THEMATIC SYNTHESIS OF TRANSPORT RESEARCH RESULTS

PAPER 4 OF 10

ENVIRONMENTAL ASPECTS OF SUSTAINABLE MOBILITY

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Contents

EXECUTIVE SUMMARY

This paper provides a structured guide to the findings and policy implications of research carried out in the Transport RTD Programme[1] that relate to the environmental aspects of sustainable mobility. (See Section 1 for advice on how to use the paper.)

There is common agreement that the environmental impacts of transport have to be reduced. Greenhouse gas emissions are set to get worse under current trends for growth in traffic. Air quality hotspots remain an issue, despite substantial reductions in vehicle tailpipe emissions. Perhaps 20% of Europe's citizens suffer from damaging levels of noise. Therefore policy action is needed to introduce appropriate regulatory controls, promote good practice in environmental management, and stimulate people to take account of the environment in their mobility decisions. RTD is providing a vital foundation for this, developing guidelines and tools to support the implementation of policy measures, and demonstrating their likely impacts.

In this paper, results are reviewed for "clusters" of research projects in three inter-related areas:

Understanding environmental impacts
A methodology for Strategic Environmental Assessment (SEA) of transport policies, plans and programmes has been devised. This is supported by software for calculating impacts and a comprehensive set of methods and emissions factors for estimating transport emissions. These outputs were used in the recent pilot SEA of the Trans-European Transport Network (TEN-T).

New and improved methods have been developed for assessing environmental impacts, both at a site-specific level and for major infrastructure investments such as the TEN-T. The cost-effectiveness of non-technical policy measures in reducing vehicle emissions has also been reviewed.

Research has shown that all of the main externalities of transport (air pollution, global warming, congestion, accidents etc.) may be taken into account in user charges, even though some uncertainty exists in their estimation. Specific evaluation methods have been recommended for particular impacts and illustrated in case studies. The resulting effects on transport prices have been estimated – the changes are strongly dependent on the local context, although certain trends are apparent (like higher charges for urban car trips at peak periods).

Mitigating the environmental impacts of transport
A range of techniques have been developed and tested for measurement of railway exterior noise. This is to support type testing of rolling stock, monitoring of ambient noise and diagnosis of the sources of noise. In addition, new methods for separating vehicle and track noise have been demonstrated. These results have already been fed into a new draft of the ISO standard for noise type testing of rail vehicles.

[1] Part of the Fourth Framework Programme for Community activities in the field of research, technological development and demonstration for the period 1994 to 1998.

For the air sector, promising procedures for noise abatement have been identified, and recommendations made on modelling approaches.

In the maritime sector, the MARPOL Regulations on pollution from ships have been shown to be having a positive effect on the marine environment. Research has also supported the exchange of good practice between port managers on environmental management, as well as promoting the use of sediment data to improve pollution control in dredging operations.

Support has been given for the greater use of alternative materials in the construction of road infrastructure, leading to less use of natural aggregates and greater recycling.

Development of environmentally-friendly forms of transport
Potential environmental benefits have been evaluated for all sorts of new transport technologies and concepts. Urban areas are one of the most sensitive environments, creating a vital role for cleaner vehicles and alternative fuels. Software and good practice guides have been developed to help vehicle operators and policy-makers introduce such vehicles and fuels, through demonstration projects and a range of supporting non-technical measures.

Guidelines and other information tools have been developed to help city authorities in giving greater priority to the "environmentally-friendly" modes of cycling and walking. These include a review of good practice in the design of infrastructure and advice on the implementation of a wide range of measures.

1. INTRODUCTION – HOW TO USE THIS PAPER

This paper provides a structured guide to the results of Research and Technical Development (RTD) projects relating to the *environmental aspects of sustainable mobility*, carried out in the European Community's Transport RTD Programme. It is one of a series of papers:

Paper no.	Theme
1	Sustainable mobility – integrated perspective
2	Sustainable mobility – economic perspective
3	Sustainable mobility – social perspective
4	Sustainable mobility – environmental perspective
5	Urban transport
6	Efficiency and quality
7	Safety and security
8	Human factors
9	Interoperability
10	Freight intermodality

Of the 275 projects within the Programme, 23 dealt (partly or fully) with specific environmental issues. Most of these projects were finalised in the year 2000.

How to use this paper:
You are recommended to use this paper to locate RTD results on topics where you have a particular interest, rather than reading the paper from start to finish:

- Start in Section 5 to get an overview of the topics addressed by "clusters" of RTD projects.
- Read the part of Section 6 that summarises the findings for each topic of interest to you.
- Use Annex 1 to identify the individual projects relating to that topic.
- Use Annex 2 to review the key results from each of these projects.

Further details on individual projects can be obtained from their web sites (noted in Annex 2, where available) and from the following Commission web sites:

- http://europa.eu.int/comm/transport/extra/home.html, which includes summaries and the full final reports of individual projects, as well as a variety of analyses and publications prepared by the EXTRA project;
- http://cordis.lu/transport/src/project.htm, which provides the project objectives and summary results as compiled by the RTD project teams.

The other Sections of this paper can help you to gain an overall picture of the urban transport theme, associated policy issues and the objectives for RTD.

The analysis in this paper is the responsibility of the EXTRA project team, and does not represent the official viewpoint of the European Commission.

2. SCOPE OF THE THEME

2.1 Definition of Sustainable Mobility

Concept of Sustainable Development

A new consciousness towards the environment and the use of natural resources has led to the development of the concept of sustainable development. This was first put forward by the World Commission on Environment and Development[1] (the "Brundtland Commission") in 1987 and defined as:

"Development that meets the needs of the present without compromising the ability of future generations to meet their own needs."

Sustainable development is generally considered to comprise two main elements:
- minimising environmental impacts, and
- making the best and most equitable use of resources.

In promoting sustainable development, the challenge for policy-makers is to reconcile three objectives:
- securing higher standards of living through economic development;
- protecting and enhancing the environment;
- ensuring an equitable distribution of the benefits between present and future generations.

Subsequently, the Treaty on the European Union (Amsterdam Treaty[2]) explicitly included sustainable development as one of the European Union's objectives for the first time (in Article 2). Article 6 of the same Treaty requires environmental protection to be integrated into the definition and implementation of all Community policies and activities.

Concept of Sustainable Mobility

The mobility of people and goods provides benefits (i.e. effective and efficient transportation from one location to another) and a series of unwanted economic, environmental and social side effects. The causes of these problems are relatively well known and solutions have been suggested. One notable example is the set of solutions defined at the UN Conference for Environment and Development in June 1992, and formulated in the document known as 'Agenda 21'.

In the formal Agenda 21 document, six objectives are set for transportation[3]. In order to make transportation more sustainable or to make it less unsustainable, Agenda 21 requires society:
- to reduce transportation demand;
- to develop public transport;
- to promote non-motorised transport (cycling and walking);
- to integrate all aspects in planning and to maintain public infrastructure;
- to develop and communicate processes between the different countries/communities;
- to change the patterns of consumption and production in our societies.

Thus the term sustainable mobility stands for a process and a path to be followed, rather than simply representing a vision of a future situation. The following objectives can be mapped out for this path:

1. *To provide access to goods, resources and services, while reducing the need to travel - such that economic, environmental and social needs can be met efficiently and in an integrated manner.*
2. *To ensure that transport infrastructure and travel use does not exceed the capacity of the environment to withstand their impact.*
3. *To ensure that users pay the social and environmental costs of their transport decisions without making industry uncompetitive or preventing those on low incomes from meeting their transport needs.*
4. *To reduce the growth in car and lorry traffic to sustainable levels.*
5. *To ensure that transport infrastructure investments take proper account of environmental aspects.*
6. *To increase the choice, and encourage the use, of economically, environmentally and socially efficient transport modes.*
7. *To protect critical natural and physical capital.*
8. *To meet environmental quality standards based on critical ecological limits and precautionary public health requirements.*
9. *To ensure that renewable natural resources are used in ways which do not diminish the capacity of ecological systems to continue providing those resources over time.*
10. *To ensure that non-renewable natural resources are used in ways which account for future needs and the availability of alternative resources.*
11. *To enhance public health and safety, reduce accidents and improve security.*
12. *To ensure the economic and social acceptability of new measures.*

Based on these objectives, sustainable mobility can be defined in practical terms as:

A transport system and transport patterns that can provide the means and opportunities to meet economic, environmental and social needs efficiently and equitably, while minimising avoidable or unnecessary adverse impacts and their associated costs, over relevant space and time scales.

As in the pursuit of sustainable development, the challenge is to reconcile economic growth and social demands for mobility with the environmental and other costs of traffic movements. The solution is widely perceived to lie in an integrated approach, combining:

- a change in people's transport behaviour and the way they live (affecting travel demand, land-use patterns etc.);
- technological improvements to raise efficiency while reducing environmental impacts and improving safety;
- a pricing regime which incorporates the true costs of transport into decision-making, thereby influencing the overall consumption of transport services and promoting the least damaging mode of transport;
- a focus on accessibility, intermodality and mobility management, to meet transport needs with the most efficient traffic volumes and patterns, while respecting quality and other social goals such as safety and security.

2.2 Topics included in the theme

The impacts covered under this theme are:

- environmental sustainability
  - energy resource use
  - non-energy resource use
  - global warming
  - stratospheric ozone depletion
  - bio-diversity/habitat destruction
- local air quality
  - health
  - material damage (corrosion and soiling)
- regional air quality
  - crops, forestry, aquatic and terrestrial ecosystem damage
- nuisance
  - noise and vibration
  - visual intrusion/landscape degradation
  - severance
- waste
  - land contamination
  - water pollution

There are three types of measure that can be applied to reduce environmental impacts:

- **operational measures** which reduce the impact per vehicle-km or per unit of infrastructure;
- **strategic measures** that optimise the use of the vehicle or the transport system, for instance affecting the number of vehicle-km driven for a given transport "output";
- **demand measures** which reduce the actual demand for travel.

Operational measures include**:**

- technology improvements and optimum technology choice;
- good operating and fuel management practices, including effective monitoring of fuel use, driver awareness, training and incentive schemes, and preventive maintenance;
- traffic management schemes which smooth traffic flow.

Strategic measures include**:**

- optimising travel routes e.g. using routing software, vehicle location and direction systems, and traffic information systems;
- improving load factors e.g. through better utilisation of freight vehicles and car sharing, fleet management and logistics integration;
- mode switching for both freight and passenger transport.

Demand measures include**:**

- land-use planning;
- travel substitution methods such as tele-working, video conferencing and home delivery;
- influencing travel choice (time, route) in order to reduce congestion.

The policy instruments and levers which act on the operational, strategic and demand effects include:

- fiscal measures, pricing and incentives;
- regulatory measures;
- infrastructure measures, including traffic management;

- information and public awareness initiatives;
- voluntary agreements.

Many of these measures, instruments and levers form part of an integrated policy approach, where environmental impacts are balanced against other economic and social objectives. Such an approach and the associated RTD are discussed in some detail in the thematic paper on *Sustainable mobility - integrated perspective*. Therefore the current paper focuses specifically on the following environmental aspects:

- the development of mitigation measures, such as the control of vehicle emissions;
- the introduction of new environment-friendly technologies and transport concepts;
- the acquisition of knowledge and development of tools - to support environmental impact assessment and the formulation of integrated strategies for impact abatement.

2.3 Significance of the theme

The external costs of environmental impacts of transport are enormous - air pollution and noise are estimated to cost the EU at least 0.6% of GDP every year, or some 40 billion ECU (OECD, 1995)[4]. Over 90% of these costs are due to road transport, i.e. 90 ECU per person per year.

Air pollution problems (e.g. ozone) in summer are requiring that, on more and more occasions, citizens across Europe have to refrain from outdoor activities. It is estimated that thousands of European citizens die each year from just one form of air pollution (particulate matter). Transport causes over half the emissions of carbon monoxide and nitrogen oxide, and represents a major source of ozone precursors. Thus the local pollution effects are significant, especially given the close proximity of the main receptors (people) to vehicle tailpipes in urban areas. It has also been calculated that 20% of Europe's citizens (around 80 million people) suffer from unacceptable levels of noise from road traffic.

Some forms of pollution are expected to go down in the near-term on the basis of current policies (e.g. tighter vehicle emission and fuel quality standards). However, in the longer-term, transport emissions may increase again as traffic growth outstrips technological improvements. And despite the technological progress, some urban areas anticipate problems in meeting air quality standards for nitrogen oxides and particulate matter over the next ten years.

Meanwhile, emissions of the main greenhouse gas CO_2 are set to increase substantially. In particular, on current trends, CO_2 from transport will be some 40% higher in 2010 compared to 1990, whereas the Kyoto agreement is targeting a real reduction in CO_2 emissions economy-wide. Transport already accounts for around 26% of carbon dioxide emissions in the EU, and EU transport CO_2 emissions contribute about 3.5% of global CO_2 emissions. This means that the energy and climate change impacts of transport are moving high on the political agenda.

Road transport is generally perceived to be the greatest problem area for CO_2, partly due to traffic volumes, but also as a consequence of the high emissions per passenger-km/tonne-km. Passenger cars account for about 50% of transport CO_2, and road freight for about 35%.

