



European
Commission



Thematic Research Summary

Passenger Transport

COMMUNICATING TRANSPORT RESEARCH AND INNOVATION

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Transport



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Preface

This Thematic Research Summary (TRS) has been produced as part of the activities of the Transport Research and Innovation Portal (TRIP). The purpose of TRIP is to collect, structure, analyse and disseminate the results of EU-supported transport research and research financed nationally in the European Research Area (ERA), and by selected global research programmes. The main dissemination tool used by TRIP is the public web portal www.transport-research.info.

The Thematic Research Summaries provide a structured guide to the topics and results of research projects carried out mainly at EU level, either as part of a framework programme or as a study commissioned by the European Commission (EC). These summaries are intended for policy makers at European, national and local levels, stakeholders and researchers.

This Thematic Research Summary covers Passenger Transport which is one of the 24 themes in TRIP, and provides:

- an overview of research on passenger transport focusing on EU-funded projects;
- analysis and compilation of research findings and recommendations.

An overview of all Thematic Research Summaries is presented in Table 1.

Table 1: Transport themes used in TRIP

Domains	TRIP Themes
Sector	Passenger transport
	Freight transport
Mode	Air transport
	Rail transport
	Road transport
	Urban transport
	Water transport (sea and inland)
	Multimodal transport
Policy	Financing, pricing and taxation
	Regulation, competition and public services
	Infrastructure and TEN-T
	Land use and transport planning
	Climate policy and energy efficiency
	Security and safety
	International cooperation and EU Neighbourhood Policy
	Awareness, information and user rights
Technology	Intelligent transport systems
	Innovative technologies
	Transport management
Evaluation	Long-term perspectives
	Assessment and decision support methodologies
	Environmental impacts
	Economic and regional impacts
	Accessibility, social and equity impacts

Executive Summary

This Thematic Research Summary (TRS) presents an overview of research on passenger transport financed under the EU Sixth and Seventh Framework Programmes (FP6 and FP7). The research is directed to supporting decision making in improving passenger transport throughout the EU, contributing to making transport safer, more user-friendly, and reducing the environmental impact.

Research projects are grouped in **four sub-themes** according to their key focus as follows:

- Safer individual transport
- High-quality public transport
- Integrated transport services
- Environmentally sustainable mobility behaviour.

Research on **safer individual transport** is directed to developing technology to increase the safety of road vehicles and infrastructure in Europe. A promising technical means to reduce the risk of accidents and to improve traffic flows are innovative 'cooperative systems', in which vehicles exchange data and interact with infrastructure and with nearby vehicles. Another research focus is finding ways and means to stimulate safe driving behaviour through, for instance, on-board drive assistance and vehicle information systems. However, the increasing reliance on technology measures may have a downside of distracting drivers. This concern has led to research to gain better understanding of how to support safe driving.

Research directed to developing **high-quality public transport** covers all modes of local and regional transport (e.g., rail and bus) as well as long-distance services (e.g., rail, air, sea and inland waterways). The scope is wide ranging in developing measures to meet political targets of transport efficiency, sustainability and equal access for all, and innovation targets with regard to technology, organisation and decision support systems. In meeting targets for high-quality public transport, the needs and behaviour of users are being analysed, technologies and management systems improved, and new concepts in transport services developed.

Research on **integrated transport services** focuses on developing and implementing flexible, reliable and efficient intermodal concepts, smart information systems for intermodal travel, and platforms to coordinate integrated transport services. Research on intermodality concepts aim at combining the strengths of different transport modes to increase flexibility and efficiency without compromising reliability and comfort. Much research in this area is devoted to developing smart solutions to meet information needs of passengers before and during intermodal journeys, such as schedules, trip planning, and ticketing across transport modes. Platforms are being developed to support coordination of transport operators and terminal managers in providing integrated transport services.

Research on **environmentally sustainable mobility behaviour** focuses on stimulating passengers to be more discerning in their transport choices. Thus, the primary research focus is to develop incentive systems using targeted passenger information to enable passengers to include environmental impact in their travel decisions.

Meeting the ambitious targets presented in the Transport White Paper 2011 (EC, 2011a) for 60% reduction in greenhouse gas emissions by 2050 will require further research. External expert Prof. Professor John Preston has identified **four focal areas for on-going and future research**: volume of travel, carbon emissions from travel, choice of travel, and integrated transport.

Volume of travel: Research on a European scale is needed to determine the extent to which car ownership is reaching saturation, supply-side constraints are limiting demand, and the extent to which information technology is suppressing travel. Furthermore, instead of focusing on ease of movement (mobility), emphasis needs to be placed on the ease of reaching activities (accessibility), either physically or virtually. Thus, the interrelationship between accessibility and mobility needs investigation on a European scale.

Carbon emissions from travel: Technological improvements should not be limited to vehicles but should also contribute to reducing the carbon footprint of infrastructure, which can be substantial, but has been relatively neglected to date.

Choice of travel: In promoting a shift to more environmentally friendly transport modes, research needs to focus on gaining better understanding of mode choice including social, psychological and cultural and economic aspects. As bus travel is likely to continue to be one of the most important public transport facilities for local journeys, research on the next generation of trolley buses should be considered in terms of environmentally friendly transport. In addition, walking and cycling are likely to play a greater role, and land-use planning will need to encourage shorter trips and the built environment to promote active travel. Thus, integrated land use and transport planning is an area for further research focus.

Integrated transport: Research and practice have focused on integration of information and on physical connections. However, there is now need to investigate how to integrate policy and governance, where the greatest challenge is for introducing policies that promote behavioural change to more integrated and, thus, more sustainable transport solutions. Research in this area should continue and include consideration of change that can be enhanced by social media.

1. Introduction

Between 1990 and 2010, passenger transport in the EU27 increased 35% to 6.4 billion passenger kilometres, which is on average almost 13,000 km per person. Of the total passenger kilometres, passenger cars accounted for 73.7%; buses and coaches 7.9%; railways 6.3%; powered two-wheelers 1.9%; and tram and metro 1.4%. Intra-EU air and intra-EU maritime transport contributed 8.2% and 0.6%, respectively (EC, 2012b). In 2010, € 904 billion or roughly 13.0% of the total household consumption was spent on transport-related items (EC, 2012b).

EU-funded research is targeted at developing and implementing new concepts and solutions, and bringing innovations to the market to make passenger transport safer, more reliable, more convenient and more sustainable. Because of the wide range of research needed to meet these objectives, research projects presented in this publication are grouped under four sub-themes:

- Safer individual transport
- High-quality public transport
- Integrated transport services
- Environmentally sustainable mobility behaviour.

Safer individual transport

In 2010, transport by passenger cars accounted for more than 82% of passenger kilometres in the EU (EC, 2012b). The use of passenger cars will continue to be essential in future mobility. However, increasing road traffic in the EU, particularly in urban areas, has adverse effects on both passengers and infrastructure. Improving the safety and comfort of passenger cars is a strong focus of EU-funded research. The most promising technical means to reduce the risk of accidents and to improve traffic flows are innovative 'cooperative systems', in which vehicles exchange data and interact with infrastructure and with nearby vehicles. Another research focus is finding ways and means to stimulate safe driving behaviour through, for instance, the use on-board driver assistance systems and vehicle information systems.

However, the increasing reliance on technology may have a downside of distracting drivers. This concern has led to research to gain better understanding of how to support safe driving.

High-quality public transport

Increasing scarcity of fuel resources and space will make public transport increasingly more important in meeting growing mobility demands. Thus, improving the quality of public transport is a key objective of EU-funded research, which is directed to all modes of local and regional transport (e.g., rail and bus) as well as long-distance services (e.g., rail, air, sea and inland waterways). The scope is wide ranging in developing measures to meet political targets such as transport efficiency, sustainability and equal access for all, and innovation targets with regard to technology, organisation and decision support systems. In meeting targets for high-quality public transport, the needs and behaviour of users are being analysed, technologies and management systems improved, and new concepts in transport services developed.

Integrated transport services

Smart combination of transport modes facilitates more efficient use of existing infrastructure and allows passengers to choose the mode the highest comparative advantage. Research on integrated transport services focuses on developing and implementing flexible, reliable and efficient intermodal concepts, smart information systems for intermodal travel, and platforms to coordinate integrated transport services. Intermodality concepts aim to combine the strengths of different transport modes to increase flexibility and efficiency without compromising reliability and comfort. Much research in this area is devoted to developing smart solutions to meet information needs of passengers before and during intermodal journeys, such as schedules, trip planning and ticketing across transport modes. Platforms are being developed to support coordination of transport operators and terminal managers in providing integrated transport services.

