic Area 2 (PTA2)	www.airnet-project.com	if reports become available
ATENAA	Advanced Technologies for Networking in Avionic Applications	FP6-AEROSPACE - Aeronautics and Space - Priority Thematic Area 4 (PTA4)	www.atenaa.org	if reports become available
CAATS II	Co-operative approach to air traffic services	FP6 - AERO-1.4 "Increasing operational capacity and safety of the air transport system"	www.caats.isdefe.es	if reports become available

Sub-theme 2: Air traffic management and control				
Project acronym	Project title	Programme	Project website	Coverage
Episode 3	Single European Sky Implementation Support Through Validation	FP6 - AERO-1 "Aeronautics"		
IFATS	Innovative Future Air Transportation System	FP6-AERO-1.4 - Increasing Operational Capacity and Safety of the Air Transport System	www.ifats-project.org	if reports become available
iFLY	Safety, Complexity and Responsibility based design and validation of highly automated Air Traffic Management	FP6 - AERO-1 "Aeronautics"		if reports become available
NEWSKY	Networking the Sky for Aeronautical Communications	FP6 - AERO-1.4 "Increasing operational capacity and safety of the air transport system"		if reports become available
OPTAG	Improving airport efficiency, security and passenger flow by enhanced passenger monitoring	FP6 - AERO-1.4 "Increasing operational capacity and safety of the air transport system"		if reports become available
SUPER-HIGHWAY	Development of an Operationally driven Airspace Traffic Structure for High-Density High-Complexity Areas, based on the use of dynamic Airspace and Multi-Layered Planning	Aeronautics and Space - Priority Thematic Area 4 (PTA4)		this paper
SWIM-SUIT	System Wide Information Management - Supported by Innovative Technologies	FP6-AERO-1.4 - Increasing Operational Capacity and Safety of the Air Transport	www.swim-suit.aero	if reports become available

Sub-theme 2: Air traffic management and control				
Project acronym	Project title	Programme	Project website	Coverage
		System		
THEATRE	Thematic Network on Air Transport	FP5 – Growth, KA 2	www.theatre.isdefe.es	EXTR@Web paper

Sub-theme 3: Maritime traffic management and control				
Project acronym	Project title	Programme	Project website	Coverage
INDRIS	Inland navigation demonstrator of river information services	FP4	http://waterland.net/indris	EXTR@Web paper
MARNIS	Maritime Navigation and Information Services	FP6-SUSTDEV-2 - Sustainable Surface Transport	www.marnis.org	this paper
OPTINAV	The Optimal Navigation Support System	FP5 - IST - KA1 - Systems and services for the citizens	www.wondermar.net/optinav.htm	

Sub-theme 4: Safety and emergency systems				
Project acronym	Project title	Programme	Project website	Coverage
ADVISORS	Annotated Digital Video for Surveillance and Optimised Retrieval	FP5 - IST - KA1 - Systems and services for the citizens	www-sop.inria.fr/orion/ADVISOR	EXTR@Web paper
AIDE	Adaptive Integrated Driver-vehicle Interface	FP6-IST - Information Society Technologies - Priority Thematic Area 2 (PTA2)	www.aide-eu.org	this paper