Urban traffic is responsible for about half of the road transport figure. The specific emissions of CO_2 for the various modes have been estimated (EU average, 1995)[5] to be:

- passenger transport
  - car 125 g/pkm
  - bus 45 g/pkm
  - rail 65 g/pkm
  - air 175 g/pkm
- freight transport
  - road 190 g/tkm
  - rail 30 g/tkm
  - inland navigation 30 g/tkm
  - pipeline 7 g/tkm

For the transport sector as a whole, CO_2 emissions have been growing at a rate faster than GDP growth in Europe. In the period 1985 to 1995, economic growth in the EU-15 led to an increase in GDP of 26%, whereas CO_2 emissions from transport grew by 37%. In contrast, CO_2 emissions from the non-transport sectors seem to have been decoupled from general economic growth, with a 5% decline over the same period.

About 7% of the CO_2 growth from transport was due to a shift to less energy efficient modes, and 30% to transport growth in general. (The modal share of road for EU-15 freight transport has increased from 54 to 61 to 72% over the period from 1975 to 1985 to 1995. Similarly, the share of passenger transport undertaken by private car has increased by 18% since 1970, while the relative use of buses, urban rail, walking and cycling have all declined.)

Major impacts of transport sector emissions include:

- health - respiratory diseases and heart attacks;
- damage to buildings and crops;
- global warming.

Other impacts include the use of non-renewable primary aggregates, particularly for road construction and maintenance, and the burden of residues from vehicle disposal, which are expected to increase as the use of steel declines.

3. POLICY CONTEXT

3.1 Policy objectives related to the theme

The 1992 White Paper[6] on the future development of the CTP calls for a global programme in pursuit of sustainable mobility. This includes *measures to ensure that the development of transport systems contributes to a sustainable pattern of development by respecting the environment and, in particular, by contributing to the solution of major environmental problems such as the limitation of CO_2.*

Following on from this, the Common Transport Policy Action Programme 1995-2000[7] identifies as one of its three main areas:
"Improving quality by developing integrated and competitive transport systems based on advanced technologies which also contribute to environmental and safety objectives".

In more detail, the following policies and actions are proposed to address environmental sustainability:
- better integration of modes to give greater recourse to environmentally-friendly and energy-saving modes;
- stimulation of new technologies;
- land use planning to reduce the transport-environment impacts of business location and residential development;
- the identification of the environmental impact of transport as an integral part of policy planning - such as Strategic Environmental Assessment of the Trans-European Transport Network;
- active pursuit of modal shift towards the more environmentally friendly modes in the fields of costs and charges, setting the regulatory framework, technical harmonisation and infrastructure;
- internalisation of external costs.

The Fifth Environmental Action Programme for the period 1992-2000 set out a similar set of actions. In 1996, a Progress Report[8] on this Programme highlighted the following areas as priorities:
- demand side management;
- setting the prices right;
- infrastructure/modal shift;
- technical improvements;
- information and public awareness.

These actions would be applied at European, national and/or local levels. Specific points for action were:
- focusing more on the determinants of transport demand at a local/regional level and their implications for land-use planning;
- promotion of mobility-reducing initiatives (such as tele-working, car-free city centres and anti-mileage programmes);
- promoting research into traffic management and demand management;
- internalisation of external costs in transport prices;

- assessing Structural and Cohesion Fund support for projects to promote a better balance between modes;
- developing and applying a clear set of criteria and methodologies for the strategic environmental assessment of plans and programmes for infrastructure, including TEN-T;
- stimulating attractive and high quality public transport as an alternative to the car;
- developing a framework for environmentally-friendly freight transport including modal shift from road to rail or water, through supportive fiscal and regulatory policies and investments in the necessary infrastructure;
- stricter standards for air and noise emissions, and for fuels;
- stricter enforcement of standards and in-use control;
- further stimulation of research in relation to technical improvements, the dissemination of results and their practical application;
- increasing public awareness and education.

More recently, the Community's own role within the overall policy framework has been proposed in two Communications[9]. Its priorities within the transport sector are:

(a) to give greater attention to the determinants of transport demand by:
- developing measures to achieve a greater internalisation of external costs in transport prices, as a prerequisite for influencing user choices in order to arrive at a more rational level of transport demand;
- promoting the better integration of land-use and transport planning and promoting demand-management measures, such as the use of telematics;

(b) to pursue its aim of reducing the imbalances between the different transport modes, in particular by:
- developing and applying an appropriate set of criteria and methodologies for the strategic environmental assessment of transport infrastructure plans for trans-European networks;
- investigating possibilities for the use of Community funding to promote a better balance between transport modes;
- developing a framework for the solution of the environmental problems caused by traffic of heavy goods vehicles, including the situation of transit regions;
- promoting the use of more environmentally friendly modes of transport, for example by encouraging public transport;

(c) to further tighten the provisions on emissions and noise from road vehicles and aircraft and on fuel quality, to develop action to reduce CO_2 emissions from passenger cars and to strengthen Community provisions on the inspection and maintenance of vehicles;

(d) to promote exchanges of experience between local authorities in relation to sustainable transport initiatives, including local action-based Agenda 21 plans on the basis of co-operation between public authorities and local people.

A key policy action aimed at reconciling the individual objectives of sustainable mobility (economic, social, environmental) is in the area of costs, charges and pricing. This was addressed in the Green Paper on Fair and Efficient Pricing[10], which explored ways of making transport pricing systems fairer and more efficient - by giving users and manufacturers

incentives to adjust their transport behaviour. A subsequent White Paper[11] has further developed ideas on a harmonised approach to paying for infrastructure use across all modes of transport. The underlying principle is that charges should be related to marginal social costs, i.e. those variable costs that reflect the cost of an extra vehicle using the infrastructure, including "external" costs such as congestion, pollution and accidents. This is to remove the huge competitive distortions between modes, within modes and between Member States created by the existing different charging systems.

As far as severe localised air quality problems are concerned, Council Directive 96/92/EC on ambient air quality assessment and management was agreed in 1996. This established a framework under which the Community will agree air quality limit or guide values for specific pollutants. This new Directive requires the continuous monitoring and assessment of air quality especially in urban areas. Where air quality standards are exceeded, local air quality management plans have to be drawn up. These invariably will contain a strong transport element. Rising congestion could significantly affect the extent to which environmental objectives are met.

Concern over air quality was a key factor in the Auto-Oil Programme, where vehicle and fuel suppliers worked with the Commission to define cost-effective standards for future vehicle emission and fuel quality regulations. New standards have recently been embodied in EC Directives.

As far as CO_2 emissions are concerned, the direct link with fuel use and the absence of "end of pipe" solutions imply strongly increasing emissions on a business-as-usual trend. Passenger cars account for approximately 50% of transport CO_2 emissions and fuel efficiency improvements have recently been outweighed by a trend towards heavier and more powerful cars. The Community has adopted a strategy to reduce the CO_2 emissions from passenger cars through improved fuel economy. An important element of this strategy has been to conclude an environmental agreement with the European car manufacturer's organisation ACEA. ACEA's commitment (made on 27 July 1998)[12] is to achieve an emissions target of 140g of CO_2 per kilometre, for the average of new car sales by ACEA members in the EU by 2008. The agreement with ACEA has now been approved in the Council.

A considerable part of the additional costs associated with improved fuel efficiency of passenger cars is likely to be balanced by fuel savings. Future fuel use and cost are not major considerations at the moment of purchase. Therefore, fiscal measures to influence the decision of the buyer will be a major second pillar of the CO_2 strategy. In addition, a proposal on fuel economy labelling ("eco-labelling") has been prepared as the third pillar of the CO_2 strategy[13].

Following the Amsterdam Treaty, environmental protection requirements must be integrated into EU policies and activities to promote sustainable development. In this respect, the implementation of the Kyoto Protocol on CO_2 and other greenhouse gas emissions is seen as a priority area[14].

In June 1998, the Transport Council was invited to establish its own strategy for giving effect to environmental integration within its policy area. The first joint Transport-Environment Council invited the Commission to develop a comprehensive set of indicators of the sustainability of transport. These indicators will be used in the Transport Environment

Reporting Mechanism TERM (currently being established) to monitor the progress on the integration of environmental concerns in transport policies[15]. Environmental assessment of policy initiatives and work on indicators are also highlighted in the Commission's action programme 1998-2004 for transport[16].

The strategy for environmental integration for transport and other sectors has fed into an overall EU strategy for sustainable development[22], adopted by the European Council in Gothenburg in June 2001. This is seen as part of the preparation for the World Summit on Sustainable Development to be held in 2002 (Rio+10). The strategy calls for a shift of balance between the modes – towards the railways, inland waterways, short sea shipping and intermodal operations. Relevant measures have since been outlined in policy guidelines[23] for a new White Paper on the Common Transport Policy, due in 2001. The aim is to provide the European Community with a programme of actions to gradually decouple growth in traffic from economic growth, while respecting environmental concerns. One example of the proposed approach is to make air traffic management more efficient while controlling aircraft noise and pollution.

Another example of a modal strategy is the Community framework proposed to help resolve the environmental problems of heavy goods vehicles[17]. Such attention to specific problem areas is also seen in the recognition of the need for special treatment for sensitive areas like the Alpine regions[18] and the marine environment[19].

3.2 Policy issues related to the theme

Two key policy issues are:

- the appropriate scale of contribution of the transport sector in reaching the Kyoto targets for CO_2 emissions abatement, and the identification of the most appropriate policy measures;
- the identification of cost-effective policies for achieving air quality targets, covering vehicle emissions standards, fuel quality standards and non-technical measures.

A Community approach on transport and CO_2 has already been proposed[20]. Forecasts suggest that, up to 2010, the increase in CO_2 emissions could be halved using cost-effective approaches. However, the challenge is substantial: on unchanged trends, transport CO_2 emissions will be 40% higher in 2010 compared to 1990, whereas the Kyoto target is an economy-wide *reduction* of 8% from 1990 levels by 2008-2012. Therefore early and vigorous policy action will be needed. Promising policy approaches include[20]:

- improved logistics;
- strategy to reduce CO_2 emissions from passenger cars;
- revitalisation of railways;
- promotion of public transport;
- promotion of short-sea shipping;
- promotion of intermodal transport
- measures to enhance ATM in air transport;
- fiscal measures in aviation (kerosene duty, VAT);
- stepwise introduction of fair and efficient pricing in all modes of transport;
- Strategic Environmental Assessment of TEN-T transport infrastructure investments;

- promotion of a series of complementary measures to be taken by national, regional and local authorities, including land-use planning.

The Commission has now put forward a set of proposed common and co-ordinated policies and measures at Community level for greenhouse gas abatement[21]. These will complement national strategies for the energy, transport and industry sectors. The Community measures will be taken forward in the European Climate Change Programme, based on a multi-stakeholder approach. For the transport sector, the list of priority measures at Community level includes:

- transport pricing and economic instruments for aviation;
- a fiscal framework to support the strategy on "CO_2 and cars";
- extension of the environmentally enhanced vehicle concept to passenger cars and light duty vehicles (providing recognition of the most fuel efficient and low emission vehicles);
- a European campaign for more fuel efficient driver behaviour;
- revision of the Common Transport Policy, covering all modes;
- policies to address the growing concern over urban congestion, including pricing, fiscal measures, parking initiatives and improved public transport
- satellite assisted navigation systems (GALILEO);
- RTD investment.

The search for a common position on European fuel and vehicle standards for 2000 and 2005 has recently been settled by conciliation, following intensive analysis in the Auto-Oil Programme. This has centred on the identification of the most cost-effective means of reducing vehicle emissions and improving air quality (especially in urban hot spots). The issues have centred on determining (a) what benefits each technical change could deliver and at what cost, (b) the necessary level of emissions reduction to give acceptable air quality in "average" versus specific cities, and (c) the appropriate contribution of non-technical measures.

Other important policy issues where RTD may provide answers are:

- how large are the external costs of environmental damage, and therefore what levels of pricing are needed to internalise these costs? (Damages and external costs are difficult to estimate, and different methods give different answers).
- how do transport demand and location decisions respond to planning policies for land-use and transport infrastructure. (The effects are complex and develop over many years).
- what is the longer-term potential of new technologies such as fuel cells, and how can market penetration be assisted?

4. RTD OBJECTIVES

Environmental assessment is an aspect of many of the projects in the Transport RTD Programme. The focus in this paper is on RTD aimed specifically at underpinning policy development for the environmental aspects of sustainable mobility. However, it is instructive first to consider the broad range of environment-related RTD objectives, which are:

- to develop scenarios and transport policy options which reflect CTP targets and sustainable mobility strategies, with particular reference to environmental impacts and goals;
- to develop methods for valuing the externalities and real costs of transport systems (including comparison between modes), and assess their potential contribution to pricing measures;
- to develop indicators, models and methods for environmental impact assessment of transport systems and measures, across all modes;
- to develop strategies and policy instruments which would influence modal split towards more environment-friendly transport means;
- to develop strategies and policy instruments for rational management of demand and traffic patterns, with a view to minimising environmental impact cost-effectively;
- to assess the environmental impacts of new technologies and transport concepts, and assess the consequent policy issues;
- to assess the environmental impacts of the TEN-T, including strategic-level assessment;
- to define, develop and assess regulations, certification procedures, operational measures and in-service maintenance procedures affecting future vehicle emissions;
- to improve resource use and re-use in the building and maintenance of infrastructure.

