EFFICIENCY IN SUSTAINABLE MOBILITY
THEMATIC RESEARCH SUMMARY
Efficiency in Sustainable Mobility

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Marco Valerio Salucci

Date 12-02-2009
### Abbreviations and acronyms used

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
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<tbody>
<tr>
<td>ACARE</td>
<td>The Advisory Council for Aeronautics Research in Europe</td>
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<tr>
<td>ADAS</td>
<td>Advanced Driver Assistance Systems</td>
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<td>ADS-B</td>
<td>Automatic Dependent Surveillance - Broadcast</td>
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<td>AS</td>
<td>Airborne Surveillance</td>
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<td>ASAS</td>
<td>Airborne Separation Assistance System</td>
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<td>A-SMGCS</td>
<td>Advanced Surface Movement Guidance and Control System</td>
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<td>ATC</td>
<td>Air Traffic Control</td>
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<td>ATCo</td>
<td>Air Traffic Controller</td>
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<td>ATM</td>
<td>Air Traffic Management</td>
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<tr>
<td>CBA</td>
<td>Cost Benefit Analysis</td>
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<td>CEC</td>
<td>Commission of the European Communities</td>
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<td>CTP</td>
<td>Common Transport Policy</td>
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<td>DSRC</td>
<td>Dedicated Short-Range Communication</td>
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<td>EATMS</td>
<td>European Air Traffic Management System</td>
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<td>EC</td>
<td>European Commission</td>
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<td>EDP</td>
<td>Electronic Data Processing</td>
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<td>EFC</td>
<td>Electronic Fee Collection</td>
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<td>EIRAC</td>
<td>European Intermodal Research Advisory Council</td>
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<td>ERA</td>
<td>European Research Area</td>
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<td>ERRAC</td>
<td>European Rail Research Advisory Council</td>
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<tr>
<td>ERTMS</td>
<td>European Rail Traffic Management System</td>
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<td>ERTRAC</td>
<td>European Road Transport Research Advisory Council</td>
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<td>EU</td>
<td>European Union</td>
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<td>DGTREN</td>
<td>Directorate General Transport and Energy</td>
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<td>Acronym</td>
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<td>FP4</td>
<td>Fourth Framework Programme</td>
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<td>FP5</td>
<td>Fifth Framework Programme</td>
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<td>FP6</td>
<td>Sixth Framework Programme</td>
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<tr>
<td>GDP</td>
<td>Gross Domestic Product</td>
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<td>GS</td>
<td>Ground Surveillance</td>
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<td>HGV</td>
<td>Heavy Goods Vehicles</td>
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<td>IC</td>
<td>Integrated Circuit</td>
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<td>ICT</td>
<td>Information and Communication Technologies</td>
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<td>IST</td>
<td>Information Society Technologies</td>
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<td>IT</td>
<td>Information Technology</td>
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<td>ITS</td>
<td>Intelligent Transport Systems</td>
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<tr>
<td>KA</td>
<td>Key Action</td>
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<td>LCC</td>
<td>Life Cycle Cost</td>
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<td>MOS</td>
<td>Maritime Operational Service</td>
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<td>PDA</td>
<td>Personal Digital Assistant</td>
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<td>RD&amp;I</td>
<td>Research, Development and Innovation</td>
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<td>RIS</td>
<td>River Information Services</td>
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<td>RTD</td>
<td>Research and Technological Development</td>
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<td>RU</td>
<td>Railway Undertaking</td>
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<td>SAR</td>
<td>Search And Rescue</td>
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<td>SIRA</td>
<td>Strategic Intermodal Research Agenda</td>
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<td>SMCP</td>
<td>Social Marginal Cost Pricing</td>
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<td>SME</td>
<td>Small Medium Enterprise</td>
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<td>SRRA</td>
<td>Strategic Rail Research Agenda</td>
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<td>SRA</td>
<td>Strategic Research Agenda</td>
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<td>TEN</td>
<td>Trans-European Networks</td>
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<td>TMA</td>
<td>Terminal Management Area</td>
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<td>TN</td>
<td>Thematic Network</td>
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<tr>
<td>Acronym</td>
<td>Description</td>
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<tr>
<td>TRKC</td>
<td>Transport Research Knowledge Centre</td>
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<td>TRS</td>
<td>Thematic Research Summary</td>
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<td>VTMIS</td>
<td>Vessel Traffic Management and Information System</td>
</tr>
<tr>
<td>WATERBORNE</td>
<td>The Advisory Council for Waterborne Transport Research in Europe</td>
</tr>
<tr>
<td>WSRA</td>
<td>Waterborne Strategic Research Agenda</td>
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Thematic Research Summary: “Efficiency in Sustainable Mobility”

Foreword

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

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

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

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

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

Disclaimer

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

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

The paper is one of the thematic research summaries (TRS). The TRSs aim at providing a synthesis of research results and policy implications from completed projects. Each TRS deals with a theme according to the classification which the TRKC project has adopted. The theme of this TRS is “efficiency of transport systems”.

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

The theme “efficiency of transport systems” deals with the minimisation of the resource costs of a given transport system and the maximisation of its performance. Costs considered include those borne by the transport users and those by the transport operators. The relief of congestion and reliability is a significant element in the consideration of efficiency. External costs borne by society at large such as those of accidents and of environmental impacts are not considered as they are tackled within other TRSs.

Policy developments at EU level have traditionally been related to: the promotion of intermodality and interoperability, with particular regard to traffic management systems; the development of the Trans-European network infrastructure; legislative initiatives to open market of transport services to competition; infrastructure charging as a means to achieve better modal balance. Recently, the principle of co-modality has been advocated to achieve optimal utilisation of resources by efficient use of different modes on their own and in combination.

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

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

In the sub-theme concerning infrastructure and vehicle development and maintenance:
- long-term perspectives linking long-term visions and ideas to short-term actions in order to support policy-makers and decision-makers in taking the right decisions concerning use, design, construction and maintenance of infrastructure have been developed (Vision 2040);
- in the field of construction and maintenance of infrastructures, research has shown that progresses in optimisation of existing concepts will no longer meet the more and more demanding requirements, so it is necessary to develop new concepts, for which the introduction of new proven research technologies from other sciences such as physics and chemistry is vitally important.