Sub-theme 4: Safety and emergency systems				
Project acronym	Project title	Programme	Project website	Coverage
APOLLO	Intelligent tyre for accident-free traffic	FP5 - IST - KA1 - Systems and services for the citizens	virtual.vtt.fi/virtual/proj3/apollo	EXTR@Web paper
APROSYS	Advanced Protection Systems	FP6-SUSTDEV-2 - Sustainable Surface Transport	www.aprosys.com	this paper
ASSTAR	Advanced safe separation technologies and algorithms	FP6-AERO-1.4 - Increasing Operational Capacity and Safety of the Air Transport System	www.asstar.org	if reports become available
BOJCAS	Bolted Joints in Composite Aircraft Structures	FP5 - GROWTH - KA4 (AERONAUTICS) - New Perspectives in Aeronautics	www.smr.ch/bojcas	EXTR@Web paper
CHAMELEON	Pre-crash application all around the vehicle	FP5 - IST - KA1 - Systems and services for the citizens	www.crfproject-eu.org	EXTR@Web paper
E-MERGE	Pan-European harmonisation of vehicle emergency call service chain	FP5 - IST - KA1 - Systems and services for the citizens	www.gstforum.org/en/subprojects/rescue/about_gst_rescue/introduction/e-merge.htm	this paper
ESCOPE	eSafety observatory	Information Society Technologies - Priority Thematic Area 2 (PTA2)	www.escope.info	this paper
EUDDPLUS	European Driver´s desk advanced concept implementation	FP6-SUSTDEV - Sustainable Development, Global Change and Ecosystems - Priority Thematic Area 6 (PTA6)		if reports become available
HUMANIST	Human Centered Design for	FP6-IST - Information Society	www.noehumanist.org	this paper

Sub-theme 4: Safety and emergency systems				
Project acronym	Project title	Programme	Project website	Coverage
	Information Societies Technologies	Technologies - Priority Thematic Area 2 (PTA2)		
IN-SAFETY	Infrastructure and Safety	FP6-SUSTDEV-2 - Sustainable Surface Transport	www.insafety-eu.org	if reports become available
PREVENT	Preventive and active safety application	FP6-IST - Information Society Technologies - Priority Thematic Area 2 (PTA2)	www.prevent-ip.org	this paper
REACT	Realizing Advanced Safety & Efficiency in European Road Transport	FP6-SUSTDEV-3 - Global Change and Ecosystems	www.react-project.org	if reports become available
SAFEDMI	Safe Driver Machine Interface (DMI) for ERTMS automatic train control	FP6-SUSTDEV-3 - Global Change and Ecosystems	www.safedmi.org	if reports become available
SAMNET	Safety management and interoperability Thematic Network	FP5 - GROWTH - KA2 - Sustainable Mobility and Intermodality	samnet.inrets.fr v	EXTR@Web paper
SEAM	Assessing concepts, systems and tools for a safer, efficient and environmentally aware and friendly maritime transport	FP5 - GROWTH - KA2 - Sustainable Mobility and Intermodality	seam.mettle.org	EXTR@Web paper
SUNFLOWER	Comparative assessment of safety strategies in Sweden, Britain and the Netherlands	DGTREN - Energy & Transport DG - Miscellaneous projects	sunflower.swov.nl	EXTR@Web paper

Sub-theme 5: Satellite based technologies				
Project acronym	Project title	Programme	Project website	Coverage
ASPASIA	Aeronautical Surveillance & Planning by Advanced Satellite-Implemented Applications	FP6-AERO-1.4 - Increasing Operational Capacity and Safety of the Air Transport System	www.aspasia.aero	if reports become available
Egnos	EGNOS TRANSITION into GALILEO	FP5 - GROWTH - KA4 (AERONAUTICS) - New Perspectives in Aeronautics		this paper
GADEROS	Galileo Demonstrator for Railway Operation System	FP5 - GROWTH - KA2 - Sustainable Mobility and Intermodality		EXTR@Web paper
GALA	Galileo overall Architecture Definition	FP5 - GROWTH - KA2 - Sustainable Mobility and Intermodality		EXTR@Web paper
GALLANT	Galileo for Safety of Life Applications of Driver Assistance in Road Transport	FP5 - GROWTH - KA2 - Sustainable Mobility and Intermodality		EXTR@Web paper
GEMINUS	Galileo European Multimodal Integrated Navigation User Service - Galileo Service Definition	FP5 - GROWTH - KA2 - Sustainable Mobility and Intermodality		this paper
GENESIS	Galileo European Network of Experts to Support the European Commission	FP5 - GROWTH - KA2 - Sustainable Mobility and Intermodality		EXTR@Web paper
HEAVYROUTE	Intelligent Route Guidance of Heavy Vehicles	FP6-SUSTDEV-2 - Sustainable Surface Transport	heavyroute.fehrl.org	if reports become available