The more specific set of RTD objectives addressed in this paper are:

- to develop operational and policy measures which directly reduce environmental impacts;
- to assess and promote environment-friendly technologies and transport concepts;
- to provide the means for environmental impact assessment.

In terms of the policy issues discussed in previous Sections, this RTD can be expected to make the following contributions:

- By providing a common basis for decisions on fair and efficient pricing, based on the best knowledge available, consensus among Member States on transport pricing across modes may be reached at an earlier point. This should lead to more rational decisions on technology choice, modal choice and travel patterns with reduced environmental damage.
- By pooling knowledge at a European level on the environmental impacts of different measures, best practice can be promulgated, consensus reached on regulations, and choices made between impact abatement measures on a cost-effective basis.
- By characterising the potential impacts of new forms of transport and associated technologies, policy options can be identified to promote beneficial innovations and to limit the detrimental side-effects of other trends.
- By developing shared state-of-the-art approaches to the estimation of impacts, environmental factors can be integrated into all areas of decision-making. This will impact on market actors responsible for procurement and operations, as well as transport policy-makers (e.g. responsible for Strategic Environmental Assessment).

5. SUMMARY OF RESEARCH CLUSTERS

5.1 Overview

As indicated previously, the main focus of this paper is on specific environmental aspects:
- the development of abatement strategies and mitigation measures such as regulations;
- the introduction of new environment-friendly technologies and transport concepts;
- the acquisition of knowledge and development of tools to support environmental impact assessment.

Therefore the research projects contributing to this environmental theme can be considered within three topic areas or "clusters". These clusters are:

Understanding environmental impacts

Mitigating the environmental impacts of transport

Development of environmentally-friendly forms of transport

In addition, other projects include research on the environmental benefits of more generic control strategies (e.g. pricing, traffic management and mobility management), and on the implications for CTP environmental objectives. These are covered in detail in the EXTRA thematic papers on *Sustainable mobility - integrated perspective* and *Urban transport*.

5.2 RTD clusters

This Section defines the scope of research in each cluster. More specific objectives are given in Section 6. The titles and objectives of relevant RTD projects are listed in Annex 1, together with a Table identifying the cluster to which each project contributes most strongly.

Understanding environmental impacts

Research on *assessment techniques* is providing new methods for measuring environmental impacts. This includes pollutant emission and dispersion, and the consequent damage to environmental receptors.

Evaluation tools are being developed to support decisions where environmental impacts form a key criterion. The specification of indicators forms an important aspect of this work. The research forms part of the preparatory work for Strategic Environmental Assessment of the TEN-T.

A series of projects are developing the methods for *evaluation of external costs*. Specifically from an environmental perspective, the interest is in ensuring that travel decisions reflect the environmental costs imposed by trips. Associated policy measures include fuel taxes, vehicle taxes, road user charges and parking fees.

Mitigating the environmental impacts of transport

Some research is aimed at *preparation of regulations*, showing how emissions can be measured and controlled. The RTD projects are typically mode-specific.

Related work looks more broadly at the development of *abatement strategies*. Again the research is generally mode-specific, and aims to provide tools and methods to help decision-makers assess the environmental consequences of current operations and alternative future strategies.

Development of environmentally-friendly forms of transport

One contribution to impact abatement is the introduction of *new technologies and transport concepts*. These may offer reduced emissions per vehicle, or encourage switching to more environment-friendly modes. Research in this area identifies the potential for innovation, its environmental and other impacts, and the policy options that can influence change.

Another way of reducing environmental impacts is to persuade travellers to minimise the number of vehicle trips by switching to *non-motorised modes*. Research in this area aims to support initiatives to promote walking and cycling instead of short car trips.

Other research in the Transport RTD Programme underpins the development of city logistics schemes for efficient transfer of goods to an urban delivery system. Such schemes are likely to have beneficial environmental side effects. This work is described in the EXTRA thematic paper on *Urban transport*.

6. SYNTHESIS OF FINDINGS FROM COMPLETED PROJECTS

This Section provides a synthesis of the research objectives and main findings from completed projects for each of the RTD clusters defined in Section 5. The key results, policy implications and achievements of individual projects are summarised in Annex 2.

Results from the following projects have been included in the current version of this thematic paper:

Clusters	**Relevant RTD projects**
Understanding environmental impacts	AFFORD, CANTIQUE, CAPRI, COMMUTE, FISCUS, INTERNAT, MEET, QUITS, TRENEN
Mitigating the environmental impacts of transport	ALT-MAT, ECO, EMARC, H-SENSE, METARAIL, SOURDINE
Development of environmentally-friendly forms of transport	ADONIS, FANTASIE, PROMISING, UTOPIA, WALCYNG

6.1 Understanding environmental impacts

Research objectives

Research in this area has developed tools for evaluating the environmental impacts of policy options. Specific targets have been:

- a methodology for assessment of aggregate emissions across all modes – supporting strategic environmental assessment (SEA);
- a comprehensive standard European database of emissions factors for the range of vehicle and fuel technologies used across Europe;
- a compilation of data on the environmental benefits of non-technical measures - leading to a ranking of measures in terms of cost-effectiveness and feasibility;
- innovative techniques for estimating the impacts of transport infrastructure corridors, such as remote sensing - in particular to help develop an effective approach to SEA of European transport networks.

In addition, research has laid the foundation for pricing policies that reflect environmental impacts. The evaluation of external costs is an essential step in the reform of pricing policy, aimed at charging users for the costs they impose on the transport system and on society. Objectives in this area have been:

- to provide a methodology for incorporating externalities into the evaluation of transport system costs, and to translate these into practical guidelines for decision-makers;
- to provide modelling tools to help identify optimal combinations of pricing and regulatory measures to solve energy-environment-transport problems, by taking external costs into account;
- to share best practice concerning research results on transport pricing and external costs.

Main findings

Strategic environmental assessment: a new instrument for the development of transport infrastructure networks

Policy development requires environmental assessments on a much larger scale than individual projects. In particular, the guidelines for the development of the Trans-European Transport Network (TEN-T) require the development of methods for strategic environmental assessment (SEA) of the network and complete corridors (Decision 1692/96/EC). This is to ensure that the full environmental impacts of the policy initiative are assessed, and not just the impacts of individual sections of infrastructure.

Therefore research has provided a methodology for Strategic Environmental Assessment (SEA) of transport policies, plans and programmes. This comprises:

- a framework covering the basic methodological requirements for SEA of multi-modal transport developments, together with guidelines on the integration of various analytical approaches (such as cost-benefit and multi-criteria analysis);
- detailed methods for assessing major types of impact (emissions, energy, noise, safety) for road, rail, air and waterborne transport. Methods for other impact categories such as land use and ecological damage were also outlined.

These impact assessment methods have been made operational in a software tool covering air pollutant emissions, energy consumption, noise and safety impacts. The tool focuses on

impacts at European, national, regional and corridor levels, aggregated from the impacts associated with individual transport links and nodes (such as urban areas, harbours and airports). The calculation includes the life-cycle emissions for power stations and refineries.

A pilot SEA of the TEN-T was then conducted (also exploiting other RTD outputs such as transport models and scenario forecasts). This provided an initial quantification of the impacts of TEN-T policies and infrastructure, and also demonstrated the feasibility of the SEA methods. TEN-T is 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. *TEN-T is estimated to reduce CO_2 emissions relative to a do-nothing scenario, and to improve traffic safety*.

Strategic environmental assessment of a whole network proved to be a very complex and challenging task. The value of SEA depends strongly on the quality of the scenarios studied, which have to reflect real alternative policies, and on the quality of the traffic forecasts. Data on land use and land take still lack sufficient homogeneity and completeness to envisage using them at a full European scale for the purpose of planning infrastructure according to environmental performance. However, strategic environmental assessment of corridors or at a regional level is more practicable and can usefully be carried out for planning purposes.

The harmonised compilation of emissions factors assists policy development
The SEA work was supported by the compilation of a comprehensive catalogue of methods and emissions factors for estimating pollutant emissions and energy consumption in transport. This catalogue has already contributed to policy-related initiatives in other areas:

- methodological support to Member States in reporting emissions according to their obligations under the UNECE Convention on Long Range Trans-boundary Pollution and the UN Framework Convention on Climate Change;
- assessment of vehicle and fuel standards to meet EU air quality objectives, within the Auto-Oil II programme.

New techniques will help to broaden the scope of Strategic Environmental Assessment
Research has identified new techniques that can be used to broaden the scope of SEA, to give a broader and more accurate assessment of the current and future impacts of the TEN-T. In particular, the work has:

- proposed indicators for the impacts of transport infrastructure on the landscape, differentiating different types of landscape according to value and vulnerability;
- proposed a framework for cumulative impact assessment, designed to take account of long-term effects and existing conditions (such as global warming);
- developed prototype software for the use of a geographic information system in SEA (e.g. to analyse data from remote sensing by satellite), applicable on EU (network), regional and local (corridor) levels;
- demonstrated that digital representations of the elevation of terrain can be combined successfully with representations of transport networks and corridors for the purpose of emissions modelling.

The work also highlighted the need for research to develop complex spatial models of biodiversity, as this is an important area of impact assessment for SEA where standardised and user-friendly methods are missing.

"Non-technical" measures can be cost-effective in reducing local pollutant emissions
One of the broad conclusions from Auto-Oil II was that Europe should not see new technologies as the only route to reducing emissions. Increasingly, air quality problems are confined to local "hotspots", which may be tackled more cost-effectively by local "non-technical" policy measures. Therefore a study has been made of the effectiveness of such measures in reducing traffic emissions, based on a review of existing European experiences.

The work found that *the most cost-effective measures to reduce CO_2, CO and NO_x emissions are typically parking charges, parking management regulations, road pricing and low emission zones.* A positive cost-benefit balance was identified for these measures when demonstrated in certain cities – although in other cities similar measures (particularly road pricing) have shown a benefit/cost ratio of less than one. Infrastructure-based measures such as bus lanes, freight distribution centres and telematics systems seem less cost-effective in meeting environmental objectives, on the evidence available to date.

Regulatory measures have given emissions reductions up to 6%, with parking management and traffic control working best in highly congested cities, while speed limits work well 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 proportion of car use. Improvements in public transport have given savings up to 6%, but with less effect in highly congested cities.

It was concluded that the following non-technical measures should be considered as prime candidates when developing local transport strategies:
- *in highly congested cities*, pricing policies (road pricing, parking pricing) complemented by regulatory policies such as parking controls;
- *in moderately congested cities with high car usage*, measures to promote public transport;
- *in less congested cities*, pricing and taxation (although with only limited effectiveness).

However, the expected costs and benefits have to be estimated for each city situation, and pilot testing may be the most practical first step, both to confirm expectations and to develop public acceptance.

Charges can take account of pollution and accidents in practice
In order to support the introduction of new pricing measures, a methodology has been demonstrated for assessing the various costs specific to individual journeys/routes, for different modes of transport, trip purposes, desired times of arrival and expected lengths of stay at destination. These costs include direct costs (e.g. fuel), the value of travel time, and external costs such as accidents, air pollution, noise and global warming. The methodology focuses on modal comparison, and therefore is useful for benchmarking purposes. For instance, substantially lower externalities (50% or less) have been illustrated for rail compared to road transport on selected major European routes. *This type of assessment is an essential prerequisite to the use of efficient pricing measures to control environmental damage and level the playing field between modes.*

To help decision-makers at a city level in applying such methods for themselves, *a handbook has been produced giving practical guidelines on evaluating the costs of urban mobility*. This is intended particularly for policy-makers, planners and the managers of operating companies.

Seven types of cost are addressed, i.e. those associated with infrastructure, vehicle-related operations, congestion, accidents, emissions, noise and other external effects. The reader is given a step-by-step method of estimating these costs for their own city, with worked examples. Given that the availability of data may vary from city to city, the handbook offers two levels of assessment with different data input requirements (light and full). The results show the extent to which users bear the costs they cause – whether full costs, external costs (such as environmental damage) or variable costs.

More generally, the Transport RTD Programme has provided a framework for information exchange between the large number of research projects on transport pricing. This activity set up a dialogue with Member States and sought to build consensus on the research results. Concerning the evaluation of external costs, it was concluded that *all of the main externalities (air pollution, global warming, congestion, accidents etc.) could be taken into account in pricing structures*, even though some uncertainty exists in their estimation. Specific evaluation methods were recommended for particular impacts.

Charges may go up or down

It was noted that the existing range of pricing policies in EU Member States is so varied that the effects of pricing reform have to be assessed on a case-by-case basis. The extent and direction of any price changes will depend strongly on current levels of taxation and charging. Nevertheless, as a broad conclusion, pricing reform to reflect "social marginal cost" would involve:

- a decrease in prices for inter-urban road and rail passenger transport and an increase in the price of urban road travel (particularly for the private car);
- an increase in prices for both road and rail freight.

