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**ROAD TRANSPORT  
THEMATIC  
RESEARCH SUMMARY**

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**Thematic Research  
Summary:**

# **Road Transport**

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## Foreword

This paper has been produced as part of the TRKC (Transport Research Knowledge Centre) project of the Sixth Framework Programme, priority thematic area “Sustainable Development, Global Change and Ecosystems”.

TRKC, as its predecessor project EXTR@Web, aims at collecting, structuring, analysing and disseminating transport research results. It covers EU-supported research as well as key research activities at the national level in the European Research Area (ERA) and selected global programmes. The main dissemination tool used by TRKC is the web portal at [www.transport-research.info](http://www.transport-research.info).

The approach to dissemination of results of 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 thirty themes, fixed for the project life time; 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 a representative group of research users.

The present Thematic Research Summary deals with road transport. The aim is to provide the reader with a synthesis of completed EU-funded projects which have dealt with the theme. The paper is intended for policy makers at the European, national and local levels, as well as any interested reader from other stakeholders and from the academic and research communities.

### ***Disclaimer***

The TRKC team is fully responsible for the content of this paper. The content of this paper does not represent the official viewpoint of the European Commission and has not been approved by the coordinators of the research projects reviewed.

## Executive Summary

This paper has been produced as part 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 “road transport”.

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 road transport theme is very wide ranging and overlaps with numerous other themes. The focus of research covered in this paper is on road infrastructure planning and operation, road vehicles and road use (including driving). Walking and cycling is also included in the road transport theme.

Policy developments at EU level have traditionally been related to the competitiveness and efficiency of road transport; connectivity, accessibility and quality of road transport; road safety and environmental effects of road transport.

The second part 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, as well as a small selection of relevant national projects where results have been made available to the TRKC. Projects that had been synthesised in the related paper produced within the predecessor project EXTR@Web are briefly summarised.

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

In the sub-theme concerning **road infrastructure planning and operation**, key results cover:

- Road construction and maintenance aspects, such as the feasibility of detecting pavement defects using probe vehicles and in-situ sensors, maintenance concepts allowing work to proceed under bad weather conditions, improving the mechanical properties of low-noise sections of road and pavement construction incorporating industrial waste. Longer life pavements and intelligent status monitoring of them (to optimise maintenance management) are key areas where application and further research need to be focused.
- Safety aspects of road infrastructure, including provision of a performance-based ranking of safety recommendations addressing active and passive safety measures and the development of a measurable parameter that can be used for assessing and monitoring the safety of a road segment.

- Traffic management issues such as guidance on traffic management techniques and data collection for secondary roads, bus priority strategies, signal management and ramp metering recommendations.

In the sub-theme on **road vehicles**, research results included:

- Development of an accident-avoiding vehicle using a Decision Control System (DCS), which compensates driver failure probability, and development of a scalable platform approach which supports the Integration of X-by-Wire/DCS and active safety systems.
- Vehicle safety results including a database of in-depth studies on vehicle rollover cases and the development of key rollover scenarios, a physical demonstrator and performance criteria. Also, an overview of safety-based systems together with information on socio-economic impact assessment methods and methods of market penetration of Intelligent Vehicle Safety Systems (IVSS).
- Driver interface (HMI) issues: the human component of driver assistance systems and generally the training of drivers in its relation with ITS. A Driver-Vehicle Environment (DVE) model structure was produced for implementation in a simulation tool and an Adaptive Integrated Driver-vehicle Interface was developed and validated.

In the sub-theme concerning **road use and driving**, key research results covered:

- Driver training, behaviour and assistance aspects, including the development of an interactive, multimedia training tool and two modules of a driving simulator (static and semi-dynamic), paying attention to their cost-effectiveness. Also, three different virtual reality systems were developed, including generic force effectors able to give the person the sense of reaching and operating a real control.
- The development of real-time traffic safety indicators for use for driver warning, including indicators based on single-source data (speeds, headways) and on aggregated data (speed and density of flow) and establishment of their relationship with real accidents.
- Creation of a system which sends up-to-the-minute information on driving conditions, accidents, traffic jams and road works to drivers' in car devices and/or mobile phones.
- Development and testing of a platform for advanced positioning and mapping technologies in vehicles.
- The development of an architecture of a complete automatic driving enforcement system based on different types of sensors (at-site or in-vehicle) and including detection, fining and record on a database.
- The relationship between braking distance and pavement friction (skid resistance) in order to display a warning to the driver about wet, snowy or icy conditions based on real-time information from the pavement.
- Bringing together a wide range of statistics on accident data in EU countries (including their causes) together with different models describing the trends of accident, injury and fatality numbers as part of a European Road Safety Observatory.

- The development and demonstration of an in-vehicle device designed for flexible collective transport service (both regular and demand responsive).

A final sub-theme concerns **slow modes** (walking and cycling). The only EU project within this sub-theme aimed to promote pedestrian traffic in urban areas by improving the quality and attractiveness of public spaces. A range of recommendations and good practice solutions was provided for city planners in a guidebook. Three national projects are also covered in this theme, focusing on non-motorised mobility and land-use resources (providing an interdisciplinary approach to planning), a marketing approach for the promotion of pedestrian and bicycle traffic in Switzerland, and on built environment variables influencing pedestrian trips.



## Abbreviations and acronyms used

|                 |   |
|-----------------|---|
| ADAS            | Advanced Driver Assistance Systems  |
| AEBS            | Advanced Emergency Braking Systems  |
| APM             | Accident Prediction Models  |
| BAS             | Brake Assist Systems  |
| CEC             | Commission of the European Communities  |
| CO <sub>2</sub> | Carbon monoxide   |
| DRT             | Demand-responsive transport   |
| DVE             | Driver-Vehicle Environment  |
| EFV             | Environmentally Friendly Vehicle  |
| ERA             | European Research Area  |
| ESC             | Electronic Stability Control  |
| EU              | European Union  |
| DGMOVE          | Directorate General for Mobility and Transport (European Commission DG from 2010)       |
| DGTREN          | Directorate General for Transport and Energy (European Commission DG up to end of 2009) |
| EES             | Electrical and Electronic System  |
| ERDF            | European Regional Development Fund  |
| FP5             | Fifth Framework Programme   |
| FP6             | Sixth Framework Programme   |
| GDP             | Gross Domestic Product  |
| GSM             | Global System for Mobile telecommunications   |
| GPS             | Global Positioning System   |
| HGV             | Heavy Goods Vehicle   |
| HMI             | Human-Machine Interface   |
| ICT             | Information and Communication Technologies  |
| ISA             | Intelligent Speed Adaptation  |



|                 |   |
|-----------------|---|
| ITS             | Intelligent Transport Systems                 |
| IVIS            | In-vehicle Information Systems                |
| IVSS            | Intelligent Vehicle Safety Systems            |
| KA              | Key Action (sub-groupings in FP5)             |
| LDW             | Lane Departure Warning.                       |
| NoE             | Network of Excellence                         |
| NO <sub>x</sub> | Nitrogen oxide                                |
| OEM             | Original Equipment Manufacturer               |
| PTA             | Priority Thematic Area (sub-groupings in FP6) |
| RFID            | Radio Frequency Identification                |
| RTD             | Research and Technological Development        |
| RTTI            | Real-time Traffic and Traveller Information   |
| TEN             | Trans-European transport Network              |
| TRKC            | Transport Research Knowledge Centre           |
| TRS             | Thematic Research Summary                     |
| UNECE           | United Nations Economic Council for Europe    |
| V2I             | Vehicle to Infrastructure                     |
| V2V             | Vehicle to Vehicle                            |
| VMS             | Variable Message Sign                         |
| WAP             | Wireless Application Protocol                 |
| WIM             | Weigh in Motion                               |

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# 1. Introduction

This paper provides a structured review of the research relating to road transport carried out in EU-funded research projects. “Road transport” is one of thirty themes in the classification scheme adopted by the TRKC project, shown in the table below.

*Table 1. The classification scheme adopted in TRKC*

|   |   |
|---|---|
| <i>Sectors</i>                          |   |
| ✓                                       | passenger transport                                 |
| ✓                                       | freight transport                                   |
| <i>Geographic</i>                       |   |
| ✓                                       | urban transport                                     |
| ✓                                       | rural transport                                     |
| ✓                                       | regional transport                                  |
| ✓                                       | long-distance transport                             |
| ✓                                       | EU accession issues                                 |
| <i>Modes</i>                            |   |
| ✓                                       | air transport                                       |
| ✓                                       | rail transport                                      |
| ✓                                       | <b>road transport including walking and cycling</b> |
| ✓                                       | waterborne transport                                |
| ✓                                       | innovative modes                                    |
| ✓                                       | intermodal freight transport                        |
| <i>Sustainability policy objectives</i> |   |
| ✓                                       | economic aspects                                    |
| ✓                                       | efficiency  |
| ✓                                       | equity and accessibility                            |
| ✓                                       | environmental aspects                               |
| ✓                                       | user aspects  |
| ✓                                       | safety and security                                 |
| <i>Tools</i>                            |   |
| ✓                                       | 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](http://www.transport-research.info/web/projects/transport_themes.cfm).

In the predecessor project EXTR@Web, TRSs were produced for 28 out of the 30 themes (the reduced number of TRSs resulting from merging of some themes into a single TRS). The TRKC project has planned to produce final versions of the TRSs for all themes by June 2010. This is the final version of the TRS on Road Transport and substitutes the first version issued in January 2009.

A large number of research projects have dealt with the road transport theme 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 "Road Transport" TRS produced in the predecessor project EXTR@Web<sup>1</sup>, reviewed research from 14 European projects belonging to the Fourth Framework Programme (FP4), the Fifth Framework Programme (FP5) and 22 selected national projects – 36 projects overall. The present paper adds 37 new projects, from FP5 and the Sixth Framework Programme (FP6), and eight national projects.

The research reviewed in this paper does not represent the entire range of research dealing with road transport carried out in Europe. The paper focuses on research from those projects which have made documentation on results available to the TRKC team after the issue of the EXTR@Web paper in 2006. A summary of the research on road transport topics reported on in the previous EXTR@Web paper is also included to make the reader aware of the full range of research which has dealt with the theme. For completeness, projects from FP6 which are on-going or which, although completed, have not yet made results publicly available, are also listed.

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 research. The section is structured into four sub-themes to make the broad area of research in the road transport field more manageable. For each sub-theme, overall research objectives are presented and linked to policy goals, then research findings are synthesised. A special focus is given to the policy implications of research results. Sources for section 4 are documents available from the projects and reporting on their achievements, essentially the project final reports.

The sub-themes covered in section 4 are:

- Road infrastructure planning and operation (including traffic management issues);
- Road use and driving;
- Road vehicles; and
- Slow modes (walking and cycling).

The Annex includes the list of the EU-funded research projects for each of the four sub-themes. Addresses of the websites of the projects are included with hyperlinks. In several cases these websites make the project documentation available to the public. This may include final reports and project deliverables.

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<sup>1</sup> EXTR@Web (2006)



Given the very wide breadth of the road transport theme, this paper deals with projects which treat only the road mode and does not treat projects where road is one of several modes considered (e.g. projects related to urban public transport or intermodal freight). Readers interested in specific aspects of road transport are further invited to consult the relevant Thematic Research Summaries listed in Table 1.

## 2. Scope of the Road Transport theme

The “road transport” theme covers all transport which runs exclusively or principally on roads (including walking and other non-motorised modes), together with road infrastructure and road traffic management systems. This theme however excludes ground activities in ports and airports which are directly associated with the functioning of air, maritime or inland waterway transport. Guided vehicles are included in the road theme if they have the capacity to run on normal roads as well, for instance guided buses, but not trams (which are covered under the rail mode).

Road transport can be broken down into a number of **road transport modes**, as follows:

- Public or collective passenger transport by road. This can be scheduled public transport (e.g. public bus and coach services), non-scheduled or demand-responsive public transport (e.g. taxis and semi-scheduled minibus services), or collective transport which is not public but aimed at specified users only (e.g. dedicated school buses, private hire coaches);
- Individual motorised passenger transport (e.g. cars, motorcycles), which may also be used in a collective way (e.g. car sharing, car pooling)
- Individual non-motorised transport (“slow modes”, principally walking and cycling, but may also cover horse riding, rollerblading, etc);
- Freight transport by road.

For each of the above, the following **physical elements** are employed:

- Vehicles (cars, buses, lorries, motorcycles, bicycles, etc);
- Basic road infrastructure (roads, pavements, bridges, tunnels, etc);
- Terminal infrastructure (bus stations, depots, terminals, service areas, car parks, etc);
- Roadside and remote operating equipment (signing, lighting, telecommunications, and intelligent transport systems such as traffic control, enforcement, safety, information or toll systems, as well as facilities such as traffic control centres).

The above are planned, managed and regulated by legal frameworks, control and management systems, etc, in order to meet objectives such as safety, efficiency, environmental protection, user-friendliness and accessibility. The main aspects, which make up the key European research priorities and focus, are:

### **Road safety and security:**

- Safety of vehicles (design, ergonomics, maintenance, vehicle licensing, etc);

- Safety of infrastructure (e.g. road design standards);
- Safety of operation (education, training, regulations, enforcement, etc);
- Security of infrastructure and transport operations.

**Road efficiency:**

- Efficiency of vehicles (including fuel consumption, etc);
- Network efficiency (planning, operation, pricing, traffic management, ITS);
- Operational efficiency (freight logistics and public transport planning).

**Effects of roads and road traffic on the environment** (at global level, e.g. climate change, as well as at local level):

- Technical aspects (vehicle design, highway design, etc);
- Fiscal and legislative aspects (standards, controls, enforcement, road pricing);
- Awareness aspects.

**Economic and regulatory aspects related to road networks and operation:**

- Regional and Europe-wide accessibility by road;
- Harmonisation of regulations and levels of service;
- Taxes, tolls and other charges on road traffic and the road transport industry;
- Agreements between the EU and non-EU countries;
- Competition policy and the single European market.

**Social aspects:**

- Pricing (subsidies and/or charges for public transport and private vehicle use);
- Access to and quality of public transport services;
- Training, working conditions and recognition of professional qualifications;
- Effects of roads and road transport on non-users;
- Rights and obligations of road users (transport providers and customers).

Note that several of the above issues are dealt with in other Thematic Research Summaries (see table in the Introduction chapter for the full list).

**Research in the road transport domain** can be categorised in a simple way under four sub-themes:

1. Road infrastructure planning and operation (including traffic management issues);
2. Road vehicles;
3. Road use and driving;
4. Slow modes (walking and cycling).

These are further elaborated in Chapter 4.



The previous Thematic Research Summary, produced by the EXTR@Web project (EXTR@Web 2006), included the above four sub-themes, with the addition of two others: “Public/Collective passenger transport by road” and “Freight transport by road”. However, among recent projects there were too few to make these sub-themes viable, as most FP6 passenger and freight-related projects have a co-modal focus and are therefore included in the Passenger Transport and Freight Transport thematic papers.



### 3. Policy context

Road transport dominates the transport scene in Europe. It serves all Europeans every day (even those who do not travel consume food or goods which have been moved by road). It accounts for **83.1% of motorised passenger-kilometres (pkm)** in the EU<sup>2</sup> and **45.6% of tonne-kilometres (tkm) for freight**<sup>3</sup> (CEC, 2009a). The figure for freight disguises the fact that the other modes (rail, waterborne and pipeline transport) can carry far bigger loads in a single trip, so in terms of vehicle-km for freight, the road share is considerably larger.

Road transport is a major employer in its own right, with 5.6 million jobs in the EU in the road passenger and freight transport industry<sup>4</sup> – not counting employment in vehicle manufacture, retail, repair and insurance, fuel delivery and retail, road construction and maintenance, traffic management, road user information, etc (CEC, 2009a).

Growth in the demand for road transport has been spectacular: freight tonne-km by road in the EU-27 increased by 49.6% in just 12 years, from 1995 to 2007. Passenger-km by car increased by 21.4% from 1995 to 2007, with current increases of 1.2% per year (CEC, 2009a). The consequences of this growth have been both extended mobility and increased access to goods and services, but also changes in land use patterns and more centralised services. Transport costs **to industry have generally been reduced**. On the other hand, road transport presents a number of serious issues in terms of **negative effects**, most notably regarding safety, inefficiency (including congestion), the environment and social effects (e.g. increasing disparity between those with access to a car and those without, especially in rural areas).

The EU's responsibilities regarding road transport operations, particularly regarding the road haulage industry, but also in passenger transport by bus and coach, have been built up in successive stages. This has been to ensure progress on many specific points within national rules and regulations, and to bring common development and improvements. The EU also plays a major role in providing frameworks to address the negative effects of road transport through policy formulation and support to research, development and deployment activities, particularly in these four key areas:

- Competitiveness and efficiency of road transport;
- Connectivity, accessibility and quality of road transport;
- Road safety;
- Environmental effects of road transport, including the emission of greenhouse gases.

<sup>2</sup> Figure is for 2007 and refers to EU-27. It includes intra-EU passenger transport by sea and air. Concerning land transport (road, rail and tram/metro) only, road accounts for 90.6% of pkm.

<sup>3</sup> Figure is for 2007 and refers to EU-27. It includes intra-EU coastal shipping and air freight transport. Concerning land transport only, road accounts for 62.6% of tkm.

<sup>4</sup> Figures are for 2007 and refer to EU-27.

Key European policy initiatives in recent years affecting road transport include:

- The **2001 EU Transport White Paper** (CEC, 2001), which proposed economic policies to reduce the demand in road transport and restore a more equal balance between different modes of transport, specific urban policies, and continued development of the Trans-European Networks (TEN-T) in order to increase efficiency and bridge bottlenecks.
- The **2003 Road Safety Action Programme** (CEC, 2003) is pursuing an ambitious overall objective of halving the number of people killed on the roads by 2010.
- The **2006 mid-term review of the White Paper** (CEC, 2006).
- The **2007 Freight Transport Logistics Action Plan** (CEC, 2007a), which proposed measures to improve the efficiency and sustainability of freight transport in Europe (for all modes).
- The **2007 Green Paper on Urban Transport** (CEC, 2007b), which proposed priorities aimed at making towns and cities less congested, more accessible, with greener, smarter and safer transport, a new urban mobility culture and improved knowledge.
- The **2008 Greening Transport Package** (CEC, 2008a), which intends to steer transport towards sustainability, with measures relating to road transport focusing on pricing.
- An **Action Plan for Intelligent Transport Systems** (CEC, 2008b) which sets out the short and medium term targets to accelerate the implementation of ITS.
- A communication on **The Future of Transport** (CEC 2009b), aimed at identifying policy options to be tested and eventually included in the next White Paper in 2010.

