Transport Research Knowledge Centre

ENVIRONMENTAL ASPECTS OF SUSTAINABLE MOBILITY

THEMATIC RESEARCH SUMMARY

Directorate-General for Energy and Transport

EUROPEAN COMMISSION

www.transport-research.info

European Commission

DG Energy and Transport

Specific Support Action

Transport Research Knowledge Centre

Thematic Research Summary:

Environmental Aspects of Sustainable Mobility

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Date 15-10-2008

Abbreviations and acronyms used

CBA	Cost-Benefit Analysis
CEC	Commission of the European Communities
CO_2	Carbon Dioxide
DfT	(UK) Department for Transport
DGTREN	Directorate General Transport and Energy
EC	European Commission
EEA	European Environment Agency
EIA	Environmental Impact Assessment
ERA	European Research Area (EU, EFTA and CEECs)
EU	European Union
EXTR@Web	Exploitation of Transport Research Results via the Web (DG TREN FP 5 Accompanying Measure project)
FP5	Fifth Framework Programme
FP6	Sixth Framework Programme
FSEA	Formal Safety and Environmental Assessment
GDP	Gross Domestic Product
GIS	Geographical Information System
ICT	Information and Communication Technologies
ITS	Intelligent Transport Systems
JEGTE	Joint Expert Group on Transport and Environment
KA	Key Action
MCA	Multi-Criteria Analysis
OECD	Organisation for Economic Co-operation and Development
PTA	Priority Thematic Area

RTD	Research and Technological Development
SEA	Strategic Environmental Assessment
TEN	Trans-European transport Networks
TERM	Transport and Environment Reporting Mechanism
TRKC	Transport Research Knowledge Centre; TRKC website available at www.transport-research.info
TRS	Thematic Research Summary

Table of Contents

FOREWORD **7**
EXECUTIVE SUMMARY **8**
1. INTRODUCTION **10**
2. SCOPE OF THE THEME "ENVIRONMENTAL ASPECTS" **13**
3. POLICY CONTEXT **15**
4. RESEARCH FINDINGS **19**
4.1 INTRODUCTION 19
4.2 SUB-THEME 1: ENVIRONMENTAL IMPACT ASSESSMENT 20
4.2.1 BACKGROUND 20
4.2.2 RESEARCH OBJECTIVES 21
4.2.3 RESEARCH RESULTS 22
4.2.4 POLICY IMPLICATIONS 27
4.3 SUB-THEME 2: MITIGATION MEASURES 28
4.3.1 BACKGROUND 28
4.3.2 RESEARCH OBJECTIVES 28
4.3.3 RESEARCH RESULTS 29
4.3.4 POLICY IMPLICATIONS 34
4.4 SUB-THEME 3: DEVELOPMENT OF ENVIRONMENT-FRIENDLY FORMS OF TRANSPORT 35
4.4.1 BACKGROUND 35
4.4.2 RESEARCH OBJECTIVES 36
4.4.3 RESEARCH RESULTS 36
4.4.4 POLICY IMPLICATIONS 38
4.5 IMPLICATIONS FOR FURTHER RESEARCH 38
5. REFERENCES **40**
ANNEX: LIST OF EU-FUNDED PROJECTS WITHIN EACH SUB-THEME **43**

Foreword

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

The aim of TRKC (as with its predecessor project EXTR@Web) is to collect, structure, analyse and disseminate transport research results. It covers EU-supported research as well as research financed nationally in the European Research Area (ERA) and selected global RTD programmes. The main dissemination tool used by TRKC is the web portal at 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 life time of the TRKC project; the product of this analysis activity is the set of **Thematic Research Summaries** (**TRS**); the present document belongs to this set;
- Policy Analysis, which pools findings of research projects according to combinations of themes based on ad-hoc policy priorities which are agreed with DGTREN of the European Commission and a representative group of research users.

This particular Thematic Research Summary deals with the environmental aspects of transport and sustainable mobility. The aim is to provide the reader with a synthesis of results of completed European projects related to the theme of environmental aspects. 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 Thematic Research Summary on the environmental aspects of transport and sustainable mobility aims to provide the reader with a synthesis of results of completed European research projects related to that theme. It consists of two main parts. The first part includes a brief overview of the scope of the theme and summarises the main policy developments at EU level relevant to the theme. The second part contains a synthesis of the main findings and policy implications from research projects and identifies the implications for further research. The research projects for which the synthesis is provided are European (EU-funded and national) projects that are completed and with results publicly available. The EU projects have been funded by the Fourth, Fifth and the Sixth Framework Programmes. Projects that had been reviewed in the related paper produced within the predecessor project EXTR@Web are only briefly summarised in the background section for each sub-theme.

Environmental aspects include all the adverse side effects of transport on the environment, including air and water pollution, noise, vibration, visual impacts, social impacts and waste disposal. The contribution of transport to climate change is also included. Research includes assessment of the severity of these impacts, analysis of mitigation measures and the development of environmentally-friendly technologies and transport concepts.

The environment impact of transport has become fundamental to the development of European transport policy and has been considered in various policy documents such as the White Paper “European transport policy for 2010: time to decide” and the “Mid-term Review of the European Commission’s 2001 White Paper on Transport”. The package of proposals put forward in the White Paper is designed to re-direct the common transport policy towards sustainability. Difficult choices will need to be made between maintaining the status quo and making changes that will result in a sustainable system. Bearing in mind the current insufficient account taken of environmental protection and the need to ensure greater security of supply, environmental considerations need to be integrated into Community policies. Environmental aspects feature prominently in transport fiscal policy in the White Paper, which states that the internalisation of external costs must encourage the use of modes of lesser environmental impact. There is considerable and justifiable emphasis in the White Paper on issues relating to air transport, given the rapid current expansion of this mode. Shifting freight from road to rail is also advocated, and particularly for freight there is also considerable emphasis on the scope for water transport possibilities where current capacity is largely underutilised. Within each mode, the development of alternative fuels and environmentally friendly vehicles as well as infrastructure is advocated. More recently, the general context of EU transport policy established in the

2001 Transport White Paper has changed. To be able to adapt the instruments of the 2001 White Paper to the new context, the European Commission has identified the need for additional policy tools to help ensure that these changes can be achieved.

Three sub-themes are considered in the synthesis of the findings from research projects.

The first sub-theme relates to the assessment of the environmental impacts associated with transport. A wide range of methodologies has been developed and tested for such assessment, often based on Cost-Benefit Analysis (CBA) or Multi-Criteria Analysis (MCA), and many have been implemented as tools available to other analysts and researchers. Such tools are often spreadsheet based and increasingly available online. The costs imposed on society by the environmental impacts are typically shown to be high but vary significantly depending on mode, on circumstance and by location. Global warming is identified as an increasingly severe problem.

The second sub-theme is concerned with reviewing potential strategies for the mitigation and abatement of environmental problems. The key finding from research in this field is that such mitigation requires not only significant research and development of new transport technologies, but also considerable changes in operating practices in the transport industry as well as changes in transport behaviour, both in the shorter term through mode switching and in the longer term, such as through changes in land-use planning.

The final sub-theme reviews research into the development, encouragement and use of more environment-friendly forms of transport. Findings highlight the need for more research into new environment-friendly transport technologies, across all modes. In addition, innovations such as car sharing or car pooling schemes can help to reduce environmental impacts, and there is also considerable scope for greater use of non-motorised modes of transport (walking and cycling), especially in urban areas.

The implications of research findings for policymaking and future research activities have also been considered.

1. Introduction

This paper is the first version of the Thematic Research Summary (TRS) on Environmental Aspects produced within the TRKC project. It provides a structured review of the research relating to environmental aspects of transport and sustainable mobility, carried out in European transport research projects. The theme "environmental aspects" is one of the thirty themes in the classification scheme adopted by the TRKC project. The full scheme is shown in the table below.

Table 1. The classification scheme adopted in TRKC

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

The categories in the classification scheme shown in the above table have been adopted

to enable comprehensive searching for project information available through the TRKC portal, and to ensure comprehensive coverage of research results and appropriate policy analysis in the Thematic Research Summaries (TRSs). Definitions for each category (which is also a theme in its own right) can be found on the TRKC website available at http://www.transport-research.info/web/projects/transport_themes.cfm.

In the predecessor project EXTR@Web, TRSs have been produced for 28 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 first versions of TRSs for a sub-set of themes for which a critical mass of results from projects is available by July 2008. The preparation of final versions of TRSs for the full set of themes is planned by the end of the TRKC project in December 2009.

A high number of research projects have been related to the theme addressed by this paper. The thematic research summary "environmental aspects" produced in the predecessor project EXTR@Web (EXTR@Web, 2006) had reviewed research from European projects belonging to the Fifth Framework Programme (FP5) and national projects. The paper here adds new projects to the analysis that have reported since that paper, including various European projects from FP5 and FP6.

The research reviewed in this paper does not represent the whole gamut of research dealing with environmental aspects carried out in the ERA. 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 (EXTR@Web, 2006). A summary of the research reported on in the EXTR@Web paper is also included to make the reader aware of a wider range of research relevant to the theme.

The paper is organised as follows. Section 2 includes a brief analysis of the scope of the theme. Section 3 provides an overview of the relevant policy developments at EU level, explaining at the same time why the theme is important from a policy viewpoint. The sources for this section are principally European Commission documents which have set the policy agenda such as white papers, green papers and communications. EU legislation – directives, regulations, rulings of the Court of Justice – is mentioned where relevant.

Section 4 reports on the results from research projects. The section is structured according to sub-themes to make the broad area of research which has dealt with environmental aspects more manageable.

The following three sub-themes have been considered:

- Sub-theme 1: Environmental impact assessment;

- Sub-theme 2: Mitigation measures;
- Sub-theme 3: Development of environment-friendly forms of transport.