Environmentally sustainable mobility behaviour

In meeting the EU target of a more environmentally sustainable transport sector, European citizens will need to adjust their mode choice and mobility behaviour. Research focuses on stimulating passengers to be more discerning in their transport choices. The primary focus is to develop incentive systems using targeted information to enable passengers to include environmental impact in their travel decisions. An overview of research on sustainability and energy efficiency, much of which is relevant to passenger transport, is presented in the TRS on climate policy and energy efficiency.

2. Policy Background

Passenger transport is a key priority in EU policy, and the European Commission is working towards mobility that is disconnected from adverse effects on the environment, energy consumption, and traffic safety. An integral part of this process is linking transport modes in multimodal systems for safe, efficient and comfortable movement of passengers.

The European Commission has launched a range of initiatives to respond to the increasing demand for passenger transport and mobility. As a result, the market has been opened up in air and road transport and partly in rail passenger transport (EC, 2011a). With the adoption of the fourth rail package in January 2013, even domestic passenger services will be open to competition from December 2019 (EC, 2013). Furthermore, safety and security of passengers in all transport modes has increased. New rules on passenger rights have been adopted in air, rail and road transport. The Trans-European Transport Networks (TEN-T) and high-speed rail links are contributing to territorial cohesion.

There are still major challenges in passenger transport. Mobility has to be more sustainable and energy-efficient in order to reduce environmental emissions and dependence on fossil fuels. Moreover, congestion on roads and in the sky is of major concern in present and future mobility because passenger transport is expected to increase 34% by 2030 (EC, 2009a).

Against this background, the European Commission is working towards a new form of mobility disconnected from adverse effects on the environment, safety and resource use (EC, 2011a). EU transport policy is directed to developing a multimodal transport system that underpins economic development, enhances competitiveness, and that offers high quality mobility services. In this context, all transport has to use less and cleaner energy, to make more efficient use of infrastructure, and to reduce environmental impacts.

Safety and security

Safety and security of passenger transport are high on the EU agenda. The European Commission is committed to developing a European Strategy for civil aviation safety, which includes new technologies and international cooperation.

In 2010, 'policy orientations' on road safety were adopted directed to reducing road fatalities in the EU (EC, 2010). The Commission is committed to harmonising and deploying technology to enhance road safety, such as driver assistance systems and vehicle-infrastructure interfaces. Particular attention is being given to the safety of vulnerable road users such as pedestrians, cyclists and motorcyclists, by using safer infrastructure and vehicle technologies.

Passenger needs

A key component of EU policy in the coming years is improving the quality, accessibility and reliability of public transport services especially with regard to an ageing population, and the needs of vulnerable groups such as the disabled. Since the EU took initiative in 2000, a comprehensive body of EU Regulations has been issued covering passenger rights in all transport modes and these regulations will be further consolidated (EC, 2011a).

Multimodal transport

Public transport needs to make more effective use of integrated transport modes in order to offer passenger modal choices (EC, 2009b). In this respect, airports, railways, metros, and bus stations have to be linked and transformed into multimodal platforms for passengers.

Intelligent transport systems

Multimodal travel can be facilitated by IT systems such as electronic booking and payment systems. The White Paper 2011 highlights the need to create a framework for developing and employing intelligent transport systems in interoperable and multimodal scheduling, information, online reservation systems and smart ticketing (EC, 2011a). In addition, traffic management and information systems (ITS) can facilitate more efficient use of infrastructure.

Environmental impacts

Improving energy efficiency in all transport modes and developing and deploying sustainable fuels and propulsion systems are essential in reducing the environmental impact of passenger transport, in individual and public transport vehicles. The European Union adopted legislation in 2009 on vehicle efficiency, with mandatory targets for emission reduction set for new cars (EU, 2009). Under the Regulation, the target fleet average for all new cars is 130 grams CO₂ emissions per kilometre (g/km) by 2015 and 95 g/km by 2020.

3. Sub-Theme: Safer individual transport

Research on improving private transport focuses on innovative technologies in making transport safer and more convenient, in motorised and non-motorised modes. Although considerable improvements have been made in traffic safety, road fatalities are still unacceptably high in the EU. Research focuses on new technologies for vehicles and infrastructure, and on technologies better adapted to the needs of road users.

Background

Private transport – motorised and non-motorised – plays a major role in mobility and quality of daily life. Cars and motorbikes are the main transport mode in the daily activities of 55% of EU citizens, and 20% of people are cycling and walking (EC, 2011b). However, compared to other types of passenger transport (e.g., public transport), individual transport carries higher risk in traffic safety. Even though road deaths in the EU have almost halved in the last decade, 31,030 people died on roads in the EU in 2010 (EC, 2012b). The Transport White Paper states that initiatives in technology, enforcement and education with particular attention to vulnerable road users are essential in drastically reducing loss of lives further (EC, 2011a).

Research

Against this background, EU-funded research focuses on improving the safety and user-friendliness of private motorised transport, and the safety of cyclists and pedestrians.

The project summaries have been divided into two categories as follows:

- **Road safety and intelligent infrastructure** is directed to developing technology to make road vehicles and infrastructure safer in Europe. Promising technical means to reduce accident risk and to improve traffic flows are the deployment of 'cooperative

systems', in which vehicles exchange data and interact with infrastructure and nearby vehicles.

- **Safe driving behaviour** is directed to gaining better understanding of what is needed to support drivers and thus improve road safety. For instance, increasing reliance on driver assistance systems and vehicle information systems could lead to driver distraction or to task overload.

Road safety and infrastructure

REPOSIT (Intelligent cooperative system in cars for road safety, FP6, 2006-2007) integrated Relative GPS (relative to other vehicles) and wireless vehicle-to-vehicle communications into Collision Avoidance Systems. Information exchange between GPS devices in vehicles was combined to obtain more precise positioning between vehicles in traffic. An embedded device was developed for automatic communication with nearby vehicles equipped with such devices. This information alerts the user to potentially dangerous situations and thus reduces the reaction time required.

eVADER project (Electric Vehicle Alert for Detection and Emergency Response, FP7, 2011-2014) is investigating the interior and exterior soundscape of electric vehicles for safe operation with regard to driver feedback, pedestrian reactions, driver and pedestrian warning systems and pedestrian safety. Road safety research highlights that electric vehicles (either hybrid or pure electric vehicles) are considerably quieter and thus might constitute a safety risk to pedestrians and cyclists in traffic. Innovative methods will be analysed to improve acoustic detectability of electric vehicles in urban scenarios. Effective means will be defined to warn vulnerable users of a nearby moving vehicle.

INROADS (INtelligent Renewable Optical ADvisory System, FP7, 2011-2014) is developing Intelligent Road Studs to replace traditional road studs (also known as cat's eyes) that are only illuminated by vehicle headlights. New intelligent road lighting is being designed that combines LED lighting, sensor systems and communication technologies. Integration of communication technology and sensors will enhance traffic management and driver information because the lights will communicate with one another and with a central controller. Renewable energy technologies will help to make the devices self-contained.

SAFER BRAIN (Innovative guidelines and tools for vulnerable road users safety in India and Brazil, FP7, 2009-2012) analysed the risk factors for vulnerable road users in India and Brazil, based on experience and best practice in Europe. As vulnerable road users are at high risk in emerging countries, methodologies and tools are being developed for planning, designing, and maintaining safe infrastructure. A Decision Support System was designed to support two approaches to pedestrian and cyclist safety:

- preventive approach – verification of safety conditions and definition of improvements in infrastructure under design (Road Safety Audit) or for existing infrastructure (Road Safety Inspection);
- corrective approach – correction of unsafe conditions in infrastructure where road accidents are frequent and/ or serious, based on definition of accident causes and identification of possible counter-measures.