### 3.1 Competitiveness and efficiency

The demand for Road Transport is increasing constantly and many examples of inefficiency exist, such as lorries running empty rather than carrying a return load, or traffic jams of single-occupancy cars. Bus operators normally need to maintain a fleet of vehicles to cover peak-period services, many of which then lie unused for the rest of the day.

EU policies aimed at increasing the competitiveness and efficiency of road transport, including the reduction of congestion, focus on the following:

- **Market liberalisation and fair competition** for freight and passenger transport operators, including agreements with non-EU countries.
- **Co-modality** (the efficient use of different modes on their own and in combination) and **modal balance** for an optimal and sustainable utilisation of resources, assisted by advanced Information and Communication Technologies (ICT). This includes shifting freight transport from road to sea, rail and inland waterways (**modal shift**) and promoting **intermodal freight transport** to reduce the external costs of freight transport (e.g. the MARCO POLO programme).

- Improving the **efficiency of freight transport and logistics**, including aspects such as vehicle dimensions and loading standards, promotion of the concept of e-Freight (a paper-free, electronic flow of information associating the physical flow of goods), addressing the shortages of skilled personnel in many areas of the logistics industry and measurement of performance in the industry.
- Fair and efficient **infrastructure charging** so that users pay the true costs of road use, including social costs such as pollution, and promoting **interoperability** between different pricing systems.
- **Maximising the capacity of road infrastructure and optimising traffic flows** by completing missing links in the network and through the development and deployment of Intelligent Transport Systems (ITS) to improve traffic management.

### 3.2 Connectivity, accessibility and quality

The objectives of EU transport policy are “to offer a high level of mobility to people and businesses throughout the Union. The availability of affordable and high-quality transport solutions contributes vitally to achieving the free flow of people, goods and services, to improving social and economic cohesion, and to ensuring the competitiveness of European industry” (CEC, 2006).

The growth of car ownership has led to a society where, especially outside urban areas, those without access to a car can find themselves at a distinct disadvantage in terms of mobility. Many road passenger transport services required to serve these needs, as well as to provide an alternative to car use and to contribute to economic cohesion, cannot be operated on a commercial basis. The EC sets rules on state aid in order to govern financial compensation to operators or other measures to ensure a public service.

In terms of regional accessibility, the Trans-European Road Network (TERN – part of the TEN-T – Trans-European Network for Transport) is defined with an objective of connecting major economic centres, along with peripheral and remote regions, with a high quality road network. By 2020, the TERN will comprise some 89 500 km of roads, including an increase of 4 800 km to plug “missing links”. Of the 30 “Priority projects” which form the backbone of the TEN-T development, eight of them are partly or wholly road projects (CEC, 2005).

### 3.3 Road safety and security

Safety is one of the major concerns facing road transport in Europe, with around 43 000 people killed annually on the EU’s road network (CEC, 2009a). The four major elements contributing to road safety (or lack of it) are:

- **Safe vehicles**, including issues such as type approval and in-vehicle ICT-based safety systems;
- **Safe and secure road infrastructure** (including pedestrian and cycle facilities);
- **Safe driving**, including driver training and education;
- **Legislation, rules and enforcement.**

The mid-term review of the EU 2001 Transport White Paper (CEC, 2006) proposed to implement an integrated approach involving vehicle design and technology, infrastructure and behaviour, including regulation where needed. To increase the efforts of all road safety stakeholders, the European Commission officially launched the **eSafety Initiative** in 2002<sup>5</sup>. Aspects covered include accident causation data, impact assessment of safety systems, human-machine interaction, ICT applications, motor vehicle type approval legislation, standards and regulation, legal issues, societal aspects, business cases and user outreach. Closely linked to the eSafety initiative is the EC's **Intelligent Car Initiative**<sup>6</sup>, launched in 2006, and aimed at accelerating the deployment of intelligent vehicle systems.

Although road design standards are a national matter, the EU supports research and best practice solutions in **road infrastructure**, in terms of design, materials, signing, intelligent equipment and operation, as well as its security against human acts or natural phenomena.

**Safe driving** is another area where the EU is active. Key EU legislation affects, for example, driver training, drivers' hours and rest periods for lorry and bus/coach drivers. National **legislation** on many driving aspects emanates from EU directives. Other policies include measures to improve cross-border enforcement and penalty collection for safety-critical driving offences. The **European Road Safety Charter**<sup>7</sup> is a measure launched as part of the EU's Road Safety Action Programme which is aimed at exchanging good practice, and helping and inspiring others to take actions to reduce road accidents.

### 3.4 Environmental effects

Transport is the only sector with increasing emissions carbon dioxide (CO<sub>2</sub>) emissions in the EU (27%), with road transport accounting for 72% of all transport-related CO<sub>2</sub> emissions. Road transport causes 46% of nitrogen oxide (NO<sub>x</sub>) emissions. Transport also represents 73% of oil consumption in Europe. Overall EU goals for the year 2020 (for all uses, not just transport) are to reduce greenhouse gas emissions by 20%, to increase the share of renewable energy to 20% and to increase energy efficiency by 20%.

EU actions to reduce the effects of road transport on the environment include:

- Research and legislation on clean vehicles (emission regulations, reducing CO<sub>2</sub> from cars and light trucks, etc);
- Promotion of ICT for clean and efficient mobility and eco-driving;
- Promotion of best practice solutions in urban areas, notably within the CIVITAS initiative<sup>8</sup>.
- Promotion of traffic management systems, traveller information and integrated payment services to reduce congestion and promote co-modality.

In 2008, the European Commission put forward a package of new "greening transport" initiatives (CEC, 2008a). Two main aspects affecting road transport are a strategy for

<sup>5</sup> See [http://ec.europa.eu/information\\_society/activities/esafety](http://ec.europa.eu/information_society/activities/esafety) and [www.esafetysupport.org](http://www.esafetysupport.org)

<sup>6</sup> See [http://ec.europa.eu/information\\_society/activities/intelligentcar](http://ec.europa.eu/information_society/activities/intelligentcar)

<sup>7</sup> See [www.erscharter.eu](http://www.erscharter.eu)

<sup>8</sup> See [www.civitas-initiative.org](http://www.civitas-initiative.org)



infrastructure charging and a proposal to help Member States implement more efficient and greener road tolls for lorries, with the revenue used to reduce environmental impacts from transport and to reduce congestion.

## 4. Research findings

### 4.1 Introduction

The research which is reviewed in this paper deals with four sub-themes.

The first sub-theme deals with **road infrastructure** issues, including highway planning, construction and maintenance, roadside equipment (including Intelligent Transport Systems – ITS) and road operation (including traffic management). Readers interested in this sub-theme are also referred to the Thematic Research Summary on Vehicle Technology.

The second sub-theme is centred on **road vehicles**, where four clusters of projects have been identified: road vehicle propulsion and emissions; safety aspects of road vehicles; driver interfaces and the passenger environment within cars. Readers interested in this sub-theme are also referred to the Thematic Research Summary on Vehicle Technology.

The third sub-theme concerns **road use**. This covers research related to driving (including driver training and education, behaviour, enforcement and assistance) as well as co-operative systems for safety and mobility (which essentially straddle all three sub-themes as they link the vehicle, the driver and the infrastructure). Traffic and safety monitoring is another aspect of road use (closely linked to traffic management in the first sub-theme). A final cluster in this is research into road-based demand-responsive and innovative mobility services. Readers interested in this sub-theme are also referred to the Thematic Research Summaries on Safety and Security, Intelligent Transport Systems, Regulation/Deregulation and Transport Management.

A fourth sub-theme covers “**slow modes**” (principally **walking and cycling** but which may also include on-road horse riding, rollerblading, etc). Very few EU projects specifically address this area as it is generally researched and promoted at national and local level, although wider projects (e.g. covering urban transport issues) do address it. Only one relevant recent EU project was identified for this paper, concerning the promotion of pedestrian traffic in cities.

The previous Thematic Research Summary, produced by the EXTR@Web project (EXTR@Web, 2006), included in addition the sub-themes “Public/Collective passenger transport by road” and “Freight transport by road”.

However few recent EU projects have dealt with public transport or freight transport exclusively in the road domain – most projects covering these aspects are multimodal/intermodal in nature and are therefore not covered in this paper. They will be covered in the related Thematic Research Summaries on Passenger Transport and Freight Transport. Three projects on passenger transport are included in this paper, one of them relating to bus priority, which is included in sub-theme 1: road infrastructure planning and operation, and two relating to demand-responsive and innovative mobility services by road, which are included as a cluster within sub-theme 2: road use and driving.

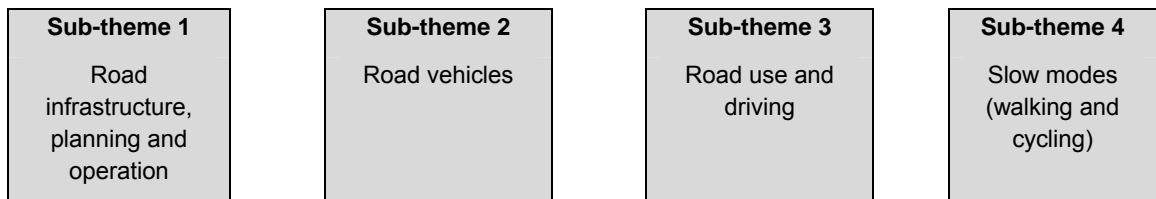


Table 2 shows the EU-funded projects which have dealt with each sub-theme. The Table includes:

- 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 had been synthesised in the EXTR@Web TRS and which are briefly summarised in the background of the following sub-sections;
- Projects of FP6 which have not yet made results publicly available.

Table 2. EU-funded projects relevant to the theme

| Sub-theme                                  | Contributing projects   |
|--|---|
| Road infrastructure planning and operation | <p><u>Projects covered in this paper:</u><br/>           BESTUFS II, ERTRAC (covered in Chapter 4.6.2 as it cuts across several sub-themes), EURAMP, HeavyRoute, IN-SAFETY, INTRO, NR2C, OMNI, PRISCILLA, RANKERS, RIPCORD, RISER, ISEREST, SENSOR, SMART NETS,</p> <p><u>Projects covered in EXTR@Web paper:</u><br/>           ITSWAP, POLMIT</p> <p><u>Other FP6 projects for which the TRKC project has not yet received results, and which will be included in a future update of this paper:</u><br/>           ARCHES, CERTAIN, EcoLanes, ERTRACII, ITARI, INQUEST, MISS, RCI, SELCAT, SPENS</p>                     |
| Road vehicles                              | <p><u>Projects covered in this paper:</u><br/>           AIDE, CARS-21, ERTRAC (covered in Chapter 4.6.2 as it cuts across several sub-themes), FURORE, PReVENT, ROLLOVER, SEES, SEISS, SPARC</p> <p><u>Projects covered in EXTR@Web paper:</u><br/>           ADVISORS, CHAMELEON, CyberCars, RESPONSE 2</p> <p><u>Project listed in Annex but not included in the main text as it is a support action rather than a research project with results:</u><br/>           e-Scope</p> <p><u>Other FP6 projects for which the TRKC project has not yet received results, and which will be included in a future update</u></p> |

| Sub-theme                        | Contributing projects  |
|----------------------------------|--|
|                                  | <u>of this paper:</u><br>AC-DC, APSN, EASIS, ECO-ENGINES, ERTRAC II, HUMANIST, HyTRAN, IPSY, LITEBUS, OPTO-EMI-SENSE, PAGODE, PEIT, PISa, POMEROL, PROTECTOR, RADAR-NET, SEE,, SLC, TOP EXPERT, TOPMACS, ULYSSES   |
| Road use and driving             | <u>Projects covered in this paper:</u><br>ERTRAC (covered in Chapter 4.6.2 as it cuts across several sub-themes), FAIR, GST, HIGHWAY, IM@GINE IT, IN-SAFETY, INTRO, INVETE, I-WAY, PEPPER, PReVENT, PROSPER, REPOSIT, SafetyNet, SAFETY-TECHNOPRO, TRAINER, VIRTUAL<br><br><u>Projects covered in EXTR@Web paper:</u><br>BESTUFS, DESIRE, MARETOPE, TRAVEL-GUIDE, VERA2, VOYAGER<br><br><u>Project listed in Annex but not included in the main text as it is a support action rather than a research project with results:</u><br>e-Scope<br><br><u>Other FP6 projects for which the TRKC project has not yet received results, and which will be included in a future update of this paper:</u><br>CARSENSE, CAST, DRUID, ERTRAC II, FAMS, MISS, PROCEED, REACT, TRAIN-ALL |
| Slow modes (walking and cycling) | <u>Projects covered in this paper:</u><br>PROMPT<br><br><u>Projects covered in EXTR@Web paper:</u><br>VELO INFO<br><br><u>Other projects which may have some relevance but not included in this paper as walking/cycling is not the main focus:</u><br>CIVITAS projects  |

## 4.2 Sub-theme 1: Road infrastructure planning and operation

### 4.2.1 Background

The sub-theme deals with research into the road itself, associated infrastructure (including roadside equipment and other ITS applications), and the management and charging of traffic.

Research reported in the EXTR@Web paper (EXTR@Web, 2006) in the field of road infrastructure planning and operation covered results of projects related to the following:

- Metal emission rates from roads and vehicles, depending on road surface characteristics;
- ITS implementation strategies;
- ITS services over Wireless Application Protocol (WAP);
- Integrated tracking, tracing and positioning of vehicles in a fleet using GPS/GSM;



- Improving junctions for vulnerable road users (pedestrians and cyclists);
- System architecture for traffic information systems;
- Establishing a reference framework for interurban road pricing schemes;
- Design of heavily trafficked roads in cities.

Research in this area focuses on many diverse issues. A major theme relates to Intelligent Transport Systems related to road infrastructure, traffic management and safety. Another relates to charging for road use, both in terms of economic aspects (charging objectives, policy and tariffs) and technical aspects (toll payment systems). Increasing the efficiency of road maintenance is another research priority – with fewer roads now being built than in previous decades, road authorities and operators are spending a greater proportion of their budget on “asset management”, maintaining existing infrastructure in an efficient way, ensuring that it meets safety standards and optimising its use. This issue is particularly important in the New Member States of the EU where proper maintenance of road infrastructure has often been neglected in the past and where state budgets for bringing roads up to required standards is limited.

#### 4.2.2 Research objectives

A first set of research objectives in this sub-theme concerns **road construction and maintenance**. EU policies on increasing the efficiency of transport apply to the infrastructure as well as operations, and road infrastructure owners and operators are faced with ageing assets which need to be maintained and understood in an effective way to deal with increasing traffic. “Intelligent” road pavements are one possible solution, using in-situ sensors to obtain new information that can be added to the traditional road monitoring systems, and also to give information to the road operator on pavement conditions in order that maintenance can be planned in an efficient way rather than only responding when a visible structural fault actually occurs (INTRO).

At a more general level, addressing practically the whole range of road-related policy objectives, was the creation of a long-term perspective for road infrastructure (vision 2040), focusing on urban and interurban road infrastructure and civil engineering structures (NR2C).

A second set of objectives covers **safety aspects of road infrastructure**, including enhancing the forgiving and self-explanatory nature of roads in order to reduce accidents (IN-SAFETY), using combinations of new technologies and traditional infrastructure best practice applications. Objectives also include developing guidelines on road infrastructure safety enabling optimal decision-making by road authorities in their efforts to promote safer roads and eradicate dangerous road sections (RANKERS and RISERS projects), as well as giving support to practitioners concerned with road design and traffic safety by developing best practice guidelines, focusing on secondary roads (essentially single carriageway rural roads) which is where most accidents occur (RIPCORDER ISEREST).

Finally, a group of research objectives cover traffic management issues to address the policy goals of improving the flow and efficiency of road transport. These include traffic management research conducted into intersection-based traffic management models (OMNI), ramp metering (motorway access control) (EURAMP) and traffic management strategies for secondary road networks (SENSOR) and traffic types (HeavyRoute). At the urban level, where tackling congestion and promoting modal shift are a particular priority,

objectives included urban traffic signal management in real-time (SMART NETS), strategies for bus priority (PRISCILLA) and freight guidance (BESTUFS II).

### 4.2.3 Research results

#### 4.2.3.1 Road construction & maintenance

The use of intelligent pavements and intelligent vehicles allows improvements in maintaining the road infrastructure in that it provides a precise assessment of the integrity of the pavement and structures such as bridges. Being better targeted and planned, maintenance works, both preventive and corrective, would cause less disruption to traffic.

The main findings of the “Intelligent Roads” project (INTRO, 2008) in that field are:

- The feasibility of detecting defects in the pavement on inter-urban roads via the analysis of recorded parameters of probe vehicles, preferably fitted with vertical acceleration sensors;
- The feasibility of identifying pavement conditions through the monitoring of data from in situ sensors: special WIM (weigh in motion) stations using deformation gauge put during the laying phase, monitoring of bearing capacity during spring thaw on rural roads;
- The high added-value of long term monitoring of bridge conditions by the use of vibration sensors.

Innovative road construction concepts together with an insight into the future until the year 2040, in order to identify research directions, have been provided in the “New Road Construction Concepts” project (NR2C, 2008): In the field of road construction and maintenance, the main innovations proposed are: new maintenance processes allowing maintenance works to be carried out under bad weather conditions, improving the mechanical properties of low noise sections, and building crack-free semi-rigid pavement incorporating industrial waste. Research directions were, among others, new age binder design technologies (study of the long term asphalt layers behaviour), pavement lifetime engineering, modular prefabricated pavement, and energy controlled pavements.

The issue of pavement durability has been widely examined, for example the ‘New techniques for the mechanical characterisation of road materials with the aim of designing flexible pavements’ project conducted in Italy 2003-2005 (Department of Civil Engineering – University of Parma, 2005) which undertook to define and test a range of failure prediction tests and models. These included an Image Analysis System suitable for full-field strain investigations of road materials which has been able to overcome the shortcomings of traditional devices (e.g. strain gauges) and achieves comparable accuracy while allowing for exact determination of failure location. In parallel a failure prediction model for flexible pavements was developed that describes the failure/fatigue mechanism of road materials under generalised loading conditions.

The interplay between road maintenance and the economy was examined in ‘The impacts of road maintenance on regional economy’ project in Finland (Finnish Road Administration, 2008) which aimed to examine the potential for including the impacts on regional economies in the impact assessment of road maintenance projects and how this could be undertaken. Foremost in these considerations are how maintenance may affect accessibility, for example an increase in freight traffic or reducing the travel time for

business traffic may have impacts on regional costs and productivity, which in-turn may effect growth and increase traffic.