For each sub-theme research objectives are reported on and findings from research projects are synthesised. A special focus is given to the policy implications of research results. Section 4 concludes with an overview of the research gaps which could be identified from the projects, and hence topics for future research. Sources for Section 4 are documents available from the projects and reporting on achievements, essentially the project final reports and selected deliverables.

The European research projects listed under each of the three sub-themes are shown in the Annex to this paper. Hyperlinks to project websites (if available) are also included. In several cases these websites make the project documentation available to the public. This may include final reports and project deliverables.

2. Scope of the theme "Environmental Aspects"

The **Environmental aspects** of transport are concerned with sustainability. Currently, negative impacts of transport have significant detrimental effects on the environment (both built and natural) and hence individuals' lives, making transport unsustainable in the long term without mitigation measures. Sustainable transport can be defined as a system with associated travel patterns that can meet transport needs efficiently, whilst minimising avoidable or unnecessary adverse impacts and their associated costs over relevant space and time scales.

The environmental aspects of transport sustainability are concerned with local atmospheric pollution, more global impacts such as the contribution of transport to global warming, noise pollution, land take, impacts on flora and fauna, the effects of waste disposal (both scrapped vehicles and production waste) on the natural environment and safety implications. The needs for recycling to mitigate waste disposal impacts, for the development of alternative fuels to reduce reliance on non-renewable resources and to reduce pollution from the burning of fossil fuels, and the effects of all of the above, are all relevant. These environmental aspects of transport affect the lives of individuals through health impacts and nuisance.

The theme typically covers:

- the introduction of new environment-friendly technologies and transport concepts to
  - reduce energy resource use for transport,
  - improve air quality,
  - reduce transport related noise,
  - avoid waste and recycle waste related to transport;
- the acquisition of knowledge, and development of methodologies and tools to support environmental impact assessment;
- the formulation of integrated strategies for impact abatement;
- the development of mitigation measures, such as the control of vehicle emissions.

Environmental aspects include all the adverse side effects of transport on the environment. They include air and water pollution, noise, vibration, visual impacts, social impacts and waste disposal. On a wider scale they also include the contribution of transport to climate

change.

Topics within the theme of environmental aspects encompass three main groups of issues.

The first group is concerned with the assessment of the severity of the impacts of transport on the environment and relates to the development, validation and testing of methodologies and frameworks for such assessment. It is essential that such assessment tools are available to researchers and practitioners for the actual estimation of environmental impacts and the measurement of the effects of mitigation strategies. Another dimension of the efforts to measure the impact of transport on the environment is concerned with the estimation of costs imposed on society by the environmental impacts associated with transport.

The second group of issues relates to the analysis of mitigation measures and includes a wide range of potential strategies for the mitigation and abatement of environmental problems as well as various policy measures available to governments at various levels, such as those concerned with transport regulation, transport pricing and demand management.

The third group is concerned with the development, encouragement and use of more environment-friendly forms of transport. These innovative solutions encompass new more environment-friendly transport technologies (and also innovative transport concepts with potential for lower environmental impacts, such as car sharing or car pooling schemes) as well as non-motorised modes of transport such as walking and cycling.

The above summary of topics describes the principal breakdown of technical, organisational and managerial aspects that come under the theme, whereas Section 4 of this document reflects sub-themes according to actual priorities identified through review of relevant transport research projects.

3. Policy context

The impact of transport on the environment has become fundamental to the development of European transport policy and has been considered in various policy documents such as the White Paper "European transport policy for 2010: time to decide" and the "Mid-term Review of the European Commission's 2001 White Paper on Transport".

The European Transport White Paper, "European Transport Policy for 2010: time to decide" states early on in its policy guidelines that "a modern transport system must be sustainable from an economic and social as well as an environmental viewpoint", thus according equal importance to environmental aspects alongside economic and social aspects. In addition to the overarching role of environmental aspects in the drive for sustainability, they are also important in many of the White Paper's more specific guidelines, one of which is concerned entirely with environmental aspects: "developing medium and long-term environmental objectives for a sustainable transport system" (CEC, 2001). The overall package of proposals put forward in the White Paper is designed to re-direct the common transport policy towards sustainability, but specific attention is drawn to the need to tackle the following:

- "The risk of congestion on the major arteries and regional imbalance;
- the conditions for shifting the balance between modes;
- the priority to be given to clearing bottlenecks;
- the new place given to users, at the heart of transport policy; and
- the need to manage the effects of transport globalisation" (CEC, 2001).

It is noted that hard choices will need to be made between maintaining the status quo and making changes that will result in a sustainable system. In particular, new forms of regulation will be needed to "channel future demand for mobility and to ensure that the whole of Europe's economy develops in a sustainable fashion" (CEC, 2001). However, with regard to existing regulations, it is noted that international agreements are often focused on facilitating trade and commerce, rather than environmental protection. Thus, insufficient account is currently taken of environmental protection, and the associated security of supply concerns (CEC, 2001).

With this in mind, environmental considerations need to be integrated into Community policies (CEC, 2001). In 1999, the Transport Council highlighted five areas in which measures should be pursued: "(i) growth in CO_2 emissions from transport, (ii) pollutant emissions and their effects on health, (iii) anticipated growth in transport, in particular due to enlargement, (iv) modal distribution and its development, and (v) noise in transport" (CEC, 2001). There appears to be a bias here in favour of environmental aspects

concerned with atmospheric and noise pollution. Whilst growth in transport and trends in modal split both lead to social effects arising from environmental impacts, these social aspects are not specifically referenced, thus potentially leaving readers with the view that growth and modal split are purely an issue in the pollution context.

Environmental aspects are also given prominence in transport fiscal policy in the White Paper; “budget and fiscal policy [should] achieve full internalisation of external – in particular environmental – costs” (CEC, 2001). With regard to the Trans-European Network, the White Paper also states that “the Community rules will be amended to open up the possibility of allocating part of the revenue from user charges to construction of the most environmentally-friendly infrastructure” (CEC, 2001). The White Paper goes on to state that “the integration of external costs must also encourage the use of modes of lesser environmental impact” (CEC, 2001).

Specific modes are also focused on in terms of environmental policy. Modal shift away from over-dependence on motorised road transport, and revitalisation of the railways are both highlighted, as is achieving a balance between growth in air transport and the environment (CEC, 2001). With regard to air, the emphasis is on reducing the environmental impacts of engine noise, and emissions, including fuel consumption improvements. This is most likely to be achieved through the adoption of stricter standards (CEC, 2001). However, the need to restrain air traffic growth through competition regulation is also acknowledged; “the growth in road and air traffic must … be brought under control, and rail and other environmentally friendly modes given the means to become competitive alternatives” (CEC, 2001). However, the White Paper is merely advocating controlled growth, rather than advising against growth in air traffic per se. Indeed, the White Paper states clearly that “Europe will not be able to cope without new airport infrastructure” (CEC, 2001). Nevertheless, new regulatory frameworks focused on the way in which slots are allocated will be needed to make more efficient use of airport capacity, including measures to avoid the development of hub airports, and the ground and sky congestion that is associated with such airports (CEC, 2001). Further, airport charges should change to avoid bunching of flights, and intermodality with rail should be encouraged to facilitate the development of high-speed rail links between cities, focusing air links on routes where rail is not feasible. Yet at the same time, environmental rules should “encourage efforts to find alternative measures before restricting operators at an airport” (CEC, 2001). The issues surrounding the taxation on aviation kerosene also need to be addressed.

As reflected here, there is considerable emphasis on air transport in the White Paper, and rightly so, given the rapid expansion air is currently experiencing. However, there is also considerable emphasis on water transport possibilities, especially with regard to freight, since the current capacity is underutilised. Shifting freight from road to rail is also

advocated. Further, the development of alternative fuels, environmentally friendly infrastructure and vehicles is advocated.

The development of the policy summarised here, and set out in considerably more detail in the White Paper, goes back to the European Council Cardiff Summit in 1998. The Council stipulated that the Commission and transport ministers should focus their efforts on developing integrated transport and environment strategies (CEC, 2002). A strategy towards this end was adopted by the Transport Council in 1999, and the report, "Recommendations for actions towards sustainable transport: A strategy review", was released by the JEGTE (established in 1998) in 2000. At the April 2001 meeting of the Transport Council, a resolution was passed to agree pursuit of: integration by the Commission, the development of long-term and intermediate environmental targets for transport, and further development of TERM, the transport and environment reporting mechanism. Within all of this, consideration of the impacts of *e*-commerce, as stipulated under the *e*Europe 2002 Action Plan (adopted by the Heads of state and Government at the Feira European Council in June 2000), was requested.

More recently, the general context of EU transport policy established in the 2001 Transport White Paper has changed to include issues such as:

- The accession of new member states;
- consolidation of the transport industry at European level;
- technological innovations in transport which have brought along economic, environmental and social benefits;
- international environmental commitments under the Kyoto protocol which must be integrated into transport policy;
- security of supply and sustainability of energy resources;
- changes in the international context such as the sustained threat from terrorism, economic globalisation, the extension of the internal transport market to accession and candidate countries; and
- the evolving nature of European governance and the need to assist the implementation of the acquis (CEC, 2006).