SMART RRS (Innovative concepts for smart road restraint systems to provide greater safety for vulnerable road users, FP7, 2008-2012) examined new concepts for road restrained systems, free of cutting or dangerous profiles/ fixing posts and with capacity to safely absorb crash energy in accidents by detaining moving objects, vehicles and persons safely. These systems also provide timely information to emergency services, road authorities and other road users on the occurrence of a road incident.

euroFOT project (European Large-Scale Field Operational Test on Active Safety Systems, FP 7, 2008-2011) tested drive assistance systems and assessed their potential to enhance safety and to reduce environmental impact. Field Operational Tests (FOTs) are large-scale testing programmes to assess the efficiency, quality, robustness and acceptance of these systems, using ordinary road networks and drivers/ users. A variety of intelligent vehicle systems were analysed under real driving conditions:

- longitudinal control functions: adaptive cruise control, forward collision warning, speed regulation system;
- lateral control functions: blind spot information system, lane departure warning and impairment warning;
- advanced applications: curve speed warning, fuel efficiency adviser, safe human machine interface.

A link was found between these systems and improvements in driver behaviour, fuel efficiency and traffic safety, and overall cost savings.

Safe driving behaviour

AIDE (Adaptive Integrated Driver-vehicle Interface, FP6, 2004-2008) addressed the human-machine interface in large-scale deployment of Intelligent Road Safety Systems. Driver adaptation was studied with regard to advanced driver assistance systems, in-vehicle information systems and nomadic devices (e.g., mobile phones). Based on these findings, a generic adaptive integrated driver-vehicle Interface was developed to:

- maximise efficiency, and thus the safety benefits of advanced driver assistance systems;
- minimise the workload and distraction of in-vehicle information systems and nomadic devices;
- ensure the potential benefits of new in-vehicle technologies and nomadic devices in terms of mobility and comfort, without compromising safety.

2-BE-SAFE (2-wheeler behaviour and safety, FP7, 2009-2011) targeted the safety of powered two-wheelers (PTW). Research included use of a 'Naturalistic Driving Study' in which the everyday driving behaviour of participating motorcycle riders is observed by installed devices that continuously monitor, for instance, speed choice and eye movement in real traffic environment. An in-depth study was done on the underlying factors of driver failure to see PTWs and their riders. Recommendations were made for practical measures to enhance PTW rider safety.

DRUID (Driving under the Influence of Drugs, Alcohol and Medicine, FP6, 2006-2011) investigated how ability to drive safely is affected by alcohol, drugs or medicines. New insights were gained on the degree of impairment caused by psychoactive drugs and the impact on road safety. The prevalence of alcohol and other psychoactive substances in road accidents and on driving behaviour in general were analysed. A database was set up. A classification system of medicines affecting driving ability was prepared, and recommendations for implementation and a framework to classify medicines in a labelling system were elaborated.

INTERACTION (Differences and similarities in driver INTERACTION with in vehicle technologies, FP7, 2008-2012) studied driver interaction with in-vehicle technologies. A limited set of mature technologies were considered that have been adopted by European car drivers, such as communication or navigation systems, and speed control or distance control systems. The research approach combined methodologies such as focus groups, questionnaire surveys, and in-depth observations to identify driver use patterns of these systems in Europe. In addition, 'Naturalistic Driving studies' were conducted.

ISI-PADAS (Integrated Human Modelling and Simulation to Support Human Error Risk Analysis of Partially Autonomous Driver, FP7, 2008-2011) supported the design and safety assessment of new generations of driver assistance systems. An innovative methodology was developed to support risk-based design and approval of partially autonomous driver assistance systems. The methodology focuses on eliminating and mitigating driver error in integrated driver-vehicle-environment modelling.

4. Sub-Theme: High-quality public transport

Research on high-quality public transport covers local and regional transport (e.g., rail and bus) as well as long-distance services (e.g., rail, air and shipping). It addresses political targets (transport efficiency, sustainability and equal access) and innovation targets (technologies, organisation and decision support systems). Research includes fundamental analyses of the needs and behaviour of transport users, developing and improving technologies and management systems, and new concepts in transport services.

Background

Demographic change in Member States has increased the need for improved accessibility for the elderly and people with reduced mobility; demand for higher quality services; and improved efficiency to keep public transport financially viable.

Nevertheless, the modal share of public transport is stagnating, and in urban areas especially rail services are ranked below average in Europe, although indicators vary widely between Member States (Eurostat, 2012; GfK EU3C, 2012). Thus, research is essential to improve the efficiency, attractiveness and accessibility of public transport services and ensure the mobility of all citizens and reduce the negative impact of car use. In addition, new services that are energy and environmentally efficient and/ or adapted to the special needs of passenger groups are essential in a strategy to strengthen public transport.

Reducing energy use and environmental impact are major societal and political concerns, particularly in aviation services. While external costs per air passenger kilometre are lower than for car use, these costs are four times higher than for rail travel and almost twice that for bus/ coach travel (CE Delft et al., 2011).

For a number of reasons, emergency planning has received increasing attention in the last few years. A key factor is that transport modes and especially transport terminals tend to be more susceptible to terrorist attack.

Furthermore, the steadily increasing in size and scale of passenger ships poses as a potential safety risk. Technological development, for instance, the use of composite and other combustible materials to reduce aircraft weight has increased fire risk significantly.

Research

Research on high-quality public transport has been clustered into four groups as follows:

- **Accessibility** refers to improving access to regional and urban public transport, mainly rail and bus systems. Research also addresses the specific needs of the elderly and people with reduced mobility.
- **Smart and user-friendly urban transport** covers devices to support public transport operators and new designs for services and buses.
- **Safety and security** covers catastrophic events and includes public transport, passenger ships, road infrastructure (tunnel) and aviation.
- **Air transport of the future** includes new technical solutions for aviation services to make flights faster and more personalised, to improve cabin environment, and to reduce emissions and noise.

Accessibility

ACCESS2ALL (Mobility schemes ensuring accessibility of public transport for all users, FP7, 2008-2010) defined mobility schemes, guidelines and policy recommendations to ensure access for all to public transport. Based on a problem and needs analysis of all user groups with special needs in public transport, recommendations were made to remove barriers by improving vehicles, infrastructure and information and service provision. Cooperation measures and standardisation issues were considered, such as training methodology on accessibility for all, and curricula and tools for operators and other stakeholders.

GOAL (Growing Older, stAying mobiLe: the transport needs of an ageing society, FP7, 2011-2013) is developing an action plan for innovative solutions to meet the transport needs of an ageing population. Physical and mental characteristics of older people, physical and mental requirements for driving a car, using public transport, walking and cycling as well as information needs before and during travel are being analysed. To validate the approach and to gain wide acceptance, workshops are to be conducted and expertise from the USA and Japan will be included.

MEDIATE (Methodology for Describing the Accessibility of Transport in Europe, FP7, 2008-2010) contributed to developing urban transport with improved access for all citizens. Public authorities and transport operators were assisted in achieving equality of access by identifying indicators for accessibility, identifying and disseminating best practice in 30 projects in Europe, developing a self-assessment methodology to measure accessibility, and defining targets and measures.

PICAV (Personal intelligent city accessible vehicle system, FP7, 2009-2012) investigated new mobility concepts for passengers to increase accessibility in urban pedestrian environments. The design of a new vehicle, PICAV, incorporates the special needs of people with restricted mobility, such as ergonomics, comfort, and mobility dexterity. In addition, the PICAV units are the backbone of a new on-demand transport system based on car sharing. These units can communicate with one another, with the city infrastructure, with public transport in the surrounding area, and with emergency services.

PUBTRANS4ALL (Public Transportation - Accessibility for All, FP7, 2009-2012) developed a prototype for a vehicle-based boarding assistance system for new rail vehicles and retrofitted rail vehicles to improve accessibility for all. Investigations showed that a swivel lift is the only reasonable boarding assistance system that can be used in UIC wagons. A prototype was designed, factory tested, and incorporated in a UIC wagon of the Bulgarian State Railways.

SAFEWAY2SCHOOL (Integrated system for safe transportation of children to school, FP7, 2009-2012) designed and evaluated technologies for safe transport from home to school. The design includes optimal route planning and re-routing for school buses to maximise safety on the road, on-board safety applications, intelligent bus stops, effective warning and information systems for bus drivers, children, parents and the surrounding traffic.

Safety training was designed for all actors involved in home-school transport. The system was tested at four pilot sites in Austria, Italy, Poland and Sweden. Smartphones, for example, were tested with an application created for the project, which enables communication between children, parents, bus drivers and schools.

TRACY (Transport needs for an ageing society, FP7, 2011-2013) is addressing the needs of elderly people in future transport concepts in Europe. A systematic and comprehensive study of current activities is being carried out, and the results will be used to analyse the present situation, identify research gaps, and contribute to a strategy to meet the transport needs of an ageing population.