Methods have been provided to implement and evaluate pricing reform

This conclusion on changes in price is based partly on evidence from econometric modelling carried out in the Transport RTD Programme. Models were developed to illustrate the performance of different policy instruments in reflecting external costs in transport prices:

- *Parking policies*: making all road users pay for the resource cost of their parking place plus an extra charge can be very effective, achieving 1/3 to 2/3 of potential societal benefits and reducing congestion.
- *Emissions taxes and standards*: stimulating the use of cleaner cars is important for urban areas, but may not be cost-effective in non-urban areas.
- *Fuel tax policies*: higher fuel taxes could reduce car traffic in urban areas and on peak period inter-urban trips. However, other traffic (such as off-peak road freight) may also be unjustifiably inhibited. Fuel taxes are therefore not a good instrument for pricing reform, due to the lack of differentiation between different transport markets.
- *Reduced subsidies to public transport*: once the pricing of car transport has been corrected, public transport fares should not be set below the marginal social cost and should differ between peak and off-peak periods.
- *Simple congestion pricing*: cordon pricing in urban areas and congestion pricing on inter-urban highways can realise a substantial fraction of the benefits of optimum pricing.

Other results from modelling suggested that policy packages based on marginal cost pricing give rise to substantial welfare benefits for the urban population. Annual gains typically vary between 100 and 400 Euros per capita, depending on the city context and measures applied.

Environmental benefits constitute a significant part of the welfare gain, ranging between 15 and 95% depending on the city.

6.2 Mitigating the environmental impacts of transport

Research objectives

Some of the research in this area has underpinned the preparation of regulations. For example, one target was to develop new methods for measuring noise and vibration from trains, to enable the evaluation of abatement measures.

Other work has focused on the abatement strategies themselves, aiming to share knowledge of best practice and assess their performance in real-life. Specific goals were:

- the identification of options for improving noise abatement in air transport;
- the definition of commercially viable systems and associated policy guidelines for the management of ships' waste;
- the development of tools to help port authorities, operators and policy-makers assess and control the environmental situation in ports;
- the modelling of silting and environmental pollution in harbours, as an aid to improving dredging procedures and traffic management;
- the development of practical methods for assessing the release of contaminants from new materials for use in road construction, and for controlling the dispersion of pollutants from the road surface to soil and groundwater;

Main findings

New techniques for measuring railway noise will support regulatory control

A range of techniques have been developed and tested for measurement of railway exterior noise. This is to support type testing of rolling stock, monitoring of ambient noise and diagnosis of the sources of noise. The techniques were shown to give greater accuracy and reproducibility than those specified in the existing standard for type testing, especially when comparing measured data between different sites.

In addition, new methods for separating vehicle and track noise have been demonstrated. These were found to be capable of quantifying the noise reductions due to technologies such as improved braking systems and bogie shrouds.

These results have already been fed into a new draft of the ISO standard, prEN ISO 3095 (exterior noise type testing of rail vehicles), increasing its reproducibility and enabling better assessment of noise control measures for rail vehicles and tracks. In the longer term, *the results will assist national authorities in determining measures needed for compliance with future Community legislation on noise*.

Policy on noise abatement in the air sector will require new evaluation tools

Research on noise abatement practices in the air sector found that, while there is common European legislation on aircraft noise, there is a lack of harmonisation between Member States in the application of noise abatement. To assess the potential noise benefits of any specific procedure, it is necessary to use a common and validated modelling tool. Problems with existing models were highlighted in an evaluation exercise – as a result, work on a new tool is in progress.

In addition, candidate procedures for noise abatement were assessed using case studies based on selected European airports. Promising procedures were identified for both the short term and the medium term.

The final outcome of research work on noise is expected to be the agreement of new approach and take-off procedures for all European airports, supported by simulation tools and automation tools. The work to date has laid the foundation for this.

Regulations on marine pollution are proving effective

In the maritime sector, research has supported the development and implementation of environmental management, often with a regulatory basis. For example, the MARPOL 73/78 Regulations implement the International Convention for the Prevention of Pollution from Ships, 1973, and define measures to protect the marine environment from operational pollution. These regulations have been developed over a number of years and are in place, but there is significant concern over their real workability. Consequently their performance has been assessed within the Transport RTD Programme.

The results indicated that the Regulations *are* having a positive effect on the marine environment, although data are sparse. Actions were recommended for the standardisation of recording and reporting of pollution, both afloat and ashore, to allow the effectiveness of MARPOL to be assessed more readily in the future.

An extensive survey of shipping companies and ports highlighted *the need for communications between the various parties in the waste management chain to be improved*, if the Regulations are to work cost-effectively and efficiently. The research concluded that this would require actions at a European level:

- to require all ports to prepare *waste management plans*;
- to set up a system of *independent audits* of port reception facilities.

In this respect, the Commission has already presented a proposal for a Council Directive on Port Reception Facilities for Ship-generated Waste and Cargo Residues[19].

Ports are taking up good practice in environmental management

Of course, waste management is just one aspect of the broader topic of environmental management. There is a growing interest in effective environmental management in the maritime sector, to meet the challenges of increasingly stringent regulations. This also reflects the development of standards for environmental management systems (ISO14000 and the European Eco-Management and Audit System, EMAS). In response, research has aimed to facilitate an exchange of experiences and best practice between port managers, in order to increase the cost-effectiveness of developing new environmental policies for individual ports.

A web-based information system has been provided incorporating the following modules:

- *A self-diagnosis method* that allows ports to assess their environmental situation and performance. This tool incorporates the requirements under the EMAS and ISO14000 standards.
- Data resources allowing each port to *benchmark* the resulting environmental situation with the results of other European ports.
- A database containing around 100 short *case descriptions of successful projects*.

- *A methodological guide* to assist port authorities in the process of analysing environmental issues and selecting appropriate monitoring methods.
- *A communication platform* for professionals in European ports dealing with environmental management.

The self-diagnosis method has been tested by more than 60 ports. The results showed increasing uptake of environmental management procedures, although many ports do not seem to have a clear picture of the financial implications.

The risks of environmental damage from dredging can be managed

The results also showed that ports perceive dredging to be one of their most important environmental issues. For example, many harbour sediments contain industrial and domestic pollutants, which could be released as a result of harbour operations or expansion. Therefore ports need tools for hydrographic surveying and the application of sediment data to improve dredging management.

In response, the Transport RTD Programme has provided methods permitting the most cost-effective sampling techniques and the most appropriate sediment management strategies to be applied. These include predictive sedimentological models and a new system for classifying sediments according to their environmental risk.

Recycled materials are an environment-friendly option for road construction

The use of alternative materials in road construction reduces the consumption of scarce natural aggregates and recycles materials that would otherwise be disposed of as waste. In most European countries, their use is relatively low at present – one reason is concern over the potential contamination of surface and ground waters by leaching.

Research has now provided a toolkit of testing methods, compiled case studies of the successful use of these materials, and identified a number of mitigation methods. Methods for testing the mechanical and hydrodynamic properties of alternative materials and their leaching behaviour have been provided, and a model devised to assess the impact on groundwater quality on a site-specific basis.

Inspection and monitoring of existing roads showed that *alternative materials give as good support to the road pavement layers as natural reference materials*, and sometimes better. The sites investigated ranged from northern Sweden to southern France, and hence covered a wide range of climatic conditions. The performance in the field was often better than would have been predicted from laboratory test results. Leaching tests and groundwater sampling indicated that *the alternative materials do not appear to be having any negative effect on groundwater quality.*

The work focused on the use of alternative materials in road construction, but its conclusions are applicable to other transport infrastructure such as railway and canal embankments and airport runways and taxiways.

6.3 Development of environmentally-friendly forms of transport

Research objectives

New technologies and transport concepts can reduce environmental damage by reducing vehicle-specific emissions or by influencing patterns of transport demand. The aims of the research in this area have been:

- to assess the technical, economic and environmental potential of such innovations;
- to develop policy guidelines on how to promote these concepts and remove policy/market barriers;
- to provide local actors with good practice guidance on their design, introduction and operation.

Non-motorised transport is another environment-friendly form of transport. Research has aimed at providing recommendations and guidelines for initiatives to promote walking and cycling instead of short car trips and to make these modes safer. This is particularly important given the high levels of exhaust emissions in heavily populated areas often associated with short car trips.

Main findings

Key technologies for policy purposes are telematics and advanced vehicles/propulsion

The Transport RTD Programme has studied the potential contribution of all sorts of new transport technologies and concepts. In addition, it has conducted more specialised investigations of promising areas.

The most wide-ranging review identified and assessed new technologies that could have a *major* impact on transport systems in Europe and the attainment of the objectives of the Common Transport Policy over the next 30 years. This provided a wealth of information covering specific technologies, vehicle and system concepts, their market shares, and the aggregate impacts on safety, efficiency *and the environment* across the EU.

Particularly promising technologies were seen as:

- *telematic technologies* – likely to be of benefit across all impact categories – such as on-board emissions management, multi-modal traveller information and trip planning, dynamic route planning and navigation, electronic tolling, anti-collision systems, smart cards, intelligent cruise control and traffic management systems;
- *fuel cell and hybrid propulsion systems*, offering significant energy and environmental benefits;
- *improvements in the conventional car*, such as advanced turbo-diesel engines, direct injection gasoline engines and reduced weight;
- *tilt rotor technologies* for air transport, giving significant fuel savings and noise reduction;
- *airships* for moving heavy and bulky loads;
- new systems for *personal rapid transit*;
- *road trains*.

Transport technologies require generic and specific policy support

The research also identified implications for policy. Policy options to promote new technologies can be generic (trying to improve the conditions for innovation) or specific to

certain selected technologies. Some experts on technology policy prefer generic options because these allow the market actors to come up with new ideas and the most cost-effective solution. However, the realisation of specific technologies often requires changes in legislation and regulations to remove barriers – generic policy action may be insufficient. Therefore a combination of the two approaches is recommended:

- *Generic* measures are needed across the transport sector, such as standardisation, R&D funding, pilots and demonstrations.
- Packages of policy measures should be directed towards *specific clusters* of technologies, such as propulsion systems, urban transport technologies, intermodal systems, air traffic management systems, travel information, and road traffic management and payment systems.

Guidance has been developed to support the introduction of cleaner vehicles and fuels

One of the primary targets for environmental improvement is urban transport, owing to the high density of traffic, people and historic buildings. *Cleaner vehicles and alternative fuels* have a vital role to play here, helping to eliminate pollution hotspots (in combination with urban transport measures). There are many barriers to the introduction of these new technologies, such as high capital and lifetime costs and a lack of refuelling infrastructure. However, certain niche applications such as public sector fleets can provide a way of lowering some of the barriers, supported by policy actions. In addition, demonstration projects are important in developing market acceptance.

Software tools and guidelines have been developed to help project managers and policy-makers develop appropriate strategies towards cleaner vehicles, based on test site experiences across Europe. These are available on the web, and include:

- an assessment of the *most promising applications* for cleaner vehicles and supporting measures, from a city perspective;
- recommendations on *policy actions* at the European and national levels to promote or facilitate market introduction and demonstration;
- a good practice guide to setting up and running *pilot and demonstration projects*, aimed at potential project champions;
- a software tool which provides information and *assessment methodologies* covering clean transport solutions, to support city planners and vehicle operators.

Key conclusions on the role of supporting policies were as follows:

- The most important policy measures are *fiscal incentives*. A distinction is needed between incentives to kick-start the market for individual fuels, and efficient incentives in the longer term that are not technology-specific (e.g. differential rates of fuel taxation based on relative environmental damage).
- *Demonstration projects* have an important role in testing technologies, stimulating the market and raising consumer awareness.
- Information measures such as *eco-labelling* and *green fleet certification schemes* are important, especially where the label remains on the vehicle in everyday use.
- *Green procurement* by Governments, whether voluntary or mandatory, can be significant in creating an initial market for new fuels and providing a signal to private consumers that these fuels are serious.
- *Technical standards* for vehicles and fuels are important in creating a unified market and ensuring consumer confidence.

- *Low Emission Zones* that allow city centre access only for clean vehicles, and *Quality Contracts and Partnerships* between local authorities and fleet operators, are new powerful tools for encouraging cleaner vehicles at a local level. Governments may need to provide the regulatory framework for their implementation and enforcement.

Guidance has been provided on good practice in promoting walking and cycling

Extensive research has been conducted into good practice to promote cycling and walking instead of short car trips in cities. This is particularly aimed at improving mobility conditions for people without access to a car. The outputs include catalogues of basic and innovative measures, and practical guidance on their implementation. Recommendations include:

- extending and improving *pedestrian areas*;
- providing *facilities for cyclists*, such as bicycle lanes and secure types of bicycle parking, and raising awareness of these facilities;
- introducing *bicycle registration* programmes and making it possible to insure bicycles against theft;
- using *awareness and incentive campaigns* aimed at behavioural and attitudinal changes towards cars, such as Car Free Days and taxation of workplace parking spaces;
- involving big companies, for instance establishing *mobility management plans* that emphasise non-motorised transport;
- *targeting travellers to/from schools and colleges* in order to influence transport habits at an early stage;
- *enforcing a maximum speed of 30 kph* on streets where walking and cycling are significant;
- developing local and national *policies for walking and cycling*, and appointing local authority staff to promote change in the city.

In addition, an evaluation tool has been produced in the form of interactive software. This is for use by city authorities in assessing the appropriate measures to promote walking and cycling in a certain area.

Surveys of people's behaviour and attitudes to mode choice showed that:

- walking is mainly considered for trips under 1 km, while cycling competes with cars for trips up to 5 km;
- the main factor which appears to encourage the use of the car is comfort;
- safety and bicycle security are major concerns, while non-cyclists also fear an increase in travel time if they switch to cycling.