The objectives, however, of EU transport policy set up by the 1992 and 2001 White Papers remain valid. The mid-term review of the European Commission's 2001 Transport White Paper restates these objectives which aim to provide the European citizens with "efficient and effective transportation systems that:

- Offer a high level of **mobility** to people and businesses throughout the Union;
- **protect** the environment, ensure energy security, promote minimum labour standards for the sector and protect the passenger and the citizen;
- **innovate** in support of the first two aims of mobility and protection by increasing the efficiency and sustainability of the growing transport sector; and

- **connect** internationally, projecting the Union's policies to reinforce sustainable mobility, protection and innovation, by participating in the international organisations." (CEC, 2006)

To be able to adapt the instruments of the 2001 White Paper to the new context, the European Commission has identified the need for additional policy tools. CEC (2006) concludes that "A European sustainable mobility policy therefore needs to build on a broader range of policy tools achieving shifts to more environmentally friendly modes where appropriate, especially long distance, in urban areas and on congested corridors. At the same time each transport mode must be optimised. All modes must become more environmentally friendly, safe and energy efficient. Finally, co-modality, i.e. the efficient use of different modes on their own and in combination, will result in an optimal and sustainable utilisation of resources. This approach offers the best guarantees to achieve at the same time a high level of both mobility and environmental protection."

Since the publication of the 2001 White Paper, the European Environment Agency (EEA) has been closely following the trends in the development of the transport sector in Europe and has been regularly reporting on its impact on the environment (EEA, 2004a; EEA, 2004b; EEA, 2006; EEA, 2007; EEA, 2008). The EEA's summary of progress towards environmental transport objectives over the past decade suggests that transport policy with regard to environmental aspects is not likely to change significantly in the near future. In the slightly more medium term, it could be that policy shifts to favour environmentally friendly modes even more, and introduce harsher penalties for those who continue to drive and fly. Increasing attention will continue to be paid to the sector's contribution to climate change.

4. Research findings

4.1 Introduction

The research which is synthesised in this paper is reported according to three sub-themes.

The first sub-theme relates to the assessment of the environmental impacts associated with transport. Included in this sub-theme is research into the development, validation and testing of methodologies and frameworks for such assessment, as well as research that has led to the development of assessment tools available to other researchers and practitioners for the actual estimation of environmental impacts and the measurement of the effects of mitigation strategies. Finally, research evidence on the costs imposed on society by the environmental impacts associated with transport is presented.

The second sub-theme is concerned with reviewing potential strategies for the mitigation and abatement of environmental problems. Within this sub-theme the various policy measures available to governments at various levels, such as those concerned with transport regulation, transport pricing and demand management are also considered.

The final sub-theme reviews research into the development, encouragement and use of more environment-friendly forms of transport. There are two main strands to this research. The first is research into new more environment-friendly transport technologies (and also innovative transport concepts with potential for lower environmental impacts, such as car sharing or car pooling schemes). The second relates to non-motorised modes of transport -walking and cycling.

Sub-theme 1	**Sub-theme 2**	**Sub-theme 3**
Environmental impact assessment	Mitigation measures	Development of environment-friendly forms of transport

Table 2. EU-funded projects relevant to the theme

Sub-theme	Contributing projects
Environmental impact assessment	Projects covered in this paper: COMMUTE; ECO; SEAM; NPF-URBAN TRANSPORT; Projects covered in the EXTR@Web paper: AEROCERT; PROPOLIS; EMARC; H-SENSE; MEET; POLMIT
Mitigation measures	Projects covered in this paper: CANTIQUE; ECO; ICARO; TOSCA; NAUPLIOS; FURORE; SCATTER; TRANSPLUS; HYNET; TRENDSETTER; PREMIA; STEPS; SPREEX; Projects covered in the EXTR@Web paper: SPRITE
Development of environment-friendly forms of transport	Projects covered in this paper: ADONIS; TOSCA; FURORE; TRENDSETTER; Projects covered in the EXTR@Web paper: COMPOSIT; ECTOS; UTOPIA;

The research projects listed under each of the three sub-themes are shown in the Annex to this paper. Hyperlinks to project websites (if available) are also included.

4.2 Sub-theme 1: Environmental Impact Assessment

4.2.1 Background

Research reported in the Thematic Research Summary on Environmental Aspects produced in EXTR@Web (the predecessor of the TRKC project) has been concerned with the acquisition of knowledge and development of methodologies and tools to support environmental impact assessment.

Research reported in that TRS has developed a set of decision-making tools that can support the achievement of sustainability by allowing the analysis of different potential scenarios.

A number of EU-funded projects have developed tools and methodologies for evaluating and measuring the impact of transport on the environment across a variety of modes. For example, in the air transport domain, a Europe wise methodology for calculating traffic emissions and energy consumption, and hence evaluating the impact of transport on air pollution, has been developed. In the context of waterborne transport, the effects of the MARPOL (the International Convention for the Prevention of Pollution from Ships) regulations on port environments have been assessed and systems for the management of ship waste have been investigated. A harbour sediment database which will allow modelling and statistical evaluations relating to sediment settlement, dredging, traffic management and release of pollutants has also been developed. Research has also developed and improved methodologies and techniques for measurement of railway exterior noise for the purpose of type testing, monitoring and diagnostics.

Some work was motivated by the health impacts of Particulate Matters (PMs) and the need to develop effective reduction scenarios. The key results demonstrated that urban and sub-urban models were successful and differentiation between the contribution of light and heavy vehicles was possible.

4.2.2 Research objectives

The development of strategies to reduce the environmental impacts of transport requires an understanding of the costs associated with such impacts, not only in an absolute sense but also in a relative sense so that priorities can be drawn up. Ideally, monetarised valuations of impacts are required so that policies can be subjected to cost/benefit analysis. Hence the objectives of research include not only the evaluation of external costs, but also the development of assessment techniques and methodologies and the creation of evaluation tools. As the latter two of these are essential for achieving the first of these three objectives, it is unsurprising that many projects address all three of them during the course of their research (COMMUTE, 2000). Other approaches which focus primarily on the valuation of external effects rely largely on the existence of methodologies (FAIR AND EFFICIENT PRICES FOR TRANSPORTATION; Kenny, 2000). In fields where methods are not available or are felt be inadequate, emphasis is on the design and testing of new methodologies and toolkits (EVALUATION OF OPTIONS FOR REDUCING IRISH DIESEL PARTICULATE EMISSIONS). In many European countries, there is an important regional dimension to consider and hence evaluation methods have been devised which take regional differences in environmental impact into account (D4 NRP41 EXTERNAL COSTS AND INTERNALISATION – REGIONAL IMPACTS; INTEGRATED TRAFFIC,

REGIONAL ECONOMIC AND IMPACT MODELS). In addition, advantage has been taken of the huge strides in ICT in recent years to develop toolkits which make effective use of systems such as GIS, internet and advanced messaging (ECO, 1999; CLEANER DRIVE; Labrosse, 2004).

4.2.3 Research results

Assessment techniques

Rigorous research into the environmental impacts of transport is not possible without suitable techniques for the assessment of such impacts, and therefore considerable research effort has been put into the development and enhancement of such techniques at both national and supranational levels. For example in EU funded research a methodology has been produced and tested for the strategic environmental assessment (SEA) of transport policies, plans and programmes. This methodology comprises a framework covering the basic methodological requirements for SEA of multi-modal transport developments, together with guidelines on how to integrate various analytical approaches such as cost-benefit analysis (CBA) and multi-criteria analysis (MCA) and detailed methods for assessing major types of environmental impact (emissions, energy, noise, safety) for road, rail, air and waterborne transport. Outline methods for assessment of other categories of impact, such as land use and ecological damage have also been provided (COMMUTE, 2000).

Also at the EU level, there has been research into methodology for the assessment of various environmental impacts of maritime transport, most particularly on the hazards and risks associated with the use of antifouling paints, the discharge of ballast water and emissions from ship exhaust (due to part to the use of poor quality fuels). A Formal Safety and Environmental Assessment (FSEA) methodology has been proposed as a structured approach to these issues and use has also been made of Environmental Impact Assessment (EIA) to assist in scientific and technical evaluation in this field (Labrosse, 2004).

At the national level, Switzerland has undertaken wide-ranging research into the assessment and monetarisation of the environmental impacts of transport under the umbrella of a research programme investigating fair and efficient prices for transportation, which demands that the costs of environmental damage can be ascertained. Assessment of air pollution costs (specifically the health costs caused by traffic-related air pollution in Switzerland) has entailed use of pollution exposure models. In another project, attempts were made to monetarise the external costs of noise pollution due to road and rail traffic in Switzerland in the year 2000, though this assessment was limited to two main areas - residential impacts (through calculation of the number of homes affected by road and rail

transport noise and the reduction in rent payments for homes exposed to noise) and human health impacts (through the effects of noise on physical and mental health disorders and the costs associated death and illness as a result of these effects). In a further project, estimates were made of the costs associated with building damage due to road and rail transport in Switzerland, again for the year 2000. Methodology in this case involved estimating the costs of repairing and cleaning building facades exposed to high levels of traffic, base on expert opinion and a commercial database of buildings. Yet another Swiss project has estimated the external costs of transport on the landscape and natural environment, focusing most particularly on habitat loss and reduced quality of natural habitats. Habitat loss is monetarised by estimating the costs of repairing habitat damage. Fragmentation of natural habitats has been estimated through the use of aerial photography, and the costs associated with such fragmentation estimated with reference to the costs of re-linking the separated sections. It proved impossible to monetarise the costs associated with reduced quality of habitat (FAIR AND EFFICIENT PRICES FOR TRANSPORTATION).

A common method of measuring noise impacts uses the A-weighted decibel measure: dB(A). The L10 dB(A) measure calculates the noise level exceeded for 10% of the time. An example of such research into noise monitoring is the study into the impact of the Nenagh by-pass in Ireland, on noise reduction in the town. In this project, noise measurements were taken at five locations in the town in June 2000 (prior to the bypass opening) and October 2000 (after the opening), and the data used to calculate L10 (18 hour) dB(A) values (the mean of the hourly L10 levels in the period 06:00 hours to midnight) (Kenny, 2000).