In the sub-theme concerning traffic management and control:
- an operational concept validation methodology has been developed, which makes the concept validation in ATM (Air Traffic Management) R&D projects easier, facilitating earlier and more consistent evaluation of the fitness for purpose and adequacy of the concept, both for stakeholders and project managers, allowing adjustment to take place at a earlier stage, and making possible and significant comparisons among different projects;
- significant progress in the global definition, harmonisation, and validation of ASAS (Airborne Separation Assistance System) and ADS-B (Automatic Dependent Surveillance – Broadcast) applications on ground surveillance (GS) and airborne surveillance (AS) has been achieved;
- two scenarios were developed to assess through simulations a number of objectives for improving air traffic;
- a Maritime Operational Services (MOS) concept, which integrates several maritime operational services (such as Vessel Traffic Management – VTM and Search and Rescue – SAR) to enhance efficiency of maritime transport, have been developed.

In the sub-theme concerning terminals:
- the A-SMGCS (Advanced Surface Movement Guidance and Control System) concept has been extended and demonstrated by adopting an holistic, integrated air-ground approach that considers aircraft equipped with advanced systems for pilot assistance and controllers supported by A-SMGCS ground systems, which ensures consistency of traffic information given to controllers and pilots, increasing the safety and efficiency of operations;
- an affordable new acoustic system which can contribute to a better efficiency in managing airport operations by alerting controllers when a plane leaves its flight path by over six nautical miles;
• a decision making tool-set, which can address, through integrated impact and trade-off analyses for a variety of performance measures, a number of important decisions regarding airport development, planning and operations, has been developed;

In the sub-theme concerning multimodal networks:
• all kinds of organizational and business models within intermodal transport chains have been examined identifying best practice cases, and an inventory of projects and operational solutions for intermodal infrastructures and equipment was produced;
• an assessment of general progress in the establishment of a European railway area and the identification of significant best practices and particularly critical situations have been performed;
• an action strategy on intermodal rail-road transport services involving major scientific and technological activities in order to lay the foundations for achieving a significant and sustainable increase in intermodal volume on the Brenner corridor has been developed and demonstrated.

In the sub-theme concerning commercial fleet and public transport operations:
• an innovative e-logistics platform for improved management of freight distribution processes in urban areas has been developed and validated;
• a concept named “Commercial Vehicle Fleet Management System” has been developed, which permits fleet owners to take advantage of advanced logistics services made available on-line to increase the efficiency of their fleet management.

In the sub-theme concerning transport demand management:
• issues concerning cross-border interoperability of Electronic Fee Collection (EFC) systems with a view to defining a future shared standard, and building consensus in the Member States and among operators have been further investigated gaining a deeper insights into technical issues;
• possible scenarios for the transport system and energy supply of the future taking into account the state of the art of relevant research within and outside of the Sixth Framework Programme (FP6) and such criteria as the autonomy and security of energy supply, effects on the environment and economic, technical and industrial viability including the impact of potential cost internalisation and the interactions between transport and land use, have been developed, compared and assessed.
1. Introduction

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

<table>
<thead>
<tr>
<th>Table 1. The classification scheme adopted in TRKC</th>
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<tbody>
<tr>
<td><strong>Sectors</strong></td>
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<tr>
<td>• passenger transport</td>
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<td>• freight transport</td>
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<td><strong>Geographic</strong></td>
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<td>• urban transport</td>
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<td>• rural transport</td>
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<td>• regional transport</td>
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<td>• long-distance transport</td>
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<td>• EU accession issues</td>
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<td><strong>Modes</strong></td>
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<td>• air transport</td>
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<td>• rail transport</td>
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<td>• road transport including walking and cycling</td>
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<td>• waterborne transport</td>
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<td>• innovative modes</td>
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<td>• intermodal freight transport</td>
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<td><strong>Sustainability policy objectives</strong></td>
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<td>• economic</td>
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<td>• <strong>efficiency</strong></td>
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<td>• equity and accessibility</td>
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<td>• environmental aspects</td>
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<td>• user aspects</td>
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<td><strong>Tools</strong></td>
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<td>• decision support tools</td>
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<td>• financing tools</td>
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<td>• information and awareness</td>
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<td>• infrastructure provision including TEN-T</td>
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<td>• integration and policy development</td>
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<td>• Intelligent Transport Systems ITS</td>
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<td>• regulation/deregulation</td>
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<td>• land-use planning</td>
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<tr>
<td>• transport management</td>
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<td>• pricing and taxation</td>
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<td>• vehicle technology</td>
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The scheme has been adopted to enable search facilities in the TRKC portal, and to ensure comprehensive coverage of research results and appropriate policy analysis in the Thematic Research Summaries (TRS). Definitions for each theme are found on the TRKC.
In the predecessor EXTR@Web project TRSs have been produced for 28 out of the thirty themes (resulting from merging of some themes into a single TRS). The TRKC project is producing first versions of TRSs for a sub-set of themes for which a critical mass of results from projects is available by July 2008 (including this one on efficiency of transport systems). Final versions of TRSs for the full set of themes is planned for production in December 2009.

A large number of research projects have dealt with the theme addressed by this paper. The TRS “Efficiency” produced in the predecessor project EXTR@Web (EXTR@Web, 2006a), reviewed research from European projects belonging to the Fifth Framework Programme (FP5) and selected national projects. The paper here adds new projects from FP5 and the Sixth Framework Programme (FP6).

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

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

Section 4 reports on the results from research projects. The section is structured according to sub-themes to make the broad area of research which has dealt with efficiency aspects more manageable. For each sub-theme research objectives are presented, then research findings are synthesised. The policy implications of research results are given a special focus. Section 4 is concluded with an overview of topics for future research which were identified by the projects synthesised. Sources for Section 4 are documents available from the projects and reporting on their achievements, essentially the project final reports and selected deliverables.

The sub-themes covered in Section 4 are:
• sub-theme 1: infrastructure and vehicle development and maintenance;
• sub-theme 2: traffic management and control;
• sub-theme 3: terminals;
• sub-theme 4: multi-modal networks;
• sub-theme 5: commercial fleet and public transport operations;
• sub-theme 6: transport demand management.