In view of the major issue of European road infrastructure maintenance, the general recommendation is to strongly continue in the direction towards longer life pavements; especially using intelligent status monitoring and optimised maintenance management (see further research indications under Section 4.6).

#### 4.2.3.2 Safety aspects of road infrastructure

The “Infrastructure and Safety” project (IN-SAFETY, 2008a & 2008b), which aimed to improve the self-explanatory and forgiving nature of roads, conducted research into improving readability and standardisation of fixed and variable message signs. A pilot study within the projects showed that there is a potential to substitute milled rumble strips at the edge of carriageways by an in-vehicle assistance system. This will probably be best practice in future and will reduce costs in road maintenance. The project also concluded that use of high performance retro-reflective technology in combination with fluorescent colours will reduce accident rates and that there is still leeway to use markings for special purposes such as for fog speed control.

Regarding vertical signing, over 560 pictograms were tested and developed, with several being redesigned as a result of evaluations. The project produced a set of evaluated pictograms, unified keywords and a universal typeface (for signing and VMS in 25 EU languages). These results are a base for further discussions and a first step to harmonise symbols and keywords as much as possible. Freely programmable Variable Message Signs (VMS) allow pictograms to be animated for possibly further improved comprehension and to optimise them for impaired visibility conditions. An increasing number of VMS are showing messages bilingually, either in bilingual regions, in border areas or on roads with a high proportion of foreign traffic. Bilingual messages can be shown either simultaneously or consecutively with both approaches being equally acceptable. For simultaneous information, the most acceptable solution was found to be using a four line VMS (two lines per language). When combined with international pictograms, the amount of text in different languages can be limited, e.g. to different language versions of place names. For consecutive information, it is acceptable to display bilingual information in turns of two seconds each.

A project on road safety ranking (RANKERS, 2008) provided a "Road safety index" for assessing and monitoring road safety, a catalogue of road infrastructure safety recommendations ranked according to their efficiency, and an interactive application of this catalogue ("eBook"), extended to urban vulnerable road users, available through the internet.

By addressing both active (i.e. accident preventing) and passive (i.e. mitigating the effects of accidents) safety measures, the project developed a performance-based ranking of safety recommendations, helping to prioritise the different solutions and optimise allocation of funds.

RANKERS detailed experimental protocols to be conducted in field tests. These protocols were based on an extensive review of literature on accident statistics, infrastructure characterisations, human behaviour, and cost-benefit analysis. The identification of these main features influencing the occurrence of a certain accident typology (i.e. the set of scenarios defined) allowed recommendations to be put forward for specifying the experimental protocols. The project defined and developed two different experimental

protocols and undertook two kinds of field tests: one intended for infrastructure analysis and its interaction with the vehicle, and another one exclusively for human factor analysis.

The analysis task was performed in the three research areas considered (Human, Vehicle and Infrastructure), to ensure a holistic approach to accident and casualties mitigation. Its goal was to analyse the three areas considered in identified road segments, taking into account specific environmental and traffic conditions. The tests clearly indicated that road infrastructure factors provided improvement opportunities to reduce accident risk. RANKERS therefore developed a measurable parameter in road infrastructure that can be used for assessing and monitoring the safety of a road segment (site inspection).

On a similar theme, the “Roadside Infrastructure for Safer European Roads” project (RISER, 2005) has examined the role played by roadside infrastructure in single vehicle accident causation. Through the development of two databases the project has been able to assemble and promote a resource on which further studies on the inter-relationship between human factors, crash performance, and maintenance of roadside infrastructure elements could be developed. This has been aided and promoted through the production of a number of best practice reports emphasising the need for more thorough information about the road infrastructure and the causation process of the accident, stressing the establishment of, not only collection procedures covering a broad scope of information, but also a coordinated approach to ensure comparability.

A project on Road Infrastructure Safety Protection (RIPCORDER-ISEREST, 2008a/2008b) gave scientific support to the European transport policy road-safety target of 2010 by establishing two fundamental achievements:

- Best practice tools and guidelines for road infrastructure safety measures concerning accident prediction models, road-safety inspections, and black-spot management.
- Tools for cost-efficiency assessment of different safety measures in order to develop and manage a safe road infrastructure in a cost-effective way.

It produced an in-depth survey of the Accident Prediction Models (APM) and Road-Safety Impact Assessment literature. The project concluded that APM can differ for the same road-type in different countries, therefore paving the way for novel recommendations regarding the way these instruments can be used by practitioners.

RIPCORDER ISEREST also focused on the concept of "Self-explaining roads", a road designed and built in such a way as to induce adequate behaviour on behalf of the motorist. The project forwarded road-design recommendations concerning the layout and design-elements of secondary roads, incorporating road-user behaviour models.

It developed SEROES, a freely accessible database for road-authorities responsible for secondary roads, containing the "Best Practice Safety Information System", a summary of information regarding road-safety improvements. A GIS Decision Support Tool was also developed to assist local and regional road authorities in determining road safety problems, selecting appropriate safety intervention measures, giving the opportunity predicting the road safety level of a municipality/region and the cost-effectiveness of road safety projects.

SEROES was demonstrated together with a Decision Support Safety Tool, providing the user with several solutions, a cost-range, and information about the effect of each of the provided measures.

#### 4.2.3.3 Traffic Management

A project on traffic management strategies for secondary road networks provided a Handbook and a Decision Support System giving guidance on relevant questions pertaining to traffic data collection system design on non-highway roads: what, how, and where to collect (SENSOR 2004a and 2004b).

At the urban level, the project, “Bus Priority Strategies and Impact Scenarios Developed on a Large Urban Area” (PRISCILLA, 2002), showed that the benefits of the bus priority strategies, in terms of travel times and punctuality, are favourable and induce a real improvement of the service quality offered to the final users, except during certain specific conditions (improvement of commercial travel time between 5% and 15%). This improvement contributes to a modal shift in favour of public transport.

The European Ramp Metering project (EURAMP, 2007a) considered ramp metering (motorway access control using traffic signals) at four test sites: Paris, Utrecht, Munich and Tel Aviv, with various algorithms and strategies as well as a “no control” situation being tested at different periods. Utrecht used archive data between 2001 and 2006, while the other three had tests done between 2005 and 2007.

In Paris and Tel Aviv, the impact and socio-economic assessment showed that ramp metering could improve travel times and benefits over the “no control” base cases. However the data from Utrecht showed that delays on the ramp (entry slip road to the motorway) outweighed the travel time benefits achieved on the motorway itself. Where benefits were achieved; they were high in relation to costs (cost-benefit ratios of between 2.2 and 10.3).

From the various strategies tested, the Co-ordinated Strategy showed the best results (e.g. in Paris it showed a 17% reduction in congestion compared with a “no control” scenario, whereas other control strategies recorded reductions between 10% and 13%). A comparison between the 1-car-per-green light and the 2-cars-per-green metering strategy used in Utrecht resulted in the latter strategy showing better results in four out of the five cases. Regarding risk assessment, significant safety improvements were showed in the Paris case but no accident reduction in the Utrecht or Tel Aviv cases, so overall results were inconclusive. Acceptance of the systems was high both for motorway operators and for road users.

The project also provided a Handbook of Ramp Metering, targeted at those interested in designing, developing, implementing and operating a ramp metering system, and aimed at deepening understanding and providing insights on the impact, design and operation of ramp metering so as to achieve maximum benefits. Other project outputs include ramp queue estimation and control software, a method of handling measurements in the main carriageway, and other algorithms and control tools.

The project “Open model for network-wide heterogeneous intersection-based transport management” (OMNI, 2003) demonstrated the feasibility of integrated deployment of advanced Intelligent Transportation Systems (ITS) and applications, overcoming the legacy constraints imposed by existing infrastructure, and developed a network-wide intersection-driven model which is generic, open and flexible. The technological approach to implementing the OMNI model facilitated the adoption of standard communication protocols, independence from operating systems; high level of scalability; and a distributed architecture.

The OMNI model is therefore able to carry out the following functions:

- managing information exchange among all the components of the model,
- monitoring of the physical status of the different devices (local controllers, sensors, subsystems) constituting the road infrastructure,
- defining a complete model of the network,
- creating a traffic control model,
- real-time updating the dynamic status of the entities present in the urban network,
- reporting in real-time the events produced and detected by the applications.

These functionalities allow OMNI to model the topology and management infrastructures of any European city.

A project on real-time signal management urban traffic networks (SMART-NETS, 2004) provided an easy-to-implement, interoperable and easily transferable traffic control strategy (called TUC) that can provide efficient performance with a minimum amount of fine-tuning. Performance of this system, which can provide a significant reduction of travel times within urban traffic networks, was evaluated in three sites – Chania (Greece), Southampton (UK) and Munich (Germany) – and compared to the three existing Urban Traffic Control (UTC) systems in those cities. In all the test sites it was demonstrated that it is a valid and credible UTC strategy, both as a stand-alone system and as a hybrid. The five test areas in the three cities have very different characteristics, both with regard to network layout and with regard to traffic behaviour, but the new TUC system performed well in all of them.

Freight management within cities has been the subject of the “BEST Urban Freight Solutions” (BESTUFS, reviewed within Extr@Web) and continued within BESTUFS II (2006). The project addressed increasing concerns regarding the effects of freight on the quality of life in urban areas, the changing urban environment (e.g. planning city infrastructure and transport policy and commercial developments, as well as technological innovations (e.g. low emission vehicles, small containers). While continuing the work of BESTUFS, BESTUFS II has increasingly focused on small and medium sized urban areas which may be comparatively disadvantaged due to relative isolation from the primary road/freight networks.

A number of Best Practice Handbooks have been produced focused on waste transport and logistics in urban areas, experiments and incentives for environment-friendly vehicles, control and enforcement in urban freight transport, and city access restriction schemes with earlier handbooks updated to re-focus on road pricing and urban freight transport, urban freight platforms, intelligent transport systems, e-Commerce and urban freight distribution and public-private partnerships in urban freight transport.

The project has also undertaken a quantification of urban freight transport effects and produced a range of policy recommendations in relation to urban consolidation centres, last mile solutions, urban freight in small and medium-sized cities, urban waste logistics, port cities and innovative urban freight solutions, urban freight transport management, environmental zones in European cities and accommodating the needs of passenger and freight transport in cities.

Road freight traffic has also been the subject of the “Intelligent Route Guidance of Heavy Vehicles” Project (HeavyRoute, 2006), which has sought to produce an advanced route guidance and advice system for HGVs aimed at addressing the needs of freight and network operators. Working with all the major stakeholders, the project has been able to

effectively link Europe's road infrastructure, via electronic mapping systems, to the truck operators and drivers through the production of three applications based on vehicle/infrastructure interaction, together with detailed data on the vehicle itself, the infrastructure and traffic. These have included:

- Pre-trip route planning – which produces allowable routes based on 'HGV specific data', together with physical and legal restrictions on the Infrastructure, fuel consumption, emissions, noise, safety, driver comfort and infrastructure maintenance costs.
- Driving support – Real time driver warning and recommendations to avoid critical situations (for example recommended speed to avoid roll-over) .
- Monitoring and management of HGV's at bridges - for example advice on speed, minimum vehicle spacing and/or lane change to ensure appropriate loading.

Lastly, Road user charging has been the subject of a wide range of National project including for example the ARENA project in Sweden (Kilometre tax for heavy goods vehicles in Sweden - A proposal for a functional concept, ARENA, 2008) which has examined the implications and consequences of the introduction of a technology agnostic kilometre tax, taking a broad view across all stakeholders, facilitating discussion and knowledge exchange between other projects both nationally and internationally. The concept produced allows for a plurality of toll service providers (unlike other systems already in existence) and borrows from principles used in income taxation and customs with most activities carried out by private stakeholders at commercial terms and with the government collecting tax revenue and serving a supervisory role. A demonstration of the system was given at the ITS World Congress in Stockholm in September 2009 (using two electric cars with on-board equipment) and plans are in place for a subsequent project (ARENA 2.0) that will establish a research environment in ITS and e-transactions based on the knowledge gained during the course of the project.

In parallel work has been undertaken to examine the role of public transport in congestion charging and how these may be inter-related. The project 'Express buses in the Stockholm congestion charging trial' undertaken in Sweden in 2007-2008 (KTH - Kungliga Tekniska Högskolan, 2008) undertook interview based evaluations of the value allotted to time savings made by using a direct bus route running in parallel to an existing over used rail route both before and after the introduction of congestion charging. While travel times were shown to decrease by a maximum of 10% passengers were shown to be far more satisfied with the punctuality and comfort of the bus service over the rail (an average rating of 4 out of 5 as opposed to 1.6) with a shift away from private car travel of around 10%. A range of interesting evaluations were possible to be made demonstrating how commuters compare differing public transport elements, for example, one change in service was seen to be equivalent to 5-15 minutes travel time, a regular 5-10 min delay was equated as an extra 25 minutes travel time, with time being seen to be valued at 12-16 SEK per hour, and a high degree of passenger comfort being seen as the equivalent of 12 minutes travel time.

The issue of segregating car traffic according to road type within cities, has been examined in a project 'The Attractive City - Traffic integration or segregation for the sustainable city' in Sweden in 2007 and 2008 (TØI - Institute of Transport Economics, 2008) finding that car traffic speed and volume, both in single streets and districts, and as a total for the urban region are key defining features of differing types of traffic, and these may be used as a basis on which to make decisions regarding traffic management policies . Although clear benefits can be attained through segregation it was viewed that this is only a partial

solution to traffic and city problems with some cases requiring segregation while others require a continuation of the current mixed approach.

#### 4.2.4 Policy implications

##### 4.2.4.1 Road construction & maintenance

Key implications in this area from the INTRO project are:

- The need to focus on techniques to extend the life of road pavements in view of reducing direct maintenance costs (building, repairing) and indirect costs (disturbance to traffic, negative environmental effects): materials, road structure, pavement monitoring;
- The need for further research in the field of Innovative and promising sensor technologies for pavement monitoring, such as fibre optics and motes;
- The need to adopt techniques allowing sustainable development: re-use of waste, reduction of energy necessary to build the road (“cold” pavement materials), positive energy roads, etc.

In addition, the NR2C project stressed the need to move faster in the direction of the innovation level of redesigning existing concepts, including the introduction of research technologies from other sciences such as physics and chemistry. A number of priority research areas requiring special attention in the future were specified, deserving of EU and government support. These cover new age binder technologies, integrated models of urban design, lifetime engineering for roads, asset management tools, modular prefabricated pavements, low temperature asphalt with reclaimed asphalt, bridge eco-assessment, optimisation of tyre-road interaction and energy-controlled pavements.

The above are needed to contribute to policies relating to greater cost-effectiveness of infrastructure management as well as safety objectives, allowing structural faults to be identified and treated in a timely manner, issues which have also been examined at the national level for example in Finland (“The impacts of road maintenance on regional economy”) where it has been demonstrated that significant road projects can have far-reaching impacts on regional or urban economy which are not typically reflected in CBA and other impact assessments, and are mostly significant when the project has network impacts on an the extended transport system, when the project enables the expansion of the urban area, or when enabling significant changes in land use in the urban area.

##### 4.2.4.2 Safety aspects of road infrastructure

The implications of the IN-SAFETY project are classified according to work packages results are a series of recommendations covering the following:

- Application Guidelines and Further Research Issues: Decisions on innovative ITS systems should take account of parameters like feasibility, cost, effectiveness, efficiency, reliability, etc. of different solutions, however lack of qualitative and quantitative data about cost and safety, environmental and traffic effects make the utilisation of methods like Cost-Benefit-Analysis difficult. Field operational tests,



large scale experiments as well as simulation and risk analysis models can help to gain more knowledge about ITS systems, therefore it is recommended that after a decision has been taken to implement a certain system, evaluations ought to be a matter of course and evaluation processes after implementing new systems ought to be established.

- Pictograms and verbal messages, horizontal and vertical signing: The project recommended that pictograms, messages, etc be evaluated before they are used in practice and also that a systematic approach be followed to harmonise pictograms, verbal messages and the systematic organisation of message elements, giving flexibility for new developments and new requirements, and also increasing the investment safety in the field of traffic signing.
- Application of Traffic Simulation and Risk Modelling: Simulation and risk analysis models can help to solve questions without implementation of a system in reality. This can help to save money and time as well as to evaluate possible alternative measures. It ought to be kept in mind that for a certain problem an appropriate model is needed (sometimes adaptations of existing simulation and risk analysis models are necessary) as well as a reliable data input and parameters.
- Lessons learnt from Pilot Tests: Field operational tests take a long time (several years) and it might happen that new questions arise and that others are less important than predicted before the test started. It may also be that such tests turn out, for different reasons, not to answer all the questions. Such vulnerabilities should be addressed in the field test design from the very beginning. The development of a set of scenarios what might happen during test period could help to estimate these risks.
- Application of the Operators' Manual: Similar procedures for traffic management should be applied and rules should be implemented according to common standards on the TERN (Trans-European Road Network). Harmonised training for traffic management operators throughout Europe lays a basis for approaching this goal without having to harmonise all the official procedures. It may be assumed that decisions taken by different operators that are based on equal information and education are likely to be similar and therefore familiar and understandable for international as well as local drivers.
- Recommendations from multi-criteria analysis, analytic hierarchy process and cost-benefit analysis of selected systems and functions. More research on innovative ITS-systems, especially co-operative systems should be a pre-condition. Without detailed knowledge about system architectures, technology solutions and business models it is impossible to assess costs. European and national legislation bodies ought to encourage national road authorities to develop needed databases on a common European level (better standard). A result might be a guideline for the structure of national accident statistics.

This project used an adaptive policy-making approach, focusing upon managing uncertainties. Therefore, for each policy recommendation made, a few of the most relevant vulnerabilities are given in the Policy Recommendations report (IN-SAFETY, 2008d). For each vulnerability, mitigating or hedging actions are given, and the possible signposts, triggers or actions.

The fundamental policy implication of the RANKERS project lies in the proposal for modifying existing guidelines in order to improve and harmonise future EU standards. In

particular, the project forwards new criteria for road signs and infrastructure. The project has also identified different aspects of the road infrastructure safety topic that may constitute future research initiatives, either because there is a lack of knowledge or there is not enough data to establish reliable recommendations. The most relevant can be summarised as follows:

- More data about the performance of the same countermeasures in different accident situations should be collected.
- Installation and maintenance costs of several countermeasures are not available as frequently as would be desirable.
- Effectiveness of new tools, such as road safety inspections, should also be assessed in order to demonstrate the benefits they can provide to road-safety improvement.