Many transport environmental impacts are at local or regional rather than national level, and research has been undertaken to determine the regional dimension. Research in Denmark, for example, has led to the development of methodologies for the assessment of the environmental and economic impacts of transport system changes and changes in the regulation of the transport system, which are likely to be implemented at a regional level. The approach taken in this work has been to conduct a case study centred on a (hypothetical) road pricing system in Denmark. A key aspect of this work is that the evaluation of user benefits from transport activities has been extended to include option values and existence values (INTEGRATED TRAFFIC, REGIONAL ECONOMIC AND IMPACT MODELS).

Many parts of Europe are heavily dependent on the diesel engine. Ireland is one such country and the Irish government has sponsored research into options for reducing diesel particulate emissions. A new system for measuring diesel particulates has been developed and tested, and the results have been compared with those from more established measurement techniques. Further work has included the design and construction of a

diesel engine test facility (EVALUATION OF OPTIONS FOR REDUCING IRISH DIESEL PARTICULATE EMISSIONS).

Evaluation tools

The European COMMUTE project, which has developed SEA methodology for the examination of the environmental impacts of transport policy options, has provided a software tool for assessment of air pollutant emissions, energy consumption, noise and safety impacts. The tool contains detailed methods, and focuses on impacts at European, national, regional and corridor levels, aggregated upwards from the impacts associated with individual transport links and nodes (such as urban roads, harbours and airports). Various external input data including traffic flows and vehicle fleet composition must be provided. The calculation includes the life-cycle emissions for power stations and refineries in order to capture fuel use impacts. Output data are presented in a Geographical Information System, and which can differentiate according to the height of emission into the atmosphere (COMMUTE, 2000).

Other environmental assessment tools have been produced as a result of research in into maritime transport, including a numerical model which has been developed for the evaluation of risk control measures. This model is based on scientific methodologies for the evaluation of environmental risks and is interfaced with a Geographical Information System (GIS) in order to understand how to reduce the frequency of incidents such as the release of pollutants and to mitigate the effects of such problems. A CBA can be undertaken for each risk control measure and for those entities of interest which are influenced the most by identified hazards (Labrosse, 2004). Another European project has provided a web-based information system that incorporates a method allowing ports to self-diagnose their environmental situation and performance and to periodically review progress. Data has been made available to allow each port to benchmark their environmental performance against other European ports. A database contains around 100 short case studies of successful projects and providing practical advice on environmental matters. These have been provided, and are updated on-line, by various ports involved in the research. A methodological guide assists port authorities in the process of analysing the nature and extent of an environmental issue (such as dredging), the risks from specific port activities (such as painting), and appropriate monitoring methods. A communication platform and contact details for professionals in European ports dealing with environmental management have also been provided (ECO, 1999).

A range of tools for the assessment of environmental and health impacts has been by provided Swiss national research into fair and efficient prices for transportation. The study of air pollution costs used dose-response function relationships to measure the relationship between pollution exposure and rates of morbidity and mortality, for example. Further work into transport sustainability and the criteria for municipal and cantonal road traffic planning

has developed a new application-oriented system of objectives and indicators in order to assess the sustainability of road traffic projects at cantonal, regional and municipal levels. This project has applied and developed existing methods of assessing expediency which have been used together with new objectives and indicators (FAIR AND EFFICIENT PRICES FOR TRANSPORTATION).

A web-based tool has been developed as a step towards a robust European methodology for vehicle environmental rating in order to draw attention to cleaner vehicles and technologies (CLEANER DRIVE).

A decision-making tool for use in assessment of transport policy initiatives and transport sector projects has been created by Danish researchers. This takes into account both the economic and the environmental consequences of alternative decisions, by linking together three existing models (the Danish National Transport Model, the Interregional Economic Model LINE, and an Environmental and Economic Impact Assessment tool) to produce an integrated model which can be tested and applied in case study work (INTEGRATED TRAFFIC, REGIONAL ECONOMIC AND IMPACT MODELS)

METKOM and ŽELMET methodologies have been applied in research conducted in the Czech Republic. These can be used as a basis for selecting the road and rail sections which are most likely to cause danger for water and mineral quality. Other tools developed in this research allow noise data to be obtained from traffic and to determine the number of inhabitants exposed to noise from such traffic. Overall, a set of indicators has been designed for the assessment of transport in relation to sustainable development (RESEARCH OF ENVIRONMENTAL BURDEN OF TRANSPORTATION).

UK DfT sponsored research has produced a model for the calculation of the costs imposed by heavy goods vehicles, encompassing both road wear and a range of environmental impacts. This Excel-based model can distinguish between 33 different classes of heavy goods vehicle according to gross vehicle weight and axle configuration, and 16 different vintages for each. Track costs are allocated to four road types, whilst emissions initially covered NOx, PM10 and CO_2, subsequently extended to include non-methane VOCs, CO, benzene, butadiene and sulphur dioxide. Monetary values are applied to these emission rates in order to estimate both health and non-health impacts. The model also takes into account estimates of noise associated with HGVs (COSTS IMPOSED BY HEAVY GOODS VEHICLES).

Pollution dispersion models suitable for the examination of relevant policy scenarios have been developed in Ireland for the analysis of options for reducing diesel particulate emissions. These have been created by customising existing models. Models have been developed for analysis at both micro level (localised particulate emissions produced by individual vehicles in a testbed environment) and macro level (adapting existing transport

models to determine particulate emissions levels for a city as a whole). CBA has been used to determine the most cost effective ways of reducing such emissions (EVALUATION OF OPTIONS FOR REDUCING IRISH DIESEL PARTICULATE EMISSIONS).

Evaluation of external costs

Research using the assessment methodologies and tools developed and tested in EU research projects has provided an initial quantification of the impacts of TEN transport projects as well as demonstrating the feasibility of SEA methods. The TEN transport projects are projected to increase overall passenger and freight travel demand, but with a substantial shift to rail and a reduction in road network congestion. Road vehicle emissions (other than CO_2) will fall, while the air sector will see substantial increases in total emissions. The projects are estimated to reduce CO_2 emissions relative to a do-nothing scenario, and to improve transport safety (COMMUTE, 2000).

Swiss research has resulted in estimation of monetary values for many of the external costs of transport. The project investigating the external health costs of airborne pollutants has found that these costs are highly significant, with by far the largest proportion of being attributable to the intangible costs of premature death or years of life lost. Chronic bronchitis among adults is the next largest cost, with all other health outcomes being far less costly to society. The corresponding study into noise costs has found that the external costs of (road and rail) transport noise amount to some 0.25% of national GDP, with some 88% of this attributable to reduced house rental values and 12% down to various health costs associated with noise. A similar study into building damage caused by transport found that by far the largest impact was caused by air pollution, with over 90% of this emanating from road traffic (mostly in urban areas) and much smaller effects from rail and air transport. Research on environment and landscape, focusing on the impacts of transport on natural habitats, has found significant external costs of transport, of which some 86% is caused by the road infrastructure (with 37% caused by motorways and main roads alone) and around 14% caused by the rail infrastructure (FAIR AND EFFICIENT PRICES FOR TRANSPORTATION).

Additional Swiss research has studied the regional impacts of such external costs and how they might be internalised. The study found that the costs of transport not covered by transport-related taxes can differ very significantly between the various regions of Switzerland, with mountain regions suffering more than the central regions from environmental damage and particularly from the expected global warming and damage to forests. Urban areas also suffer high costs, because of high air pollution and other factors (D4 NRP41 EXTERNAL COSTS AND INTERNALISATION – REGIONAL IMPACTS). Danish research into policy and project appraisal at regional level has similarly found major differences in external costs from region to region (INTEGRATED TRAFFIC, REGIONAL ECONOMIC AND IMPACT MODELS).

Research in Ireland into strategies for reducing diesel particulate emissions has estimated that in 2003 over 3000 tonnes of diesel particulate matter was emitted nationally by the fleet of some half a million diesel vehicles. The majority of these emissions occurred in urban areas and from light goods vehicles (responsible for 60% of all emissions). Older vehicles with EURO1 or older engines were responsible for some 55% of these emissions. These issues suggest that emissions reduction strategies can be broadly grouped under the categories of technological improvements to vehicles, use of cleaner fuels, better inspection and maintenance programmes and better fleet management. Such research has also highlighted the danger of focusing particulate emission reduction strategies on reducing the total mass of emissions, without sufficient attention to the most damaging volatile matter (EVALUATION OF OPTIONS FOR REDUCING IRISH DIESEL PARTICULATE EMISSIONS).

4.2.4 Policy implications

Policy implications stemming from this sub-theme relate primarily to the valuation of environmental impacts. Research findings confirm that the external costs of transport activity in terms of environmental impact are high, and this lends support to EU policy priorities to reduce such costs through the development of improved technologies, relevant new transport investments (including the TEN investments) and the internalisation of external costs to influence transport use and travel behaviour. Application of environmental impact assessment methodologies has demonstrated that whilst the TEN investments will lead to an overall increase in passenger and freight travel demand, there will also be a substantial shift to rail and a reduction in road congestion and improvement in road safety, all current policy priority areas. As a result, road vehicle emissions (other than CO_2) will fall. Whilst the TEN investments will reduce CO_2 emissions relative to a do-nothing scenario, there will be substantial increases in emissions from the air transport which will need to be addressed (COMMUTE, 2000).

There are many uncertainties attached to the monetarisation of environmental impacts, such that prioritisation of action can be difficult. However, many policies offer the benefit of reducing several different impacts at the same time. An integrated unified approach to reducing environmental impact, applying packages of relevant measures, may be the way forward (RESEARCH OF ENVIRONMENTAL BURDEN OF TRANSPORTATION; D4 NRP41 EXTERNAL COSTS AND INTERNALISATION – REGIONAL IMPACTS).