UNIACCESS (Design of Universal Accessibility Systems for Public Transport, FP6, 2005-2006) addressed accessibility of public transport for groups with various degrees of mobility (the young, the elderly, people with disabilities, people carrying infants or shopping, pregnant women). A comprehensive review of accessibility in public transport was made in terms of infrastructure, vehicles, and legislation and standards. A roadmap was developed identifying R&D needs with regard to travel information and bookings, design of terminals/ bus stops, and platforms, boarding assistance systems, and information during a journey. A methodology was designed to stimulate collaboration between stakeholders in the innovation process.

Smart and user-friendly transport

EBSF (European Bus System of the Future, FP7, 2008-2012) analysed stakeholder needs, defined an innovative high-quality bus system that is fully integrated in the urban environment, and developed innovative designs for vehicles, infrastructure, and operations. The focus was on aspects essential to passengers, drivers, and operation management, such as accessibility, ergonomics, information systems, environment protection and energy savings. Four prototype vehicles were developed and tested by operators in Rome, Bremerhaven, Budapest and Gothenburg. Innovations explored included an interior layout that enhances accessibility and reduces time at bus stops; an innovative, low-emission engine; and a standardised IT architecture platform for on-board information for passengers.

SPUTNIC (Strategies for Public Transport In Cities, FP6, 2006-2009) tackled the challenges to public transport operators and provided a platform for public transport professionals for discussion and exchange of experience. Themes included market organisation, customer relations, corporate management, as well as equipment and operational aspects. An overview of state-of-the-art knowledge and research results in urban mobility and public transport was prepared. Best practices were analysed, and guidelines and tools developed to support best practices identified in European regions and cities.

MODERN (Mobility, Development and Energy Use Reduction, FP7, 2008-2012) outlined integrated measures in four cities - Brescia, Coimbra, Craiova and Vitoria-Gasteiz. The 49 measures included renewal of public transport fleets with clean vehicles, technological systems for traffic management and information on mobility, accessibility and interchange systems, as well as promotional and communication campaigns to support the technical developments.

MODURBAN (Modular Urban-guided Rail Systems, FP6, 2005-2008) addressed interoperability in the urban rail sector, which involves technical compatibility between existing lines and network extensions. A Functional Requirement Specification, known as D80, was formulated to encapsulate the recommended functional and performance requirements for command, control and train management systems for urban rail transport. Other innovations included a definition of system architecture for network communications, such as train control and signalling, video surveillance, and voice communication. An intelligent driving concept was developed to address variation in train parameters over time, such as braking and traction capacities and reaction times.

A prototype lightweight interior grab rail was developed. Technologies were tested on Metro de Madrid. In dedicated MODURBAN train, the following were showcased: the intelligent driving concept; operation of the Interchangeable Data Communication System; on-board and wayside equipment for passenger information and video systems; and the use of lightweight materials.

PROCEED (Principles of successful high quality public transport operation and Development, FP6, 2006-2010) has produced guidelines to support planning, developing and implementing bus public transport in small and medium-sized European cities (between 25,000 and 200,000 inhabitants).

The guidelines include methods for analysing the market side; developing and upgrading network and infrastructure; financing improvement; and marketing strategies for special target groups.

Safety and security

AIRCRAFTFIRE (Fire risks assessment and increase of passenger survivability, FP7, 2011-2013) is reviewing the design of the next generation aircraft with respect to fire prevention and fire management. The focus is on composite materials and other combustible materials used to reduce aircraft weight or to improve passenger comfort but which also raise the fire load. Fire risks are being assessed in specific zones of the aircraft using simulation tools and advanced simulation for in-flight and post-crash fires.

BEMOSA (Behavioural modelling for security in airports, FP7, 2009-2012) improved security in airports by enhancing the capability of airport authority personnel to correctly detect potential security hazards. A dynamic model of social behaviour and security decision making during security threats in airports was developed. The basis for a comprehensive and practical training programme was delivered.

SAFECRAFTS (Safe Abandoning of Passenger Ships: Improvement of Current Lifesaving Appliances Systems, FP6, 2004-2007) developed a method to evaluate the performance of life saving appliances that can be used on different types of passenger vessels, emergencies, and passenger groups. The method was validated in tests with volunteers. New concepts were developed such as a self-propelled survival craft.

SAFEGUARD (Ship evacuation data and scenarios, FP7, 2009-2012) dealt with evacuation measures for passenger ships. Human performance data in full-scale ship trials were collected and used in data calibration and validation for evacuation models. Some 4,308 passengers participated in the trials, which systematically monitored behaviour patterns. Furthermore, additional benchmark scenarios were investigated for use in certification analysis.

ASPIS (Autonomous Surveillance in Public transport Infrastructure Systems, FP7, 2008-2011) dealt with catastrophic events, such as a subway bombing or a shipwreck, that require rapid assessment.

ASPIS developed a prototype surveillance system based on autonomous, smart monitoring devices that capture data on the occurrence of an incident potentially dangerous for the passengers. This innovative system is designed for unattended surveillance of public transport (vehicles, stations), maritime transport (ferries or cruise vessels) and other public spaces. Conformity of the ASPIS prototype with the requirements and specifications was checked in two demonstrations (underground train in Paris Metro, and Ro-Ro ferry linking Piraeus to Souda).

SAVE ME (System and Actions for Vehicles and transportation hubs to support Disaster Mitigation and Evacuation, FP7, 2009-2012) dealt with disaster events in public transport terminals/vehicles and critical infrastructure (tunnels and bridges). A system was developed to detect natural disaster events (earthquake, fire) and manmade disaster events (e.g., terrorist attack), based on a Wireless Sensor Network. User behaviour including emotions and stress in panic situations was investigated. A decision support system - based upon dynamic simulation and modelling tools, and real-time data – was developed for group evacuation plans for the travelling public, and personalised evacuation plans for the most vulnerable travellers. All project developments were optimised in laboratory tests, and at the pilot sites in Monument Metro Station, Newcastle (UK) and Colle Capretto tunnel (Italy).

Air transport of the future

2050AP (2050+ Airport, FP7, 2011-2014) is developing airport concepts with different lead objectives such as passenger time-efficiency, ultra-green, and cost-effectiveness. The benefits and challenges of the concepts will be shown and trade-offs be made between the different areas, for example airport layout that includes intermodal connections.

ENFICA-FC (Environmentally Friendly Inter City Aircraft powered by Fuel Cells, FP6, 2006-2009) developed and validated a new propulsion system for light aircraft and small commuter aircraft that is low in noise and emissions. The fuel-cell system was installed in a selected aircraft for performance testing. A new world speed record of 135 km/h for electrically powered aeroplanes was set on 26 May 2010. In 2011, ENFICA-FC won the REACT competition for climate friendly transport research projects.

FAST20XX (Future high-altitude high-speed transport 20XX, FP7, 2009-2012)

investigated technologies and approaches to conquer the grey zone between aeronautics and space in Europe. Two concepts were considered. The first was ALPHA, a vehicle that is air-launched from a carrier plane before igniting a hybrid rocket. The second concept was SpaceLiner, an all-rocket powered design to transport about 50 people long distances in an extremely short time. The ALPHA concept is envisaged for the medium term of five to ten years, and the SpaceLiner concept could be achieved in the longer term (second part of the century).

FRIENDCOPTER (Integration of Technologies in Support of a Passenger and Environmentally Friendly Helicopter, FP6, 2004-2008)

addressed reduction of external noise, cabin noise, vibrations, and NOx emissions generated by helicopters. Measures were developed to improve the situation in short-term, such as dedicated flight procedures, gearbox modification, addition of damping features and optimisation of cabin panel materials, and other measures to reduce cabin noise. The effectiveness of these measures was demonstrated in flight in different types of helicopters. Active Blade Control technology was improved and validated in reducing noise and emissions.

FUSETRA (Future Seaplane Traffic - Transport Technologies for the Future, FP7, 2009-2011)

detailed information, carried out analyses, and identified requirements for renewing seaplane operation in Europe. A large number of potential seaport locations were identified. A new seaport concept – sea parks – was developed to improve accessibility of regions including tourist areas. New concepts were detailed for modifying existing modern aircraft to seaplanes and for a new boat-plane. Technical and mission requirements including cost considerations were defined.