Good practice has been compiled on traffic management for pedestrians and cyclists

One of the main barriers to walking and cycling was identified as the actual and perceived level of safety. To address this issue, a review of good practice in infrastructure design and traffic management has been prepared. For example, the costs and effects on safety and mobility of around 100 measures for pedestrians have been evaluated. It was concluded that *walking and cycling need to be planned as transport modes in their own right* – whereas current urban traffic planning systems in Europe commonly focus on cars, buses and trucks, making provisions for cycling merely as additional features of the traffic system for motor vehicles.

Cost-benefit analysis identified the following measures as the most important in promoting safety for pedestrians and cyclists:

- *a separate network of direct routes for pedestrians* and *a separate network of direct routes for cyclists*, segregated from motorised traffic and with a fair share of priority at crossings;
- a categorisation of roads to *separate flow traffic* from distribution traffic and access traffic;
- *area-wide speed reduction*, except on roads with a flow function for motorised traffic;
- development and implementation of *design standards* for infrastructure for pedestrians and cyclists;
- *regulations giving priority* to pedestrians and cyclists in urban areas;
- *education and driver training* that focuses on respect for other road users.

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ANNEX 1 RTD PROJECTS CONTRIBUTING TO THE THEME

This Annex lists (in alphabetic order) the titles and objectives of RTD projects relevant to the environmental theme. The following Table identifies the RTD cluster(s) to which each project contributes most strongly.

Clusters	**Relevant RTD projects**
Understanding environmental impacts	AFFORD, CANTIQUE, CAPRI, COMMUTE, FISCUS, INTERNAT, MEET, QUITS, TRENEN
Mitigating the environmental impacts of transport	AEROCERT, ALT-MAT, ECO, EMARC, H-SENSE, METARAIL, POLMIT, SOURDINE
Development of environmentally-friendly forms of transport	ADONIS, CATRIV, FANTASIE, PROMISING, UTOPIA, WALCYNG

Project acronym	Title	Objective(s)
ADONIS	Analysis and development of new insight into substitution of short car trips by cycling and walking	The project aims to provide recommendations and guidelines for initiatives to promote walking and cycling instead of short car trips. Best practice examples of cycle-friendly and pedestrian friendly infrastructure elements and other measures will be reviewed. Behavioural factors affecting modal choice and car-cyclist and car-pedestrian accidents will be identified.
AEROCERT	Aircraft environmental impacts and certification criteria	The main objectives are to provide and recommend options for improvements in the certification standards related to aircraft environmental impact. In particular, the project will check whether existing emission certification procedures reflect environmental impacts, and identify the effect of operational and maintenance procedures on certified emissions levels.
AFFORD	Acceptability of fiscal and financial measures and organisational requirements for demand management	The project aims to show that marginal cost based pricing measures are both efficient and feasible. The pricing methods to be considered include road user charges, parking fees, fuel taxes, vehicle taxes, and public transport fares and subsidies. In particular, it is intended to show that marginal cost pricing in combination with other fiscal and financial measures can in practice effectively internalise transport externalities such as congestion and environmental impacts, and can regulate demand in a way that is socially efficient and equitable. An equally important aim is to identify the institutional and political barriers to the implementation and acceptance of such pricing measures in Europe, and to show how they can be overcome.
ALT-MAT	Alternative materials in road construction	The aim of the project is to define methods by which the suitability of alternative materials for use in road construction can be evaluated.
CANTIQUE	Concerted action on non-technical measures and their impact on air quality and emissions	The purpose of CANTIQUE is to assess the effectiveness of non-technical measures in reducing traffic emissions, based on a review of existing European experiences.
CAPRI	Concerted action for transport pricing research integration	The aim is to facilitate dissemination to Member States of the results of projects dealing with the pricing of transport and to attempt to build up a consensus on the policy implications.
CATRIV	Conceptual analysis for transportation on rivers	The project aims to gauge the technical, economic and environmental feasibility of transporting passengers and goods on short distances in urban areas via inland waterways with a view to reducing road congestion.
COMMUTE	Common methodology for multi-modal transport environmental impact assessment	The aim of the project is to define a methodology for strategic assessment of the environmental impacts of transport policy options, in order to support transport policy decision making at the European level.

Project acronym	Title	Objective(s)
ECO	ECO-information in European ports	The project aims to provide practical and cost effective solutions to major environmental problems experienced in European ports which could provide the basis for the formulation by the European Commission of policies, guidelines and implementation programmes. Tools for use by individual ports will be provided.
EMARC	MARPOL rules and ship generated waste	The aim is to assess the problems of ship waste management and accidental discharges, and to investigate present and possible future systems for the management of ships' waste, both afloat and ashore. The work will include modelling of environmental changes, development of policy guidelines, and specification of commercially viable systems.
FANTASIE	Assessment of new technologies and environmental issues	The objectives are: to identify new technologies which are expected to have a major impact on EU transport systems and the attainment of CTP objectives; to provide a forecast and impact assessment for possible future transport systems; to identify policy implications; and to recommend a methodology for transport Technology Assessment at a European level.
FISCUS	Cost evaluation and financing schemes for urban transport systems	The project aims to analyse existing cost allocation methodologies and financing schemes for urban transport, and conceive new ones in response to identified gaps and weaknesses. The expected output is a European handbook for evaluating real urban transport costs and designing financing schemes.
H-SENSE	Harbours - silting and environmental sedimentology	The aim of the project is to develop a predictive sedimentological model for the management of harbour activities with regard to silting and the evaluation of environmental pollution. The applications of this model, especially dredging procedures and traffic management, will have importance for both the industrial potential and the overall environmental health of harbour waters and adjacent regions.
INTERNAT	Integrated Trans-European Network assessment techniques	The aim is to assess the potential of innovative techniques for environmental impact analysis of transport infrastructure corridors and plans, such as GIS and remote sensing.
MEET	Methodologies for estimating air pollutant emissions from transport	The aim of the project is to develop and provide models to estimate air pollutant emissions from transport activities for inclusion in strategic environmental assessment.
METARAIL	Methodologies and actions for rail noise and vibration control	The aim is to develop and apply new methods for measuring the noise and vibration from vehicles and trains, and to evaluate noise reduction methods.

Project acronym	Title	Objective(s)
POLMIT	Pollution of groundwater and soil by road and traffic sources: dispersal mechanisms, pathways and mitigation measures	The aims of the project are: to determine the importance of highway pollutants compared with other pollutant sources, to understand the dispersal mechanisms of these pollutants, to understand the physical and chemical impacts on the environment, and to develop practical measures which may be taken to control or mitigate this pollution.
PROMISING	Development and promotion of measures for vulnerable road users with regard to mobility integrated with safety taking into account the inexperience of the different groups	The objective of the project is to show the potential for reduction in casualties of vulnerable road users (like pedestrians, cyclists, motorised two-wheelers and young drivers) by technical measures that do not restrict mobility or directness of travel - in contrast to previous restrictive safety measures.
QUITS	Design and testing of an integrated methodology for the valuation of the quality of transport and systems and services in Europe	The aim of the project is to develop and validate a methodological framework for evaluating the direct and external costs of alternative transport modes on individual inter-urban routes.
SOURDINE	Study of optimisation procedures for decreasing the impact of noise around airports	The aim is to develop and assess noise abatement procedures in air transport to determine their contribution to reducing environmental impact. This includes improving current rules for approach and take-off procedures, and developing procedures based on new technologies.
TRENEN II STRAN	Models for transport, environment and energy - version 2. Strategic transport policy analysis	The aim of this project is to develop and apply a set of strategic models for transport policy assessment in the field of taxation, pricing, regulation and financing. The models look for optimum combinations of pricing and regulatory instruments to solve environmental, energy and pure transport problems.
UTOPIA	Urban transport options for propulsion systems and instruments for analysis	The main objective of the UTOPIA project is to provide decision-makers with the necessary tools and guidelines for hastening the market introduction of the most appropriate urban transport solutions based on new propulsion systems. The lessons from existing demonstration projects will be identified. Key outputs will include policy guidelines, a best practice guide to introduction methods for local transport operators, and an assessment of the most promising solutions.
WALCYNG	How to enhance walking and cycling instead of shorter car trips and make these modes safer	The aim of the project is to develop a conceptual marketing model for enhancing walking and cycling in order to replace shorter car trips and to make the walking and cycling modes safer. Existing 'products' for pedestrians will be evaluated and new products developed. Supporting soft policy measures (advertising, lobbying) will be defined in the guidelines.

ANNEX 2 MAIN FINDINGS FROM COMPLETED RTD PROJECTS

This Annex summarises the findings from completed projects for which the Final Report has been approved or made available. Project web page references are provided where known. Summaries of all projects are available from the two web sites given in Section 1 of this paper.

Index of RTD project results:

Project acronym and title	Key results and policy implications
ADONIS: **Analysis and development of new insight into substitution of short car trips by cycling and walking**	***KEY RESULTS*** ADONIS has provided general recommendations and guidelines regarding good practice to promote cycling and walking instead of short car trips in cities. It has produced a report and CD-ROM which include: • the first comprehensive European catalogue of (42) measures concerning walking; • a compilation of (60) innovative measures to promote cycling, as a complement to existing catalogues of basic measures. These measures include both technical solutions (such as infrastructure changes) and non-technical actions (such as education and planning). The relevance of measures is mapped onto specific situations by considering: • the extent to which a city already has certain measures in place; • the extent to which cycling and walking are already used; • the need to address two distinct groups – those who are, and are not, accustomed to cycling and walking. Recommendations for all cities include: • improving home delivery services; • introducing secure types of bicycle parking; • introducing bicycle registration programmes; • making it possible to insure bicycles against theft; • increasing the number of parking places for bicycles and decreasing the number for cars; • using awareness campaigns aimed at behavioural and attitudinal changes towards cars; • stimulating the creation and participation rates of cyclist and pedestrian organisations; • targeting travellers to/from schools and educational centres, in order to influence transport habits at an early stage. Surveys of people's behaviour and attitudes to mode choice in Amsterdam, Barcelona and Copenhagen showed that: • walking is mainly considered for trips under 1 km, while cycling competes with cars for trips up to 5 km; • the main factor which appeared to encourage the use of the car was comfort; • safety and bicycle security are major concerns, while non-cyclists also fear an increase in travel time if they switch to cycling. ***POLICY IMPLICATIONS*** The project concluded that walking and cycling require clear recognition within local and national transport policies and plans. This particularly requires changes with regard to walking, which enjoys little public advocacy (e.g. by lobbying groups). The choice of measures is largely dependent on the local situation. However certain recommendations can be made regardless of situation: • for Government - develop specific policies for walking and cycling, especially in terms of urban traffic priority and support for complementary public transport - activate employers, factories and shops to provide sufficient and safe cycle parking - activate shops to provide (free) delivery of goods • for transport planners

Project acronym and title	Key results and policy implications
	- use catalogues such as ADONIS to understand what package of measures would be most appropriate in a particular local situation, in what order of introduction. Measures specifically highlighted were: • to appoint a pedestrian and cyclist officer to advocate and promote change in the city • to promote incentives that make drivers experience the benefits of cycling and walking (e.g. Car Free Days) • to control car speeds by appropriate restrictions and/or enforcement.
AEROCERT: **Aircraft environmental impacts and certification criteria**	*The final results of this project were not available when this Thematic Paper was prepared.*
AFFORD: **Acceptability of fiscal and financial measures and organisational requirements for demand management**	***KEY RESULTS*** The aims of AFFORD were to define practical measures to implement marginal cost pricing for transport in cities, to assess the potential problems and to provide policy guidelines for introducing such measures. The project evaluated "first-best" and "second-best" policy packages based on marginal cost pricing, rather than assessing individual pricing measures. Results from modelling in four European cities (Athens, Edinburgh, Helsinki and Oslo) suggested that such packages give rise to substantial welfare benefits for the urban population. Annual gains typically vary between 100 and 400 Euros per capita, depending on the city context and measures applied. A major part of this gain may result from the effective use of the revenues, for instance allowing a reduction in labour taxes. (The benefits are therefore quite sensitive to the value or "shadow price" attributed to helping a government meet budget constraints without the need for distortionary taxation elsewhere in the economy.) The equity effects of pricing were estimated to be moderate (negative or positive). Environmental benefits constitute a significant part of the welfare gain, ranging between 15 and 95% depending on the city. Reductions in trips by private car range between 5 and 30%. Overall, accessibility is reduced, particularly for car users. However, if revenues are used to subsidise public transport services, then accessibility may even be increased for most of the population. Case studies and surveys in five cities indicated that the legal and institutional frameworks required to implement marginal cost-based pricing for urban transport have, so far, not been put in place. For example, these are different to the frameworks needed for road pricing on inter-urban motorways. Surveys of public, political and business acceptability of pricing were carried out in several cities. These showed a high awareness of the underlying pollution, congestion and parking problems, but relatively little knowledge of pricing instruments. In general, pricing was perceived to be effective, but likely to lead to disadvantages to stakeholders. A majority of motorists did not accept the proposed packages of pricing measures.