Road safety is a major plank of EU transport policy and the road infrastructure is a key factor in this respect. Moreover, because infrastructure aspects have to be designed and built, they have a longer life than other safety aspects (such as education, regulations and enforcement), so planning and implementation of best practice standards, and the knowledge and means to collect data measure their effectiveness, is essential. The Commission has proposed in 2006 a directive introducing a comprehensive system of road infrastructure safety management to ensure that safety is integrated in all phases of planning, design and operation of road infrastructure.

In general terms, the RIPCORDER-ISEREST project, through its recommendations and technical developments, contributed to setting standards and practical tools for European local road managers. In particular, the project addressed the following policy issues, highlighting them with tools and recommendations:

- Regulatory actions necessary for on Safety Impact Assessment (new roads - pre-design phase).
- Safety Audits (new roads - design, construction & early operational phases)
- Network Safety Management - management of "High accident concentration sections" on existing roads)
- Safety Inspections (existing roads).

Moreover, the project outlined organisational and implementation aspects of road safety. From a local policy point of view, the project's tools allow road-safety results to be compared with road safety goals made by regional or national policymakers, thus allowing for a "fine-tuning" of road-safety infrastructure design and Europe-wide comparisons.

#### 4.2.4.3 Traffic management

The PRISCILLA project concluded that new innovative solutions have to be found to maintain the objective of sustainable mobility while reducing energy consumption and air pollution in European conurbations, for instance trying to adapt the traffic space to the expected demand with the help of telematics technologies. The adoption of bus priority strategies across large urban areas can significantly reduce public transport travel time and could encourage modal shift in favour of public transport.

While PRISCILLA considered many aspects of providing bus priority at traffic signals, there is still considerable scope for further research. Future research should cover aspects such as the development of strategies based on bus headways, bus priority performance in relation to different traffic signal plans, integration of traffic signals in peripheral areas with centralised management systems, system evaluation and performance indicators, vehicle to infrastructure communications (including AVL), fleet regulation algorithms, bus priority conflicts and use of new technology.

Cost-effectiveness of public money is an issue clearly addressed by bus priority on large areas. Even contexts in are different Europe (regulated market, regulated competition, free market), public transport is nevertheless partly funded by public funds. Increasing punctuality means providing an improved service level with the same system cost.

The traffic management strategies for secondary road networks developed by the SENSOR project are above all a guide to operators, so do not generate policy implications as such (implications and recommendations are organisational and technical). There is however increased interest by local road authorities in traffic management tools which match their needs and budgets, and the exploitation of the results of this project is a process that can be carried out over the next decade, as the nature of the results enables the incorporation of new technologies – enhanced simulation capabilities in the road management framework – without substantial additional effort.

The European Ramp Metering project (EURAMP, 2007b) concluded that this method of tactical traffic management at motorway on-ramps can provide significant benefits in terms of congestion reduction, particularly where motorway junctions are closely spaced together and where at least some of these ramps have reasonable storage space. A political implication is that operators of roads leading to the motorway junction (e.g. local authorities) may be reluctant to support ramp metering as it may appear to act as a barrier for traffic from their town from joining the motorway, increase journey times for local traffic, or lead to traffic queues on the ramp backing up and congesting nearby local roads. Upstream consultation with local authority road operators, as well as bodies such as the police, local bus operators or public transport authorities and emergency services, is therefore essential in designing the scheme (hours of operation, what to do if queuing traffic backs up beyond the on-ramp, etc). A user acceptance campaign is also required to inform drivers how to behave when ramp metering is in operation (e.g. caution when entering the ramp as there may be queuing traffic) and to explain the benefits of the system. Regular evaluation and publicising the results is also important.

The SMART NETS project demonstrated that the TUC traffic control strategy developed has the potential to become a strong competitor in the worldwide UTC systems market. This is an innovative system that can improve services to the citizen and strengthens the European position in the global ITS market, hence meeting EU goals relating to the Common Transport Policy, deployment of ITS in the road sector and contributing towards reducing congestion and improving air quality.

Work in BESTUFS II has shown that waste management has become an important issue in European policies, and Member States have transferred EU-regulations and standards into national legislation, and most European countries have developed waste management plans based on the principle of sustainability. Along with this, great differences have been found between Western and Easter European countries, with extensive trials, experiments and demonstrations regarding environmentally friendly vehicles (EFVs) in urban freight transport having taken place in the West, while in the East EFVs and sustainable transport solutions have been taken forward on a more general level (e.g. at the level of sustainable policies and the usage of alternative fuels). Meanwhile, City access restriction schemes for freight vehicles are currently impeded through a lack of regulation or legal framework with

the introduction of any road user charge in some cases requiring revision of existing regulations.

Both ITS and Freight have been topics within the 'The Attractive City - Traffic integration or segregation for the sustainable city' project where a wide range of recommendations were produced that would enhance the development and design of the sustainable city with an environment friendly transport network including:

- Making use of information technology to control traffic volume, speed and character;
- Creating a public transport oriented network designed to support sustainability and urban life;
- Creating a two-tier car network: Highways and traffic, and calmed urban roads and streets;
- Designing urban roads for low speeds;
- Creating an urban street network that improves the competitive advantages of environmentally-friendly modes;
- Giving suburban and industrial areas more urban elements;
- Using selective filtering of motorised traffic;
- Creating more, and bigger, car-free zones;
- Significantly upgrading the role of park & ride and bike & ride.

The above projects contributed towards policy objectives of increasing the efficiency of road transport by capacity improvements, improved quality of life, improved traffic management and measures to prioritise (and thus promote) public and freight transport.

## 4.3 Sub-theme 2: Road vehicles

### 4.3.1 Background

The sub-theme deals with road vehicles and in particular their technology. While vehicle-infrastructure co-operative systems are covered in the next sub-theme (road use and driving), this group covers research on vehicle propulsion and emissions, vehicle safety features (as opposed to safety issues related to driving, which are covered in the next sub-theme) and in-vehicle aspects concentrating on HMI (human-machine interface).

Research reported in the EXTR@Web paper (EXTR@Web, 2006) in the field of road vehicles and their design and technology covered these topics:

- Development of an integrated and common Advanced Driver Assistance (ADAS) assessment methodology;
- Reduction of diesel particulate emissions;
- Definition of a concept for pre-crash applications;
- Intelligent Speed Adaptation (ISA);
- Inter-vehicle hazard warning system;
- Cyber cars and electric taxis.

## 4.4 Research objectives

Research objectives are classified into three clusters. The first, dealing with vehicle propulsion systems and emissions, includes objectives to increase safety and efficiency of HGVs by using x-by-wire technologies in the power-train (SPARC) and to develop sustainable, clean, cost- and eco-effective electrical and electronic system prototypes and dismantling/recycling processes to increase the vehicle recovery/re-use rate (SEES). Also covered in this cluster is the development of a roadmap for future vehicle research (FUORE) which focuses primarily on propulsion and power-train aspects but also covers other areas such as safety and competitiveness (CARS-21).

A second cluster deals with vehicle safety systems. Objectives are to improve the rollover safety of passenger vehicles (cars and minivans/minibuses) (ROLLOVER) and to investigate the potential socio-economic impact of the introduction of intelligent safety systems in road vehicles (SEiSS).

A third group of projects within the road vehicle sub-theme covers the interface between the driver and the vehicle (HMI – Human-Machine Interface). Objectives are to generate the knowledge and develop methodologies and HMI technologies required for safe and efficient integration of Advanced Driver Assistance Systems (ADAS), In-vehicle Information Systems (IVIS) and nomad devices into the driving environment (AIDE), research into a common framework in the area of human-centred design for ITS (HUMANIST), as well as into a range of preventative and active safety applications (PReVENT).



#### 4.4.1 Research results

##### 4.4.1.1 Road vehicle propulsion and emissions

On a general level within the road vehicles sub-theme, a Roadmap for Automotive R&D Technology was produced (FUORE, 2004). Although aspects such as safety were considered, the project focused primarily on propulsion and energy use. The work was carried out by means of workshops, individual discussions with specialists in the fields of automotive research, voting surveys among FUORE experts and a comprehensive literature analysis. Topics covered were:

- Energy & fuels (including conventional, advanced and alternative fuels),
- Power-train technologies (including today's state-of-art technologies as well as advanced and alternative systems and after-treatment technologies),
- Complete vehicle aspects (including vehicle structure, safety and noise).

Each of the above was discussed according to its current technology status, targets for the year 2020 and beyond, potential technologies which can fulfil future objectives, hurdles and barriers that might hinder the introduction of the potential technologies, and the research demand needed to overcome major technological hurdles to successfully achieve the 2020 targets. In addition, a study on the technical potentials for liquid bio-fuels and bio-Hydrogen was undertaken.

Subsequently the “Competitive Automotive Regulatory System for the 21st century” (CARS-21, EU 2006b) High-level group was set up by the European Commission in 2005 to generate recommendations to improve the worldwide competitiveness of the European automotive industry. The group, composed of prominent representatives of Member States, the European Parliament, industry, trade unions, NGOs (Non-Governmental Organisations), users and the Commission, made a range of recommendations for short, medium and long-term public policy and regulatory framework for the European automotive industry, in order to enhance global competitiveness and employment while sustaining further progress in safety and environmental performance. Project results consist of a number of recommendations in key areas such as regulatory simplification, environmental protection, road safety, research and development, trade, taxation/fiscal incentives and intellectual property, to be achieved by economic, taxation and internal market policies that encourage investment in profitable manufacturing, reviewing the regulatory burden and compliance cost, and stimulating R&D.

A project on “Secure Propulsion using Advanced Redundant Control” (SPARC, 2007) developed an accident-avoiding vehicle using a Decision Control System (DCS), which compensates driver failure probability (driver incapacity, dead man state, etc). It described and validated clear software/hardware interfaces for automotive redundant control systems to combine results from other related European projects and then extended this concept of HGV to full tractor-trailer combination. The project validated the scalability of the concept by transferring it from heavy-duty trucks to small passenger cars. Four validator vehicles were built.

SPARC successfully demonstrated the integration of several new and important control functions for higher levels of system automation, e.g. secure vector, co-pilot assistance, electromechanical wedge brakes, a fault-tolerant processing architecture, intelligent

energy distribution and management. Additionally, a key success of this project was the development of a scalable platform approach which supports the Integration of X-by-Wire/DCS and active safety systems.

Lastly, the end to end sustainability of the components of vehicle electronic systems has been examined in the “Sustainable Electrical and Electronic System (EES) for the Automotive Sector” project (SEES, 2006). The project has aimed to improve the present design of automotive EES and to analyse innovative end-of-life processes, contributing towards the overarching goal of sustainability. EES materials include electronics containing copper and precious metals as well as regulated substances (e.g. lead in solder) and different kinds of plastics which have a potential value for recycling/recovery and thus the project plays a major role in the fulfilment of the European Directive on end-of-life vehicles (2000/53/EC). The project has investigated and conducted tests on processes for the optimal transport, dismantling and shredding procedures for automotive EES, and demonstrations have been performed of metal and plastic recycling technologies. Additionally, environmental and economic assessment of the EES life cycle steps using Life Cycle Assessment (LCA) and Life Cycle Costing (LCC) methodologies have been undertaken.

#### 4.4.1.2 Vehicle safety

A project on the rollover safety of passenger vehicles (ROLLOVER, 2006) produced a database of in-depth studies of rollover cases, which was used to derive significant rollover scenarios for development and validation of new rollover systems. This case library included general data for 150 accidents from Germany, Austria, Spain and the United Kingdom. Rollover accident statistics showed a rollover share of 5-10% of all road vehicle accidents, rising to 15% in some countries. Rollovers account for a 10-20% share of fatalities, again depending on the country. Computerised in-depth accident reconstructions were carried out for 75 cases and the results included in the case library. The statistical importance of different rollover types was assessed, with the four main categories being: impact induced; ramp objects induced; skidding and yawing (swerving) induced, and other causes. In studies of occupant movement in the different types of accident, significant differences were found between the movement of volunteers in simulated accidents and those of test dummies.

Key rollover scenarios were identified that would benefit from the application and optimisation of existing and new restraint systems. A physical demonstrator was built to show the improvements in rollover performance through seatbelt pre-tensioning. Performance criteria were also defined and evaluated for structural design (head clearance and structural stiffness), restraints (seatbelt and airbag performance) and sensing (type and trigger performance). A best practice standard framework, design instructions and software tools were developed, to allow European component and vehicle manufacturers to develop such systems more efficiently. These were based on aspects such as counter-measures against ejection and intrusion of the roof and occupant impact against interior parts.

An exploratory study on the potential socio-economic impact of the introduction of intelligent safety systems in road vehicles (SEISS, 2005) concluded that intelligent safety systems are promising instruments that can reduce the number of accidents and their severity. These systems are already showing remarkable results. The study delivered an overview of safety-based systems, characterised the markets, identified key variables, and developed methods for the assessment of socio-economic impact.

Regarding technology, SEiSS provided a brief description of intelligent vehicle safety systems (IVSS) and discussed their potential impact on road safety. Safety function interdependencies and their combined potential influence on road safety were considered, as well as possible drawbacks, for example the fact that new technologies can lead to driver distraction and in some cases contribute to an increase in accidents. On the economic side, SEiSS outlined different methods of market penetration, the target figure being the rate of equipment with IVSS on a given date. The project also analysed traffic effects resulting from the market introduction of IVSS, using traffic forecast data. The main outcome of the project was a methodology for assessing the socio-economic Impact of IVSS, a key element of this being the benefit-cost analysis.

#### 4.4.1.3 Driver interface (HMI)

A large Integrated Project on Preventive and Active Safety Applications (PReVENT, 2008) produced a considerable number of results within several sub-projects. As most of these relate to the topic “vehicle-infrastructure co-operative systems for safety and mobility”, they are covered in Chapter 4.4 on road use and driving. However, as regards Human-Machine Interface (HMI) aspects, the INSAFES sub-project focused on the full coverage of the vehicle surroundings in order to warn the driver, intervene, or mitigate the effects of an accident. INSAFES integrated the different longitudinal and lateral safety systems developed by other PReVENT sub-projects into a safety zone surrounding the vehicle.

A project on Adaptive Integrated Driver-vehicle Interface (AIDE, 2008) produced a considerable number of results, starting with a synthesis of models for Joint Driver-Vehicle interaction design and requirements for HMI design and driver modelling. It then produced a Driver-Vehicle Environment (DVE) model structure for implementation in a simulation tool. Behavioural effects of driver assistance systems and road situations were also reviewed and a general experimental plan for long term behavioural assessment was produced to address the current lack of knowledge about learning processes and long-term effects of driver assistance systems. Experiments on learning, appropriation and effects of adaptiveness were performed.

AIDE also developed a Visual Demand Measurement (VDM) tool as well as a specification of the actual tool followed by a user’s guide. It then looked at how the effects usually measured in behavioural studies evaluating driver support systems can be “translated” into estimates of (reductions in) accident risk. Ultimately, AIDE designed, developed and validated an Adaptive Integrated Driver-vehicle Interface including an Interaction and Communication Assistant (system responsible for the centralised management of information and adaptive interface functions) and integration of nomadic devices.

#### 4.4.2 Policy implications

While a number of projects have generated specific policy recommendations in key areas (see below) perhaps the most wide ranging project has been CARS-21 (EU, 2006b) which, consisting of high level experts, has focussed on the provision of a large number of key drivers that would benefit the position of the EU vehicle industry. These have ranged from better regulation and homologation, through to environmental and road safety considerations, to trade, competition regulations, and potential taxation and fiscal incentives for manufacturers.



#### 4.4.2.1 Road vehicle propulsion and emissions

The FURORE future vehicle technology roadmap (FURORE, 2004) provided the following key statements which have policy implications to road vehicle propulsion / energy use and emissions:

- In the year 2020 and beyond there will be a greater plurality of different propulsion technologies, but still with a main focus on internal combustion engines (ICEs).
- A greater variety of fuels (conventional, advanced as well as alternative fuels) will be on the market, with designed fuels for new combustion processes.
- An overriding objective will be to save energy wherever possible (regardless of future scenarios on propulsion systems or fuels).
- Adequate research investment in the evolution of powertrain technology based on ICEs and conventional-based fuels would guarantee global competitiveness of the European automotive industry together with reduced energy dependency and environmental benefits.
- Research in completely new technologies is an additional requirement to promote sustainable advances in environment and energy security.
- For fuel cell and hydrogen based powertrain systems only improvements in terms of production and distribution will make them a competitive alternative.
- The main challenge for electric vehicles is the development of cost effective advanced batteries / energy storage systems.
- Vehicle weight is crucial for both fuel consumption and safety issues. Research is needed into new materials and production processes, including recycling technologies.
- A great research potential exists in the area of vehicle noise. Future vehicle technologies focus on road/tyre interaction, the engine, the exhaust and intake system and the vehicle driving condition.
- Advanced simulation techniques for vehicle technology are necessary to establish basic detailed knowledge in order to simulate physical processes more precisely and to increase the accuracy of predicted results.
- A system approach which integrates the concerned stakeholders (infrastructure, vehicle manufacturers, research providers etc.) and the concerned scientific areas (materials, electronics, telematics, etc) will lead to remarkable technological progress.
- The integration of specific and generic technologies as well as development tools and platforms will lead to better, faster and cheaper research results, strengthening the sustainable development of the European road transport sector.

The SPARC project was technical in nature so did not generate direct policy implications. However, the work on the homologation within the project can be used as base for the homologation in other x-by-wire projects.

#### 4.4.2.2 Vehicle safety

The FUIORE project concluded that active and passive safety show great research potential and requires an integrated approach to deliver the best results. Some of the other FUIORE policy implications listed in section 4.3.4.1 above also apply to vehicle safety, such as the need to research into new materials for vehicle construction in order to reduce weight without compromising safety.

The ROLLOVER project showed belt excursion (the reeling out of the seatbelt) to be a critical factor with respect to partial ejection of occupants from vehicles in an accident. Extension of existing human models through integration of active muscle models to improve rollover simulations was recommended by the project. Another implication was that assessment tools for rollover safety need to be made more efficient, i.e. further evaluation is needed of test methods for vehicle roof strength, restraint testing and sensor systems. These could be addressed in a future research project.

A full evaluation of rollover on an EU-wide basis was found to be impossible due to the lack of a comprehensive uniform European accident database (also, rollover is not defined in most European databases). The set-up of such a database including more detailed information was one of the recommendations of the project. It was also recommended to enforce the development of active virtual human body models in order to allow improved analysis of rollover-induced injuries.