Sub-theme 5: Satellite based technologies				
Project acronym	Project title	Programme	Project website	Coverage
HIGHWAY	Breakthrough Intelligent maps&geographic tools for the context-aware delivery	FP6-IST - Information Society Technologies - Priority Thematic Area 2 (PTA2)	www.ist-highway.org	this paper
IM@GINE IT	Intelligent MobilityAgents, Advanced Positioning and Mapping Technologies, Integrated Interoperable multimodal location based services	FP6-IST - Information Society Technologies - Priority Thematic Area 2 (PTA2)	www.imagineit-eu.com	this paper
RELY	Integrating Satellite DAB, terrestrial cellular technology and EGNOS capabilities to demonstrate real-time wireless navigation and fleet-management services	FP5 - IST - KA1 - Systems and services for the citizens	www.rely-europe.com	this paper

Sub-theme 6: ITS Architecture				
Project acronym	Project title	Programme	Project website	Coverage
EASIS	Electronic Architecture and System Engineering for Integrated Safety Systems	FP6-IST - Information Society Technologies - Priority Thematic Area 2 (PTA2)	www.easis-online.org	this paper
FRAME-NET	Framework Architecture Made for Europe - Network	FP5 - IST - KA1 - Systems and services for the citizens	www.frame-online.net	this paper
FRAME-NET	Framework Architecture Made for Europe - Network	FP5 - IST - KA1 - Systems and services for the citizens	www.frame-online.net	EXTR@Web paper

Sub-theme 6: ITS Architecture				
Project acronym	Project title	Programme	Project website	Coverage
FRAME-S	Framework Architecture Made for Europe - Support	FP5 - IST - KA1 - Systems and services for the citizens	www.frame-online.net	this paper
FRAME-S	Framework Architecture Made for Europe - Support	FP5 - IST - KA1 - Systems and services for the citizens	www.frame-online.net	EXTR@Web paper

Sub-theme 7: Cross border cooperation systems				
Project acronym	Project title	Programme	Project website	Coverage
CITY FREIGHT	Inter- and Intra-City Freight Distribution Networks	FP5 – EESD, KA 4 "The City of Tomorrow and Cultural Heritage"	www.cityfreight.org	EXTR@Web paper
CONPASS	Better Connections in European Cross-Border Passenger Transport	FP5 – Growth, KA 2 "Sustainable Mobility and Intermodality"	www.conpass.org	EXTR@Web paper
CREAM	Customer-driven Rail-freight services on a European mega-corridor based on Advanced business and operating Models	FP6 - SUSTDEV-2 "Sustainable surface transport"		if reports become available
EDIP	On-board radio-based control of multiple-locomotive freight trains for trans-European operation	FP5 - GROWTH - KA3 - Land transport and marine technologies	www.edip.martec.fr	if reports become available
ESCUGIBRI	ESC UserGroup and InfoBank to support Rail Interoperability	FP5 - GROWTH - KA3 - Land transport and marine technologies	www.esc-infobank.com	EXTR@Web paper