The regional dimension is important in many parts of Europe, and it has been shown that environmental impacts can vary significantly from region to region, even within individual European countries. Policy formulation therefore needs to take regional impacts into consideration (POLICY AND PROJECT APPRAISAL AT REGIONAL LEVEL).

4.3 Sub-theme 2: mitigation measures

4.3.1 Background

The synthesis of project results reported in EXTR@Web by Jopson, 2006 has focused on the development of mitigation measures, such as the methods of reducing the level of emissions from vehicles and the formulation of more integrated strategies for impact abatement.

Research offered an insight into a wide-ranging set of mitigation measures to deal with waste from fleet turnover, oil spillages, atmospheric pollution (more specifically measures to decrease CO_2 and tropospheric ozone), noise and vibration (including recommendations and guidelines to tackle nuisance due to traffic induced vibrations in buildings).

A number of measures aimed at separating transport intensity and economic growth have been identified by EU-funded research. An integrated approach that combines two or more measures to separate transport intensity from GDP has been advocated.

In the area of sustainable mobility, which is in the heart of the European transport policy, research has found that strategies targeting sustainable recreational traffic should focus on the essential requirements of people in their leisure activities. Research into the evaluation of the effects of local mobility plans on traffic viability and the environment has developed an instrument that assessed impacts on accessibility, traffic viability, noise nuisance, air quality, mobility and road safety. A study conducted in a UK context argued in favour of improving interchanges and their role in promoting seamless travel.

A Swiss study of transport and land use interactions has identified a number of key challenges for the regional planning and transport policies.

4.3.2 Research objectives

A key objective of much of the research into future transport technologies is concerned with developing a full understanding of future requirements and hence the specifications that vehicles and systems will need to achieve and which technologies might be placed to fulfil such needs (FURORE, 2004; ELODIT). In addition, the infrastructure requirements and the amount of public financial and other support that might be needed to bring new technologies fully to market also need to be understood (HYNET, PREMIA). Such research requires massive collaboration between stakeholders so is designed to be undertaken at a pre-competitive stage of technological development.

Within the constraints of existing technologies, it is also important to determine the potential contributions of non-technological factors to the reducing environmental impacts. Examples include the contributions of traffic management (Brand et al, 2000), car sharing or car-pooling schemes (ICARO, 1999; Armandi and Stridi, 2002) and transfer to more environmentally friendly modes (Brand et al, 2000; TRENDSETTER; Derek Halden Consultancy, 2005). The potential impacts of improved operating and fuel management practices, including effective monitoring of fuel use, driver awareness, training and incentive schemes, and preventive maintenance also need to be investigated (DfT, 2003; REDUCE).

The potential to utilise web-based information and other ICT technologies is potentially vast, and needs to be determined. Relevant applications include communication systems and benchmarking tools for the provision of management information and evidence on best practice for reducing environmental damage (ECO, 1999), ICT systems for the provision of information on ship positioning and safe navigation (Maréchal, 2004; SPREEX, 2007), ICT-based reservation systems and payment processing to support car sharing schemes (Armandi and Stridi, 2002).

In addition, there is a need to explore the links between transport environmental impact and land-use planning (TRANSPLUS, 2003; Gayda et al, 2005) and the potential impacts of increased levels of tele-working (COMMUTING, TELEWORKING AND TRANSPORT).

4.3.3 Research results

Technology improvements and optimum technology choice

A great deal of research will need to be undertaken to produce technological advancements which will ensure that environmental impacts resulting from the use of transport vehicles are minimised, both for conventional (internal combustion engine) vehicles and for vehicles powered by alternative systems in the future (FURORE, 2004). Engine and powertrain research will be needed to improve conventional technologies, but research investment in completely new technologies is also important to promote sustainable advances in environmental performance and energy security. The main challenge for electric vehicles is the development of cost effective advanced batteries / energy storage systems. For fuel cell and hydrogen based systems, improvements in terms of production and distribution will make them a competitive alternative and the sustainability of fuel production must also be ensured. For all vehicles, vehicle weight has important implications for both fuel consumption and safety, and in terms of vehicle manufacturing there is a need for intensive research into new materials and production processes including recycling technologies. Research into noise reduction needs to concentrate on road/tyre interaction, engine noise and the exhaust and intake system.

Active and passive safety show considerable further research potential. The optimum approach to such research is by promotion of a systematic integrated programme involving all stakeholders in a pre-competitive environment (FURORE, 2004).

Research into the future use of hydrogen technology in transport has taken place within much wider research programmes into the development of hydrogen technology more generally. Such research has identified the importance of developing and gaining acceptance for standards within which industry should work. The challenges of developing effective hydrogen systems are not simply technical but are also socio-economic in nature and to ensure success, governments will need to be proactive in stimulating research, development and large-scale demonstration. Early in its life cycle, hydrogen will be more expensive than conventional fuels, and long-term policy support will be essential and fiscal instruments will be needed to stimulate commercialisation of such systems. Such assistance should last long enough to effectively bridge the gap between the early immature market and the point that the hydrogen economy becomes robust, self-financing and competitive in a free market (HYNET). Similar research has been conducted to understand what needs to be done to support the large-scale introduction of biofuels (PREMIA).

Rail is a more sustainable mode than road for freight transport, but many freight trains need to use non-electrified routes, depots and sidings and hence are unable to use electric traction. Research has therefore been conducted in France into the development of specifications for a high-powered but environmentally-friendly freight locomotive for non-electrified lines, allowing freight trains to integrate more readily with passenger services and utilise rail capacity more efficiently (ELODIT). Both diesel solution and gas turbine solutions have been investigated, both offering advantages and drawbacks. The gas turbine engine has the major advantages of emitting lower levels of pollution, better reliability and lower life-cycle costs and was therefore the favoured solution, despite having higher energy consumption than the diesel option (ELODIT).

Improved operating and fuel management practices

Other research into mitigation of environmental impacts has focused not on technological change but on improved operating and fuel management practices, including effective monitoring of fuel use, driver awareness, training and incentive schemes, and preventive maintenance. Establishment and dissemination of best practice in such aspects of transport management can yield major environmental benefits, including around 10% reduction in fuel use (and hence associated reduction in pollution and CO_2) through the use of driver training in fuel efficient driving techniques alone. Such schemes also bring important health and safety benefits (DfT, 2003). Such driver training can be linked to data on driving behaviour and fuel consumption collected by telematic on-vehicle equipment and fed back to drivers either in real time or through subsequent de-briefing (REDUCE).

Web-based information and communication systems can be extremely useful in providing management information and evidence on best practice for reducing environmental damage. Self-diagnosis tools available on a European scale have been made available to support many aspects of improved environmental management of ports, helping them towards the achievement of ISO14000 certification (ECO, 1999).

Traffic management schemes to promote smoother traffic flow

Non-technical measures such as traffic management, pricing measures and promotion of public transport offer ways of supplementing the gains from vehicle technology by acting on modal split and / or the total demand for travel.

European experiences of the effectiveness of such non-technical measures in reducing traffic emissions have been extensively reviewed. Parking charges, parking management regulations, road pricing and low emission zones have been found to be the most cost-effective measures to reduce CO_2, CO and NOx emissions, although cost-benefit ratios vary greatly from city to city, especially for road pricing initiatives (Brand et al, 2000). Integrated land-use and transport modelling of various future scenarios for fuel technologies and fuel prices has shown that demand management appears to be more cost-effective in the long term than investment in new technology, because new technologies may possibly increase the demand for long distance travel (Fiorello, 2006). On the evidence available to date, infrastructure-based measures such as bus lanes and the establishment of freight distribution centres appear to be less cost-effective ways of achieving environmental objectives. Regulatory measures have given emissions reductions up to 6%, with parking management and traffic control working best in highly congested cities, while speed limits have greater impact in less congested cities. Pricing measures may reduce emissions by up to 14%, particularly through road pricing and parking charges in cities with a high degree of car use. Model-based extrapolation of evidence from various cities studied in such research suggests that at a European level there is potential for an average 16% abatement of the CO_2 emissions from transport in cities across Europe, equating to a 6% contribution to the achievement of Kyoto targets (Brand et al, 2000).

Optimising travel routes e.g. using routing software, vehicle location and direction systems, and traffic information systems

Following a number of maritime accidents around the coasts of Europe, there has been an evaluation of the potential safety contribution of improved monitoring and surveillance of hazardous goods and in particular how tracking systems, possibly using the GALILEO system, could offer benefits in terms of minimising the impact of spillages and improving maritime navigation security more generally. This could be achieved through use of a system architecture involving a positioning system, satellite communications and long-

range messaging based on the Automatic Identification System (AIS). Such proposals have been tested in a six-month demonstration campaign involving six different types of vessel relevant to European maritime trade and have been subjected to cost/benefit analysis on the assumption that by 2008 all vessels in European waters will be equipped with a suitably modified AIS terminal (Maréchal, 2004; SPREEX, 2007).

Improving load factors

Given the high level and attractiveness of private car use, car sharing or car-pooling are amongst the most attractive options for better vehicle utilisation. Car-pooling has been found to work best for employees from the same work place and hence initiatives are best targeted on the workplace. The willingness to car-pool increases with the distance between home and work. Initiatives that can be linked with car sharing or car-pooling schemes include the use of High Occupancy Vehicle (HOV) lanes, preferential work place parking for scheme participants and formalised workplace 'Green Commuter Plans' or 'Travelwise' campaigns, particularly as more general marketing of schemes appears to be relatively ineffective. Tax incentive and insurance implications of car sharing or car-pooling schemes need to be determined at national level to encourage their uptake (ICARO, 1999).