MYCOPTER (Enabling Technologies for Personal Air Transport Systems, FP7, 2011-2014)

is developing an integrated approach to the first viable personal air transport system for home-work travel and for flying at low altitude in urban environments. It is based on fully or partially autonomous Personal Aerial Vehicles, not requiring ground-based air traffic control. In contrast to previous projects related to Personal Aerial Vehicles, MYCOPTER is investigating the technologies needed to deliver the operational infrastructure required for a transport system with personal aerial vehicles for large-scale use.

PPLANE (Personal Plane: Assessment and Validation of Pioneering Concepts for Personal Air Transport Systems, FP7, 2009-2012) identified new concepts for the personal air transport system of the future. In this system, air vehicles would be publicly available to all citizens but would be owned and operated by either the state or private companies. Low passenger numbers would make it possible to share a journey with other people or dedicate the journey to a family. PPLANE defined, evaluated, and selected promising new concepts for future personal air transport systems. In addition, the most suitable system architecture to develop and operate the systems was recommended.

RECREATE (Research on a Cruiser Enabled Air Transport Environment, FP7, 2011-2015) is investigating cruiser-feeder operations for air transport of the future. Airworthy operational concepts for cruiser-feeder operations, for example air-to-air refuelling, are being determined and studied. The benefits in terms of reduction in CO₂ emissions will be derived and quantified. A conceptual and preliminary design study of the aircraft will be made, as well as automatic flight control concepts to reduce the workload of the pilots, and concepts to transfer passengers, supplies, and waste. Flight simulations will be conducted of the cruiser-feeder operations.

E-CAB (E-enabled Cabin and Associated Logistics for Improved Passenger Services and Operational Efficiency, FP6, 2006-2009) developed an electronic information management system to improve passenger comfort and for passenger handling by airports and airlines. An integrated communication infrastructure was developed to enable airlines, airports, and service providers to exchange information on travellers and flight handling via web services. In addition, value added (opt-in) passenger services were developed that built on tracking passengers in the terminal building, and new services for the handling freight and baggage.

CREDO (Cabin noise Reduction by Experimental and Numerical Design Optimisation, FP6, 2006-2009) addressed the need to validate and calibrate prediction models and advanced design tools for the cost-effective design of low-noise cabins. The tools were developed to evaluate new configurations, materials and new passive and active solutions; fast trouble shooting in existing aircraft and helicopters to fix manufacturing errors; acoustic quality control for new aircraft before delivery to the customer; and time and cost reduction in flight tests.

ICE (Ideal Cabin Environment, FP6, 2005-2008) addressed concerns about the impact of flying on the health and well-being of passengers. The impacts of varying levels of environmental parameters (including cabin pressure) on passenger health were investigated and a predictive model developed that incorporates passenger profiles and flight characteristics. Standards were drafted for cabin pressure, and practical design guidelines and operational recommendations were provided on aspects such as air temperature and relative humidity.

ISPACE (Innovative systems for personalised aircraft cabin environment, FP7, 2009-2012) developed concepts for enhanced aircraft cabin environment and passenger comfort with regard to temperature, humidity, ventilation, and well-being by controlling the individual's climate. Innovations beyond the state-of-the-art in science and technology were provided in concepts and technologies for individual passenger cabin environment, simulation tools for individualised cabin environment, and recommendations for existing and future commercial aircraft.

SEAT (Smart Technologies for stress free Air Travel, FP6, 2006-2009) developed smart responsive seats and interior environment with the capability to detect physiological changes in passengers in real time. These changes are analysed and appropriate adjustments made, such as temperature control, air ventilation, seat parameters. The approach was developed to create an environment that responds to individual requirements and needs, and that is not centrally controlled or manually adjusted.

VR-HYPERSPACE (Innovative use of virtual and mixed reality to increase human comfort by changing the perception of self and space, FP7, 2011-2014) is investigating the minimum physical space for air passengers, while providing a high level of comfort and satisfaction. A radical approach to aircraft cabin design is being investigated for passenger comfort in a limited space. This state-of-the-art research is combined with neuroscience, psychology of perception, and future visions of virtual and mixed reality technologies.

5. Sub-Theme: Integrated transport services

EU transport policy focuses on making more efficient use of transport infrastructure, increasing the attractiveness of public transport, and integrating transport modes, networks and services. To support this policy, research focuses on developing and implementing flexible, reliable and efficient intermodal concepts, smart information systems for intermodal travel, and platforms to coordinate integrated transport services.

Background

Since demand for passenger transport is expected to increase further in the coming decades, more efficient use of existing capacity is vital in maintaining the performance of passenger transport sector. This requires better connection between transport modes and better use of each mode's comparative advantage. Integrating and combining transport modes based on their comparative advantages enables more efficient use of the transport system as a whole and offers a wider range of alternatives in passenger transport.

The White Paper 2011 (EC, 2011a) promotes multimodal transport, notably on facilitating multimodality in urban areas where transport modes are usually closer to one another, and on the core network of the TEN-T, which connects urban areas in Europe by several modes of transport.

Another policy objective is to raise awareness of intermodal transport services and to reduce barriers to the use of these services. This requires integrated information across transport modes and national borders, and smart ticketing. The information technology to provide these services is being developed in research supported with EU funding.

Research

Research on integrated passenger transport is presented in three clusters as follows:

- **Intermodality concepts** combine the strengths of different transport modes to increase flexibility and efficiency without compromising reliability and comfort. Research focuses on aspects such as barriers to interconnectivity of transport networks, integrated transport planning, physical integration of infrastructure and services.
- **Integrated passenger information** focuses on smart solutions to meet information needs of passengers before and during multimodal journeys, such as schedules, trip planning, and ticketing across transport modes.
- **Platforms for intermodal coordination** support coordination of transport operators and terminal managers in providing integrated transport services. Research covers information platforms, interoperability of information and ticketing systems, and standards for physical interoperability.

Intermodality concepts

HERMES (High Efficient and Reliable arrangeMEnts for CroSsmodal Transport, FP7, 2010-2011) enhanced cross-modal arrangements in passenger transport, and developed prototypes of new business models for interconnectivity. The interconnectivity analysis covered physical, institutional, contractual, economic, and informational aspects.

INTERCONNECT (INTERCONNECTION between short and long-distance transport networks, FP7, 2009-2011) examined local, regional and intermodal transport interconnections. The extent, impact, and causes of poor interconnectivity were identified. Good practices and potential solutions were highlighted to increase economic efficiency, and to reduce the environmental impact of longer distance and inter-regional passenger journeys in Europe.

ORIGAMI (Optimal Regulation and Infrastructure for Ground, Air and Maritime Interfaces, FP7, 2011-2013) is concerned with improving long-distance, door-to-door passenger transport chains by enhancing co-modality and intermodality.

The potential for greater efficiency and reduced environmental impact of passenger transport is being addressed through stimulation of integration, cooperation and, where appropriate, competition in provision of local connections.

BIKE INTERMODAL (INTERMODAL BIKE: Multimodal integration of cycling mobility through product and process innovations in bicycle design, FP7, 2010-2013) is examining synergies with the bicycle and other forms of transport, public and private, as a seamless individual alternative to the car. A new hinged bicycle frame has been developed that combines lightweight, strength and high compactness when folded for carrying on-board public transport.

Integrated passenger information

eMOTION (Europe-wide Multimodal On-trip Traffic Information, FP6, 2006-2008) defined ICT infrastructure for pan-European travel and traffic information Services that are standard-based, interoperable and multimodal. This framework enables step-by-step integration of information services, such as real-time information for road traffic and public transport, and dynamic and multimodal routing services.

ENHANCED WISETRIP (Enhancing Intermodality of Content, Personalised Information and Functionality of WISETRIP Network of Journey Planning Engines, FP7, 2011-2014) is building on the knowledge developed in the previous WISETRIP project on planning, booking and travelling multimodal journeys. Criteria considered include environmental impact, elderly and disabled preferences, as well as factors such as time and cost.

IM@GINE IT (Intelligent Mobility Agents, Advanced Positioning and Mapping Technologies, Integrated Interoperable multimodal location based services, FP6, 2004-2006) created a platform to provide an access point for travel-related user services. The platform supports travel by car, inter-urban and urban transport modes, ship, airline and airport facilities. The platform enables users to obtain location-based, intermodal transport information, mapping and routing as well as navigation services.

I-TOUR project (intelligent Transport system for Optimized URban trips, FP7, 2010-2013) is developing an open framework for intelligent multimodal mobility services. The client application will promote sustainable travel choices and suggest, in a user-friendly way, the use of different forms of transport. Recommendations will be based on information provided by users and will take account of user preferences and real-time information on road conditions, weather and public transport networks.