Sub-theme 7: Cross border cooperation systems				
Project acronym	Project title	Programme	Project website	Coverage
e-THEMATIC	Thematic Network on e-logistics/e-fulfilment	FP6 – IST – KA1 “Systems and Services for the Citizen”	www.e-thematic.org	EXTR@Web paper
FREIGHTWISE	Freightwise - Mangement Framework for Intelligent Intermodal Transport	FP6 – SUSTDEV-2 - "Sustainable surface transport"	www.freightwise.info	this paper
GIFTS	Global intermodal freight transport system	FP6 – IST – KA1 “Systems and Services for the Citizen”	http://gifts.newapplication.it	EXTR@Web paper
HISPEEDMIX	High Speed Freight on the European High Speed Railway Network”	FP4		EXTR@Web paper
IDIOMA	Innovative Distribution with Intermodal Freight Operation in Metropolitan Areas	FP4	www.idioma.gr	EXTR@Web paper
ISHTAR	Integrated Software for Health, Transport efficiency and Artistic heritage Recovery	FP5 – EESD, KA 4 "The City of Tomorrow and Cultural Heritage"	www.ishtar-fp5-eu.com	EXTR@Web paper
KITE	A Knowledge Base for Intermodal Passenger Travel in Europe	FP6 – SUSTDEV-2 - "Sustainable surface transport"		if reports become available
NAUPLIOS	Navigation and perilous goods input and output system	FP5 - GROWTH - KA2 - Sustainable Mobility and Intermodality	nauplios.cnes.fr	EXTR@Web paper
NEW OPERA	New European Wish: Operation Project for European Rail network	FP6-SUSTDEV-2 - Sustainable Surface Transport	www.newopera.org	this paper
NOPSEURA	Quality Assurance System - SPEEDAUDIT	FITS - FITS R&D Programme on Infrastructure and Services		EXTR@Web paper

Sub-theme 7: Cross border cooperation systems				
Project acronym	Project title	Programme	Project website	Coverage
		2001-2004		
RAILCOM	Electromagnetic Compatibility between Rolling Stock and Rail-infrastructure Encouraging European Interoperability	FP6-SUSTDEV-2 - Sustainable Surface Transport	www.railcom.info	if reports become available
ROLLING SHELF	Palletised rail goods	FP4		EXTR@Web paper
S240B	Rural Speed Management	DFT - ROAD SAFETY RESEARCH PROGRAMME - Department for Transport: Road Safety Research Programme	www.dft.gov.uk/rmd/project.asp?intProjectID=10064	EXTR@Web paper
SAMRAIL	Safety management in railways	FP5 - GROWTH - KA2 - Sustainable Mobility and Intermodality	samnet.inrets.fr	EXTR@Web paper
SIMBA	Transforming road transport through worldwide cooperation	FP6-SUSTDEV-3 - Global Change and Ecosystems	www.simbaproject.org	if reports become available
SIMTAG	Safe InterModal Transport Across the Globe	FP5 - GROWTH - KA2 - Sustainable Mobility and Intermodality		EXTR@Web paper
THEMES	Thematic Network for Safety Assessment of Waterborne Transport	FP5 - GROWTH - KA2 - Sustainable Mobility and Intermodality	www.martrans.org/rthemes.htm	EXTR@Web paper

Sub-theme 8: Electronic fee collection				
Project acronym	Project title	Programme	Project website	Coverage
CAESAR	Coordination Action for the European Strategic Agenda of Research on intermodalism and logistics	FP6-SUSTDEV-2 - Sustainable Surface Transport	www.eirac.net	if reports become available
CARDME	Concerted Action for Research on Demand Management in Europe: work of CARDME team in support to cross-border interoperability of electronic fee collection systems	FP5 - KA 1, Cluster 1 "Mobility and Intelligent Infrastructure for Transport"		this paper
INTRO	Intelligent Roads	FP6-SUSTDEV-3 - Global Change and Ecosystems	intro.fehrl.org/?m=1	this paper
PROGRESS	Pricing Road use for Greater Responsibility, Efficiency and Sustainability in cities	FP5 - GROWTH - KA2 - Sustainable Mobility and Intermodality	www.progress-project.org	this paper
TRACE	Costs of Private Road Travel and their Effects on Demand, Including Short and Long Term Elasticities	FP4 - TRANSPORT RTD - Transport Research and Technological Development	www.stratec.be	EXTR@Web paper
TRAFFIC	Traceability of the Evolution of Communication Navigation Surveillance	(4th RTD Framework Programme		EXTR@Web paper

Remark: the projects listed in the annex are those that have had the focus on the theme “ITS”. On the TRKC portal www.transport-research.info it is possible to use the “advanced search” functionality, with the option “Intelligent Transport Systems”, and find all research projects, EU-funded and national, which have treated, to a variable extent, aspects that can be related to the theme.