Car sharing can be made to work on a relatively informal basis, but there has also been research into how car sharing can benefit from more formalised technological and operational support and the adoption of IT-based technologies in areas such as reservation systems and payment processing, including a demonstration study undertaken in Bologna with the support of the public transport operator and taxi operators (Armandi and Stridi, 2002).

Mode switching

Improvements in public transport have given emissions reductions of up to 6%, but can be less effective in highly congested cities (Brand et al, 2000). Other research in European cities which have made large efforts to improve the public transport system in order to attract more passengers has demonstrated that it is important to improve access to public transport, provide enhanced safety and security, introduce integrated fares and ticketing systems and to create bus lanes, Park & Ride facilities and improved multimodal nodes. In addition, public transport service quality must be constantly monitored and maintained. Information offices, real-time public transport information systems and trip-planning tools on the web can all help boost patronage, and marketing activities have been shown to be an effective way of changing peoples' behaviour and encouraging them to choose public transport (TRENDSETTER)

Land-use planning

Research has been conducted to identify best practices towards land use and transport policy in order to achieve a sustainable pattern of transport and land use in European cities and regions, promoting environmental as well as economic and social improvement. Trends in land use and transport planning have been analysed and likely future trends have been considered. Best practice case studies relating to integrated land use and transport policies and to overcoming the barriers to successful implementation of such policies have been disseminated. Consideration has been given to the development of a consistent set of indicators for the evaluation of integrated land use and transport policy packages and to ways of promoting consistency and transferability of approaches between countries (TRANSPLUS, 2003).

Urban sprawl is a major challenge to transport planners in European metropolitan areas because it is problematic for the implementation of improved suburban public transport. The mechanisms by which urban sprawl works and its impacts on transport have been evaluated in order to design effective measures for its control or reduction. Policy recommendations have been made available to cities to assist them in improving public transport services in sprawling urban areas. An integrated approach to the problem is advocated, using a range of measures such as transport pricing (both of public and private transport), office location strategies, design of housing estates and influencing suburban residential development through fiscal policy (Gayda, 2005).

Travel substitution methods such as tele-working

Research conducted in Denmark has constructed a model of commuting which incorporates tele-working as one of the modal options. This allows the future impact of tele-working on transport, and hence the impact of this on emissions, to be estimated. As part of this research, the causal mechanisms behind the growth of tele-working have been analysed, the types and characteristics of firms or organisations which promote tele-working have been investigated and the barriers to its implementation have been studied. Whilst tele-working leads to an overall reduction in transport use, the net effect is reduced because often a family car becomes available for other travel purposes (COMMUTING, TELEWORKING AND TRANSPORT).

Influencing travel choice (mode, time, route) in order to reduce congestion

Use of the car for travel to and from school has been increasing and this is a growing cause for environmental concern. UK and international research on school travel published since 1995 has been reviewed in order to identify factors affecting school travel and the effectiveness of school travel initiatives. Factors influencing school travel choice were found to include organisational changes within education, planning policy factors and social, economic and demographic trends. The growth in car travel to school mirrors substantial growth in car ownership and particularly the growing number of two-car

households. Whilst many children would like to walk and cycle more, the balance between car travel and other modes still appears to favour the speed and convenience of car travel for an increasing number of trips. In addition it is often perceived that car travel is safer than such alternatives, though actual risks may not match such perceptions. School bus travel tends to have a negative image, and delivering the required change in image will call for significant changes in the ways that services are provided and operated (Derek Halden Consultancy, 2005).

4.3.4 Policy implications

Transport in Europe will remain heavily dependent on the internal combustion engine for many years to come, but in the future more propulsion technologies will be in use and it will be important for policymakers to decide on appropriate incentive/disincentive structures in each case. New propulsion technologies are able to contribute significantly to the mitigation of the environmental problems caused by transport activity, but will need much more research in order to bring them fully to market. The rate of technological progress can be accelerated through the promotion of a systems approach to such research which integrates the concerned stakeholders (infrastructure, vehicle manufacturers, research providers etc.) and the concerned scientific areas (materials, electronics, telematics etc.) (FURORE, 2004).

EU policy considerations regarding energy security, resource depletion and the need to reduce greenhouse gas emissions in the medium and long term mean that a transition to low CO_2 or CO_2 neutral technologies will be required. Action is required urgently to ensure the future of hydrogen technologies in the transport field. This involves further technological research but also policies to support the introduction of such technology before it can become fully cost competitive (HYNET). Demonstration projects and trials will need to be sponsored to prove new technologies in practical situations (ELODIT)

Governments can play major roles in ensuring the dissemination and encouragement of best practice, for example in transport energy use, by a wide variety of methods such as the development of sponsored driver training programmes (DfT, 2003; REDUCE).

ICT is a potent tool for the making information and spreading environmental best practice in a quick and cheap way, and hence needs to be embraced as fully as possible in these respects (Maréchal, 2004; ECO, 1999). ICT can also support the implementation of various policies such as car sharing (Armandi and Stridi, 2002).

Many new technologies offer only a longer-term prospect of environmental improvement. Hence policymakers should continue to make use of the wide range of non-technical measures such as regulatory policies (such as parking controls), pricing policies (such as

road pricing and parking pricing to move towards the internalisation of external costs) and the promotion of public transport (to meet the priority objective of modal shift), according to the characteristics of the city in question (Brand et al, 2000). Communication, information and marketing are all important when trying to increase the use of public transport and other modes of sustainable transport. Such soft measures are relative inexpensive and are efficient, especially when combined with other measures such as infrastructure improvements (TRENDSETTER). Policies need to be designed carefully to avoid unwanted effects; for example, car sharing may reduce the use of public transport (ICARO, 1999), whilst encouragement of tele-working may simply divert car use to other trips (COMMUTING, TELEWORKING AND TRANSPORT).

Continued use of integrated land-use and transport planning is required in order to encourage development that is most amenable to the use of public transport, walking and cycling (TRANSPLUS, 2003; Gayda, 2005).

Finally, governments need to ensure that fiscal regimes are suitably aligned to transport policy, so that for example there are no tax-based disincentives to the use of car sharing (ICARO, 1999).

4.4 Sub-theme 3: Development of environment-friendly forms of transport

4.4.1 Background

Research results reported in the former thematic paper (Jopson, 2006) had been concerned with the introduction of new environment-friendly technologies and transport concepts to reduce energy resource use for transport, improve air quality, reduce transport related noise, avoid waste and recycle waste related to transport.

More specifically, EU-funded research demonstrated and evaluated the social, environmental and economic factors affecting the viability of hydrogen based bus service, including the refuelling infrastructure. The study has concluded that the costs of hydrogen infrastructure and bus operations are not yet commercially viable.

Measures to improve sustainable urban mobility through the use of electric vehicles, car sharing and promotion of walking and cycling have been the focus of research in a number of European projects.

Technological developments that can contribute to more environmentally friendly transportation have also been investigated. An example is the use of composites

(fibreglass, for instance) in manufacturing resulting in lighter vehicles and thus lower fuel consumption.

4.4.2 Research objectives

A key research need is to understand the future mix of transport technologies, including the extent to which Europe will continue to rely on the internal combustion engine, the extent to which the various alternative technologies will be able to penetrate the market, the amount of support they will need to achieve this and the likely environmental impacts if they do (FURORE, 2004; TRENDSETTER; TAXEL, 2002).

It is also important to determine the contribution that can be made by transport concepts such as car sharing or car pooling which may also need considerable public support to reach viability as a means of environmental improvement (Armandi and Stridi, 2002). In addition, greater use of non-motorised modes (walking and cycling) offers great potential for environmental improvement, and hence it is important to learn how they can be promoted to best advantage (ADONIS; TRENDSETTER).

4.4.3 Research results

New technologies and transport concepts

Considerable research effort has been devoted to developing an understanding of the research needs for development of vehicles for the future (i.e. year 2020 and beyond) (FURORE, 2004). This research has served as a platform for European stakeholders to discuss breakthrough technologies and has drawn up a roadmap of future research needs. Emphasis has been largely on vehicles with internal combustion engines but other technologies have also been considered, with the scope of the research encompassing energy and fuels, current and potential future powertrain technologies and other aspects of vehicle technology including vehicle structures and noise and safety performance.

The general conclusions from such research is that whilst there will be a greater mix of fuels and technologies in use by the year 2020, there will still be a need for a significant amount of research into new technologies to bring them into mainstream use and hence there will still be heavy dependence on the internal combustion engine. Research needs to address many aspects of vehicle design and technology in a highly integrated way and there is great scope for collaborative research in a pre-competitive environment (FURORE, 2004).

Many different aspects of the use of alternative fuel cleaner vehicles have been trialled in Europe with research undertaken on their impacts (TRENDSETTER), including the use of biofuels for public transport vehicles, commercial freight vehicles, refuse collection vehicles and other vehicles in municipal fleets. It has been shown that use of such vehicles by municipal authorities can promote their use by private operators as well, and that such use can be encouraged, for example by exemptions from congestion charges. Given the growing concern over the environmental merits of biofuels, it is important to ensure that such fuels are derived from sustainable sources (TRENDSETTER).

Research undertaken in France has focused on potential designs for electric powered taxi vehicles (TAXEL, 2002). Building on a comprehensive user needs analysis and field research on taxi operations in Paris, a set of basic performance requirements have been set out for such vehicles, alongside the basic technological characteristics such as battery, engine and transmission and braking systems. The potential driving range of such vehicles (some 200 – 300 km per charge) remains a limitation of such vehicles. Some exploratory research has also been undertaken into the potential for hybrid (diesel/electric) and fuel cell taxi vehicles (TAXEL, 2002).