Project acronym and title	Key results and policy implications
	POLICY IMPLICATIONS
	The dependence of the welfare benefits of pricing on how the revenue is used implies that urban transport pricing is a general policy issue that goes beyond the local policy level and also beyond the transport sector. AFFORD concluded that the introduction of marginal cost-based pricing will require the creation of supporting institutions and laws, and the removal of inconsistencies in national-level policies. For example, strong institutions are needed with the powers to control multi-modal transport pricing across urban regions, rather than trying to construct complex relationships across multiple local authorities.
	Successful pricing will also need effective communication to overcome public opposition. Marginal cost pricing, especially prior to implementation, will be regarded with a lot of scepticism and even hostility. It may be politically vital to redistribute a significant majority of revenues to the local or regional population that pays, whether or not the funds are used for transport.
	PROJECT WEB PAGE: http://www.vatt.fi/afford/
ALT-MAT:	***KEY RESULTS***
Alternative materials in road construction	The use of alternative materials in road construction reduces the consumption of scarce natural aggregates and recycles materials that would otherwise be disposed of as waste. In most European countries, use of alternative materials in road construction is relatively low at present for several reasons, including high transport and treatment costs, uncertainties about the mechanical performance of alternative materials, and potential environmental concerns about contamination of surface and ground waters by leaching from alternative materials.
	The ALT-MAT project promotes the use of alternative materials in road construction by providing a toolkit of testing methods, presenting case studies in which such materials have been used successfully, and describing a number of mitigation methods. Methods for testing the mechanical and hydrodynamic properties of alternative materials and their leaching behaviour are provided, and a model for assessing the environmental impact on groundwater quality on a site-specific basis is presented.
	Inspection and monitoring of existing roads has shown that alternative materials give as good support to the road pavement layers as natural reference materials, and sometimes better. The sites investigated ranged from northern Sweden to south-western France, and hence covered a wide range of climatic conditions. The performance in the field was often better than would have been predicted from laboratory test results. Leaching tests and groundwater sampling have indicated that the alternative materials do not appear to be having any negative effect on groundwater quality.
	POLICY IMPLICATIONS
	Overall, the results of the ALT-MAT project are very positive and provide support for the use of alternative materials in road construction. This in turn will lead to less use of natural aggregates and reduce the amount of alternative materials sent to landfill sites. This is in line with the waste disposal options set out by the European Commission in the *Community Strategy for Waste Management* (COM(96) 399).
	The project focused on the use of alternative materials in road construction, but its

Project acronym and title	**Key results and policy implications**

conclusions are applicable to such other earth structures as railway and canal embankments and airport runways and taxiways.

The outputs from ALT-MAT can benefit several categories of end users, including engineering contractors and highway designers, scientists and researchers, environmental regulatory bodies, standardisation bodies, regulators and specifiers, and producers of alternative materials.

PROJECT WEB-PAGE: http://www.trl.co.uk/altmat/index.htm

CANTIQUE:

Concerted Action on non-technical measures and their impact on air quality and emissions

KEY RESULTS

The purpose of CANTIQUE was to assess the effectiveness of non-technical measures in reducing traffic emissions, based on a review of existing European experiences. The project found that the most cost-effective measures to reduce CO_2, CO and NO_x emissions were typically parking charges, parking management regulations, road pricing and low emission zones. A positive cost-benefit balance was identified for these measures when demonstrated in certain cities – although in other cities similar measures (particularly road pricing) have shown a benefit/cost ratio of less than one. Infrastructure-based measures such as bus lanes, freight distribution centres and telematics systems seem less cost-effective in meeting environmental objectives, on the evidence available to date.

Regulatory measures have given emissions reductions up to 6%, with parking management and traffic control working best in highly congested cities, while speed limits work well 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 proportion of car use. Improvements in public transport have given savings up to 6%, but with less effect in highly congested cities.

Extrapolation of city experiences to the European level by modelling indicated a potential for 16% abatement of the CO_2 emissions from transport in European cities (on average, but varying by country). This equates to a 6% contribution to the achievement of Kyoto targets.

CANTIQUE also reviewed the potential for transferring these experiences to Central and Eastern Europe. A number of barriers were identified, particularly in the policy and institutional frameworks (such as the need for better enforcement of regulations), and in the development of financing mechanisms to feed revenues into investments in infrastructure and public transport.

POLICY IMPLICATIONS

CANTIQUE concluded that the following non-technical measures should be considered as prime candidates when developing local transport strategies, according to the characteristics of the city in question:

- in highly congested cities, pricing policies (road pricing, parking pricing) complemented by regulatory policies such as parking controls;
- in moderately congested cities with high car usage, measures to promote public transport;
- in less congested cities, pricing and taxation (although with only limited effectiveness).

However, the expected costs and benefits have to be estimated for each city situation, and pilot testing may be the most practical first step, both to confirm expectations and

Project acronym and title	Key results and policy implications
	to develop public acceptance.
CAPRI:	***KEY RESULTS***
Concerted Action on transport pricing research integration	The purpose of CAPRI was to facilitate the transfer of information from research projects dealing with the pricing of transport. Key objectives were: • to aid dissemination of results to Member States and other stakeholders; • to develop a synthesis of research findings; • to help to build a consensus on the implications for policy. CAPRI drew conclusions in six areas (pricing principles, valuation of externalities, road pricing, rail and other public transport, air transport, and the likely impacts of pricing policy). These were based on EC-funded research as well as other evidence from inside and outside the EU. ***Pricing principles***: Pricing policy should be based on an understanding of marginal social costs, where the user pays the costs that they cause through additional infrastructure use. This will not deter trips that offer a net benefit to society, but it will discourage trips where the benefit to the individual user is less than the cost to society as a whole. Marginal social costs should be used as the starting point for price determination, with other important considerations such as financial needs incorporated in a way that does least damage to society's welfare. One of the main implications of pricing based on social costs is that prices should vary to a greater extent according to location and travel time. ***Valuation of externalities***: All of the main externalities (air pollution, global warming, congestion, accidents etc.) can be taken into account in pricing structures, even though some uncertainty exists in their estimation. CAPRI recommended specific evaluation methods for particular impacts. ***Road pricing***: Greater differentiation in road charges by time period and area is necessary to cope with congestion resulting from heavy peaks in travel demand. The main impact is likely to be travel at different times or by different routes, rather than a change in mode. To increase acceptability, the introduction of pricing should be staged, starting with simple systems with low charge levels, and the revenue should be earmarked for specific spending programmes such as public transport. ***Rail and other public transport***: Efficient pricing is likely to require greater peak/ off-peak differentials, and also an element of government funding (particularly for short-distance urban services). Improving the service quality and investment in infrastructure may be the most important measures for improving modal shares, as opposed to internalisation of externalities for all modes via the pricing mechanism – this is particularly the case for freight transport. ***Air transport***: Environmental pricing can be based on kerosene consumption and/or landing and take-off operations, but policy development in this area requires further research. ***Likely impacts of implementing efficient pricing***: Pricing based on marginal costs may result in price reductions for some modes as well as price rises for some others. For example, inter-urban passenger travel in uncongested conditions, by road or rail, is typically *over-priced* at present. For inter-urban freight transport, evidence suggests that there is often significant *under-charging* for both road and rail. Finally, urban transport by means of road-based modes is typically *dramatically under-charged*, particularly in congested conditions.

Project acronym and title	Key results and policy implications

POLICY IMPLICATIONS

The existing range of pricing policies in EU Member States is so varied that the impacts of marginal cost pricing have to be assessed on a case-by-case basis. The extent and direction of any price changes will depend strongly on current levels of taxation and charging, and will not necessarily imply lower travel demand. Nevertheless, as a broad conclusion, pricing reform to reflect social marginal cost would involve:

- a decrease in prices for inter-urban road and rail passenger transport and an increase in the price of urban road travel (particularly for the private car);
- an increase in prices for both road and rail freight.

Regulatory policy may often be more powerful than pricing policy in the control or reduction of some categories of environmental emission, such as noise. For emissions of greenhouse gases, CAPRI recommended that pricing should be based on political decisions about target emission levels, given the lack of consensus about the values to be placed on each tonne of pollutant.

PROJECT WEB PAGE: http://www.its.leeds.ac.uk/projects/capri

CATRIV:

Concepual analysis for transportation on rivers

The final results of this project were not available when this Thematic Paper was prepared.

COMMUTE:

Common methodology for multi-modal transport environmental impact assessment

KEY RESULTS

COMMUTE delivered two main end products:

- a methodology for Strategic Environmental Assessment (SEA) of transport policies, plans and programmes;
- a software tool for assessment of air pollutant emissions, energy consumption, noise and safety impacts.

The SEA methodology comprises:

- a framework covering the basic methodological requirements for SEA of multi-modal transport developments, together with guidelines on the integration of various analytical approaches (such as cost-benefit and multi-criteria analysis);
- detailed methods for assessing major types of impact (emissions, energy, noise, safety) for road, rail, air and waterborne transport. Methods for other impact categories such as land use and ecological damage are also outlined.

The software tool embodies the detailed methods. It focuses on impacts at European, national, regional and corridor levels, aggregated from the impacts associated with individual transport links and nodes (such as urban areas, harbours and airports). The calculation includes the life-cycle emissions for power stations and refineries. Output data are presented in a Geographical Information System, and also are differentiated according to the height of emission into the atmosphere. External input data include traffic flows and vehicle fleet composition.

A pilot SEA of the TEN-T was conducted in collaboration with three other projects. Each link and node in the TEN-T was assessed. The interfacing of the COMMUTE

Project acronym and title	Key results and policy implications

software with a transport model was also demonstrated, and comparisons made between COMMUTE results and those from other models.

POLICY IMPLICATIONS

The pilot SEA work provided an initial quantification of the impacts of TEN-T policies and infrastructure, and also demonstrated the feasibility of the SEA methods. TEN-T is 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. TEN-T is estimated to reduce CO_2 emissions relative to a do-nothing scenario, and to improve traffic safety.

ECO:

KEY RESULTS

ECO-information in European ports

The aim of the ECO-information project was to develop and test a dedicated information system for all types of ports and port authorities, designed to facilitate port environmental management. This system was required to be cost-effective, environmentally effective and practical.

The project has provided a web-based information system incorporating the following modules:

- A self-diagnosis method that allows ports to assess their environmental situation and performance, including periodic review of progress. This tool incorporates the requirements under the EMAS and ISO14000 standards.
- Data resources allowing each port to benchmark the resulting environmental situation with the results of other European ports.
- A database containing around 100 short case descriptions of successful projects, giving practical experiences with environmental solutions (both managerial and technical) contributed and updated on-line by various ports. Each solution is described in a standard format, and background information is given on the port characteristics and regulatory context to allow applicability in another port to be assessed.
- A methodological guide to assist 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.

The self-diagnosis method has been tested by more than 60 ports in the ECO network. Analysis of the aggregate results showed that the most important environmental issues are dredging and dredging disposal, waste management, health and safety impacts and water quality. Noise, dust and air quality are also significant. The most important drivers for environmental action are national/European legislation, port policy and complaints. The results also show increasing uptake of environmental management procedures.

27% of all environmental solutions in the database were reported by the participating ports to have resulted in cost savings. Good image and reduced complaints were also cited as benefits. However, many ports do not seem to have a clear picture of the financial implications of environmental management. Consequently they focus their attention on visible issues such as dredging and waste management, while other issues such as energy consumption remain less noticed.

Project acronym and title	**Key results and policy implications**
	POLICY IMPLICATIONS
	Network-based sharing of experiences and tools clearly has good potential for promoting the transfer of good practice. Previously there has been no unified method for assessing the environmental performance of ports, available on a European scale. The new self-diagnosis tool should support the wider implementation of certified environmental management systems, the possibilities of self-ruling in an industrial sector, as well as helping to highlight the effects of new legislation or the need for new regulations. However, it would need some further improvement before it is ready for introduction to all European ports.
	PROJECT WEB PAGE: http://www.ecoports.com/
EMARC:	***KEY RESULTS***
MARPOL rules and ship-generated waste	The MARPOL 73/78 regulations implement the International Convention for the Prevention of Pollution from Ships. They define measures to protect the marine environment from operational pollution such as oil, sewage and garbage. EMARC has provided a first evaluation of how effective and workable they are at a European level.
	Evidence collated by EMARC indicates that the MARPOL regulations are having a positive effect on the marine environment, although data are sparse. For example, oil pollution decreased by 60% in the 1980's. However, beach litter may have worsened subsequent to MARPOL.
	EMARC found that current environmental data are well intentioned but too fragmented for firm conclusions to be drawn. National statistics from ports are needed in a comprehensive and standardised form. In addition, the accurate reporting of annual totals for each MARPOL Annex would be a major step forward. This standardisation of recording and reporting on a long-term common basis, both afloat and ashore, is essential if the full impact of MARPOL and its degree of enforcement are to be assessed.
	An extensive survey of shipping companies and ports highlighted the need for communications between the various parties in the waste management chain to be improved, if the Regulations are to work cost-effectively and efficiently. This can be achieved relatively simply by ensuring that the ship reports its requirements, is acknowledged by the port and the information is passed on to the waste contractor. Measures such as the implementation of "port waste management plans" would set the framework for such a communications system.
	A conceptual model of the working of the MARPOL regulations has been developed. This is designed to help legislators assess the potential implications of a new rule or constraint in the shipping/port operational system.
	POLICY IMPLICATIONS
	EMARC concluded that improving and evaluating the implementation of MARPOL requires actions at a European level: • to establish criteria for assessing the environmental impact of the Regulations, and to provide common standards and databases for reporting quantities of waste; • to require all ports to prepare waste management plans; • to set up a system of independent audits of port reception facilities; • to establish common standards and procedures for beach monitoring campaigns and definition of beach litter sources.