ITRAVEL (Service Platform for the Connected Traveller, FP7, 2008-2009) developed a travel assistant that uses time and context-specific information, such as location, proximity to transport services, journey purpose, time of day or calendar entries to plan a journey and co-pilots the traveller along the itinerary. The service helps the traveller to link journey stages made with different modes and alerts him/ her to problems and choices to be made.

VIAJEO (International Demonstrations of Platform for Transport Planning and Travel Information, FP7, 2009-2012) designed and validated an open platform to facilitate cross-modal journey planning by promoting information exchange between transport operators. The platform was demonstrated in the cities of Athens, São Paulo, Beijing, and Shanghai. It enables harmonisation of individual operation strategies and optimised transport modelling, and long-term policy evaluation.

WISETRIP (Wide Scale Network of E-systems for Multimodal Journey Planning and Delivery of Trip Intelligent Personalised Data, FP7, 2008-2010) developed an innovative mobility service platform that provides and personalises multimodal travel information sourced from connected journey planners. Information on urban and long distance transport is incorporated and is accessible to travellers through mobile and fixed devices before and during a journey.

Platforms for intermodal coordination

CLOSER (Connecting LOng and Short distance networks for Efficient tRansport, FP7, 2010-2012) provided an overview of ways to support knowledge sharing about the interface between long- and short-distance transport networks. A method for systematic knowledge sharing was developed that incorporates new mobility patterns and organisational schemes, and the views of all stakeholders involved.

2DECIDE (Toolkit for sustainable decision making in ITS deployment, FP7, 2009-2011) provided an up-to-date toolkit for decision making in Intelligent Transport System applications. The Toolkit assists transport authorities to address problems, such as congestion, accidents and environmental pollution. Furthermore, it contributes to promoting intermodality by improving user services and access to information.

DELTA (Concerted coordination for the promotion of efficient multimodal interfaces, FP7, 2009-2010) initiated dialogue among projects, research stakeholders, experts, and political representatives in regions with steep seasonal demand. A decision support instrument was developed for management of seasonal traffic in regions where this is a problem. It addresses reducing unnecessary passenger trips, efficient multimodal interfaces, and synergies between the local transport means.

KITE (Knowledge Base for Intermodal Passenger Travel in Europe, FP7, 2007-2009) created a knowledge base on intermodal travel in Europe. The knowledge base includes data on user abilities, attitudes and requirements, and best options in intermodality as well as recommendations for standards on intermodal services, ticketing and interfaces. It also enables stakeholders to develop and evaluate intermodality related measures.

LINK (European Forum on Intermodal Passenger Travel, FP6, 2007-2010) created a European Forum on Intermodal Passenger Travel focusing on long-distance and cross-border journeys. The platform exchanges and transfers knowledge and promotes intermodal solutions to the many stakeholders, and serves as a communication node between authorities, associations, operators and user groups.

IC-IC project (Enhancing interconnectivity through infoconnectivity, FP7, 2011-2014) is developing an Info Connectivity System to facilitate mode transfer and to improve travelling experience. The system will provide information on transport providers and facilities, and services at each immediate destination. Airports in Amsterdam, Frankfurt, Paris and Vienna as well as ground transport and airlines are involved, and representing short- and long-distance transport.

6. Sub-Theme: Environmentally sustainable mobility behaviour

A key objective of EU transport policy is improving the sustainability of passenger transport. The research presented in this publication focuses on stimulating passengers to be more environmentally friendly in their transport choices. This includes research to develop incentive systems using targeted passenger information to enable passengers to consider environmental impact in their travel decisions.

Background

The European growth strategy EUROPE 2020 and corresponding flagship initiative for a resource-efficient Europe have set the target of decarbonising energy system by 2050 (EC, 2010). The White Paper (EC 2011a) presents a vision for a low-carbon, resource efficient transport system by 2050 which is expressed in following targets:

- phase out conventionally fuelled cars from cities by 2050;
- shift 50% of medium-distance passenger transport to more sustainable modes by 2050;
- achieve a 60% reduction in CO₂ emissions and comparable reduction in oil dependency.

In reaching these targets, technological developments contribute considerably, but can only bring about effective improvements if transport users are aware of and committed to using more sustainable transport services. The White Paper 2011 (EC, 2011a) sets out four initiatives to promote more sustainable mobility behaviour of passengers:

- **Travel information** to promote awareness on more deliberate car use and alternatives to car use (drive less, walk and cycle more, car sharing, park and ride, intelligent ticketing);
- **Vehicle labelling for CO₂ emissions and fuel efficiency** to promote sustainability considerations in decisions on purchasing vehicles;

- **Carbon footprint calculators** to facilitate consideration of environmental impacts in travel choices;
- **Eco-driving and speed limits** directed to train drivers in fuel-saving techniques and to promote driving at energy-efficient cruising speeds.

Research

Research on environmental sustainability in passenger transport ranges from vehicle and fuel technology to efficient transport management, integrated transport planning, and transport concepts of the future. In many cases, research and innovation is not limited to passenger transport, but has implications for freight transport. The research presented in this publication focuses on the contribution of passengers to making the transport system more environmentally sustainable. A key topic is to create passenger awareness of the implications of their mobility behaviour.

An overview of research on sustainability and energy efficiency is presented in the TRS on climate policy and energy efficiency. The following project summaries provide an overview of research to support environmentally sustainable mobility behaviour.

CATCH (Carbon aware travel choices in the climate-friendly world of tomorrow, FP7, 2009-2012) developed and disseminated a knowledge platform to increase awareness of the environmental impacts of mobility. The platform also provided potential solutions to impact management and to stimulate climate-friendly decision-making by citizens. User understanding and user-based design were created involving 40 cities and global carbon constraint professionals in mobility and related fields.

COMPASS (Optimised CO-Modal PASSenger Transport for Reducing Carbon Emissions, FP7, 2011-2013) is identifying key trends in mobility patterns in the 21st century, and is analysing how the demands identified can be met in future. This includes integration of multimodal and co-modal transport solutions, and an assessment of how these solutions can contribute to decarbonising transport.

DEMOCRITOS (DEveloping the MObility CRedits Integrated platform enabling travellers to improve urban TranspOrt Sustainability, FP7, 2009-2011)

introduced the 'Mobility Credits Model' as a transport-specific platform to increase understanding of the implications of climate policy. The rationale of this model is based on setting as quantitative target the 'sustainable load of greenhouse gases' in a study area. The greenhouse gas load is converted to a 'total amount of mobility credits' distributed over all travellers in the area.

GREENTRANSPORT (Enhancing public awareness on the results of European research actions on Climate Friendly Transport Systems through the professional use of television media, FP7, 2009-2010)

used television media to raise public awareness of the results of research on climate friendly transport systems. A series of high quality, free of rights, video news releases were produced and included in the broadcasting mainstream of European television stations.

MOVE TOGETHER (Raising Citizens Awareness and Appreciation of EU Research on Sustainable Transport in the Urban Environment, FP7, 2008-2009)

focused on raising citizen awareness and appreciation of EU research on sustainable transport in the urban environment. Under the key message 'we do not move alone, we always move around the city together with many other people', greater use of public transport alternatives was promoted, including mass public transport, flexible on demand services, and car-pooling.

OPTIMISM (Optimising Passenger Transport Information to Materialise Insights for Sustainable Mobility, FP7, 2011-2013)

proposes strategies, recommendations, and policy measures for the integration and optimisation of transport systems. These are based on scientific analysis of social behaviour, mobility patterns, and business models as well as on an impact assessment of co-modality and ICT solutions for transport.

USEMOBILITY (Understanding Social behaviour for Eco-friendly multimodal mobility, FP7, 2011-2013)

is applying a novel approach to identify the reasons for behavioural change in citizen mobility in Europe. The findings are used to produce scenarios for future eco-friendly multimodal mobility, including demographic, economic, and social trends, and the needs of different social groups.

7. Future Challenges for Research and Policy

By external expert Professor John Preston

The future policy challenges for the European passenger transport are framed by the targets presented in the White Paper on Transport (EC, 2011a). The targets are to reduce greenhouse gas emissions by 60% between 1990 and 2050, and by 20% between 2008 and 2020. Mid-term reviews (such as that in 2006) have illustrated that the transport sector is struggling to deliver on its environmental targets with cars maintaining a stubbornly high share of the EU passenger market at around 76%. More research is needed in four key areas: the volume of travel, carbon emissions from travel, choice of travel mode, and integrated transport.