The Annex includes the list of the research projects relevant to the theme. Addresses of the websites of the projects are included with hyperlinks. In several cases these websites make the project documentation available to the public. This may include final reports and project deliverables.
2. Scope of the theme "efficiency"

Efficiency in transport represents the relationship between resource use and costs on the one hand and productivity on the other. The concept applies to the European transport system as a whole and to any specific transport system. Measures of efficiency indicate the extent to which changes in infrastructure and service provision and in trip choices by shippers, carriers and travellers have been successful in reducing the amount of expended resources per trip supplied or made.

Transport decision-makers at all levels need to respond to the demands for passenger and freight services, the main efficiency challenges being as follows.

- Increased mobility. The challenge for the transport sector is to manage limited resources efficiently to provide access and mobility for all segments of population, and particularly for the transport-disadvantaged population not using the car (young, elderly, poor, disabled).
- Reduced congestion. As mobility needs grow and the demand for transport increases, the resulting growth in transport activities places nearly unsustainable pressure on traffic congestion; the cost of road congestion is estimated 1% of GDP (CEC, 2006a); congestion on road occurs especially in urban areas and on the inter-urban roads around cities; increasing congestion is expected in airports and ports.
- Increased productivity. Freight transport and business-related passenger transport are integral parts of the productive process. Thus, cost-reducing improvements in transport increase economic productivity.

To respond to these challenges the transport sector needs to increase the capacity and operational efficiency of the transport system. The entire transport system, including all modes and the connections among them, both locally and internationally, needs to reduce the operating costs and increase the passenger and freight throughput of the existing fleets and facilities (thus, among the others, reducing the need for construction of new conventional facilities).

On the other hand, changes in trip choices by shippers, carriers and travellers can induce a more efficient use of the transport system, by reducing use of transport modes by road as an example, with the social benefit of a reduction in the total costs which are spent to move persons and freight.

The efficiency concept would cover a broad range of topics if external costs (environmental, socio-economic, safety) were internalised. In a more restricted sense, which is the perspective adopted here, efficiency includes the following:
capital, operating and maintenance costs (including energy);
• costs to the user and related topics: journey speed, delays, congestion, price for the use of road space, fare;
• benefits to the users (expressed by the consumer surplus concept) and the operator (revenues minus costs);
• productivity (expressed e.g. as operating cost per passenger trip or passenger revenue per vehicle hour);
• capacity offered (vehicle and service capacity);
• utilisation by mode, including shift of passenger trips from single occupancy vehicles and load factor for freight and public transport;
• incremental costs or travel time per addition to capacity; and
• accessibility in terms of service area coverage capability.

There are different domains for policy action with the potential for improving efficiency. First are supply-oriented domains including infrastructure, vehicle and operations-related issues. They move from individual elements – infrastructure and vehicles – to the operations of commercial and public transport fleets, to the management of traffic flows on modal networks, to nodal centres and services in the multi-modal networks. Demand-oriented domains focus on measures able to influence demand patterns and the use of transport systems: transport demand management and, particularly, pricing. A final domain focuses on the institutional/legal framework, addressing in particular deregulation and re-regulation and financing issues.

The sub-themes that are adopted in Section 4 of this paper to structure the presentation of the research projects reflect the above recalled domains for policy action.
3. Policy context

3.1 First steps of the Common Transport Policy

Efficiency was identified as a main objective of the Common Transport Policy (CTP) already in the 1992 White Paper (CEC, 1992) where it was recognised that efficient, accessible and competitive transport systems are vital to the society and the economy of the EU. In particular the contribution of an efficient transport system to the competitiveness of Europe and to growth and employment is stressed. At the same time the CTP recognises the need to reconcile the conflict between the objective of effective functioning of the EU transport system with the imperatives of ensuring a high level of safety and of protection of the environment.

The translation of the efficiency objective into priorities for actions in different policy domains was done by the Action Programmes 1995-2000 (CEC, 1995a) and 1998-2004 (CEC, 1998a).

The following specific objectives for policies and initiatives are identified:

- improving quality by developing integrated and competitive transport systems based on advanced technologies which also contribute to environmental and safety objectives;
- improving the functioning of the single market in order to promote efficiency, choice and a user-friendly provision of transport services while safeguarding social standards;
- broadening the external dimension by improving transport links with third countries and fostering the access of EU operators to other transport markets.

Policies include:

- promotion of intermodality and interoperability as key measures to achieve better integration of transport modes;
- stimulus to new technologies and applications, especially telematics for intermodality and for interoperability of traffic management systems in the various modes;
- development of Trans-European Network (TENs) measures to ensure progressive integration of transport networks to serve all EU regions through co-ordinated planning of investments and better traffic management;
- promotion of best practice in local and regional passenger transport to provide people with attractive alternatives to the private car;
• enforcement of the competition and legislative initiatives in specific transport sectors to create the single market in transport services and support the transition from a national regulatory system; and
• convergence in the charging regimes applicable to different modes to achieve optimal modal balance.

3.2 The 2001 White Paper and its mid term review

Later, the 2001 White Paper “European Transport Policy for 2010: Time to Decide” (CEC, 2001) has proposed an action programme extending until 2010 which centres around three strategies: revitalisation of alternatives to road, targeted investments in the TENs and pricing. The following are the main issues of relevance to efficiency that are discussed in the White Paper.

Rail transport is considered a strategic sector on which the success of the efforts to shift the balance between modes will depend, particularly in the case of goods. Revitalising the railways means competition between the railway companies. The priority is to open markets not only for international services but also for cabotage on the national markets and for international passenger services. This is to be accompanied by further harmonisation in the filed of interoperability. A network of railway lines must be dedicated exclusively to goods services.

Short-sea shipping and inland waterway transport are recognised as two modes which could provide a means of coping with the congestion of certain road infrastructure and the lack of railway infrastructure. Both these modes are still mostly underused. The way to revive short sea-shipping is to build sea motorways within the framework of the master plan for the TENs. This will require better connections between ports and the rail and inland waterway network with improvements in the quality of port services. Certain shipping links, particularly those providing a way around bottlenecks – the Alps, Pyrenees and Benelux countries today and the frontier between Germany and Poland tomorrow – will become part of the TENs just like roads or railways. To reinforce the position of inland waterway transport which is, by nature, intermodal, waterway branches must be established and transhipment facilities must be installed to allow a continuous service all year round.