Project acronym and title	**Key results and policy implications**
	In this respect, the Commission has already presented a proposal for a Council Directive on Port Reception Facilities for Ship-generated Waste and Cargo Residues, (COM(98)452).
FANTASIE:	***KEY RESULTS***
Forecasting and assessment of new technologies and transport systems and their impacts on the environment	FANTASIE identified and assessed new technologies that could have a major impact on transport systems in Europe and the attainment of CTP objectives. The project produced a wealth of information covering specific technologies (such as propulsion and information systems), vehicle concepts and transport system concepts, for a range of time horizons (2005, 2020 and 2030), journey types (urban, inter-urban etc.) and socio-economic scenarios. Particularly promising technologies were seen as: • telematic technologies – likely to be of benefit across all impact categories – such as on-board emissions management, multi-modal traveller information and trip planning, dynamic route planning and navigation, electronic tolling, anti-collision systems, smart cards, intelligent cruise control and traffic management systems; • fuel cell and hybrid propulsion systems, offering significant energy and environmental benefits; • improvements in the conventional all-purpose car, such as advanced turbo-diesel engines, direct injection gasoline engines and reduced weight; • tilt rotor technologies for air transport, giving significant fuel savings and noise reduction; • airships for moving heavy and bulky loads; • new systems for personal rapid transit; • road trains. Quantitative estimates of market shares and impacts at a European level were prepared. ***POLICY IMPLICATIONS*** Policy options to promote new technologies can be generic (trying to improve the conditions for innovation) or specific to certain selected technologies. Some experts on technology policy prefer generic options because these allow the market actors to come up with new ideas and the most cost-effective solution. However, the realisation of specific technologies often requires changes in legislation and regulations to remove barriers – generic policy action may be insufficient. Therefore FANTASIE recommended a combination of the two approaches: • Generic measures are needed across the transport sector, such as standardisation, R&D funding, pilots and demonstrations. • Packages of policy measures should be directed towards specific clusters of technologies, such as propulsion systems, urban transport technologies, intermodal systems, air traffic management systems, travel information, and road traffic management and payment systems. Specific policy proposals are included in the project Deliverables. ***PROJECT WEB PAGE:*** http://www.etsu.com/fantasie/fantasie.htm

Project acronym and title	**Key results and policy implications**
FISCUS:	***KEY RESULTS***
Cost evaluation and financing schemes for urban transport systems	FISCUS has produced a handbook giving practical guidelines on evaluating the costs of urban mobility and selecting ways to finance it. This is intended particularly for policy-makers, planners and the managers of operating companies. The handbook covers two main issues: who pays for what, and who puts up the money (e.g. for new investments). Seven types of cost are addressed, i.e. those associated with infrastructure, vehicle-related operations, congestion, accidents, emissions, noise and other external effects. The reader is given a step-by-step method of estimating these costs for their own city, with worked examples. Given that the availability of data may vary from city to city, the handbook offers two levels of assessment with different data input requirements (light and full). The results show the extent to which users bear the costs they cause – whether full costs, external costs (such as environmental damage) or variable costs. FISCUS reported evidence that existing pricing mechanisms and levels are failing to provide appropriate signals to influence behaviour. For example, prices need to show greater differentiation according to the time of day and current traffic levels. Also, existing financing mechanisms (which typically rely on user charges and public budgets) are often not providing sufficient funding for the infrastructure and services that would support an optimal mix of traffic. Therefore the relative merits of new mechanisms such as private finance, value capture (such as taxing land values that benefit from transport infrastructure investment) and cross funding (e.g. from private to public transport) are explained. FISCUS identified three financing *packages* for consideration, each combining various pricing mechanisms and sources of finance. The circumstances in which each package might work well are described. • One is based on electronic road pricing, parking/cordon charges and public transport tariffs all being differentiated by time of day, with public budgets providing subsidies and capital as necessary. • Another is again based on differentiated charges, but with private finance and value capture. • The third is based on making each mode commercially viable, with no subsidies or cross financing. The first two packages are given preference (against criteria of economic efficiency, acceptability and practical feasibility), with the choice depending primarily on the adequacy of funds for investing in the transport system. ***POLICY IMPLICATIONS*** The FISCUS handbook aims to provide practical support for both long-term mobility planning and short-term operational decisions. By promoting the harmonisation of the knowledge base for policy decisions across Europe, it should increase efficiency and fair competition between operators and modes. Electronic road pricing is often seen as the most powerful way of implementing efficient pricing. However, this will not necessarily be the most cost-effective or practical solution in many situations. Therefore FISCUS gives advice on simpler pricing solutions (such as parking and cordon charges), depending on city characteristics such as size, severity of environmental problems and the financial position of public transport. FISCUS concluded that there will be many cases where marginal cost pricing leaves a

Project acronym and title	Key results and policy implications
	need for additional funding. In most cases a mix of financing measures will be required, and FISCUS gives advice on when each mechanism is most likely to be appropriate. Public funding is seen as having many attractions, but may not provide adequate resources for investment, in which case a mix of private sector funding and simple approaches to value capture are recommended.
H-SENSE:	***KEY RESULTS***
Harbours – silting and environmental sedimentology	The aim of H-SENSE was to develop predictive sedimentological models for the management of harbour activities with regard to silting, evaluation of pollution, dredging procedures and traffic management. Through experimental work in the harbours of Göteborg (Sweden), Bergen (Norway) and Ventspils (Latvia), the project made recommendations on routine and specialist techniques for surveying sediment – including methodological developments resulting from this project. Geochemical databases were established for the three test harbours. These included the vertical distribution of sediment as well as spatial variations, since dredging and ship turbulence can affect sediment at considerable depth and thereby re-mobilise old contaminants. A new system for comparing contaminated sediments with different composition was proposed, since current classifications used by most harbour authorities are not sensitive to the mobility and toxicity of elements in different phases. Three modelling approaches were developed and compared for the spatial prediction of clay distribution, harbour bed conditions, zinc pollution and sediment thickness. Further work will be needed to take these tools into general application. GIS modelling may reduce the cost of monitoring schemes currently used by harbour authorities. ***POLICY IMPLICATIONS*** Hydrographic surveying and the application of sediment data are important for improved dredging management and environmental protection. Many harbour sediments contain industrial and domestic pollutants, which could be released as a result of harbour operations or expansion. H-SENSE has provided methods permitting the most cost-effective sampling techniques and the most appropriate sediment management strategies to be applied. The uncertainties in the distribution of sediment contamination, and in the significance of the various chemicals in given concentrations, favour the application of a risk-based approach to environmental protection. The generic modelling developed by H-SENSE provides a basis for the audit trail that is critical to such risk-based management. One of the main barriers to sediment modelling is the lack of suitable input data. H-SENSE recommended that harbours review their procedures and strive to construct archives containing the type of data shown to be valuable for modelling. Routine monitoring in connection with maintenance dredging, as well as specific construction and remediation projects, will, if planned appropriately, provide the basic requirements. This would substantially reduce the costs of modelling. ***PROJECT WEB PAGE:*** http://hjs.geol.uib.no/Hsense/index.html

Project acronym and title	**Key results and policy implications**
INTERNAT:	***KEY RESULTS***
Integrated Trans European Network assessment techniques	The guidelines for the development of the Trans-European Transport Network (TEN-T) require the development of methods for strategic environmental assessment (SEA) of the network and individual corridors (Decision 1692/96/EC). This is to ensure that the full environmental impacts of the policy initiative are assessed, and not just the impacts of individual sections of infrastructure. INTERNAT has assessed the potential for new and improved methods as part of an integrated tool for SEA in the following areas: • evaluation of the impacts of transport infrastructure on the landscape, differentiating different types of landscape according to value and vulnerability; • the use of indicators for spatial impacts, such as land take, noise, pollutant emissions and visual impact; • the choice of methods for cumulative impact analysis, designed to take account of long-term effects and existing conditions (such as global warming, forest die-off and development of new settlements in response to easier access); • the integration of recent standards for life cycle analysis (defined in ISO14040) into SEA methods, to take account of the environmental impacts of the production and disposal stages in a product's life as well as its use; • combining remote sensing for data capture with geographic information systems for data handling; • the modelling of the effects of terrain gradients on vehicle emissions. In developing the state-of-the-art in these fields, INTERNAT has: • proposed indicators for impacts on landscape; • proposed a framework for cumulative impact assessment within the SEA methodology for the TEN-T; • developed prototype software for the use of a geographic information system in SEA, applicable on EU (network), regional and local (corridor) levels; • demonstrated that digital representations of the elevation of terrain can be combined successfully with representations of transport networks and corridors for the purpose of emissions modelling. ***POLICY IMPLICATIONS*** INTERNAT has identified new techniques and methods that can be used to broaden the scope of SEA, so that it gives a broader and more accurate assessment of current and future impacts of the TEN-T. The project highlighted the need for research to develop complex spatial models of biodiversity, as this is an important area of impact assessment for SEA where standardised and user-friendly methods are missing. In addition, more spatially detailed databases are needed on land use, and quality control procedures should be used to ensure consistency between different databases. Further work is needed to make lifecycle and cumulative impact analysis methods practical.
MEET:	***KEY RESULTS***
Methodology for calculating transport emissions and energy consumption	MEET has compiled a comprehensive catalogue of methods, emissions factors and functions, for use in estimating pollutant emissions and energy consumption from transport. It covers all current vehicle technologies for all different types or classes of road vehicles, as well as rail, shipping and air transport. For road transport, cold start extra emissions, evaporative losses, road gradient and vehicle load effects are addressed. In addition, guidance is given concerning the emissions behaviour of future

Project acronym and title	Key results and policy implications

vehicles and fuels. Data are also provided on the pollutant emissions associated with energy production.

Examples of the use of the methodologies are given:

- For road and rail transport, a set of aggregated emissions factors have been calculated for use in simple strategic-level assessments.
- Comparisons are provided for passenger and freight journeys using different modes of transport.

POLICY IMPLICATIONS

The results from MEET are being incorporated in the COPERT3 methodology and the EMEP/CORINAIR Atmospheric Emission Inventory Guidebook. These tools are provided by the European Environment Agency to help Member States in reporting emissions according to their obligations under the UNECE Convention on Long Range Trans-boundary Pollution, the UN Framework Convention on Climate Change and the EC Monitoring Mechanism of Community CO_2 and other Greenhouse Gas Emissions.

The interim results have also been incorporated in the TREMOVE model of the EU transport sector, developed under the Auto-Oil II programme. This is being used to assess the most appropriate vehicle and fuel standards in order to meet EU air quality objectives in a cost-effective way.

In a third policy arena, MEET is contributing to the pilot study of the traffic and emission levels on the Trans-European Transport Network. The study is a building block to establish a Strategic Environmental Assessment methodology for taking into account high-level environmental policy objectives when decisions are made on individual infrastructure projects that will enhance the European transport system.

PROJECT WEB PAGE: http://www.inrets.fr/infos/cost319/index.html

METARAIL:	***KEY RESULTS***
Methodologies and actions for rail noise and vibration control	METARAIL developed techniques for measurement of railway exterior noise for the purposes of type testing of rolling stock, monitoring of ambient noise and diagnosis of the sources of noise. Thirteen techniques were studied, including the testing of four new ones. Hardware and/or software were developed for six techniques.

Some of the techniques have been put forward as potential improvements to the ISO3095 standard for railway exterior noise type testing. The changes would give greater accuracy and reproducibility, especially when comparing measured data between different sites.

These methods were applied in a round robin test with a special test train at sites in four countries. Due to the improved procedures, measurement results were reproducible within a range of +/- 2 dB(A), which is a substantial improvement on the previous range of +/- 5 dB(A) or more. This was only possible due to accurate assessment of rail roughness, accurate speed control and careful monitoring of site-specific characteristics.

New methods for separating vehicle and track noise were demonstrated, such as a low-noise reference vehicle method and improved acoustic antenna techniques. The procedures were shown to be capable of quantifying the noise reductions due to low noise solutions such as improved braking systems and bogie shrouds. For example, it was possible to show which part of the noise reduction was due to lower roughness

Project acronym and title	Key results and policy implications

and which was due to shrouds.

In the round-robin tests, cast-iron block-braked wagons were the noisiest, followed by sintered metal block-braked wagons (about 6-8 dB(A) quieter) and then disc-braked and shrouded wagons (a further 4 dB(A) quieter). The largest reduction was due to lower wheel roughness, which was comparable to the rail roughness levels at most of the test sites. The bogie shrouds reduced vehicle noise by 4-7 dB(A), but the effect was limited by the remaining track noise contribution.

POLICY IMPLICATIONS

The METARAIL project maintained an interaction with the European Rail Research Institute's Advisory Group on Noise and Vibration, the Union International de Chemin de Fer's Task Force on Noise, the CEN standards body and other stakeholders. The project results have already in part been fed into a new draft of the ISO standard, prEN ISO 3095 (exterior noise type testing of rail vehicles), increasing its reproducibility and enabling better assessment of noise control measures for rail vehicles and tracks. The results of METARAIL are also serving as input to an EU working group on railway noise, which is advising on impending noise legislation (via Interoperability Directives) on high speed and conventional rail systems.

In the longer term, the project results will assist national authorities in determining measures needed for compliance with future Community legislation on noise.