Volume of travel

The forecasts of continued growth in the passenger travel need to be re-assessed. The concept of peak travel is gaining traction with evidence in a number of countries suggesting that rates of growth are declining or, in some cases, being reversed. This may reflect for some Member States saturated car ownership, congestion, and substitution of transport by information technology. Changing demographics, including an ageing population, may also be contributing, whilst the evidence is confounded by the current economic downturn and rising fuel prices. Nonetheless, it would seem unwise to base future forecasts on extrapolation of past trends. Research is needed on a European scale to determine the extent to which car ownership is reaching saturation, supply-side constraints are limiting demand, and information technology is suppressing travel.

Moreover, policy goals based on mobility need to be re-assessed in the information age. Policy objectives based on fossil-fuelled mobility will not meet carbon reduction targets. Instead of a focus on the ease of movement, emphasis needs to be placed on the ease of reaching activities, either physically or virtually. In other words, policy needs to be phrased in terms of accessibility not mobility. It is possible that in congested conditions, policies that promote mobility reduce accessibility. This interrelationship between accessibility and mobility is worthy of further investigation on a European scale.

Carbon emissions

Existing transport technology needs to be re-assessed. Further environmental improvements can be made to petrol and diesel engine technology, although diminishing return might be expected. Biofuels, especially those from microbes and waste, may contribute but it is likely to be at the margins. Electric vehicles depend on improvements in the energy density of batteries and on decarbonising electricity supply. If the costs of fuel cells (and their catalysts) can be reduced, hydrogen has potential as an energy carrier, particularly from intermittent renewable sources.

However, it seems unlikely that technology alone will enable carbon reductions targets to be met (although more research is needed to confirm this). Improved environmental technologies will need to be promoted across all modes. Some sectors that should have an environmental advantage (such as rail) have not to date maximised this advantage, and continued R&D could be beneficial. Moreover, as conventional transport fuels become scarce, they are likely to be prioritised for specific sectors, such as aviation for passengers, and road- and water-based modes for freight.

Technological improvements should not be limited to vehicles but should also contribute to reducing the carbon footprint of infrastructure, which can be substantial but has been relatively neglected to date. Although the recent focus on mitigation measures is understandable, there is now a realisation that some climate change will happen whatever mitigation measures are put in place and that adaptation, particularly of infrastructure, is going to be required. European-wide assessments of the vulnerability of passenger transport to climate change will be required, along with measures to increase resilience and adaptability.

Choice of travel

A shift to more environmentally friendly modes should be promoted and better understanding of mode choice (including the social, psychological and cultural, as well as the economic) obtained.

Electrification of rail-based technologies (both heavy and light) can provide quick environmental gains.

However, for local journeys, bus travel is likely to be the main form of public transport and roll out of the European Bus System of the Future should be a key policy priority. Research into the next generation of trolley buses should also be considered. In addition, walking and cycling are likely to play a greater role in the future, reversing a long-term decline in many Member States. This will need to be associated with land-use planning to encourage shorter trips and the design of the built environment to promote active travel. New technologies, such as personal and group rapid transit, may play a role but probably at the margins.

Integrated transport

The concept of integrated transport needs to be pursued with greater vigour and is so doing, the related concepts of the ladder of integration might be helpful. Research and practice to date have focused on integration of information and on physical connections, which are the lowest rungs on the integration ladder. Smartcards have the potential to revolutionise aspects of passenger travel.

If the transport sector's targets for reduction in greenhouse gas emissions are to be met, then behavioural change will be required. Higher rungs of the integration ladder concern the integration of policy and governance and it here that the greatest challenges exist for introducing policies that promote behavioural change. The recent emphasis has been on how improved information and marketing of smarter choices may 'nudge' people towards more sustainable behaviour. Research in this area should continue, including consideration of change that can be enhanced by social media. However, this suggests a focus on the lower rungs of the intervention ladder. The higher rungs involving regulation and pricing should also be considered but such interventions are a challenge given the fractured governance of passenger transport.

Although issues related to carbon and environmental performance should be the main research and policy priorities for passenger transport, congestion should not be neglected.

This includes the contribution of passenger travel to congestion, and the impact of congestion on passenger travel given the relatively high (compared to freight) values of time.

Scope for limiting congestion, particularly through improved forms of traffic management and control, and more efficient use of existing infrastructure (rather than the provision of extra capacity), should continue to be key research areas.

Improved vehicle-to-vehicle and vehicle-to-infrastructure communications are likely to be particularly important.

In the above, areas for continued or increased research have been suggested. There are areas where research is more contentious. For example, making public transport more resilient to security threats and more accessible to persons with restricted mobility may have unintended consequences if similar requirements are not made of private transport. If such measures make public transport more expensive than private transport, they are likely to be counter-productive. The focus instead might be in making private transport achieve the safety performance of public transport. Similarly, research into improving the comfort and convenience of less environmentally friendly modes (such as automotive and aerospace) might be counter-productive and intervention at a European level, at least on social grounds, is more difficult to justify.

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Glossary

EC	European Commission
ERA	European Research Area
EU	European Union
FOT	Field Operational Test
GPS	Global Positioning System
ICT	Information and Communication Technology
ITS	Intelligent Transport System
LED	Light-emitting diode
PTW	Powered Two Wheeler
R&D	Research and Development
Ro-Ro	Roll on-Roll off
TEN-T	Trans-European Transport Network
TRIP	Transport Research & Innovation Portal
TRS	Thematic Research Summary

ANNEX: Projects by Sub-Theme

Sub-Theme: Safe and convenient individual transport				
Acronym	Title	Funding Programme	Project Website	Duration
2-BE-SAFE	2-wheeler behaviour and safety	FP7	http://www.2besafe.eu	2009 - 2011
AIDE	Adaptive Integrated Driver-vehicle Interface	FP6	http://www.aide-eu.org	2004 - 2008
DRUID	Driving under the Influence of Drugs, Alcohol and Medicine	FP6	http://www.druid-project.eu	2006 - 2011
euroFOT	European Large-Scale Field Operational Test on Active Safety Systems	FP7	http://www.eurofot-ip.eu	2008 - 2011
EVADER	Electric Vehicle Alert for Detection and Emergency Response	FP7	n/a	2011 - 2014
HIGHWAY	Breakthrough intelligent maps and geographic tools for the context-aware delivery of e-safety and added	FP6	n/a	2004 - 2006
HUMANIST	Human Centered Design for Information Societies Technologies	FP6	http://www.noehumanist.org	2004 - 2008
I-WAY	Intelligent cooperative system in cars for road safety	FP6	http://www.iway-project.eu	2006 - 2009

INROADS	INtelligent Renewable Optical ADvisory System	FP7	n/a	2011 - 2014
INTERACTION	Differences and similarities in driver INTERACTION with in-vehicle technologies	FP7	http://interaction-fp7.eu/index.php	2008 - 2012
ISI-PADAS	Integrated Human Modelling and Simulation to Support Human Error Risk Analysis of Partially Autonomo	FP7	http://www.isi-padas.eu	2008 - 2011
ITERATE	IT for Error Remediation and Trapping Emergencies	FP7	http://www.iterate-project.eu	2009 - 2011
PISa	Powered Two-wheeler Integrated Safety	FP6	http://www.pisa-project.eu	2006 - 2009
REPOSIT	Relative Positioning for Collision Avoidance Systems	FP6	http://www.ist-reposit.org	2006 - 2007
SAFER BRAIN	Innovative guidelines and tools for vulnerable road users safety in India and Brazil	FP7	http://www.saferbrain.eu	2009 - 2012
SAFETRIP	Satellite application for emergency handling, traffic alerts, road safety and incident prevention	FP7	http://www.safetrip.eu	2009 - 2013
SIM	Safety In Motion	FP6	n/a	2006 - 2009
SMART RRS	Innovative concepts for smart road restraint systems to provide greater safety for vulnerable road users	FP7	http://smartrrs.unizar.es	2008 - 2012