Today there is not yet “single sky” in Europe. The EU suffers from over-fragmentation of its air traffic management systems which adds to flight delays, wastes fuel and puts European airlines at a competitive disadvantage. Community legislation on air traffic is therefore advocated.
Intermodality is of fundamental importance for developing competitive alternatives to road transport. There have been few tangible achievements apart from a few major ports with good rail or canal links. Action is therefore advocated to ensure fuller integration of the modes offering considerable potential transport capacity as links in an efficiently managed transport chain joining up all the individual services. The priorities must be technical harmonisation and interoperability between systems particularly for containers. In addition, the new Community support programme Marco Polo targeted on innovative initiatives, particularly to promote sea motorways, will aim at making intermodality more than just a simple slogan and turning it into a competitive, economically viable reality.

Given the saturation of certain major arteries and the consequent pollution, it is essential for the EU to complete the TEN projects already decided. For this reason a revision of the Community guidelines is needed which concentrates on removing the bottlenecks in the railway network, completing the routes identified as the priorities for absorbing the traffic flows generated by enlargement, particularly in frontier regions, and improving access to outlying areas. The review of the trans-European network must aim at introducing the concept of sea motorways, developing airport capacity, linking the outlying regions on the European continent more effectively and connecting the networks of the new Member States with the network of older Member States.

Amendment of the funding rules is recognised as a priority in order to allow the Community to make a higher contribution to cross-border railway projects crossing natural barriers but offering a meagre return yet demonstrable trans-European added value like the Turin-Lyon. Projects to clear bottlenecks still remaining on the borders of the new countries could also qualify for the maximum Community contribution. Given the low level of funding from the national budgets and the limited possibilities of public/private partnerships, innovative solutions based on a pooling of the revenues from infrastructure charges are needed. To fund new infrastructure before it starts to generate the first operating revenue, it must be possible to constitute national or regional funds from the tolls or user charges collected over the entire area or on competing routes. The charges imposed by Switzerland particularly on lorries from the Community to finance its major rail projects are a textbook example.

It is generally acknowledged that not always and not everywhere do the individual modes of transport pay the costs they generate. The situation differs enormously from one Member State and mode to another. This leads to dis-functioning of the internal market and distorts competition within the transport system. As a result, there is no real incentive to use the cleanest modes or the least congested networks. Therefore harmonisation of fuel taxation for commercial users, particularly in road transport, and alignment of the principles for charging for infrastructure use are proposed. The integration of external costs must also encourage the use of modes of lesser environmental impact and, using the revenue raised in the process, allow investment in new infrastructure.
This kind of reform requires equal treatment for operators and between modes of transport. Whether for airports, ports, roads, railways or waterways, the price for using infrastructure should vary in the same manner according to category of infrastructure used, time of day, distance, size and weight of vehicle, and any other factor that affects congestion and damages the infrastructure or the environment. To produce maximum benefit for the transport sector it is essential that available revenue, whenever external costs are higher than needed to cover the costs of the infrastructure used, be channelled to finance measures to lessen or offset external costs (double dividend). Priority is to be given to building infrastructure that encourages intermodality, especially railway lines, and offers a more environmentally-friendly alternative.

The mid term review of the White Paper (CEC, 2006a) has recognised that economic growth has been less than expected. On this basis the principle of decoupling transport from economic growth is no longer valid. Mobility is essential to competitiveness of Europe economy. Mobility needs to be disconnected from its negative side effects. The future transport policy will need to optimise each transport mode’s own potential to meet the objectives of clean and efficient transport systems. Shifts to more environmentally friendly modes must be achieved where appropriate, in particular on long-distance, in urban areas and on congested corridors. Co-modality, i.e. the efficient use of different modes on their own and in combination will result in an optimal and sustainable utilisation of resources.

Intelligent mobility solutions and transport demand management based on smart charging will alleviate congestion but new or improved infrastructure will also be needed. In the longer run there is no reason why aircrafts should have sophisticated communication, navigation and automation, and not ships, trans or cars. New technologies coming to market will allow improved real-time management of traffic movements and capacity use.

Investment in viable alternatives to congested road corridors can support intelligent solutions involving co-modal logistic chains which optimise the use of transport infrastructure within and across different modes. This includes transalpine tunnels, rail corridors and intermodal nodes for rail, sea and air transport.

### 3.3 Specific initiatives

Following the general priorities stated in the above recalled policy documents (CEC, 1995a; CEC, 1998a; CEC, 2001; CEC, 2006a), policy developments and consequent legislation that has come into force have been related mainly to the following specific areas.

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

In the telematics technologies area, the European global satellite system (Galileo) for location and timing is under development, the Intelligent Car Initiative (CEC, 2006b) promotes intelligent technologies for cars.

In the traffic management area, the focus has been on technical interoperability of telematics infrastructure and devices: the electronic fee collection for road transport; the development of a European Air Traffic Management System (EATMS) for a single European sky with the SESAR programme; the development of the European Rail Traffic Management System (ERTMS); the development of Vessel Traffic Management and Information Systems (VTMIS) and River Information Services (RIS) systems.

In the local and regional passenger transport area, a major initiative has been the promotion of a Citizens’ Network for the development of high quality collective transport of all kinds, including appropriate interfaces for the car user (CEC, 1995b; CEC, 1998b). Recently a green paper on urban mobility has been issued (CEC, 2007b).

In the regulatory framework area, the liberalisation in the rail and air sectors has taken place following specific Directives. In the rail sector, the first and second railway packages had been related to the reform of infrastructure management and the liberalisation of freight train services. In 2007 the third railway package has come into force: international passenger services have been opened to competition while the opening up of domestic markets has been deferred. In the local passenger sector new rules for contracting of public transport services by road and rail, aimed at guaranteeing the provision of services of general interest, have come into force in 2007.