Car sharing is often cited as a means of reducing traffic levels and hence also pollution levels, especially in peak periods, but its organisation can benefit from the use of IT based systems, for instance for trip matching. Hence there has been research into the provision of technological and operational support for car sharing schemes. Such systems aim to increase overall awareness of the benefits of car sharing, as well as providing the organisational know-how and utilising the currently available technologies in areas such as booking systems, access to vehicles and payment handling) (Armandi and Stridi, 2002). A demonstration pilot study has been undertaken in conjunction with the public transport operator and taxi operators in Bologna, where car sharing is seen as highly complementary to public transport and taxi use in encouraging integrated travel, with a view to developing best practice which can be implemented in other European cities (Armandi and Stridi, 2002).

Non-motorised modes

Non-motorised modes are particularly environmentally-friendly transport options and hence their greater use offers considerable potential to reduce environmental impacts while improving health and city life. There has been research aimed at planners and policy-makers at local, regional, national and European levels, which provides a comprehensive catalogue of recommendations and guidelines regarding good practice in the promotion of walking and cycling to replace short car trips in cities (ADONIS). Such research highlights the importance of both technical solutions (such as infrastructure changes) and non-technical actions (such as education and planning) in encouraging such modes of transport, with safety and bicycle security identified as major concerns to be addressed.

Recommendations include better cycle parking and security and insurance arrangements and better promotion of walking and cycling, including the focusing of marketing efforts on major employers and large establishments such as schools, colleges frequented by younger people whose travel habits can be influenced for the longer term. Appointment of a pedestrian and cycling officer is a useful way of advocating and promoting change, and incentives such as Car Free Days can be adopted. It may also be necessary to enforce reduced car speed limits to encourage walking and cycling (ADONIS).

Cities involved in the TRENDSETTER Programme, aiming for sustainable urban mobility and an improved city life, have tended to focus on greater use of public transport, but several including Lille and Graz have introduced initiatives to make cycling an attractive alternative even over longer distances, by marketing cycling, extending their cycling networks and equipping tram and bus stops and metro stations with Bike & Ride facilities. Internet based walking and cycling route finders can be made available. Other cities, such as Pécs, have implemented car-free zones which also encourage walking and cycling. There is considered to be great potential for transfer of lessons learnt and best practice to many other cities (TRENDSETTER).

4.4.4 Policy implications

A great deal of research and development remains to be done to determine which are the best transport technologies and most environment-friendly vehicles for the future, how to undertake trials to prove their utility, how to bring them to market and how to incentivise their use (FURORE, 2004; TAXEL, 2002). Public sector organisations can be encouraged to introduce cleaner vehicles into their fleets (TRENDSETTER).

Policymakers could do much more to promote walking and cycling as transport modes, and clear recognition needs to be given to such modes within local and national transport policies and plans. In addition to more active marketing and promotion and the use of many positive measures such as cycle lanes, in some places it may be necessary to restrict vehicle access in order to reduce the disincentives to walking and cycling (ADONIS).

The research discussed in this section and the resulting policy implications are most relevant to the policy priorities relating to mode shift and the reduction of congestion.

4.5 Implications for further research

For the first sub-theme, which deals with the assessment, measurement and valuation of the impacts of transport on the environment, much emphasis has been placed on engine

emissions and their impacts at the more local level, for example on health, and also on noise impacts. As a result, many mitigation policies have been implemented in these areas. Global warming is now acknowledged to be an urgent issue, but this is not yet feeding through into research findings and there is a more urgent need for research into carbon creation in transport and its impacts on global warming. In similar vein, the need to act swiftly on the findings from the large and growing amount of research into the rapid expansion of air transport, its environmental impacts and how they might be mitigated is becoming more pressing.. More research on how to cost carbon emitted from transport most meaningfully is also required.

For the second sub-theme, which deals with mitigation and abatement strategies, much of the requirement for fundamental research appears to have been met. There is still a need for much research into new environment-friendly vehicle designs and new propulsion technologies, though over time the emphasis will need to shift from more fundamental research towards the testing of concepts, demonstration projects and trials and other pre-market activities to allow cost-effective implementation. There are however growing concerns over the true sustainability of alternative fuels. These concerns relate to both hydrogen, where the issue hinges on how the fuel is created, and to biofuels, where there are important concerns relating to the sustainability of the farming practices involved as well as issues relating to the pressure being placed on food production and food prices. Some previous research in these areas may have to be revisited and additional research into the life-cycle sustainability of such fuels may be called for.

Whilst there is now a good body of evidence on the efficacy of the many and varied policy measures that can be used to mitigate environmental impacts, we know far less about the public understanding of why such measures need to be implemented, their attitudes to the need for behaviour change in the face of the growing evidence of the impacts of global warming, and how people can be motivated to change their behaviour in a beneficial way.

For the third sub-theme, which deals in part with cycling and walking, it is clear that we need to develop a better understanding of how strategies for the promotion of such modes can be embedded successfully into overall transport strategies, and how to achieve an appropriate balance between promoting environment-friendly modes and penalising the use of less sustainable methods.

5. References

Armandi, M. and Stridi, A. (2002) TOSCA (Technological and Operational Support for Car Sharing), Final Report for Publication, Funded by 5th Framework RTD Programme [online] http://www.transport-research.info/Upload/Documents/200607/20060727_160959_99525_TOSCA_final_report.pdf (August 2008).

Brand, C. et al (2000) CANTIQUE (Concerted Action on Non-Technical Measures and Their Impact on Air Quality and Emissions), Final Report for Publication, Funded by 4th Framework RTD Programme [online] http://www.transport-research.info/Upload/Documents/200310/cantique.pdf (August 2008).

Commission of the European Communities (2001) 'White Paper – European Transport Policy for 2010: time to decide,' Office for Official Publications of the European Communities, Luxembourg [online] http://ec.europa.eu/transport/white_paper/documents/doc/lb_texte_complet_en.pdf (July 2008).

Commission of the European Communities (2002) 'Integration: towards an operational approach', Joint Expert Group on Transport and Environment, Office for Official Publications of the European Communities, Luxembourg.

Commission of the European Communities (2006) 'Keep Europe Moving – Sustainable Mobility for Our Continent. Mid-term review of the European Commission's 2001 Transport White Paper', Office for Official Publications of the European Communities, Luxembourg [online] http://ec.europa.eu/transport/transport_policy_review/doc/2006_3167_brochure_en.pdf (August 2008).

Commission of the European Communities (2008) 'EU Energy and Transport in Figures' – Statistical pocketbook 2007/2008, DG TREN in co-operation with Eurostat, Luxembourg [online] http://ec.europa.eu/dgs/energy_transport/figures/pocketbook/doc/2007/2007_pocketbook_all_en.pdf (August 2008).

COMMUTE (2000) COMMUTE (Common Methodology for Multi-modal Transport Environmental Impact Assessment) Final Report for Publication, Funded by 4th Framework RTD Programme [online] http://www.transport-research.info/Upload/Documents/200310/commute.pdf (August 2008).

Derek Halden Consultancy (2005) Evaluation of the School Travel Co-ordinator Initiative, Research Findings No.208/2005, a publication produced for the Scottish Executive Development Department [online] http://www.transport-research.info/Upload/Documents/200607/20060728_162709_43083_Review%20of%20Research_Final_Report.pdf (August 2008).

DfT (Department for Transport) (2003) The Safe and Fuel Efficient Driving (SAFED) Standard, Good Practice Guide, part of a series of publications produced for the Department for Transport under the TransportEnergy Best Practice Programme [online]

http://www.transport-research.info/Upload/Documents/200607/20060728_163035_17819_SAFED_Final_Report.pdf (August 2008).

ECO (1999) ECO (ECO-information in European Ports) Final Report for Publication, Funded by 4th Framework RTD Programme [online] http://www.transport-research.info/Upload/Documents/200310/eco.pdf (August 2008).

European Environment Agency (2004a) 'Transport and Environment in Europe', Briefing 03, European Environment Agency, Copenhagen [online] reports.eea.eu.int/briefing_2004_3/en/Briefing-TERM2004web.pdf (July 2008).

European Environment Agency (2004b) 'Ten key transport and environment issues for policy-makers. TERM 2004: Indicators tracking transport and environment integration in the European Union' Report 03, European Environment Agency, Copenhagen [online] reports.eea.eu.int/TERM2004/en/TERM2004web.pdf (July 2008).

European Environment Agency (2006) 'Transport and environment: facing a dilemma. TERM 2005: indicators tracking transport and environment in the European Union' Report 03, European Environment Agency, Copenhagen [online] http://reports.eea.europa.eu/eea_report_2006_3/en/term_2005.pdf (July 2008).

European Environment Agency (2007) 'Transport and environment: on the way to a new common transport policy. TERM 2006: indicators tracking transport and environment in the European Union' Report 01, European Environment Agency, Copenhagen [online] http://reports.eea.europa.eu/eea_report_2007_1/en/eea_report_1_2007.pdf (July 2008).

European Environment Agency (2008) 'Climate for a transport change. TERM 2007: indicators tracking transport and environment in the European Union' Report 01, European Environment Agency, Copenhagen [online] http://reports.eea.europa.eu/eea_report_2008_1/en/EEA_report_1_2008_TERM.PDF (July 2008).

Fiorello, D. (2006) STEPS (Transport Strategies under the Scarcity of Energy Supply) Final Report for Publication, Funded by 6th Framework RTD Programme [online] http://www.steps-eu.com/reports.htm (August 2008).

FURORE (2004) FURORE (Future Road Vehicle Research - A roadmap for the future), Final Report for Publication, Funded by 5th Framework RTD Programme [online] http://www.transport-research.info/Upload/Documents/200607/20060727_145413_00658_FURORE%20BTL%20Final%20Report.pdf (August 2008).

Gayda, S. et al (2005) SCATTER (Sprawling Cities And Transport: from Evaluation to Recommendations) Final Report for Publication, Funded by 5th Framework RTD Programme [online] http://www.transport-research.info/Upload/Documents/200607/20060727_155741_37971_SCATTER_Final_Report.pdf (August 2008).