Evaluation of rollover safety is only a legal requirement in the USA. Consideration should be given to evaluating proposed EU standards as well as harmonisation with US regulations.

Some key implications from SEiSS (Exploratory Study on the potential socio-economic impact of the introduction of Intelligent Safety Systems in Road Vehicles) were the need for harmonisation of Intelligent Vehicle Safety Systems (IVSS) definitions and input parameters (a topic requiring further discussion), further dissemination and outreach on current IVSS understanding and information exchange on current research. The study also recommended close co-operation between accident causation analysis and the evaluation of socio-economic impacts related to safety systems, as well as further improvement work on databases (common data and EU standardisation for better compatibility of results of different investigations). Databases involved are those with figures on the definition of accident probability and accident mitigation as well as accident severity.

#### 4.4.2.3 Driver interface (HMI)

According to the INSAFES roadmap, developed within the PReVENT project, integrated safety systems, including both longitudinal and lateral control applications, are estimated to enter the market around 2013. In terms of HMI, PReVENT concluded that although the skills and knowledge exist to realise a prototype system which works to present the functions and has a basic Human Machine Interface, there is not the in-depth knowledge that is necessary to design a HMI that fulfils the high requests of a production system.

Since the time necessary to transfer PReVENT prototype systems into marketable products must be as short as possible, marketability issues need to be considered at the beginning, where the help of HMI experts is important. Another important implication of HMI in safety systems is that the systems must be self explanatory and easy to understand. A system that (hopefully) becomes active only very rarely, such as an emergency braking system, must, through the HMI, ensure that the driver is not surprised

or shocked by the sudden system intervention and, in the worst case, overrides the system, where it had been better to let the system work in order to prevent an accident.

The AIDE project concluded that HMI development requires large scale European collaboration in order to facilitate the industrial take-up of technologies, methodologies, HMI design guidelines and standards, which will increase the penetration rate of HMI RTD results and enable them to have a real impact on road safety. The overview of tools and methodologies for HMI evaluation developed by AIDE is a useful tool for the planning of future HMI evaluations.

A review of available guidelines and standards for HMI by the AIDE project found that most of the guidelines deal with HMI aspects in general, and thus cover a broad scope of devices and functions. However general guidelines often do not fully apply to specific new devices. To meet the specific requirements of the new systems and functions the question arises whether it would be useful to have more system-specific or function-specific guidelines (while avoiding detailed specifications which are not scientifically justified, which could obstruct the development and employment of better solutions).

The above contribute to road safety policy goals, in particular concerning safe vehicles and safe driving, as well as improving quality and comfort for the user.

## 4.5 Sub-theme 3: Road use and driving

### 4.5.1 Background

The sub-theme deals with road use, including driving and safety aspects. A key theme is driving behaviour, which includes driver training, education, assistance and legal frameworks. Closely linked to this is research into co-operative systems, linking the vehicle to the infrastructure in order to enhance safety and provide relevant information to drivers and/or the road operator. Although co-operative systems are also associated with the previous two sub-themes (on road infrastructure planning/operation and on road vehicles), they are included here as emphasis is generally on the desired function, which is to assist and inform the driver. Monitoring of traffic and safety is another focus of research in this sub-theme, whether for statistical purposes or for enforcement. Finally, provision of collective transport services is considered, in particular innovative road-based services (e.g. demand responsive mobility).

Research reported in the forerunner paper to this one (EXTR@Web, 2006) in the field of road use and driving covered results of projects covered the following:

- Compulsory use of daytime running lights by road vehicles;
- Guidelines for traffic related information provision by in-car and infrastructure based systems;
- Cross-border traffic enforcement for violations caught on automated systems (e.g. speed cameras);
- An innovative approach for advanced traveller information systems on road networks based on an elastic compliance;
- Effects of hands-free legislation on mobile phone use while driving.

#### 4.5.2 Research objectives

A first set of research objectives within this sub-theme relates to driver training, behaviour and assistance. Using interactive evaluation tools to improve driver training and assessment is one focus, involving the development of a cost-effective pan-European driver training methodology both for existing, and future vehicles and technology (TRAINER and SAFETY-TECHNOPRO projects). Virtual Reality technology is included in this cluster, with respect to studying and improving the ergonomic design of vehicles, in order to make the driving tasks simpler and more comfortable as well as to increase safety (VIRTUAL).

A second cluster of objectives covers vehicle-infrastructure, and vehicle to vehicle, co-operative systems for safety and mobility. Safety-related objectives include developing a driver skid-risk warning system based on braking distance and pavement friction, and safety monitoring through an open dynamic surveillance network, comprising on-board units fitted to a fleet of cars and a unified operative centre (INTRO and MISS projects). Further safety objectives were to conduct research into a range of preventative and active safety applications using advanced sensor, communication, positioning and driver monitoring technologies integrated into on-board systems (PReVENT, REPOSIT and I-WAY projects). Other goals are vehicle-infrastructure systems to make roads more forgiving and easily understandable by drivers, the development of intelligent maps, development of a platform for location-based intermodal transport information and creation of a horizontal market for online services based on open standards (IN-SAFETY, HIGHWAY, IM@GINE IT and GST projects).

Thirdly, this sub-theme includes a topic on traffic and safety monitoring. Activities in this area comprise an observatory, providing statistics and information rather than applied research, while the development of real-time safety indicators was an objective in one project (SafetyNet and INTRO projects). Another focus of this sub-theme is monitoring for enforcement purposes (PEPPER) – one such objective was the automation of road control, including designing an architecture of a complete automatic driving enforcement system based on different types of sensors (FAIR).

A fourth sub-theme concerns innovative and demand-responsive transport services by road. Outside of public transport corridors, demand-responsive transport is the only possibility for achieving seamless public transport and research in this respect covered the development of an in-vehicle device for flexible collective transport services (INVETE).

#### 4.5.3 Research results

##### 4.5.3.1 Driver training, behaviour and assistance

The project “System for driver Training and Assessment using Interactive Evaluation tools and Reliable methodologies” (TRAINER, 2003), developed an interactive, multimedia training tool and two modules of a driving simulator (one static and one semi-dynamic), paying attention to their cost-effectiveness. An in-depth study among 24 countries first identified gaps and inefficiencies in the driving training courses on the basis of a 4-level driving task model: “vehicle manoeuvring”, “mastering traffic situations”, “goals and context of driving”, and “goals for life and skills for living” subcategories and approximately 100

driving scenarios were designed in order to be taught in driving schools via multimedia training tools or driving simulators. The project provided prototypes and practical guidelines for the deployment of the proposed curriculum and training tools.

Another project, “Virtual Reality Systems for perceived ergonomic quality testing of driving task and design” (VIRTUAL, 2003), developed methods based on Virtual Reality (VR) which can significantly improve the quality and the validity of the ergonomic evaluation of the vehicle and reduce the risks and the costs of problem-solving after prototyping. The VIRTUAL project developed three different VR systems, including generic force effectors able to give the person the sense of reaching and operating a real control, and performed tests with the aim of training people to drive a car in virtual environment.

Related to these projects is “Training System on New Safety Technologies for Road Transport Addressed to Professional Bodies of the Automotive Sector” (SAFETY-TECHNOPRO, 2008), which has examined the organisational training that would be required in order to more widely introduce in-vehicle ITS. The project has aimed to improve the information available to professionals regarding both the technologies and the benefits of associated training, and as part of this process examined issues such as awareness of safety, through cultural meaning of safety and safety technologies, to expectations on a cognitive and emotional level and behavioural adaptation. The twelve country review that was conducted as part of this process has led to an accompanying training system that explains such systems to professional bodies, by using standard psychological and cognitive tools.

#### 4.5.3.2 Vehicle-Infrastructure co-operative systems for safety and mobility

The Intelligent Roads project (INTRO, 2008) studied the relationship between braking distance and pavement friction (skid resistance) in order to display a warning to the driver. It was found that a reference friction value alone is not sufficient to predict the braking distance during all pavement situations (wet, icy or snowy), but that information on the pavement situation itself was necessary. Tests with an advanced driving simulator were made to define the best way of warning the driver when reaching a low friction road section; it was found that a speed display with a timing of 6 seconds led to the best behaviour regarding safety.

The “Infrastructure and Safety” project (IN-SAFETY, 2008c) performed a preliminary prioritisation of a large number of alternative systems, whereby 18 potential types of systems were taken into account (e.g. digital maps, warning by VMS, electronic beacons, speed alert systems, Advanced Cruise Control, etc). These 18 types result from combining the six most important causes of errors identified in accident statistics (excessive speed in unexpected sharp bends, speeding in general, violation of priority rules, wrong use of the road, failure when overtaking and insufficient safety distance), with three dimensions along which systems can be developed (the vehicle, the infrastructure and the co-ordination between the vehicle and the infrastructure). The 18 types of systems were considered to have a preliminary character only (i.e. hypothetical systems as opposed to actual systems available now). A set of criteria was then derived during a number of interactive workshops, and a prioritisation was made based on stakeholder responses.

A striking result was the high discrepancy among stakeholder priorities regarding some specific scenarios, such as the scenarios “overtaking assistant with oncoming vehicle detection” and “safe curve speed warning”, which were ranked at the top by users and society, but at the bottom by manufacturers (the latter considering that the risk associated with this scenario is too high). On the other hand, the concept of a system which displays

information from VMS inside the vehicle has a high level of support from both users and manufacturers.

A project on preventive and active safety applications (PReVENT, 2008) produced a considerable number of results within its various sub-projects. Key results were:

- The development of speed management and headway control systems (SASPENCE sub-project), introducing several innovations based on previous projects and existing technologies related to the restriction of lateral acceleration inside curves, speed control depending on the external situation and distance control to objects to avoid rear-end collisions.
- Creation of an electronic safety horizon for foresighted driving, based on ad-hoc methods for V2V (vehicle to vehicle) communication and vehicle positioning (WILLWARN sub-project). The system functioned well and offered a high benefit to drivers even at low rates of equipment of the overall vehicle fleet, as warnings are stored and physically transported in the cars when the equipment rates or traffic is low, also oncoming traffic is used for warning dissemination.
- Development of an application to enhance the driver's perception and reduce collision risks at the side and rear of the vehicle, a lateral collision warning system and a lane change assistance system with integrated blind spot detection (LATERAL SAFE sub-project).
- Development of a next-generation lane-keeping support system, improving existing Lane Departure Warning systems (SAFELANE sub-project).
- A successful first attempt to develop an Intersection Driver Warning System based on bidirectional vehicle to infrastructure (V2I) communication and path prediction (INTERSAFE sub-project).
- Development of applications to protect vehicle occupant (APALACI sub-project), including collision mitigation (semi-autonomous braking), detection of collision conditions to reduce the crash severity in cases of unavoidable impacts, and real-time object classification by high performance sensor systems using data fusion techniques.
- Demonstration of the feasibility of collision mitigation systems by autonomous braking (COMPOSE sub-project).
- Development of sensors for more reliable detection and classification of road users, vehicles and traffic obstacles using solid-state micro systems technology (UseRCams sub-project).
- Elaboration of a code of practice for development and testing of ADAS (RESPONSE3 sub-project<sup>9</sup>).
- Development of safety-related map data (MAPS&ADAS sub-project) by defining requirements, specifications, architecture, implementation, test and validation for ADAS safety maps, standardised ADAS interface and Driver Warning System.

The topic of V2V cooperation, was also explored in the "Relative Positioning for Collision Avoidance Systems" project (REPOSIT, 2008), aiming to advance systems that improve safety by increasing driver awareness of the position of the other vehicles and how they

<sup>9</sup> Follow-up to RESPONSE2, which was covered in the previous TRS paper on Road Transport (EXTR@Web, 2006)

are moving – primarily through the use of GPS technology – and examining many similar issues to the PReVENT-WILLWARN sub-project.

In order to do so the project developed a range of systems and algorithms as well as an integrated simulator for positioning functions, V2V communications, and the provision of associated collision warnings to the driver should the system determine that vehicles are, or are about to be, on a collision path. Seventy two simulation tests were performed on a wide range of scenarios and potential software configurations with findings showing that the system was sufficiently accurate to detect and prevent lane change collisions and allow longitudinal collision warning. Practical considerations were also key results, with extensive examination being made of the feasibility of integrating the system into a vehicle as well as the establishment of a certification and standardisation policy (including a business plan and CEN considerations) and consideration of deployment issues such as the effectiveness of the system on 'non-linear' (lower geometric standard) roads.

The project "Global System for Telematics" (GST, 2005) identified the requirements of users, car manufacturers, control centre operators, middleware providers, terminal manufacturers and service providers, and defined an overall framework architecture for open telematics across its seven sub-projects, as well as specifications for the key interfaces. The seven areas covered were: Open Systems, Certification, Service Payment and Security, Rescue, Enhanced Floating Car Data and Safety Channel.

GST developed a common validation plan to ensure that the site validation results can be aggregated and compared at the project level. The project also has addressed relevant operational and business aspects for market introduction of open telematics.

The HIGHWAY project (Breakthrough Intelligent maps & Geographic tools for context-aware delivery) created a system which sends up-to-the-minute information on driving conditions, accidents, traffic jams and road works to drivers' in car devices and/or mobile phones. This also allows the driver to receive suggestions of alternative, safer courses to follow, accompanied by the same up-to-date information service. The system works by integrating smart real-time maps, modern mobile phone technology, positioning systems, 2D/3D spatial tools and speech/voice recognition interfaces. The prototype of the traffic information service developed by the project was successfully tested on a motorway in Finland and a comparable traffic information service was tested in the city of Turin.

The project "Intelligent mobility agents, advanced positioning and mapping technologies integration interoperable multimodal, location based services" (IM@GINE IT, 2005) developed a Multi-Agent System for the e-Market Place. This is an agent platform hosting a broker agent with the optional capability to host one or more provider agents. The broker has the capability to federate with other brokers in other such platforms, thus forming a distributed service network. Its objective was to provide a single access point through which the end user can obtain location based, intermodal transport information (dynamic and static), mapping & routing, navigation and other related services everywhere in Europe, anytime, taking into account personal preferences. Test cases in Germany, Italy, Finland, Hungary and Greece, showed completeness of the required content, while other European countries could be also partly covered.

The information aggregation for the content is performed at two levels. One at national level (called "Service provider" level), at which basic content services are gathered and then synthesised and provided to the next level as web services. The second level is the MAS (multi agent system) itself (called "Service integrator" level), at which the web services are transformed to system use cases. In between the two levels there are a few alternatives such as interfacing (either web service alone or agent based communication). A key innovation factor was that the overall system aggregates information from multiple

service content providers in Europe, and allows the end user to access this information through a set of web services, designed for a variety of business domains (transport, tourism and travel). The core principle in the system design is to allow more service content providers to be integrated into the system later on.

An IM@GINE IT prototype was developed and deployed using a subset of the initially declared services. Through this prototype an end user can access directly a service integrator and request a "plan a trip" and a "show me around" service.

Another shared services system approach, this time for safety, was explored in the "Intelligent cooperative system in cars for road safety" project, (I-WAY, 2009). This project built on the work undertaken in the AWAKE and PREVENT projects regarding "driver hypo vigilance" as a cause of road accidents, where unobtrusive systems had been developed which monitored the driver and the environment and detected changes in the drivers alertness in real time. By enabling a dedicated cooperative CVHS system that would enhance this functionality, the project was able to demonstrate enhancements that could be delivered by equipping vehicles with sensors to monitor road and environment features that may affect the drivers ability to perceive and react to hazards, e.g., weather conditions, distance from various types of obstacle on the road, road geometry etc.

#### 4.5.3.3 Traffic and safety monitoring

SafetyNet – the European Road Safety Observatory – produced a wide range of statistics on accident data in EU countries (including their causes) together with different models describing the trends of accident, injury and fatality numbers. Statistics cover road safety management, roads, vehicle safety, speeding, speed enforcement, fatigue, alcohol, pedestrians and cyclists, powered two-wheelers, eSafety, novice drivers and older drivers, post-impact care, cost-benefit analysis, safety ratings, work-related road safety and road safety targets.

The INTRO "Intelligent Roads" project demonstrated that real-time traffic safety indicators can be computed and used for driver warning. Several indicators have been built based on individual data (speeds, headways) and on aggregated data (speed and density of flow) and their relationship with real accidents established (real-time crash risk indicator). Further research should involve field tests including tests of the best various information means (VMS, radio broadcast, in-vehicle warning, etc) and of their impact on flowing and safety.

The project "Fully Automatic Integrated Road Control" (FAIR, 2006a & 2006b) designed the architecture for a complete automatic driving enforcement system based on different types of sensors (at-site or in-vehicle) and including detection, fining and recording on a database. Violations include speed according to vehicle type, axle load, headways, non-wearing of seatbelts, driving time for HGVs, etc. Dynamic measurement of parameters related to safety, like pressure and temperature of tyres, temperature of brakes, was also included within the scope of the project.

FAIR produced a state-of-the-art of needs and of existing automated enforcement systems including a description of various available sensors and guidelines about how to design such systems (architecture).

Enforcement has been studied in a more general sense within the "Police Enforcement Policy and Programmes on European Roads" Project (PEPPER, 2008), which has addressed several key goals set out in the European Commissions' 2003 Road Safety Action Programme, and has provided decision makers with data and clarification on a wide



range of key issues. These have included the provision of tools with which to implement conventional and innovative safety measures, methods for prioritising different enforcement and safety measures, the assembly of models with which to assess the deployment and impacts of enforcement on a European level, and a comparison and analysis of traffic Enforcement chains across EU Member States.

Experimental pilot studies were also undertaken in the use of data collection systems in six countries in order to clarify which variables can be used for monitoring the efficiency of the enforcement chain, and evaluating enforcement performance with regard to behaviour, accidents and fatalities for three test systems: speeding, drink-driving and use of seatbelts.

One method of delivering increased speed enforcement or advice on speed is that of Intelligent Speed Adaptation (ISA) which has been explored in the “Project for Research on Speed Adaptation Policies on European Roads” (PROSPER, 2006), with a view to building on a wide range of earlier national projects and building a more complete European perspective regarding ISA deployment.

As part of this, driving simulator experiments and field studies (in Hungary and Spain) were performed in combination with interviews and surveys, demonstrating that ISA and traditional physical speed enforcement should be seen as complimentary systems (with ISA generating network wide benefits that would otherwise be unavailable), and with ISA reducing accidents by 20-40% through not only speed reduction but also by the reduction of its variance. Of the differing types of ISA, mandatory (intervening) systems were found to bring a more substantial effect than the informative (Speed Alert) systems, however with such systems the design of the driver interface has been found to be key to the long term safety effect.