In the TENs area, the Commission has proposed amendments to the rules for granting of financial aids (CEC, 2003). In the charging regime area, the development of the framework for transport infrastructure charging based on the user pays principle and the internalisation of external costs (CEC, 1995c; CEC, 1998c) has been followed up by the Directive on rail infrastructure charging (Directive 2001/14), and by the Eurovignette Directive on the charging of heavy goods vehicles (Directive 1999/62). This latter directive has been reformed, with the aim of introducing modulated tolling, in 2006 (Directive 2006/38). A further amendment to the Eurovignette directives has been proposed by the Commission in 2008 (CEC, 2008a) in order to extend the scope of the current directives beyond the TENs. In 2008 the Commission has put forward a strategy for the internalisation of external costs (CEC, 2008b) where they set out how external costs can be internalised in all modes of transport.
4. Research findings

4.1 Introduction

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

The first sub-theme relates to the material components of transport systems: the infrastructure and the vehicles. Aspects of relevance to efficiency relates to both the development stage and the maintenance and operation. The aim is to use innovative tools and methodologies to reduce costs along the entire life cycle.

The second sub-theme concerns traffic management and control. Intelligent transport systems (ITS) play a key role in the management of traffic in all modes of transport: road, air, rail and waterborne. The use of ITS for traffic management and vehicle control aims at improving capacity and reducing costs to the users. Relevant costs perceived by the users relate to the time spent travelling. The reliability is another relevant aspect of concern of both users and operators.

The third sub-theme deals with terminals. Terminals are nodes of the transport networks where passengers are transferred between modes and freight handled. Terminals include airports, ports and railway stations. Interchanges are nodes where passenger transfer among public transport modes and between these and car. Intermodal freight terminals are nodes where freight, possibly in loading units such as swap bodies and containers, is moved between modes. Aspects of relevance are the design, planning and operation of terminals for the efficient transfer of passengers and goods.

The fourth sub-theme concerns multi-modal networks. Issues of relevance include the enhancement of the attractiveness of sustainable modes – rail and maritime above all in order to lower traffic on congested roads – and the development of intermodality in freight transport – which is beneficial in terms of efficiency as far as the time spent for handling goods is affected. The planning, design and operation of networks are tackled here under a system perspective.

The fifth sub-theme deals with the management of fleet of commercial vehicles, including goods vehicles, and the operation of public transport services, including conventional
public transport as well as innovative services such as car sharing. The key aim is to achieve journey time savings (passenger), lead time savings (freight), and reliability increases (all). ITS are of relevance here to enable real-time and demand-responsive capabilities.

The sixth sub-theme relates to transport demand management. This includes measures such as road pricing and, more generally, charging for infrastructure use, which are aimed at achieving an efficient use of the transport infrastructure via the internalisation of costs that are not taken into account by decision makers in their trip choices.

A seventh sub-theme had been included in the paper on efficiency produced within the predecessor project EXTR@Web (EXTR@Web, 2006). This sub-theme is related to the regulatory framework and addresses in particular the opening up to competition of the markets of transport services, which is beneficial in terms of efficiency as this has the potential to decrease costs and improve the magnitude and quality of the outputs. This sub-theme is not considered in the present paper as at this stage there is no new contributing project with results available.

Table 2 shows the EU-funded projects which have dealt with each sub-theme. The Table includes:
• completed projects which are synthesised in this TRS and for which the following sub-sections report on research objectives, research results, policy implications and implications for further research;
• projects which had been synthesised in the EXTR@web TRS and which are briefly summarised in the background of the following sub-sections;
• other EU-funded projects which have not yet made results publicly available.
### Table 2. Projects relevant to the theme

<table>
<thead>
<tr>
<th>Sub-theme</th>
<th>Contributing projects</th>
</tr>
</thead>
</table>
| 1. Infrastructure and vehicle development and maintenance | Projects covered in this paper: NR2C  
Projects covered in EXTR@Web paper: IDD; IMCAD; PROMAIN; RESPONSE 2; SEAM; TALIS; SAFED (UK)  
Other FP6 projects with results not yet available: ALERT; ARTIMA; ASPASIA; AUTOCOM; CATIEMON; CITYMOBIL; CLEANMOULD; CREATE3S; EcoLanes; EURO PAC; FIDELIO; HISMAR; HP-FUTURE BRIDGE; INFRACLEAR; INTEGRAL; LOGBASED; MODURBAN; QCITY; RAIL; RAILENERGY; REACT; RETRACK; SAFE-RAIL; SAFEICE; SAND,CORE; SCOUT; SLC; SMOOTH; SUPERPROP; SUSTAINABLE BRIDGES; TATEM; URBAN TRACK; VRShips-ROPAX; WIDEM |
| 2. Traffic management and control            | Projects covered in this paper: ASAS-TN; CAATS; C-ATM Phase I; MarNIS; Super-Highway  
Projects covered in EXTR@Web paper: DENSETRAFFIC; EYE IN THE SKY; SMARTNETS; INDRIS; RESPONSE 2; THEATRE; TASKU (FI)  
Other FP6 projects with results not yet available: ASAS-TN2; CAATS II; CIVITAS CATALIST; Episode 3; eMOTION; iFLY; NEWSKY; REDUCE; STREETWISE; |
| 3. Terminals                                 | Projects covered in this paper: PLUG; SECURCRANE; SPADE-2                                                                                               |
| 4. Multi-modal networks                     | Projects covered in this paper: BRAVO; PROMIT; TREND  
Projects covered in EXTR@Web paper: CITY FREIGHT; CONPASS; e-THEMATIC; GIFTS; HISPEEDMIX; IDIOMA; ISHTAR; ROLLING SHELF; Effects of cycle parking arrangements on bicycle use (FI); Market analysis in trans-Alpine freight transport (CH); Passenger Rail Services and Economic Performance (UK); Railways – competition and basic mobility (CH); Supply Chain Resilience (FL0123) (UK); UG220: Multi-modal modelling – A new look (UK)  
Other FP6 projects with results not yet available: eMOTION; EURO PAC; FastRCargo; FREIGHTWISE; |
5. Commercial fleet and public transport operations

Projects covered in this paper:
Bestufs; eDRUL

Projects covered in EXTR@Web paper:
FIRE; GAUSS; LIBERTIN; MOSCA; TOSCA; VOYAGER; Assessing the potential for rationalising road freight operations (UK); Guidelines For Programming Local Public Transport Services (IT); UG423I: Bus Real-Time Information – Business Case (UK)

Other FP6 projects with results not yet available:
CARAVEL

6. Transport demand management

Projects covered in this paper:
CARMEN-4; IMPRINT-NET; STEPs

Projects covered in EXTR@Web paper:
SCATTER; Fair and efficient pricing (CH); Multi-modal freight model for distance-based HGV charging (UK); UG346: Monitoring the effects of road user charging in Durham (UK)

Other FP6 projects with results not yet available:
CARAVEL; CREAM; CURACAO; FIDEUS; MAX; MIDAS; MOSES; MOVE; NICHES; RCI

4.2 Sub-theme 1: infrastructure and vehicle development and maintenance

4.2.1 Background

Research reviewed in the related EXTR@Web paper (EXTR@Web, 2006) has addressed mainly the vehicle level, to a minor extent the infrastructure level. Insights have been
provided on:
- approaches to the efficient management of railway infrastructure;
- areas of collaboration, as far as vehicle design is concerned, among the three industries: automotive, rail and aerospace;
- new design tools in avionics aimed at shortening time-to-market;
- development of a code of practice for the deployment of advanced driver assistance systems (ADAS) for cars;
- guidance for fuel efficient driving aimed at drivers of heavy goods vehicles (HGV).