ICARO (1999) ICARO (Increase of Car Occupancy through Innovative Measures and Technical Instruments), Final Report for Publication, Funded by 4th Framework RTD Programme [online] http://www.transport-research.info/Upload/Documents/200310/icaro.pdf (August 2008).

Jopson, A. (2006) 'Third Annual Thematic Research Summary – Environmental Aspects', Deliverable D2.E-3.4 of the EXTR@Web project [online] http://www.transport-research.info/Upload/Documents/200608/20060831_113400_42876_environmental-aspects_D2E_issue1-0.pdf (August 2008).

Kenny, L. (2000) Nenagh ByPass - Noise Aspects, Final Report produced for the National Roads Authority, Dublin [online] http://www.transport-research.info/Upload/Documents/200607/20060728_160636_13411_Nenagh_Bypass_Final_Report.pdf (August 2008).

Labrosse, M. (2004) SEAM (Assessing concepts, systems and tools for a safer, efficient and environmentally aware and friendly maritime transport) Final Report for Publication, Funded by 5th Framework RTD Programme [online] http://www.transport-research.info/Upload/Documents/200607/20060727_155903_36303_SEAM_Final_Report.pdf (August 2008).

Maréchal, J. (2004) NAUPLIOS (Navigation and Perilous Goods Input and Output System) Final Report for Publication (an Executive Summary), Funded by 5th Framework RTD Programme [online] http://www.transport-research.info/Upload/Documents/200607/20060727_153921_34691_NAUPLIOS_Final_Report.pdf (August 2008).

Nash, C. with contributions from partners (2003) UNITE (UNIfication of accounts and marginal costs for Transport Efficiency) Final Report for Publication, Funded by 5th Framework RTD Programme [online] http://www.its.leeds.ac.uk/projects/unite/ (August 2008).

SPREEX (2007) SPREEX (Spill Response Experience and Research for Preparedness), Final Conclusions presented at the Centre for the Development of Industrial Technology (CDTI), Spain, Funded by 6th Framework RTD Programme [online] http://spreex.net/outcomes.htm (August 2008).

TAXEL (2002) TAXEL (Recherche sur un taxi électrique – Research into an Electric Taxi), Final Report for Publication [online] http://www.transport-research.info/Upload/Documents/200608/20060811_124447_59339_TAXEL_Final_Report.pdf (August 2008).

TRANSPLUS (2003) TRANSPLUS (TRANSport Planning, Land Use and Sustainability), Final Report for Publication, Funded by 5th Framework RTD Programme [online] http://www.transport-research.info/Upload/Documents/200607/20060727_161314_91463_TRANSPLUS_Final_Report.pdf (August 2008).

Winder, A. with contributions from partners (2005) NPF - URBAN TRANSPORT (National Policy Frameworks for Urban Transport) Final Report for Publication, Funded by 5th Framework RTD Programme [online] http://www.transport-research.info/Upload/Documents/200608/20060811_135232_55698_NPF-UT_Final_Report.pdf (August 2008).

Annex: List of EU-funded projects within each sub-theme

Sub-theme 1: Environmental Impact Assessment			
Programme: FP4 – TRANSPORT RTD – Transport Research and Technological Development			
Project acronym	Project title	Project website°	
COMMUTE	Common Methodology for Multi-Modal Transport Environmental Impact Assessment	N/A*	covered in this paper
ECO	Information in European Ports	http://www.ecoports.com/	covered in this paper
AEROCERT	Aircraft Environmental Impacts and Certification Criteria	N/A*	covered in EXTR@Web paper
EMARC	MARPOL Rules and Ship-Generated Waste	N/A*	covered in EXTR@Web paper
H - SENSE	Harbours - Silting and Environmental Sedimentology	N/A*	covered in EXTR@Web paper
MEET	Methodology for Calculating Transport Emissions and Energy Consumption	http://www.inrets.fr/infos/cost319/index.html	covered in EXTR@Web paper
POLMIT	Highway Pollutants	N/A*	covered in EXTR@Web paper

Programme: FP5 – EESD KA4 - City of Tomorrow and Cultural Heritage			
PROPOLIS	Planning and Research of Policies for Land Use and Transport for Increasing Urban Sustainability	http://www.ltcon.fi/propolis	covered in EXTR@Web paper
Programme: FP5 – GROWTH - KA2 - Sustainable Mobility and Intermodality			
Project acronym	Project title	Project website°	
SEAM	Assessing concepts, systems and tools for a safer, efficient and environmentally aware and friendly maritime transport	N/A*	covered in this paper
DGTREN – Energy & Transport DG – Miscellaneous projects			
Project acronym	Project title	Project website°	
NPF-Urban Transport	National Policy Frameworks for Urban Transport	N/A*	covered in this paper

Sub-theme 2: Mitigation Measures			
Programme: FP4 – TRANSPORT RTD – Transport Research and Technological Development			
Project acronym	Project title	Project website°	
CANTIQUE	Concerted Action on Non-Technical Measures and Their Impact on Air Quality and Emissions	N/A*	covered in this paper

ECO	Information in European Ports	http://www.ecoports.com/	covered in this paper
ICARO	Increase of Car Occupancy through Innovative Measures and Technical Instruments	http://www.boku.ac.at/verkehr/icaro.htm	covered in this paper
Programme: FP5 – IST – KA1 - Systems and Services for the Citizens			
Project acronym	Project title	Project website°	
TOSCA	Technological and operational support for car sharing	N/A*	covered in this paper
Programme: FP5 – GROWTH - KA2 - Sustainable Mobility and Intermodality			
Project acronym	Project title	Project website°	
NAUPLIOS	Navigation and perilous goods input and output system	http://nauplios.cnes.fr/	covered in this paper
SPRITE	Separating the Intensity of Transport from Economic Growth	http://www.its.leeds.ac.uk/projects/sprite/	covered in EXTR@Web paper
Programme: FP5 – GROWTH – KA3 - Land transport and marine technologies			
Project acronym	Project title	Project website°	
FURORE	Future Road Vehicle Research - A roadmap for the future	N/A*	covered in this paper
Programme: FP5 – EESD - KA4 - City of Tomorrow and Cultural Heritage			
Project acronym	Project title	Project website°	
SCATTER	Sprawling Cities And	http://www.casa.ucl.ac.uk/scatter/	covered in this

	Transport: from Evaluation to Recommendations		paper
TRANSPLUS	Transport Planning, Land Use and Sustainability	http://www.transplus.net/	covered in this paper
Programme: FP5 – EESD – KA6 - Economic and Efficient Energy for a Competitive Europe			
Project acronym	Project title	Project website°	
HYNET	Towards a European Hydrogen Energy Roadmap	http://www.hyways.de/hynet/	covered in this paper
TRENDSETTER	Setting Trends for a Sustainable Urban Mobility	N/A*	covered in this paper
Programme: FP6 – SUSTDEV-1 – Sustainable Energy Systems			
Project acronym	Project title	Project website°	
PREMIA	Assessment of Initiatives to Facilitate and Secure the Introduction of Alternative Motor Fuels in the European Union	N/A*	covered in this paper
Programme: FP6 – SUSTDEV-2 – Sustainable Surface Transport			
Project acronym	Project title	Project website°	
STEPS	Scenarios for the Transport System and Energy Supply and their Potential Effects	http://www.steps-eu.com/	covered in this paper
Programme: FP6 – SUSTDEV-3 - Global Change and Ecosystems			

Project acronym	Project title	Project website°	
SPREEX	Spill Response Experience	http://www.spreex.net	covered in this paper

Sub-theme 3: Development of Environment-friendly Forms of Transport			
Programme: FP4 – TRANSPORT RTD – Transport Research and Technological Development			
Project acronym	Project title	Project website°	
ADONIS	Analysis and Development of a New Insight into the Substitution of Short Car Trips by Cycling and Walking	http://www.vejdirektoratet.dk/document.asp?page=document&objno=7134	covered in this paper
UTOPIA	Urban Transport: Options for Propulsion Systems and Instruments for Analysis	N/A*	covered in EXTR@Web paper
Programme: FP5 – IST – KA1 - Systems and Services for the Citizens			
Project acronym	Project title	Project website°	
TOSCA	Technological and operational support for car sharing	N/A*	covered in this paper
Programme: FP5 – GROWTH – KA3 - Land transport and marine technologies			
Project acronym	Project title	Project website°	
FURORE	Future Road Vehicle Research - A roadmap for the future	N/A*	covered in this paper

Programme: FP5 – EESD – KA6 - Economic and Efficient Energy for a Competitive Europe			
Project acronym	Project title	Project website°	
TRENDSETTER	Setting Trends for a Sustainable Urban Mobility	N/A*	covered in this paper
Programme: FP5 – GROWTH – KA4 (AERONAUTICS) – New Perspectives in Aeronautics			
COMPOSIT	The Future Use of Composites in Transport	N/A*	covered in EXTR@Web paper
Programme: FP5 – EESD - KA4 - City of Tomorrow and Cultural Heritage			
Project acronym	Project title	Project website°	
ECTOS	Ecological City Transport System	http://www.ectos.is/en/projects/finished%5Fprojects/ectos/	covered in EXTR@Web paper

Notes:

(°) Accessed on 06-8-2008

(*) More information (project profile, results summary and/or a final report) is available at www.transport-research.info

This Annex concentrates on those projects for which “Environmental Aspects” is the primary theme of the research. A much wider set of research projects, EU-funded and national, which have considered environmental aspects to a greater or lesser extent, can be viewed online by entering “environmental aspects” into the “advanced search” functionality available on the TRKC portal www.transport-research.info.