While there are several very positive aspects to the systems (for example the benefit to cost ratio is 3 or higher, and the vehicle industry is positive to informative ISA), Europe-wide coverage of high quality speed limit information is required before large scale implementation can take place, and there is currently no functioning method for collection and distribution of speed limit information for cross-border applications.

#### 4.5.3.4 Demand responsive and innovative mobility services by road

Concerning demand-responsive transport (DRT), the project “Intelligent In-vehicle Terminal for Multimodal Flexible Collective Transport Services” (INVETE, 2002), developed and demonstrated an in-vehicle device designed for flexible collective transport service (both regular and demand responsive). A Base Module (handling vehicle data and external multi-communication links) is connected to two possible Application Modules (text and icon display, entry buttons) depending on the use (regular or demand responsive). Tests undertaken in Italy and Finland showed a good level of acceptance by operators and a very positive evaluation of the support brought by this terminal.

## 4.5.4 Policy implications

### 4.5.4.1 Driver training, behaviour and assistance

An implication of the TRAINER project is that common and harmonised driver training and assessment procedure should be implemented across Europe by means of best practice guidelines and multimedia tools. This would lead not only to novice drivers being implicated in fewer accidents but also to more experienced drivers being assessed and benefiting from driving advice and enhancement.

Social benefits are expected from the potential application of Virtual Reality based vehicle testing systems for education and for training, as developed in the VIRTUAL project. Although primarily aimed at enhancing the ergonomic qualities of the driving environment, and therefore contributing towards road safety policies, the VIRTUAL project showed the added value of virtual reality in driving simulation capabilities and could benefit training and assessment systems such as in driving schools or in mobility centres for disabled or elderly users.

### 4.5.4.2 Vehicle-Infrastructure co-operative systems for safety and mobility

From the initial research on the relationship between braking distance and pavement friction done in the INTRO project, it was recommended that further research be conducted for both the braking distance real-time evaluation and the long term behaviour of the driver (possible adverse effects on sections whose friction is deemed high). The development and implementation of a final could lead to significant safety benefits, with a simulation based on a possible deployment scenario in Austria, based on a 20-year timeframe, estimating a reduction in accidents of less than 0.1% in the first year of deployment (due to only about 9000 cars being equipped), but progressing to a 5.7% reduction in accidents in the twentieth year (assuming over 800 000 cars equipped, representing 27% of car-kilometres driven in Austria).

Next steps should include awareness-raising on skid resistance relevance for road safety and proceeding to a field operational test with a fleet providing friction information. This would allow better estimations to be made of likely deployment and operating costs, benefits, user acceptance, the level of interest from car manufacturers to install such systems and that of road operators or service providers to operate them.

From IN-SAFETY, an implication was that certain potential applications are desired by users but not by manufacturers due to the risk entailed. For example a system detecting oncoming vehicles, to advise drivers when and when not to overtake, has clear market potential but is not likely to come on the market in the near future. The same is the case of a system warning of safe speeds on bends. Further research may therefore be needed to make such concepts more reliable and to reduce the risk associated, if they are to become realities. On the other hand, the fact that drivers could rely too much on an in-vehicle advice system based on detection which is not failsafe, could lead to drivers taking greater risks and leaving manufacturers open to liability for resulting accidents: this explains the reluctance of industry to progress certain types of system.

This project also brought together various other requirements with respect to co-operative systems. In summary, these are:

- Guidelines are presently lacking for co-operative systems and that reliable indicators/measurements for the analysis of safety benefits are largely absent in benefit analyses.
- The requirement was identified for more standardisation in order to satisfy the long-term commercial interests of manufacturers and operators.
- Educational guidelines are necessary for (integrated) system operators and drivers.
- Making the reporting of accidents more uniform internationally is necessary in order to obtain statistics that are comparable across Member States.
- Regarding legislation, both systems and drivers must be supervised, but at the same time privacy laws must be respected.

The PReVENT project concluded that one reason for the limited deployment of Intelligent Vehicle Safety Systems (IVSS) so far is the lack of public awareness on their benefits. The PReVAL sub-projects quantified these benefits and found that the estimated safety impacts vary quite considerably. The highest benefits were for collision mitigation and vulnerable road user protection systems, followed by lateral area safety systems for co-operative and proactive driving.

Given that PReVENT focused on systems that are close to production, many of the applications prototyped in this project can quickly be transferred into the development departments of the project's industrial partners. Therefore additional pre-competitive research is not needed in many areas of IVSS, and the project has paved the way for affordable components and sub-systems and a faster market introduction of future IVSS.

This process has been complemented by the REPOSIT Roadmap which has identified roles for industry developers, regulators (standardisation), car manufacturers (implementation once demonstrations have proved successful), end users (in terms of awareness) and public authorities/agencies (for eSafety funding) and has identified that low-cost solutions ('cost-affordable') are a key to the provision of successful future systems.

On the other hand, further research is needed into less developed applications such as collision avoidance by evasive manoeuvres, where perception and decision-making capabilities need to be improved. Another area for future research action is sensor development, particularly if powerful perception technology is to become standard in cheaper vehicles.

"Green driving" is one field where co-operative systems have potential and require more research, and further activities are needed in terms of system assessment.

Implications from the GST project are the potential for its results to help transform the market for on-line services from a closed market based on proprietary approaches to an open one based on public standards. As such, the potential market for the GST solution is huge as it is possible that all vehicle manufacturers could at one point in the future decide to factory-install GST-compliant terminals in their vehicles. These will give access to a wide range of services that will continuously evolve and create a new market for service providers.

Such open standards have the potential to deliver benefits such as helping to solve the conflict between lifecycles of vehicles and telematics, allowing users to easily subscribe to new services and to only pay for services of their choice, minimising the need for users to

provide administrative information, increasing the number of service providers to choose from, and facilitating the use of a common platform for the European and worldwide market through increased flexibility to customise to local markets.

Implementation of the systems developed in the HIGHWAY and REPOSIT projects would ensure that drivers are more aware of the obstacles in their paths and would thus be less likely to be involved in accidents. This could be an important step towards reaching policy objectives on road safety (reduction of number of fatalities and injuries and improvement in road accident assistance). Other likely implications are the prompt delivery of customised or location-specific integrated and dynamic information; more accurate provision of real-time traffic information; lower costs and greater quality due to a better integration of data sources and elimination of data duplication; and reduced hardware/software costs from the integration of data often residing on different systems.

Results and implications in this sub-cluster therefore relate principally to safety policy objectives, but also to goals of increasing competitiveness by bringing forward the availability on the market of innovative systems from OEMs (original equipment manufacturers).

#### 4.5.4.3 Traffic and safety monitoring

The SafetyNet project does not lead to implications as such, as its function was to gather and present data. However this knowledge has great potential to assist actors in working towards the ambitious goal of a 50% reduction of fatalities in 2010, as set by the EU in 2004 (where 43,000 people were killed on the roads of the EU25 and over 3.3 million injured). Some guidelines/implications were given regarding aspects such as safety ratings and targets:

- Safety rating systems, which present impartial information to policy makers, employers, professionals, practitioners and end users on aspects of traffic system safety, require high quality data from realistic tests in order to be credible. Since rating systems need to promote objective safety data, it is important that the 'messenger' is independent (and recognised as such) from governments and industry. Assessment procedures need to be transparent and results need to be effectively targeted, e.g. at the road using public, fleet buyers and decision-makers in general.
- Quantitative targets are expressions of national road safety ambition; Research and experience indicate that long term goals and interim targets lead to increased political will and stakeholder accountability for road safety, closer management of strategies and programmes, better safety programmes, better safety performance, better use of public resource and increased motivation of stakeholders. Current good practice involves a combination of top-down long term goals as well as bottom-up interim targets (usually of 7-10 year duration), which are soundly related to interventions. Targets lacking political support are unlikely to obtain the level of funding or other resources needed for their attainment. A purely symbolic target has no value. Targets should be accompanied by appropriate safety programmes designed to realise them, and good practice shows that interim targets set within the specific timeframe of a road safety strategy or programme need to be ambitious but realistic.

An implication from the INTRO project is that real-time information and warning about local safety conditions related to current flow characteristics should be developed, especially to cope with situations encountered on motorways when speeds are transitorily too high according to density.

In view of the huge challenge of reducing the accident costs in Europe, the FAIR project recommended that the feasibility and efficiency of the automatic enforcement systems developed in the projects be tested as a priority, in order to promote their dissemination among EU countries. The modular application design of a multi purpose control system as recommended by FAIR, covering longer road sections with detail violation analysis and the integration of sensors, processing and transmission equipment, is expected to have a very high impact on the performance of future control systems and their efficiency. Note that the follow-up of FAIR, including field tests, is being undertaken by the FP7 project ASSET Road, which started in May 2008.

As regards enforcement, the PEPPER project has provided compelling evidence backing a wide range of road safety policies already in existence, and demonstrating that enforcement plays a key role in maintaining safe road user behaviour, and needs to be made more efficient and effective. Most of the practices promoted by the 2004 EC Recommendation on Enforcement have been shown to be supported by most stakeholders in all Member States for example drink drive legislation (and indeed support for stronger sanctions) and increased cross-border harmonisation. There is however, less agreement within EU institutions and among stakeholders, about the legitimacy, feasibility, practicality or desirability, of having a top-down, EU mandated traffic enforcement policy that goes into specific tactical issues. Additionally, while some states have now instituted systematic collection of traffic and road user behaviour measures and performance indicators for assessing the extent and efficiency of traffic police activity, such measures are virtually non-existent for the other elements of the enforcement chain.

#### 4.5.4.4 Demand responsive and innovative mobility services by road

As costs of car use increase and as environmental concerns grow, there is a need to promote public transport and make it more attractive to people. In areas outside public transport corridors, demand-responsive transport (DRT) is the only way for providing seamless, and therefore attractive, public transport as an alternative to the car. Development of DRT should be encouraged at both the technical and the organisational levels.

Thematic Research Summaries on Passenger, Regional and Rural transport, as well as the Equality and Accessibility paper, focus more closely on such issues relating to accessibility and connectivity, including innovative public transport solutions.

## 4.6 Sub-theme 4: Slow modes (walking and cycling)

### 4.6.1 Background

The sub-theme deals with non-motorised traffic on roads and associated infrastructure (footpaths, cycle tracks, etc), often known as slow modes. In the main, this consists of

projects associated with walking and cycling, although this category may also include horse riding, rollerblading, etc as a means of transport.

The amount of EU-sponsored research into this topic is limited, as policy and planning for such local and short-distance transport is the responsibility of Member States (principle of subsidiarity). One relevant project was covered in the EXTR@Web Thematic Research Summary on Road Transport (EXTR@Web 2006): this concerned a European network for cycling expertise (VELO INFO project).

National research into slow modes is much more widespread and examples reported in the EXTR@Web paper focused on the following:

- strategies for the promotion of pedestrian and cycle traffic (in cities, and on scenic rural and village roads);
- promotion of leisure cycling and exercise/health issues;
- use of private roads for pedestrian and cycle routes;
- inspection methods for cycle paths;
- quality level objectives for pedestrian and cycle paths including engineering solutions;
- child pedestrian safety training;
- effects of cycle parking on cycle use;
- separation of pedestrians and cyclists;
- rollerblading as a mode of transport and recreational activity;
- guidance for visually impaired pedestrians; and
- complementarity between public transport and cycling, including bicycle park-and-ride.

#### 4.6.2 Research objectives

Only one recent EU project (PROMPT) is directly relevant to this theme. Its objective was to promote pedestrian traffic in urban areas by improving the quality and attractiveness of public spaces.

In addition, walking and cycling issues are covered to some extent within the various CIVITAS projects<sup>10</sup>, although these were not their primary focus.

#### 4.6.3 Research results

The main outputs of the project “New Means to Promote Pedestrian Traffic in Cities” were the PROMPT Guidebook (PROMPT 2003a) and the Solutions Report (PROMPT 2003b). The project analysed pedestrian environments in terms of problems related to safety, accessibility, comfort, attractiveness, intermodality and implementation. Six major problem clusters were identified, as follows:

- Lack of, or scarce offer of physical or social space;

<sup>10</sup> [www.civitas-initiative.org](http://www.civitas-initiative.org)



Issues surrounding the promotion of walking and cycling have been examined in the Swiss Project “A marketing approach for the promotion of pedestrian and bicycle traffic in Switzerland” (SVI 2001/504, Büro für Mobilität, 2006). The study aimed to examine ways to promote ‘slow traffic’ through marketing and publicity by developing a new approach to shifting modal split and the assembly of a set packages of individual measures aimed at key target groups. The formation of packages was carried out on the basis of 114 possible measures for pedestrian traffic and 179 possible measures for cycling. The approach was found to be successful through the focus on promising fields of action based on quantitative and qualitative goals, the explicit consideration of target groups, and the synergy obtained between the measures within each package.

Urban characteristics and how they affect pedestrian mobility has been examined in the Spanish project “Built environment variables influencing pedestrian trips: Guidelines for the design of pedestrian-oriented urban development: Towards a walkable city” (Escuela Técnica Superior de Arquitectura - Universidad Politécnica de Madrid, 2008) which sought to prepare a set of guidelines for a more pedestrian oriented urban design. Chief among these were the examination of urban density (for example how the number of buildings and surface effects pedestrian desire), the relationship with differing land use types, urban morphology (e.g. types of intersections, lengths of section, block size and connectivity), urban landscape (relationship between the building and street, spatial definition of the street or road etc) and street geometry and kerb type.

#### 4.6.4 Policy implications

Policy recommendations made by PROMPT are too numerous to list in this report. However a selection is as follows:

- Recommendations to address offer of physical or social space: Give priority to pedestrians in transport planning (e.g. 50% of public space to pedestrians, a continuous and dense network), implementation a pedestrian policy, make streets mode liveable day and night (reduce boundaries between buildings and streets, promote mixed use in districts), etc.
- Recommendations to address lack of equipment and services in outdoor spaces: provide high-quality pavements, differentiated and appropriate lighting, easy orientation, shops and other meeting points at close range), etc.
- Recommendations to reduce interference with motor vehicles: avoid through traffic, implementation speed control through design, mixed use zones (vehicle/cycle/walking), etc.
- Recommendations to improve support by, and connection to, other modes of transport: direct pedestrian access to stops from all directions and for all users, safe and comfortable bus stops (day and night), etc.
- Recommendations to improve natural, architectonic and psychological features of the environment: provide a green network in every city, use design, materials and furniture to enhance local identity, etc.
- Recommendations to improve environmental performance: integrate a pedestrian scale into the city design (city plans and signing for pedestrians), noise control standards, appropriate waste collection and street cleaning, use of water and green elements, etc.



Such projects on walking and cycling contribute to policy goals on co-modality, accessibility and the environment. Safety and security goals are also pursued, e.g. reducing conflicts between slow modes and motorised traffic, or measures to address fear of crime when walking in hours of darkness.

## 4.7 Implications for further research

This section summarises implications and recommendations for further research, based on the outputs of the projects reviewed and also summarises the main research needs identified in the European Road Transport Research Advisory Council's Strategic Research Agenda (ERTRAC, 2004). These are given in the following two sub-chapters respectively.

### 4.7.1 Implications for further research from projects reviewed

For the first sub-theme, which deals with the planning and operation of road infrastructure, the need for further research in the field of road construction and maintenance was identified. For example, research on embedding of deformation sensors at the bottom of the asphalt layer and connecting them to Weigh-in-Motion stations in order to monitor pavement health; on the correlation between pavement strain and frost thaw depth in view of developing a more flexible and dynamic management of traffic restrictions during spring; and research on promising sensor technologies for pavement monitoring such as fibre optics and motes. Further research was identified as being needed into pavement lifetime engineering, for longer life pavements, and also into reducing the energy used to build roads (for example re-using waste materials). Further research into traffic management and bus priority should include aspects such as integration of traffic signals, system evaluation and improvements to Automatic Vehicle Location (AVL).

For the second sub-theme – road vehicles – active and passive safety show great research potential and require an integrated approach to deliver the best results. A need was identified for future research to further study vehicle occupant movement and injury severity for restrained active human models in cars as well as sensors and structural aspects of vehicles to protect occupants in the event of a crash.

For the third sub-theme – road use and driving – a demonstration of automated road control was recommended and is now planned, as well as research on green driving. Driver training and assistance (including HMI in vehicles) is another area of further development.

For all the main three sub-themes, Field Operational Tests were recommended in many cases in order to obtain user reactions, iron out operational problems, evaluate real benefits and establish business cases for road technologies and systems which are now ready for deployment. This is of course now a major plank of FP7.

#### 4.7.2 Summary of further research recommended by ERTRAC

The following is a summary of the directions for further research that were given in ERTRAC’s Strategic Research Agenda (ERTRAC, 2004) and revised in the subsequent Research Framework (ERTRAC, 2008). ERTRAC had initially classed road transport research issues into four major themes:

- Mobility, transport and infrastructure;
- Safety and security;
- Environment, energy and resources; and
- Design and production.

However due to the substantial degree of overlap these were reviewed and reissued in 2008 and are presented below.

The directions are listed by these themes rather than the sub-themes in this paper, as many of them are cross-cutting (e.g. ERTRAC’s road transport safety theme covers all four sub-themes in this paper). It should be noted that many of the recommendations, although relating to road transport in general, relate more specifically to themes such as safety, efficiency and the environment, which are covered by other TRKC Thematic Research Summaries. It should also be noted that these recommendations were published in March 2007; so some of them are already being addressed, e.g. in FP7.