4.2.2 Research objectives

Research has investigated conceptual and technical issues concerning the mobility and transport demands of the future with a view to generating future-oriented initiatives for addressing accessibility problems and issues related to road infrastructure. This research was motivated by the fact that the constant increase in traffic volumes and axle loads is causing high road congestion, wear and tear of structures and, last but not least, air pollution and noise emissions. As a consequence the road sector demands more efficient production, construction and maintenance of infrastructures. In fact, a better overall quality of infrastructures can reduce downtime of roads for maintenance activities. Furthermore, the increasing demand of infrastructure availability requires tighter time slots for repair and maintenance works, so they must be done more and more quickly through more efficient techniques and methods (NR2C).

4.2.3 Research results

The definition and publication of the “Vision 2040” by NR2C¹ (available on the FEHRL website: www.fehrl.org/nr2c) has provided long-term perspectives for the road infrastructure with a view to reconciling future transport and social needs, as well as sustainability goals². The “Vision 2040” is characterised by a wider consideration of users and stakeholders, a deep analysis of urban and peri-urban issues, and the great importance given to “human” aspects. This vision is based on four key concepts representing the dominant characteristics of the society’s expectations for the road of the

¹ When elaborating the "Vision2040", the project consortium took into account other visions provided in the same period: ERTRAC Vision 2020 (European Road Transport Research Advisory Council - www.ertrac.org), FEHRL Vision 2025 (FEHRL Europe’s road research centres - www.fehrl.org), ECTP Vision 2030 (European Construction Technology Platform - www.ectp.org).
² This Vision 2040 this vision is a realistic and most likely description of future society and shows what the world might look like in thirty-five years and how society thinks about use, design construction and maintenance of infrastructure for the coming decades. It has provided the basis for the NR2C’s objective consisting in identifying and specifying the research activities required in road engineering.
future (NR2C):

- “Reliable infrastructure”, standing for optimizing the availability of infrastructure. Availability and reliability are the key issues of durable infrastructure, which means higher quality and low maintenance of each part of the infrastructure and the infrastructure as a whole. The impact of maintenance activities on traffic flows must be as low as possible. Furthermore upgrading infrastructures must be possible without dismantling the existing construction.
- “Green (environmentally-friendly) infrastructure”, standing for reducing the environment impact of traffic and infrastructure on the sustainable society. Green infrastructures must fit into environment and must be designed so that the impact of traffic (noise, air pollution and vibrations) and energy consumption of the transport system is minimised. They also must optimise the use of non-traditional materials for road building and reduce the use of natural resources.
- “Safe and smart infrastructure”, standing for optimizing flows of traffic and road construction work safety. Smart and safe infrastructures monitor traffic flows, external conditions and themselves, interpret the information acquired, decide and act to promote safe and comfortable travel and help keeping infrastructure components in safe condition.
- “Human infrastructure”, standing for harmonizing infrastructure with the human dimensions. The main characteristics of this concept are multi-functionality and multi-use of the space occupied by infrastructure. Human infrastructures offer road user the basic facilities which provide social security. The main points are sharing the space with non-road users (for leisure, etc.) and exploring the space above and below the road surface to facilitate other socially relevant functions (transport and non-transport related).

Research has shown that, in the field of construction and maintenance of infrastructures, progresses in optimisation of existing concepts will no longer meet the more and more demanding requirements. As a consequence, it is necessary to develop new concepts, for which the introduction of new proven research technologies from other sciences such as physics and chemistry is vitally important. Research has selected a number of projects (defined as “development required”) needing special attention from all stakeholders involved, since they will provide the sector with new basic knowledge standards for trend setting developments and innovations. In fact, they are crossing the traditional borders of common research approaches or solutions, or they are incorporating knowledge from other sciences or delivering fundamental basic knowledge for break-through inventions. They require high research investments in the initial stage of development, so European-wide cooperation and governmental support and funding are the key factors to success (NR2C).

3 These projects are: Low temperature asphalt with reclaimed asphalt; Bridge eco-assessment; TYROSAFE: optimising tyre-road interaction; Energy controlled pavements; New age binder design technologies; Integrated models of urban (human) design; Lifetime engineering for roads; Asset management tools; Modular prefabricated pave.
4.2.4 Policy implications

These long-term visions and ideas defined by the “Vision 2040” will support policy-makers and decision-makers in taking the right decisions concerning use, design, construction and maintenance of infrastructure.

Furthermore, a state-of-the art review has showed typical trends of innovative road construction, rehabilitation and maintenance, such as (NR2C):

- the use of very high quality (premium) basic materials eventually with their special treatment;
- the establishment of sophisticated construction, rehabilitation and maintenance techniques utilizing up-to-date scientific achievements;
- the development of special measures for enhancing traffic safety even in extreme conditions;
- decreasing the whole life (life cycle) costs of road pavements by constructing long-life variants with infrequent maintenance and rehabilitation need, and, consequently, minimal traffic disturbance;
- wider use of industrial by-products in road engineering without reducing pavement performance;
- wider use of recycling (eventually-re-use) of bound pavement structural layers in order to reduce the need for primary basic materials without jeopardising the performance of pavements;
- giving priority to low-energy pavement structural variants reacting to the ever increasing energy prices and the limited availability of crude oil supplies;
- using some new scientific results coming from science areas far away from highway engineering.