Sub-Theme: High quality public transport				
Acronym	Title	Funding Programme	Project Website	Duration
2050AP	2050+ Airport	FP7	http://www.2050airport.ineco.eu/2050airport/html/main.jsp	2011-2014
ACCESS 2 ALL	Mobility schemes ensuring accessibility of public transport for all users	FP7	http://www.access-to-all.eu	2008-2010
AIRCRAFTFIRE	Fire risks assessment and increase of passenger survivability	FP7	http://cms.aircraftfire.eu/front_content.php	2011-2013
ASPIS	Autonomous Surveillance in Public transport Infrastructure Systems	FP7	http://www.aspis-project.eu	2008-2011
BEMOSA	Behavioural modelling for security in airports	FP7	http://www.bemosa.eu	2009-2012
CREDO	Cabin noise Reduction by Experimental and Numerical Design Optimisation	FP6	http://www.dlr.de/as/en/desktopdefault.aspx/tabid-183/251_read-13883/	2006-2009
EBSF	European Bus System of the Future	FP7	http://www.ebsf.eu	2008-2012
E-CAB	E-enabled Cabin and Associated Logistics for Improved Passenger Services and Operational Efficiency	FP6	http://ec.europa.eu/research/transport/projects/items/e_cab_en.htm	2006-2009
ENFICA-FC	Environmentally Friendly Inter City Aircraft powered by Fuel Cells	FP6	http://www.enfica-fc.polito.it	2006-2009

FAST20XX	Future high-altitude high-speed transport 20XX	FP7	http://www.esa.int/Our_Activities/Space_Engineering/FAST20XX_Future_High-Altitude_HighSpeed_Transport_20XX	2009-2012
FRIENDCOPTER	Integration of Technologies in Support of a Passenger and Environmentally Friendly Helicopter	FP6	http://www.friendcopter.org	2004-2008
FUSETRA	Future Seaplane Traffic - Transport Technologies for the Future	FP7	http://www.fusetra.eu	2009-2011
GOAL	Growing Older, staying mobile: The transport needs of an ageing society	FP7	http://www.goal-project.eu	2011-2013
ICE	Ideal Cabin Environment	FP6	http://www.ice-project.eu	2005-2008
ISPACE	Innovative systems for personalised aircraft cabin environment	FP7	http://www.ispace-project.eu	2009-2012
MEDIATE	Methodology for Describing the Accessibility of Transport in Europe	FP7	http://www.sintef.no/Teknologi-og-samfunn/Helse/Global-helse-og-velferd/Velferd-og-levekar/Mediate/	2008-2010
MODERN	Mobility, Development and Energy Use Reduction	FP7	http://www.modern.ipacv.ro	2008-2012
MODURBAN	Modular Urban-guided Rail Systems	FP6	http://www.modurban.org	2005-2008
MYCOPTER	Enabling Technologies for Personal Air Transport Systems	FP7	http://mycopter.eu	2011-2014

PICAV	Personal intelligent city accessible vehicle system	FP7	http://www.dimec.unige.it/pmar/picav/	2009-2012
PPLANE	Personal Plane: Assessment and Validation of Pioneering Concepts for Personal Air Transport Systems	FP7	http://cordis.europa.eu/projects/233805	2009-2012
PROCEED	Principles of successful high quality public transport operation and Development	FP6	http://www.fgm.at/proceed	2006-2010
PUBTRANS4ALL	Public Transportation - Accessibility for All	FP7	http://www.pubtrans4all.eu	2009-2012
RECREATE	Research on a Cruiser Enabled Air Transport Environment	FP7	http://cordis.europa.eu/search/index.cfm?fuseaction=proj.document&PJ_RC_N=12155006	2011-2015
SAFECRAFTS	Safe Abandoning of Passenger Ships - Improvement of Current Lifesaving Appliances Systems	FP6	http://cordis.europa.eu/projects/index.cfm?fuseaction=app.details&REF=74294	2004-2007
SAFEGUARD	Ship evacuation data and scenarios	FP7	http://www.safeguardproject.info	2009-2012
SAFEWAY2SCHOOL	Integrated system for safe transportation of children to school	FP7	http://www.iiid.net/Safeway2School.aspx	2009-2012
SAVE ME	System and Actions for Vehicles and transportation hubs to support Disaster Mitigation and Evacuation	FP7	http://www.save-me.eu	2009-2012
SEAT	Smart Technologies for stress free Air Travel	FP6	http://cordis.europa.eu/projects/rcn/79965_en.html	2006-2009

SPUTNIC	Strategies for Public Transport In Cities	FP6	http://www.sputnicproject.eu	2006-2009
TRACY	Transport needs for an ageing society	FP7	http://www.tracy-project.eu	2011-2013
UNIACCESS	Design of Universal Accessibility Systems for Public Transport	FP6	http://ec.europa.eu/research/transport/projects/items/uniaccess_en.htm	2005-2006
VR-HYPERSPACE	Innovative use of virtual and mixed reality to increase human comfort by changing the perception of self and space	FP7	http://www.vr-hyperspace.eu	2011-2014

Sub-Theme: Integrated transport services				
Acronym	Title	Funding Programme	Project Website	Duration
2DECIDE	Toolkit for sustainable decision making in ITS deployment	FP7	http://www.2decide.eu	2009-2011
BIKE INTERMODAL	THE INTERMODAL BIKE - Multimodal integration of cycling mobility through product and process innovations in bicycle design	FP7	http://www.bike-intermodal.eu	2010-2013
CLOSER	Connecting Long and Short distance networks for Efficient tRansport	FP7	http://www.closer-project.eu	2010-2012
DELTA	Concerted coordination for the promotion of efficient multimodal interfaces	FP7	http://www.delta-project.eu	2009-2010
eMOTION	Europe-wide Multimodal On-trip Traffic Information	FP6	http://www.emotion-project.eu	2006-2008
ENHANCED WISETRIP	Enhancing Intermodality of Content, Personalised Information and Functionality of WISETRIP Network of Journey Planning Engines	FP7	n/a	2011-2014
WISETRIP	Wide Scale Network of E-systems for Multimodal Journey Planning and Delivery of Trip Intelligent Personalised Data	FP7	http://www.wisetrip-eu.org	2008-2010

HERMES	High Efficient and Reliable arrangeMEnts for CroSsmodal Transport	FP7	http://www.hermes-project.net	2010-2011
IC-IC	Enhancing interconnectivity through infoconnectivity	FP7	http://www.ic-ic.eu	2011-2014
IM@GINE IT	Intelligent MobilityAgents, Advanced Positioning and Mapping Technologies, Integrated Interoperable multimodal location based services	FP6	http://www.imagineit-eu.com	2004-2006
INTERCONNECT	INTERCONNECTion between short and long-distance transport networks	FP7	http://www.interconnect-project.eu	2009-2011
I-TOUR	i-TOUR: intelligent Transport system for Optimized URban trips	FP7	http://www.itourproject.com/web/	2010-2013
ITRAVEL	i-Travel - Service Platform for the Connected Traveller	FP7	http://itravelproject.wordpress.com	2008-2009
KITE	A Knowledge Base for Intermodal Passenger Travel in Europe	FP7	http://www.kite-project.eu	2007-2009
LINK	The European Forum on Intermodal Passenger Travel	FP6	n/a	2007-2010
ORIGAMI	Optimal Regulation and Infrastructure for Ground, Air and Maritime Interfaces	FP7	http://www.origami-project.eu	2011-2013
VIAJEO	International Demonstrations of Platform for Transport Planning and Travel Information	FP7	http://viajeo.eu	2009-2012

Sub-Theme: Environmentally sustainable passenger behaviour				
Acronym	Title	Funding Programme	Project Website	Duration
CATCH	Carbon aware travel choices in the climate-friendly world of tomorrow	FP7	http://www.carbonaware.eu	2009-2012
COMPASS	Optimised CO-Modal PASSenger Transport for Reducing Carbon Emissions	FP7	http://www.fp7-compass.eu	2011-2013
DEMOCRITOS	DEveloping the MObility CRedits Integrated platform enabling travellers to improve urban TranspOrt Sustainability	FP7	http://democritos.ipacv.ro	2009-2011
GREEN-TRANSPORT	Enhancing public awareness on the results of European research actions on Climate Friendly Transport Systems through the professional use of television media	FP7	http://www.proprs.com/p_green_tv.html	2009-2010
MOVE TOGETHER	Raising Citizens Awareness and Appreciation of EU Research on Sustainable Transport in the Urban Environment	FP7	http://www.move-together.net	2008-2009
OPTIMISM	Optimising Passenger Transport Information to Materialize Insights for Sustainable Mobility	FP7	http://www.optimismtransport.eu	2011-2013
USEMOBILITY	Understanding Social behaviour for Eco-friendly multimodal mobility	FP7	http://usemobility.eu	2011-2013