##### 4.7.2.1 Urban Mobility: achieve sustainable mobility for passengers and freight in the urban environment

| Research sub theme              | Topic  |
|---------------------------------|--|
| <b>Physical infrastructure</b>  | Research is needed into better understanding the many links between land use and transport, particularly how new sustainable mobility and delivery concepts may be integrated. Urban road infrastructure must be safe, environmentally acceptable, and consistently available for use.   |
| <b>Information technologies</b> | Research into information technologies is needed to be able to provide travellers with up-to-date information relating to the road network, public transport, and walking.   |
| <b>Urban traffic management</b> | New integrated urban traffic management systems will be able to be developed on new information streams that may come from greater knowledge of origin/destination patterns, and sensor nets. Research into the provision and management of effective interchanges between services is important to support seamless sustainable journeys and goods movements and promote multimodal travel decisions. |
| <b>Vehicle</b>                  | Research into new concepts for vehicle design and operations will result in low or zero carbon vehicles appropriate for short range urban use and with new approaches to vehicle ownership and use. On-board systems will encourage safer and more environmentally sustainable behaviour.  |
| <b>New systems and services</b> | These will include demand responsive services to fill the gaps between cars and public transport and integrate with them in an urban context. Some services may involve fully automated vehicles at various levels of segregation in the urban network.  |

| Research sub theme                  | Topic  |
|-------------------------------------|--|
| <b>Guiding measures and studies</b> | Research will include studies to understand market factors and changes in behaviour at all stages of travel decision making. Monitoring land use changes and their impacts will be important aspects of new data base and modelling systems.   |
| <b>External factors</b>             | Effects of changes in the availability and cost of energy, levels of economic activity, aging and migration population issues, and evolving levels of awareness and evolving attitudes to global warming and technology will all need to be better understood in an urban transport context. |

#### 4.7.2.2 Energy, Resources, and Climate Change: provide environmentally friendly road transport systems and a secure, renewable energy supply

| Research sub theme                              | Topic  |
|---|--|
| <b>Powertrains</b>                              | Research in the area of powertrains must target near-zero exhaust emissions of pollutants by 2020, and the advancement of better technologies for a potential overall CO2 emission reduction will continue to be the primary workhorses in road transportation, as powertrains for passenger cars, and light- and heavy duty trucks.   |
| <b>Energy</b>                                   | Biomass and waste represent the most readily available alternative fuel source in the short- to mid-term. Research should consider the advantages of bio-fuels of the second generation, which can be blended with gasoline and diesel and are compatible with advanced ICEs.  |
| <b>Mobility and advanced traffic management</b> | Improved management of the road network, of traffic and of infrastructure operation, can make a significant difference in terms of environmental performance, delivering improvements on many environmental and societal levels. Research in this area will focus on integrated traffic management, better vehicle labelling systems, and the development of systems for energy recovery and network design. |
| <b>Infrastructure</b>                           | To reduce the adverse effects of road and infrastructure design on fuel consumption and air pollution; and improving the sustainability of materials use will also support network operations considered under the topic of mobility management.   |
| <b>Guiding measures and studies</b>             | Applied within the framework of a comprehensive and systematic approach, guiding measures and studies will be an important resource to shape research planning and policy decision-making. They will be used to collect information on changing demographics and transport needs and will enable the development of realistic projections for the future.  |

#### 4.7.2.3 long distance freight transport

| Research sub theme                  | Topic   |
|-------------------------------------|---|
| <b>Infrastructure</b>               | Developments in infrastructure will include a focus on dynamic and flexible lane/road management for the purposes of heavy vehicle goods transport. This work will include the concepts of dedicated transport corridors that will be designed, maintained and operated from the perspective of green and efficient heavy vehicle.  |
| <b>Safety</b>                       | Improvements in the safety performance of long-distance freight transport will consider the vehicle, infrastructure, driver and the linking systems. One aspect of this will be improved information system for road conditions, weather, traffic etc that are focused on the particular needs of long-distance haulage operations.   |
| <b>Security</b>                     | Research developments will improve the security of track design to prevent intrusion and theft. Such systems will also consider the links with systems in parking areas and other higher risk environments. The research will consider intelligent surveillance systems for the security of both vehicles, drivers and infrastructure.  |
| <b>Information technology</b>       | Improved information technology systems will include the development of universal digital maps for navigation and positioning with integrated real-time updating and active vehicle data interfaces and vehicle-to-infrastructure communication. At the network level, integrated and flexible maintenance and network management systems will support the effective management of the infrastructure and traffic as a complete system to ensure maximum infrastructure capacity usage and life-time utilisation. |
| <b>Guiding measures and studies</b> | These studies will consider the barriers to market and policy implementation including the important issues of public acceptance of identified solutions. These studies will also consider how any public reluctance can be better informed by appropriate demonstration and other awareness activities.  |

#### 4.7.2.4 Road Transport Safety: reduce road transport injuries, fatalities, and accidents

| Research sub theme    | Topic  |
|-----------------------|--|
| <b>Driver</b>         | Major advances can be made through providing a wide range of driver assistance systems including On board information systems, Driver Monitoring (to guard against driver drowsiness) and Advanced Human Machine Interfaces to ensure the driver does not become overloaded by information and is assisted in a safe and timely manner.  |
| <b>Vehicle</b>        | Sensors/Actuators on the vehicle are likely to become increasing accurate and flexible leading to more complex driver assistance system that may be both individualised and more and more situation specific and flexible. Safety relevant software tool will be increasingly used to ensure safe system design and appropriate fail safe modes.   |
| <b>Infrastructure</b> | Developments in infrastructure, for example sensors and solutions for pavement condition monitoring, may lead to a complete information systems for road conditions, weather, traffic, work in progress, accidents, etc allowing drivers far more information regarding factors that may effect their safety. Development of a general concept of a passive and active safe road infrastructure (forgiving road), will allow a certain level of error to road users; |

| Research sub theme | Topic  |
|--------------------|--|
| <b>Security</b>    | Developments in Intelligent surveillance of the road and its infrastructure with allow increasing levels of security, particularly for freight traffic, which the increasing prevalence of cooperative systems will enable more detailed and effective monitoring & tracking of dangerous/sensitive goods. |

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## Annex: List of projects by sub-theme

| Sub-theme 1: Road infrastructure planning and operation |  |  |   |                             |
|---|--|--|---|-----------------------------|
| Project acronym   | Project title  | Programme  | Project website <sup>11</sup>                                       | Coverage                    |
| ARCHES  | Assessment and Rehabilitation of Central European Highway Structures                   | FP6 – PTA 6 “Sustainable Development, global change and ecosystems”                | <a href="http://arches.fehrl.org">http://arches.fehrl.org</a>       | if reports become available |
| ARENA   | Kilometre tax for heavy goods vehicles in Sweden - A proposal for a functional concept | SRA/Vägverket 2000-2009 - SRA Research and development programme 2000-2009, Sweden | <a href="http://www.arena-ruc.se">www.arena-ruc.se</a>              | covered in this paper       |
| CERTAIN   | Central European Research in Road Infrastructure                                       | FP6 – PTA 6 “Sustainable Development, global change and ecosystems”                | <a href="http://certain.fehrl.org">http://certain.fehrl.org</a>     | if reports become available |
| BESTUFS II  | Best Urban Freight Solutions II  | FP6 – PTA 2 "Information society technologies"                                     | <a href="http://www.bestufs.net">www.bestufs.net</a>                | Covered in this paper       |
| EcoLanes  | Economical and Sustainable Pavement Infrastructure for Surface Transport               | FP6 – PTA 6 “Sustainable Development, global change and ecosystems”                | <a href="http://ecolanes.shef.ac.uk">http://ecolanes.shef.ac.uk</a> | if reports become available |

<sup>11</sup> Accessed on 9-10-2008

| <b>Sub-theme 1: Road infrastructure planning and operation</b> |   |  |   |  |
|--|---|--|---|--|
| Project acronym  | Project title   | Programme  | Project website <sup>11</sup>   | Coverage   |
| ERTRAC   | ERTRAC European road transport 2020: a vision and strategic research agenda | FP6 – PTA 6 “Sustainable Development, global change and ecosystems”                | <a href="http://www.ertrac.org">www.ertrac.org</a>                    | covered in this paper, in Chapter 4.6 as it is a cross-cutting project |
| ERTRAC II  | Technology Platform for European Road Transport Research                    | FP6 – PTA 6 “Sustainable Development, global change and ecosystems”                | <a href="http://www.ertrac.org">www.ertrac.org</a>                    | if reports become available  |
| EURAMP   | European ramp metering project  | FP6 – PTA 2 “Information Society Technologies”                                     | <a href="http://www.euramp.org">www.euramp.org</a>                    | covered in this paper  |
|  | Express buses in the Stockholm congestion charging trial                    | SRA/Vägverket 2000-2009 - SRA Research and development programme 2000-2009, Sweden |   | covered in this paper  |
| HeavyRoute   | Intelligent Route Guidance for Heavy Vehicles                               | FP5 – Growth, Key Action 3 “Land Transport and Marine Technologies”                | <a href="http://heavyroute.fehrl.org">http://heavyroute.fehrl.org</a> | covered in this paper  |
| INQUEST  | Information Network on Quiet European road Surface Technology               | FP6 – PTA 6 “Sustainable Development, global change and ecosystems”                |   | if reports become available  |
| IN-SAFETY  | Infrastructure and Safety   | FP6 – PTA 6 “Sustainable Development, global change and ecosystems”                | <a href="http://www.insafety-eu.org">www.insafety-eu.org</a>          | covered in this paper  |

| <b>Sub-theme 1: Road infrastructure planning and operation</b> |  |   |   |                             |
|--|--|---|---|-----------------------------|
| Project acronym  | Project title  | Programme   | Project website <sup>11</sup>   | Coverage                    |
| INTRO  | Intelligent Roads  | FP6 – PTA 6 “Sustainable Development, global change and ecosystems” | <a href="http://intro.fehrl.org">http://intro.fehrl.org</a>   | covered in this paper       |
| ITSWAP   | Intelligent Transport Services over Wireless Application Protocol  | FP5 – IST, Key Action 1 “Systems and Services for the Citizen”      | <a href="http://www.ertico.com/en/projects/completed_projects/websites/itswap_website.htm">www.ertico.com/en/projects/completed_projects/websites/itswap_website.htm</a>  | covered in EXTR@Web paper   |
| MISS   | Monitor Integrated Safety System   | FP6 – PTA 6 “Sustainable Development, global change and ecosystems” | <a href="http://www.esafetysupport.org/en/esafety_activities/related_projects/research_and_development/miss_01.htm">http://www.esafetysupport.org/en/esafety_activities/related_projects/research_and_development/miss_01.htm</a> | if reports become available |
| NR2C   | New Road Construction Concept  | FP6 – PTA 6 “Sustainable Development, global change and ecosystems” | <a href="http://nr2c.fehrl.org">http://nr2c.fehrl.org</a>   | covered in this paper       |
|  | New techniques for the mechanical characterisation of road materials with the aim of designing flexible pavements. | PRIN calls 1999-2005, Italy   |   | Covered in this paper       |
| OMNI   | Open Model for Network-wide Heterogeneous Intersection-based Transport Management                                  | FP5 – IST, Key Action 1 “Systems and Services for the Citizen”      |   | covered in this paper       |

|                 |   |   |  |                             |
|-----------------|---|---|--|-----------------------------|
| POLMIT          | Pollution of groundwater and soil by road and traffic sources: dispersal mechanisms, pathways and mitigation measures | FP4 – Transport RTD Programme                                       |  | covered in EXTR@Web paper   |
| PRISCILLA       | Bus Priority Strategies and Impact Scenarios Developed on a Large Urban Area  | FP5 – IST, Key Action 1 “Systems and Services for the Citizen”      | <a href="http://www.trg.soton.ac.uk/priscilla">www.trg.soton.ac.uk/priscilla</a>   | covered in this paper       |
| RANKERS         | Ranking for European Road Safety  | FP6 – PTA 6 “Sustainable Development, global change and ecosystems” | <a href="http://www.rankers-project.com">www.rankers-project.com</a>   | covered in this paper       |
| RCI             | Road Charging Interoperability Pilot Project  | FP6 – PTA 6 “Sustainable Development, global change and ecosystems” | <a href="http://www.ertico.com/en/projects/completed_projects/rci.htm">www.ertico.com/en/projects/completed_projects/rci.htm</a> | if reports become available |
| RIPCORD ISEREST | Road Infrastructure Safety Protection - Core Research and Development for Road Safety in Europe                       | FP6 – PTA 6 “Sustainable Development, global change and ecosystems” | <a href="http://ripcord.bast.de">http://ripcord.bast.de</a>  | covered in this paper       |
| RISER           | Roadside Infrastructure for Safer European Roads  | FP5 - GROWTH - KA2 - Sustainable Mobility and Intermodality         |  | covered in this paper       |
| SELCAT          | Safer European Level Crossing Appraisal and Technology  | FP6 – PTA 6 “Sustainable Development, global change and ecosystems” | <a href="http://www.levelcrossing.net">www.levelcrossing.net</a>   | if reports become available |

|            |   |  |  |                             |
|------------|---|--|--|-----------------------------|
| SENSOR     | Secondary Road Network Traffic Management Strategies - Handbook for Data Collection, Communication and Organisation | FP5 – Growth, Key Action 2 “Sustainable Mobility and Intermodality”                |  | covered in this paper       |
| SMART NETS | Signal Management in Real Time for Urban Traffic Networks   | FP5 – IST, Key Action 1 “Systems and Services for the Citizen”                     | <a href="http://www.ist-world.org/ProjectDetails.aspx?ProjectId=2a91160c2ee94d0884b2e7ddd1f3969b">www.ist-world.org/ProjectDetails.aspx?ProjectId=2a91160c2ee94d0884b2e7ddd1f3969b</a> | covered in this paper       |
| SPENS      | Sustainable Pavements for EU New Member States  | FP6 – PTA 6 “Sustainable Development, global change and ecosystems”                | <a href="http://spens.fehrl.org">http://spens.fehrl.org</a>  | if reports become available |
|            | The Attractive City - Traffic integration or segregation for the sustainable city                                   | SRA/Vägverket 2000-2009 - SRA Research and development programme 2000-2009, Sweden |  | covered in this paper       |
|            | The impacts of road maintenance on regional economy   | TaTe - The Economic Efficiency of Transport System Finland                         |  | covered in this paper       |

| <b>Sub-theme 2: Road vehicles</b> |   |   |  |                             |
|-----------------------------------|---|---|--|-----------------------------|
| Project acronym                   | Project title   | Programme   | Project website <sup>12</sup>  | Coverage                    |
| AC-DC                             | Automotive Chassis Development for 5-day Cars   | FP6 – PTA 6 “Sustainable Development, global change and ecosystems” | <a href="http://www.acdc-project.org">www.acdc-project.org</a>   | if reports become available |
| ADVISORS                          | Action for advanced Driver assistance and Vehicle control systems Implementation, Standardisation, Optimum use of the Road network and Safety | FP5 – Growth, Key Action 2 “Sustainable Mobility and Intermodality” | <a href="http://www.advisors.iao.fraunhofer.de">www.advisors.iao.fraunhofer.de</a>   | covered in EXTR@Web paper   |
| AIDE                              | Adaptive integrated driver-vehicle interface  | FP6 – PTA 2 “Information society technologies”                      | <a href="http://www.aide-eu.org">www.aide-eu.org</a>   | covered in this paper       |
| APROSYS                           | Advanced protection systems   | FP6 – PTA 6 “Sustainable Development, global change and ecosystems” | <a href="http://www.aprosys.com">www.aprosys.com</a>   | if reports become available |
| APSN                              | Network of Excellence on Advanced Passive Safety  | FP6 – PTA 6 “Sustainable Development, global change and ecosystems” | <a href="http://www.ist-world.org/ProjectDetails.aspx?ProjectId=91c297543bc841e286e1d03de72b41a8">www.ist-world.org/ProjectDetails.aspx?ProjectId=91c297543bc841e286e1d03de72b41a8</a> | if reports become available |

<sup>12</sup> Accessed on 9-10-2008

|             |  |   |  |   |
|-------------|--|---|--|---|
| BESTUFS     | Harmonisation of strategies and highlighting best practice to determine optimum Urban Freight Solutions (Thematic Network) | FP5 – Growth, Key Action 2 “Sustainable Mobility and Intermodality” | <a href="http://www.bestufs.net">www.bestufs.net</a>   | covered in EXTR@Web paper   |
| CARS-21     | Competitive Automotive Regulatory System for the 21st century  | DG-Enterprise and Industry  | <a href="http://ec.europa.eu/enterprise/sectors/automotive/competitiveness-cars21/cars21/">http://ec.europa.eu/enterprise/sectors/automotive/competitiveness-cars21/cars21/</a>  | covered in this paper   |
| CHAMELEON   | Pre-crash application all around the vehicle   | FP5 – IST, Key Action 1 “Systems and Services for the Citizen”      | <a href="http://www.ist-world.org/ProjectDetails.aspx?ProjectId=8f8741880c884233b44f8ca4c83939bc&amp;SourceDatabaseId=9cd97ac2e51045e39c2ad6b86dce1ac2">www.ist-world.org/ProjectDetails.aspx?ProjectId=8f8741880c884233b44f8ca4c83939bc&amp;SourceDatabaseId=9cd97ac2e51045e39c2ad6b86dce1ac2</a> | covered in EXTR@Web paper   |
| CyberCars   | Cybernetic technologies for the car in the city  | FP5 – EESD, KA4 “The City of Tomorrow and Cultural Heritage”        | <a href="http://cybercars2.paris-rocquencourt.inria.fr">http://cybercars2.paris-rocquencourt.inria.fr</a>  | covered in EXTR@Web paper   |
| EASIS       | Electronic architecture and system engineering for integrated safety systems   | FP6 – PTA 2 “Information society technologies”                      | <a href="http://www.ist-world.org/ProjectDetails.aspx?ProjectId=d50a12df488f420d841cc8bc0af81351">www.ist-world.org/ProjectDetails.aspx?ProjectId=d50a12df488f420d841cc8bc0af81351</a>   | if reports become available   |
| ECO-ENGINES | Energy Conversion in Engines   | FP6 – PTA 6 “Sustainable Development, global change and ecosystems” | <a href="http://www.ist-world.org/ProjectDetails.aspx?ProjectId=bf d9ba20cb7f481eaa36fa608c1b2fca">www.ist-world.org/ProjectDetails.aspx?ProjectId=bf d9ba20cb7f481eaa36fa608c1b2fca</a>   | if reports become available   |
| ERTRAC      | ERTRAC European road transport 2020: a vision and strategic research agenda  | FP6 – PTA 6 “Sustainable Development, global change and ecosystems” | <a href="http://www.ertrac.org">www.ertrac.org</a>   | covered in this paper (in Chapter 4.6 as it is a cross-cutting project) |