4.3 Sub-theme 2: traffic management and control

4.3.1 Background

Research reviewed in the paper on efficiency produced within EXTR@Web (EXTR@Web, 2006) has addressed the development and demonstration of European traffic management systems in the air and waterborne modes (EATMS – European Air Traffic management System, VTMIS – Vessel Traffic Management and Information System, RIS – River Information Services). Other specific topics addressed have related to the road mode. These include: the development and demonstration of an intelligent infrastructure able to support traffic monitoring, mobility information, and emergency services functionalities; the development and demonstration of a radar for autonomous cruise control systems for cars.
4.3.2 Research objectives

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

4.3.2.1 Air transport

Objectives included the development of strategies for improving the operational capability and safety of aircrafts in the air transport system. Research was motivated by the fact that one of the main challenges the ATM currently faces is the increasing number of delays, which clearly show a capacity problem. Capacity of managing the airspace of current systems is principally limited by the controller workload associated with monitoring and controlling aircraft separation. Airborne separation assistance system (ASAS)\(^5\) can reduce the controller workload, while automatic dependent surveillance-broadcast (ADS-B)\(^6\) supports improved use of airspace, reduced ceiling/visibility restrictions, improved surface surveillance, and enhanced safety. Consequently, research has created a thematic network to accelerate the application of ASAS/ADS-B operations in the European Airspace (ASAS-TN) with a view of increasing airspace capacity and, at the same time, maintaining or increasing safety.

Research efforts were also dedicated to bring together, refine, and integrate the most promising aspects of recent research into one general and fully interoperable air/ground concept of operation in order to improve decision making, optimise system capacity through dynamic flow management and 4-D trajectory exchanges, and contribute to a better situational awareness of air and ground actors (C-ATM Phase1).

In order to improve efficiency in air traffic, a research objective was to develop innovative concepts of the operational framework of the present airspace structure. To this aim, a set of Operational Concept Scenarios were developed and validated, which ensure safer and more frequent flights along a Super-Highway. Three essential aspects have been considered: decreasing workload, improving the situational awareness and ensuring on-time performance. Impacts on capacity, efficiency and environment have been investigated, as well as economic aspects. The performance targets were mainly concerned with operational improvements and the user benefits (SUPERHIGHWAY, 5 ASAS is an aircraft system based on airborne surveillance that provides assistance to the flight crew supporting the separation of their aircraft from other aircrafts. An ASAS application is a set of operational procedures for controllers and flight crews that makes use of an ASAS to meet a defined operational goal.

6 Automatic dependent surveillance-broadcast (ADS-B) is a cooperative surveillance technique for air traffic control and related applications. An ADS-B-out equipped aircraft determines its own position using a global navigation satellite system and periodically broadcasts this position and other relevant information to potential ground stations and other aircraft with ADS-B-in equipment.)
A research objective was also the identification of best practices across EC’s FP6 ATM projects in the fields of Safety, Human Factors, and Validation, as well as their dissemination among the ATM community (CAATS, 2006). Research was motivated by the fact that the European Commission stressed on the need of coordinating processes and methodologies across the FP6 ATM projects in a cluster of seven research areas, ranging from airport efficiency to Cooperative Air Traffic Management (ATM).

4.3.2.2 Maritime transport

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

4.3.3 Research results

4.3.3.1 Air transport

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

GS applications consisted in:

7 Co-operative ATM; Advanced airborne system applications; Reduced separation minima; Airport efficiency; Advanced Surface Movement Guidance and Control System; Advanced approach and landing concepts; Innovative ATM research.

8 In response to the need for a more transparent and harmonized approach within the maritime sector, the EC is currently promoting the development of e-Maritime (mentioned in the Mid-term review of the 2001 Transport White Paper), which consists in the application of information and communication technology to the maritime sector in order to make more efficient and effective information exchanges and co-operation between maritime transport business and administrations.
• ATC surveillance for en-route airspace;
• ATC surveillance in terminal areas;
• ATC surveillance in non-radar areas;
• Airport surface surveillance;
• aircraft derived data for ground tools.

AS applications categories included:
• airborne traffic situational awareness for improving safety and efficiency;
• airborne spacing and airborne separation for improving capacity and flexibility.

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

Both the airborne and ground segments of a collaborative ATM system were addressed by research by encompassing communication and network services (CNS) and ATM concepts and capabilities such as (C-ATM Phase 1):
• ASAS procedures;
• 4-D flight management system (FMS) capabilities and trajectory planning;
• air-ground data-link;
• interoperability;
• System Wide Information Management;
• Advanced tools to support Separation Management;
• Flight Data processing and Flow Management;
• some initial Collaborative Decision Making applications.

Furthermore, the state of the art on a number of areas have been done, such as (C-ATM Phase 1):
• articulation of integrated operational concepts;
• refinement of network operational plans;
• refinement of 4-D trajectory exchange principles and collaborative flight management;
• development of compatibility between 4-D and ASAS in the TMA;
• organization of a wider community of air service providers.

Finally medium term operational concepts, a validation plan and certification documentation have been produced, and evaluation of CBA models within the context of a preliminary assessment of the costs and benefits of the C-ATM concept of operations has been performed (C-ATM Phase 1).

Research has also defined and described two scenarios in compliance with the airspace
organisation described by the SESAR operational concept (SUPERHIGHWAY, 2008). The first scenario dealt with the optimisation of the current airspace and route structure. Main changes are in the direction of closely spaced parallel lanes in the upper airspace that increase the currently available capacity. The design principles of this Scenario have been applied using fast time and real time simulations to highly loaded airspace routes in Europe⁹ in order to evaluate the Super-Highway in terms of acceptability, safety, efficiency and capacity of procedures in handling air traffic in a Super-Highway operational environment. The second Scenario describes a pan-European approach to the design of a network of highways in European airspace.

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

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

Economic impacts have also been addressed, and a rough order of magnitude of the cost-benefit relationship has been calculated, obtaining a positive and beneficial result (SUPERHIGHWAY, 2008).

Finally, the identification and consolidation of best practices of a number of European ATM R&D projects (CAATS, 2006) gave way to a first version of a global methodology in operational concept validation for all ATM R&D projects: the EUROCONTROL Operational Concept Validation Methodology (EOCVM), which was endorsed by the Joint Programme Board (JPB) as the one to be used by all EC and EUROCONTROL funded projects, and which has been adopted by a large number of projects in the ATM R&D community.