PROJECT WEB PAGE: http://www.schreiner.at/metarail

POLMIT:

Pollution of groundwater and soil by road and traffic sources: dispersal mechanisms, pathways and mitigation measures

The final results of this project were not available when this Thematic Paper was prepared.

PROJECT WEB-PAGE: http://www.trl.co.uk/polmit/gen.htm

PROMISING:

Promotion of mobility and safety of vulnerable road users

KEY RESULTS

PROMISING has:

- presented an overview of current legislation regarding walking, cycling and the use of powered two-wheelers with respect to traffic regulations, infrastructure design standards and legal limitations to vehicle use for young drivers and riders;
- highlighted best practice examples of innovative traffic concepts from Sweden and the Netherlands that aim to increase the safety of vulnerable road users;
- summarised design criteria for roads and traffic management schemes based on a knowledge of the specific mobility needs of pedestrians and cyclists;
- performed cost-benefit analyses for a set of twenty infrastructure (design) and organisational measures, ranging from roundabout design, upgrading of pedestrian crossings, design of dedicated bicycle lanes to e.g. the daytime use of lights on vehicles;
- outlined an implementation strategy that aims at a better balance between the interests of different road users, improved co-operation between local and national

Project acronym and title	Key results and policy implications

traffic authorities, and direct involvement of road users in planning and design processes.

POLICY IMPLICATIONS

A future, more mode-specific transport policy, addressing the particular requirements of pedestrians and cyclists, will have to come up with a set of practical criteria for traffic flow management, right of way regulations and other safety improvements for vulnerable road users. Cost-benefit analyses, evaluating improvements from the perspective of walkers and cyclists, are needed to avoid further bias towards the dominating motorised traffic.

QUITS:

Quality indicators for transport systems

KEY RESULTS

Decision-making on mode, technology and journey choices will be improved if all costs are taken into account - for a single journey, this means the direct costs (e.g. fuel and highway tolls), the value of travel time, and the external costs (e.g. air pollution and climate change). QUITS has demonstrated the viability of making a detailed bottom-up assessment of a wide range of such cost factors specific to individual journeys/routes, for different modes of transport, trip purposes, desired times of arrival and expected lengths of stay at destination. The QUITS methodology focuses on modal comparison, and therefore is useful for benchmarking purposes.

Case study calculations showed substantial reductions in external costs (due to air pollution, global warming, noise and accidents) for rail compared to road transport on selected major European routes. This applied to both passenger and goods transport, with savings of 50% or more. The total external costs for road transport on selected major European routes lay in the range 20-45 Euro per 1000 passenger/tonne-kilometres. The relative importance of each cost category varied with mode and route.

The bottom-up approach has provided far greater accuracy than previous top-down approaches, but includes the risk that the data collection effort could exceed the potential benefits. To overcome this issue, an intermediate approach is recommended, where "typical" values are identified for clusters of routes with similar characteristics and then used to generalise cost valuation on all routes.

POLICY IMPLICATIONS

The ability to value external costs is an essential prerequisite to the use of pricing measures to control environmental damage (as foreseen in the EC Green Paper "Towards Fair and Efficient Pricing in Transport"). QUITS has demonstrated the feasibility of evaluating external costs for journeys along specific routes, as part of the research base for the implementation of economically-efficient pricing measures in the European transport sector. However, the project has also identified the need for further research - both on the valuation methods used, and on the generalisation of the methodology for simplified application to other journeys. For example, the evaluation of *perceived* quality and security requires development work.

Project acronym and title	**Key results and policy implications**
SOURDINE: **Study of optimisation procedures for decreasing the impact of noise around airports**	***KEY RESULTS*** SOURDINE aimed to define and assess new procedures leading to a reduction in noise in the vicinity of airports, and to identify the requirements for simulation tools to validate such procedures. An inventory of current regulations and practices affecting aircraft noise was compiled, together with a study of the operational, safety, capacity and economic constraints that might influence the definition of new procedures. Five models for predicting noise exposure around airports were evaluated, and recommendations made on the capabilities and key variables for modelling. Noise abatement procedures have been selected and assessed, partly using case studies based on the Amsterdam-Schiphol, Madrid-Barajas and Napoli-Capodichino airports. For the short term, promising procedures are: • an increased altitude before the aircraft enters its final glide slope; • a reduced landing flap setting; • delayed establishment of landing configuration; • an optimised take-off procedure with rapid initial climb; • a continuous descent approach procedure (for use outside peak hours). Cost-benefit analysis highlighted the value of an approach procedure combining delayed stabilisation, reduced landing flap setting and an intercept altitude of 3000 ft for the start of the glide slope. This can reduce noise with no loss in airport capacity. In the medium term, promising procedures are: • an advanced continuous descent approach, aided by aircraft and air traffic control systems; • gradual increase of cutback thrust during climb out; • an accurate routing to and from the airport using precision area navigation systems; • an increased glide path angle. ***POLICY IMPLICATIONS*** SOURDINE found that, while there is common European legislation on aircraft noise, there is a lack of harmonisation between Member States in the application of noise abatement, particularly due to differences in modelling techniques and noise indicators. To assess the potential noise benefits of any specific procedure, it is necessary to use a common and validated modelling tool. Problems with existing models have been highlighted, and a current Eurocontrol project is working on a new tool. SOURDINE established the framework for further research to simulate and validate new procedures for noise abatement. Future work should look at the following as means of noise abatement: the use of cockpit tools for management of aircraft energy, advanced air traffic management functions, automated thrust management, and air-ground interaction between the flight management system and the arrival manager. This will require a collection of separate simulation tools, rather than an integrated validation platform. The final outcome of the research programme on noise is expected to be the agreement of new approach and take-off procedures for all European airports, supported by simulation tools and automation tools. ***PROJECT WEB PAGE:*** http://www.nlr.nl/public/hosted-sites/sourdine

Project acronym and title	Key results and policy implications
TRENEN II STRAN: **Models for transport, environment and energy – version 2 – strategic transport policy analysis**	***KEY RESULTS*** Econometric models have been developed which compute optimum prices for transport in specific cities and countries. These prices take account of external costs (such as congestion, pollution, noise and accidents) as well as taxes and resource costs. In a series of case studies, comparisons have been made between current and optimum prices. Typically, the consumer price for using a car in a city in peak periods covers only one third to half of the full marginal social cost. There are two main sources for this discrepancy: unpaid parking and the external costs of congestion. In off-peak periods, prices and social costs are much closer. By comparison, for bus travel, prices are similar to social costs. In an optimal pricing scenario, prices for car travel typically could rise by 100-250% in peak periods, depending on the city context. Current transport taxes in European cities are more or less equal between peak and off-peak. This implies that society would benefit from raising the price of using a car in peak periods. Cordon pricing (for urban access, differentiated between peak and off-peak) combined with charging for parking at resource cost is found to achieve the majority of the theoretical maximum benefit. For *inter-urban* transport, pricing inefficiencies are generally less significant. Prices of peak period car and truck use do not cover congestion costs. Bus transport is typically heavily subsidised and under-priced. Rail freight and inland waterways have prices that are reasonably in line with social costs. ***POLICY IMPLICATIONS*** The case studies indicate the relative performance of different pricing policy instruments: • **Parking policies**: making all road users pay for the resource cost of their parking place plus an extra charge can be very effective, achieving 1/3 to 2/3 of potential societal benefits and reducing congestion. • **Emissions taxes and standards**: stimulating the use of cleaner cars is important for urban areas, but may not be cost-effective in non-urban areas. • **Fuel tax policies**: higher fuel taxes could reduce car traffic in urban areas and on peak period inter-urban trips. However, other traffic (such as off-peak road freight) may also be unjustifiably inhibited. Fuel taxes are therefore not a good instrument for pricing reform, due to the lack of differentiation between different transport markets. Tax evasion may also result, across international borders and through non cost-effective investment in highly fuel-efficient vehicles. • **Reduced subsidies to public transport**: once the pricing of car transport can be corrected, public transport fares should not be set below the marginal social cost and should differ between peak and off-peak periods. • **Simple congestion pricing**: cordon pricing in urban areas and congestion pricing on inter-urban highways can realise a substantial fraction of the benefits of optimum pricing.

Project acronym and title	**Key results and policy implications**
UTOPIA:	***KEY RESULTS***
Urban transport: options for propulsion systems and instruments for analysis	The UTOPIA project aimed to provide project managers and policy-makers with the necessary information base, tools and guidelines to support the introduction of promising urban transport solutions based on cleaner vehicles. The project developed four major outputs (available on the web at http://utopia.jrc.it/): ***An assessment of the most promising applications for cleaner vehicles and supporting measures, from a city perspective*** This report assesses fuel options and applications for cleaner vehicles, and describes how best to introduce clean vehicles into cities using well-targeted demonstration projects backed by policy actions. It is illustrated by examples drawn from across Europe. ***Recommendations on policy actions at the European and national levels to promote or facilitate market introduction and demonstration*** This report examines the potential benefits of cleaner vehicles, including the results of European-level modelling. It looks at government activities across Europe: programmes of pilot and demonstration projects, and supporting measures such as tax incentives, emissions standards and green procurement. Finally it presents recommendations for: • best practice in the design of programmes of pilot and demonstration projects; • key supporting policies which can make a major impact on the introduction of cleaner vehicles in European cities. ***A good practice guide to setting up and running pilot and demonstration projects, aimed at potential project champions*** These guidelines cover the decision points and evaluation phases through the entire lifecycle of a demonstration project. Guidance is given on what to do and consider at each stage. This is supported by examples and good practice recommendations derived from a wide variety of European project experiences. The guidelines focus on urban applications of two-wheelers, cars, buses, vans and trucks. ***A software framework ("NAVIGATE UTOPIA") which provides information and assessment methodologies covering clean transport solutions*** This is primarily to support people at the local level (such as city transport planners) in pre-screening options and building the arguments in favour of a local initiative. It is a user-friendly web-based tool. Within its structured framework, it provides a wide range of information, case studies and decision aids generated within the wider UTOPIA project. It also incorporates a multi-criteria tool for assessing the promising transport options for a specific city situation according to *local* policy objectives. ***POLICY IMPLICATIONS*** UTOPIA concluded that there is a need for alternative and renewable transport fuels. However, their current costs and other limitations in vehicle applications mean that market entry will be typically be via particular niches such as urban buses. Supporting policies were evaluated: • The most important policy measures are *fiscal incentives*. A distinction is needed between incentives to kick-start the market for individual fuels, and efficient incentives in the longer term that are not technology-specific (e.g. differential rates of fuel taxation based on relative environmental damage). • *Demonstration projects* have an important role in testing technologies, stimulating the market and raising consumer awareness. • *Eco-labelling* and *green fleet certification schemes* are important, especially

Project acronym and title	Key results and policy implications

where the label remains on the vehicle in everyday use.

- *Green procurement* by Governments, whether voluntary or mandatory, can be significant in creating an initial market for new fuels and providing a signal to private consumers that these fuels are serious.
- *Standards* for vehicles and fuels are important in creating a unified market and ensuring consumer confidence.
- *Low emission zones* that allow city centre access only for clean vehicles, and *Quality Contracts and Partnerships* between local authorities and fleet operators, are new powerful tools for encouraging cleaner vehicles at a local level. Governments may need to provide the regulatory framework for their implementation and enforcement.

PROJECT WEB PAGES:
http://utopia.jrc.it/ (NAVIGATE UTOPIA decision support system)
http://www.utopia-eu.com/ (project description and results)

WALCYNG:

How to enhance walking and cycling instead of shorter car trips and to make these modes safer

KEY RESULTS

WALCYNG has produced an evaluation tool to show how walking and cycling can be promoted as an alternative to short car trips. This interactive software is intended for use by city authorities in assessing the preconditions for walking and cycling in a certain area, and as a support when developing measures. It provides:

- an inventory of solutions;
- a structured checklist of all relevant aspects to be considered;
- practical guidance on implementation, with examples of successful initiatives;
- advice on how to motivate change.

The project has provided practical support for stakeholders seeking change, such as:

- incentive and communication strategies;
- briefings and counter-arguments to assist proponents of walking and cycling in meeting the anticipated barriers/opposition;
- advice on lobbying – which is particularly important given that pedestrians currently lack an organised lobbying movement.

In a survey of European cities, the most common measures were found to be the extension and improvement of pedestrian areas and bicycle lanes.

POLICY IMPLICATIONS

The promotion of walking and cycling primarily requires policy action. Parking restrictions in inner city areas and improvements in public transport are commonly seen as important. Infrastructure measures to improve facilities for walking and cycling are also emphasised by city planners, together with public relations measures such as providing maps of the bicycle network and communicating the availability of new facilities.

Three incentive strategies are proposed by WALCYNG:

- incentives such as tax reductions for employers to establish mobility management plans for their employees;
- incentives for the general public, such as Car Free Days and reduced entry fees;
- direct incentives to employees, such as taxation of parking spaces.

A particular policy concern would be the increase in accidents if walking and cycling were promoted without corresponding action to enhance safety levels for walkers and cyclists. One of the most important measures recommended is to ensure a maximum

Project acronym and title	Key results and policy implications
	speed of 30 kph on streets where walkers and cyclists are present. The project recommended public support for pilot and demonstration projects, particularly to assess integrated packages of measures. Co-operation with big companies and institutions would be important here.