|           |   |   |  |  |
|-----------|---|---|--|--|
| ERTRAC II | Technology Platform for European Road Transport Research              | FP6 – PTA 6 “Sustainable Development, global change and ecosystems” | <a href="http://www.ertrac.org">www.ertrac.org</a>   | if reports become available  |
| e-Scope   | eSafety observatory   | FP6 – PTA 2 “Information Society Technologies”                      | <a href="http://www.esafetysupport.org/en/esafety_activities/related_projects/finished_projects/escop_e_-_esafety_observatory.htm">www.esafetysupport.org/en/esafety_activities/related_projects/finished_projects/escop_e_-_esafety_observatory.htm</a> | Specific Support Action, not a research project with results, so not included. However, website provides an important portal for eSafety |
| FURORE    | Future Road Vehicle Research - A roadmap for the future               | FP5 – Growth, Key Action 3 “Land Transport and Marine Technologies” |  | covered in this paper  |
| HUMANIST  | Human centred design for information society technologies             | FP6 – PTA 2 “Information society technologies”                      | <a href="http://www.noehumanist.org">www.noehumanist.org</a>   | if reports become available  |
| HyTRAN    | Hydrogen and Fuel-Cell Technologies for Road Transport                | FP6 – PTA 6 “Sustainable Development, global change and ecosystems” | <a href="http://www.hytran.org">www.hytran.org</a>   | if reports become available  |
| IPSY      | Innovative Particle Trap System for Future Diesel Combustion Concepts | FP6 – PTA 6 “Sustainable Development, global change and ecosystems” |  | if reports become available  |
| LITEBUS   | Modular Lightweight Sandwich Bus Concept                              | FP6 – PTA 6 “Sustainable Development, global change and ecosystems” | <a href="http://www.litebus.com">www.litebus.com</a>   | if reports become available  |



|                |   |   |  |  |
|----------------|---|---|--|--|
| OPTO-EMI-SENSE | An Optical Fibre-based Sensor Intelligent System for Monitoring and Control of Exhaust Emissions from Road Vehicles | FP6 – PTA 6 “Sustainable Development, global change and ecosystems” | <a href="http://www.liv.ac.uk/eee/research/rfma/optoemisen/index.htm">www.liv.ac.uk/eee/research/rfma/optoemisen/index.htm</a>   | if reports become available                                |
| PAGODE         | Post-treatment for the next Generation Of Diesel Engines  | FP6 – PTA 6 “Sustainable Development, global change and ecosystems” |  | if reports become available                                |
| PEIT           | Powertrain Equipped with intelligent Technologies   | FP5 – IST, Key Action 1 “Systems and Services for the Citizen”      | <a href="http://www.ist-world.org/ProjectDetails.aspx?ProjectId=00e87949275145849792f5ee1a746257">www.ist-world.org/ProjectDetails.aspx?ProjectId=00e87949275145849792f5ee1a746257</a> | if reports become available                                |
| PISa           | Powered Two-wheeler Integrated Safety   | FP6 – PTA 6 “Sustainable Development, global change and ecosystems” | <a href="http://www.pisa-project.eu">www.pisa-project.eu</a>   | if reports become available                                |
| POMEROL        | Realizing Enhanced Safety and Efficiency in European Road Transport   | FP6 – PTA 6 “Sustainable Development, global change and ecosystems” |  | if reports become available                                |
| PREVENT        | Preventive and active safety applications   | FP6 – PTA 2 "Information society technologies"                      | <a href="http://www.prevent-ip.org">www.prevent-ip.org</a>   | covered in this paper (also in Road use and driving theme) |
| PROTECTOR      | Preventive Safety For Un-protected Road User  | FP5 – IST, Key Action 1 “Systems and Services for the Citizen”      |  | if reports become available                                |
| RADAR-NET      | Multifunctional Automotive Radar Network  | FP5 – IST, Key Action 1 “Systems and Services for the Citizen”      |  | if reports become available                                |

|            |   |   |  |                             |
|------------|---|---|--|-----------------------------|
| RESPONSE 2 | Advanced Driver Assistance Systems: From Introduction Scenarios towards a Code of Practice for Development and Testing      | FP5 – IST, Key Action 1 “Systems and Services for the Citizen”      | <a href="http://www.ist-world.org/ProjectDetails.aspx?ProjectId=63d46afd1e164d79b567cbd67f87efad">www.ist-world.org/ProjectDetails.aspx?ProjectId=63d46afd1e164d79b567cbd67f87efad</a> | covered in EXTR@Web paper   |
| ROLLOVER   | Improvement of rollover safety for passenger vehicles   | FP5 – Growth, Key Action 3 “Land Transport and Marine Technologies” | <a href="http://www.vsi.tugraz.at/rollover">www.vsi.tugraz.at/rollover</a>   | covered in this paper       |
| SEE        | Sight Effectiveness Enhancement   | FP5 – IST, Key Action 1 “Systems and Services for the Citizen”      |  | if reports become available |
| SEES       | Sustainable Electrical and Electronic System for the Automotive Sector  | FP6 – PTA 6 “Sustainable Development, global change and ecosystems” | <a href="http://www.sees-project.net/index.php">www.sees-project.net/index.php</a>   | covered in this paper       |
| SEISS      | Exploratory study on the potential socio-economic impact of the introduction of intelligent safety systems in road vehicles | FP6 – PTA 2 “Information society technologies”                      | no longer available  | covered in this paper       |
| SLC        | Sustainable production technologies of emission reduced light weight car concepts   | FP6 – PTA 6 “Sustainable Development, global change and ecosystems” | <a href="http://www.superlightcar.com">www.superlightcar.com</a>   | if reports become available |
| SPARC      | Secure propulsion using advanced redundant control  | FP6 – PTA 2 “Information society technologies”                      | <a href="http://www.ist-world.org/ProjectDetails.aspx?ProjectId=6e7267ac073d47f3b4e412126aa42734">www.ist-world.org/ProjectDetails.aspx?ProjectId=6e7267ac073d47f3b4e412126aa42734</a> | covered in this paper       |

|            |   |   |  |                             |
|------------|---|---|--|-----------------------------|
| TOP EXPERT | Tailored On-board activated agents production for Exhaust after-treatment Performance Enhancement | FP6 – PTA 6 “Sustainable Development, global change and ecosystems” |  | if reports become available |
| TOPMACS    | Thermally Operated Mobile Air Conditioning Systems  | FP6 – PTA 6 “Sustainable Development, global change and ecosystems” |  | if reports become available |
| ULYSSES    | The Future Propulsion as ONE System   | FP6 – PTA 6 “Sustainable Development, global change and ecosystems” |  | if reports become available |

| <b>Sub-theme 3: Road use and driving</b> |  |   |  |   |
|--|--|---|--|---|
| Project acronym                          | Project title  | Programme   | Project website <sup>13</sup>  | Coverage  |
| BESTUFS                                  | Harmonisation of strategies and highlighting best practice to determine optimum Urban Freight Solutions (Thematic Network) | FP5 – Growth, Key Action 2 “Sustainable Mobility and Intermodality” | <a href="http://www.bestufs.net">www.bestufs.net</a>                       | covered in EXTR@Web paper   |
| CARSENSE                                 | Sensing of Car Environment at Low Speed Driving  | FP6 – PTA 6 “Sustainable Development, global change and ecosystems” | <a href="http://www.crfproject-eu.org">www.crfproject-eu.org</a>           | if reports become available   |
| CAST                                     | Campaigns and Awareness -raising Strategies in Traffic Safety  | FP6 – PTA 6 “Sustainable Development, global change and ecosystems” | <a href="http://www.cast-eu.org">www.cast-eu.org</a>                       | if reports become available   |
| DESIRE                                   | Designs for Inter-urban Road pricing schemes in Europe   | FP5 – IST, Key Action 1 “Systems and Services for the Citizen”      | <a href="http://www.tis.pt/proj/desire.htm">www.tis.pt/proj/desire.htm</a> | covered in EXTR@Web paper   |
| DRUID                                    | Driving under the Influence of Drugs, Alcohol and Medicine   | FP5 – EESD, KA4 “The City of Tomorrow & Cultural Heritage”          | <a href="http://www.druid-project.eu">www.druid-project.eu</a>             | if reports become available   |
| ERTRAC                                   | ERTRAC European road transport 2020: a vision and strategic research agenda  | FP6 – PTA 2 “Information society technologies”                      | <a href="http://www.ertrac.org">www.ertrac.org</a>                         | covered in this paper (in Chapter 4.6 as it is a cross-cutting project) |

<sup>13</sup> Accessed on 9-10-2008

| <b>Sub-theme 3: Road use and driving</b> |  |   |  |  |
|--|--|---|--|--|
| Project acronym                          | Project title  | Programme   | Project website <sup>13</sup>  | Coverage   |
| ERTRAC II                                | Technology Platform for European Road Transport Research   | FP6 – PTA 6 “Sustainable Development, global change and ecosystems” | <a href="http://www.ertrac.org">www.ertrac.org</a>   | if reports become available  |
| e-Scope                                  | eSafety observatory  | FP6 – PTA 6 “Sustainable Development, global change and ecosystems” |  | Specific Support Action, not a research project with results, so not included. However, website provides an important portal for eSafety |
| FAIR                                     | Fully Automatic Integrated Road control  | FP6 – PTA 2 “Information Society Technologies”                      |  | covered in this paper  |
| FAMS                                     | Flexible Agency for collective demand-responsive Mobility Services   | FP6 – PTA 6 “Sustainable Development, global change and ecosystems” | <a href="http://www.famsweb.com">www.famsweb.com</a>   | if reports become available  |
| GST                                      | Global system for telematics enabling on-line safety services  | FP6 – PTA 2 “Information Society Technologies”                      | <a href="http://www.ist-world.org/ProjectDetails.aspx?ProjectId=a1593a861c0643869802ffe2656e9a70">www.ist-world.org/ProjectDetails.aspx?ProjectId=a1593a861c0643869802ffe2656e9a70</a> | covered in this paper  |
| HIGHWAY                                  | Breakthrough intelligent maps and geographic tools for the context-aware delivery of e-safety and added-value services | FP6 – PTA 2 “Information society technologies”                      |  | covered in this paper  |

| <b>Sub-theme 3: Road use and driving</b> |  |  |  |                             |
|--|--|--|--|-----------------------------|
| Project acronym                          | Project title  | Programme  | Project website <sup>13</sup>  | Coverage                    |
| IM@GINE IT                               | Intelligent mobility agents, advanced positioning and mapping technologies integration interoperable multimodal, location based services | FP6 – PTA 6 “Sustainable Development, global change and ecosystems”          | <a href="http://www.imagineit-eu.net">www.imagineit-eu.net</a>                                   | covered in this paper       |
| IN-SAFETY                                | Infrastructure and Safety  | FP6 – IST, Key Action 1 “Systems and Services for the Citizen”               | <a href="http://www.insafety-eu.org">www.insafety-eu.org</a>                                     | covered in this paper       |
| INVETE                                   | Intelligent In-vehicle Terminal for Multimodal Flexible Collective Transport Services  | FP5 – IST, Key Action 1 “Systems and Services for the Citizen”               |  | covered in this paper       |
| I-WAY                                    | Intelligent cooperative system in cars for road safety   | FP6-IST - Information Society Technologies - Priority Thematic Area 2 (PTA2) | <a href="http://www.iway-project.eu">www.iway-project.eu</a>                                     | covered in this paper       |
| MARETOPE                                 | Managing and Assessing Regulatory Evolution in local public Transport Operations in Europe   | FP6 – PTA 6 “Sustainable Development, global change and ecosystems”          | <a href="http://www.tis.pt/proj/maretope/maretope.swf">www.tis.pt/proj/maretope/maretope.swf</a> | covered in EXTR@Web paper   |
| MISS                                     | Monitor Integrated Safety System   | FP6 – PTA 6 “Sustainable Development, global change and ecosystems”          | <a href="http://www.missproject.net">www.missproject.net</a>                                     | if reports become available |

|           |  |  |  |   |
|-----------|--|--|--|---|
| PEPPER    | Police Enforcement Policy and Programmes on European Roads                       | FP6 – PTA 6 “Sustainable Development, global change and ecosystems”          | <a href="http://www.pepper-eu.org">www.pepper-eu.org</a>           | covered in this paper                               |
| PREVENT   | Preventive and active safety applications  | FP6 – PTA 6 “Sustainable Development, global change and ecosystems”          | <a href="http://www.prevent-ip.org">www.prevent-ip.org</a>         | covered in this paper (also in Road vehicles theme) |
| PROCEED   | Principles of Successful High Quality Public Transport Operation and Development | FP5 – IST, Key Action 1 “Systems and Services for the Citizen”               | <a href="http://www.proceedproject.net">www.proceedproject.net</a> | if reports become available                         |
| PROSPER   | Project for Research on Speed Adaptation Policies on European Roads              | FP5 - GROWTH - KA2 - Sustainable Mobility and Intermodality                  |  | covered in this paper                               |
| REACT     | Realising Enhanced Safety and Efficiency in European Road Transport              | FP6 – PTA 6 “Sustainable Development, global change and ecosystems”          |  | if reports become available                         |
| REPOSIT   | Relative Positioning for Collision Avoidance Systems                             | FP6-IST - Information Society Technologies - Priority Thematic Area 2 (PTA2) | <a href="http://www.ist-reposit.org">www.ist-reposit.org</a>       | Covered in this paper                               |
| SafetyNet | The European Road Safety Observatory   | FP6 – PTA 6 “Sustainable Development, global change and ecosystems”          | <a href="http://www.erso.eu">www.erso.eu</a>                       | covered in this paper                               |

|                  |   |  |  |                             |
|------------------|---|--|--|-----------------------------|
| SAFETY-TECHNOPRO | Training System on New Safety Technologies for Road Transport Addressed to Professional Bodies of the Automotive Sector                           | FP6-IST - Information Society Technologies - Priority Thematic Area 2 (PTA2) | <a href="http://www.safety-technopro.info">www.safety-technopro.info</a>   | covered in this paper       |
| TRAIN-ALL        | Integrated System for driver Training and Assessment using Interactive education tools and New training curricula for All modes of road transport | FP6 – PTA 2 "Information society technologies"                               | <a href="http://www.trainall-eu.org">www.trainall-eu.org</a>   | if reports become available |
| TRAINER          | System for driver Training and Assessment using Interactive Evaluation tools and Reliable methodologies   | FP5 – IST, Key Action 1 "Systems and Services for the Citizen"               | <a href="http://www.trainer.iao.fhg.de">www.trainer.iao.fhg.de</a>   | covered in this paper       |
| TRAVEL-GUIDE     | Traveller and Traffic Information Systems: Guidelines for the Enhancement of Integrated Information Provision Services                            | FP5 – IST, Key Action 1 "Systems and Services for the Citizen"               | <a href="http://www.travel-guide.iao.fhg.de">www.travel-guide.iao.fhg.de</a>   | covered in EXTR@Web paper   |
| VERA2            | Video Enforcement for Road Authorities 2  | FP5 – IST, Key Action 1 "Systems and Services for the Citizen"               | <a href="http://www.ist-world.org/ProjectDetails.aspx?ProjectId=b66e821773124d82ba88e27f5e126f7b&amp;SourceDatabaseId=081fd37e0ca64283be207ba37bb8559e">www.ist-world.org/ProjectDetails.aspx?ProjectId=b66e821773124d82ba88e27f5e126f7b&amp;SourceDatabaseId=081fd37e0ca64283be207ba37bb8559e</a> | covered in EXTR@Web paper   |
| VIRTUAL          | Virtual Reality Systems for perceived ergonomic quality testing of driving task and design  | FP5 – Growth, Key Action 3 "Land Transport and Marine Technologies"          | <a href="http://www.ist-world.net/ProjectDetails.aspx?ProjectId=6257a0dd3cb44054889f13eae2e9f35">www.ist-world.net/ProjectDetails.aspx?ProjectId=6257a0dd3cb44054889f13eae2e9f35</a>   | covered in this paper       |



|         |  |  |  |  |
|---------|--|--|--|--|
| VOYAGER | A vision for public transport in 2020 (Thematic Network) | FP5 – IST, Key Action 1 “Systems and Services for the Citizen” |  | covered in EXTR@Web paper (under the former “public/collective passenger transport by road” sub-theme) |
|---------|--|--|--|--|

| <b>Sub-theme 4: Slow modes (walking and cycling)</b> |   |  |                               |                       |
|--|---|--|-------------------------------|-----------------------|
| Project acronym                                      | Project title   | Programme  | Project website <sup>14</sup> | Coverage              |
|  | A marketing approach for the promotion of pedestrian and bicycle traffic in Switzerland - SVI 2001/504  | SVI - Swiss Association of Transportation Engineers, Switzerland |                               | covered in this paper |
|  | Built environment variables influencing pedestrian trips: Guidelines for the design of pedestrian-oriented urban development: Towards a walkable city | CEDEX - Strategic Plan of Infrastructures and Transport, Spain   |                               | covered in this paper |

<sup>14</sup> Accessed on 9-10-2008

|                  |   |  |   |   |
|------------------|---|--|---|---|
| CIVITAS projects | <p>“Cleaner and better transport in cities” initiative, comprising:</p> <p>4 projects within FP5 (MIRACLES, TELLUS, TRENDSETTER and VIVALDI)</p> <p>4 projects in FP6 (CARAVEL, CATALIST, MOBILIS and SMILE)</p> <p>5 new projects in FP7 (ACHIMEDES, ELAN, MIMOSA, MODERN and RENAISSANCE)</p> | <p>FP5 – Growth, Key Action 2 “Sustainable Mobility and Intermodality” / FP6 – PTA 6 “Sustainable Development, global change and ecosystems” / FP7</p> | <p><a href="http://www.civitas-initiative.org">www.civitas-initiative.org</a></p> | <p>Not covered as slow modes in particular or road transport in general are not the key focus of these projects, which will be covered in the Thematic Research Summary on Urban Transport. This reference and website is included however as some actions relate to road transport including walking and cycling</p> |
|                  | <p>Non-motorised mobility and land-use resources: an inter-disciplinary comparison and design experimentation</p>   | <p>PRIN calls 1999-2005 - Research projects of national relevance, Italy</p>   |   | <p>covered in this paper</p>  |
| PROMPT           | <p>New Means to Promote Pedestrian Traffic in Cities</p>  | <p>FP5 – Growth, Key Action 2 “Sustainable Mobility and Intermodality”</p>   | <p><a href="http://www.vtt.fi/virtual/prompt">www.vtt.fi/virtual/prompt</a></p>   | <p>covered in this paper</p>  |
| VELO INFO        | <p>The European network for cycling expertise</p>   | <p>FP5 – Growth, Key Action 2 “Sustainable Mobility and Intermodality”</p>   | <p><a href="http://www.velo.info">www.velo.info</a></p>                           | <p>covered in EXTR@Web paper</p>  |

Remark: the projects listed in the annex are those that have had the focus on the theme “road transport”. On the TRKC portal [www.transport-research.info](http://www.transport-research.info) it is possible to use the “advanced search” functionality, with the option “road transport (including walking and cycling)”, and find all research projects, EU-funded and national, which have treated, to a variable extent, aspects that can be related to the theme.