The E-OCVM makes the concept validation in ATM R&D projects easier for stakeholders and project managers, facilitating earlier and more consistent evaluation of the fitness for purpose and adequacy of the concept. Furthermore, it permits to save considerable resources by allowing making adjustments at an earlier stage, as well as significant comparisons among different projects (CAATS, 2006).

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⁹ The South-West axis going from the United Kingdom to Spain and the North-East axis going from the United Kingdom to Greece
4.3.3.2 Maritime transport

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

The MOS concept coordinates these services virtually, sharing information and data, using new and emerging technologies, and adopting a functional architecture, which is independent of technology. More specifically, the technology used by the MOS concept manages data on shipping movements provided by Automatic Identification System (AIS) transponders, which are currently supported by shore-based systems in most EU States. AIS provides dynamic information about the ship movements (position, speed, course, etc.), as well as essential identification information. The AIS data are combined with Long Range Identification and Tracking (LRIT) data provided by satellites. This combination allows MOS operators to visualise and monitor vessels even outside their territorial waters, minimising the need for verbal communication with the ship. The MOS concept also centralises all relevant data on a ship (e.g., its cargo, number of passengers, last and next port of call, flag, type, age, Port State Control inspection information, estimated time of arrival, voyage plan, etc.). This is achieved through the creation of National Single Windows (NSW), through which all the data are funnelled. The NSW is like a hub, to which all authorised maritime stakeholders are connected, sharing the same information. The data are held in an enhanced, pan-European SafeSeaNet (SSN++) electronic database, distributed to stakeholders via the NSW (MarNIS).

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

4.3.4 Policy implications

4.3.4.1 Air transport

Although in recent times ASAS and ADS-B applications have gained international recognition and positive progress towards acceptance has been made, there are still many issues to be addressed. Research showed that efforts should be devoted to (ASAS-TN):
• make ASAS and ADS-B applications an integral part of the European ATM Master Plan, because it has been demonstrated that they have the potential to enhance the ATM system in the areas of safety, capacity, flexibility, efficiency and environment;
• to conduct operational trials in Europe involving revenue flight, including in-situ certification and operational approval of the applications;
• study ASAS application as an integral part of the ATM system, in order to identify synergies with other new concept elements for maximising benefits;
• involve stakeholders in ASAS-TN2 activities to ensure a common understanding (Global stakeholder participation has been excellent during the project, but an increased participation of aircraft operators, particularly the airlines, and airport operators would be very beneficial.

Research has also explored limits in concept areas that will be utilized in future ATM development within the SESAR\textsuperscript{10} project context (which is the European air traffic control infrastructure modernisation programme) and other future R&D initiatives in ATM. More generally research has pushed state-of-the-art one step further in several areas in particular (C-ATM Phase 1):
• the articulation of a truly integrated concept of operations covering all phases from strategic planning to flight execution and post-flight analysis;
• the refinement of concepts such as the Network Operations Plan, information sharing and Collaborative Decision Making principles applied in a C-ATM context;
• the refinement of 4-D trajectory exchange principles and collaborative flight management;
• the compatibility between 4-D and ASAS and transition aspects between 4-D and ASAS in the TMA.

4.3.4.2 Maritime transport

The MOS concept will potentially affect the tasks and responsibilities of the various authorities related to maritime transport and traffic, including not only maritime safety related but also enforcement authorities such as customs and immigration. A European Maritime Directive, describing the legal structure, is recommended (partly developed during the project) in order to clarify and support the interaction between all authorities and actors involved. While respecting the principle of subsidiarity, a general Directive on maritime transport and traffic will also provide uniform and transparent responsibilities for competent authorities (MarNIS).

\textsuperscript{10} The SESAR (Single European Sky ATM Research) project (formerly known as SESAME) is the European air traffic control infrastructure modernisation programme. SESAR aims at developing the new generation air traffic management system capable of ensuring the safety and fluidity of air transport worldwide over the next 30 years.
4.4 Sub-theme 3: terminals

4.4.1 Background

Research reported on in the EXTR@Web paper (EXTR@Web, 2006a) has addressed ports, intermodal freight terminals and airports. Research on ports and intermodal freight terminals has focused on solutions aimed at improving the efficiency of operations. Topics addressed for airports include:
- the impacts on the capacity of networks of the predictability capabilities at individual airports,
- issues of stakeholders’ coordination and of European harmonisation and standardisation for the efficient management of airport operations,
- improvement of A-SMGCS (Advanced Surface Movement Guidance and Control System).

4.4.2 Research objectives

Research reported on here has dealt with airports. Research objectives related to the improvement of airport capacity and to the development of a tool to support strategic and operational decisions.

4.4.2.1 Airport capacity

The continuous increase in traffic demand is more and more a challenge for airport operators, aircraft operators and air navigation service providers. Many airports run the risk to end up operating to their maximum capacity. With the Airport Operations Programme (2002-2006), EUROCONTROL, the European Organisation for the Safety of Air Navigation, has launched projects to influence the short and medium-term airport operations in order to improve safety, capacity and cost efficiency with environmental-friendly solutions. One of these projects is A-SMGCS (Advanced Surface Movement Guidance and Control System) which aims at improving airport operations, especially during reduced visibility conditions, and the controller’s situational awareness of the movement area traffic.

A first cluster of objectives was to validate the A-SMGCS concept as an integrated air-ground system, seamlessly embedded in the overall ATM system, and to enable the harmonised A-SMGCS implementation in European airports. More specifically, research aimed, in a first step, at consolidating the surveillance and conflict alert functions (respectively A-SMGCS implementation level 1 and level 2 defined within the
EUROCONTROL project A-SMGCS\textsuperscript{11}) (EMMA, 2007), and, in a second step, at investigating advanced onboard guidance support to pilots and planning support to controllers (EMMA2).

Research also focused on the need of new, more efficient and more accurate systems to prevent accidents in the skies and airports. Besides saving lives safety improvements can provide significant economic benefits. Reducing the number of near misses\textsuperscript{12} between planes, and between planes and ground vehicles would save airlines and airport operators billions of euros in lost time and efficiency. By being able to pinpoint the exact location and course of an aircraft or vehicle, airports would be able to maintain current capacity even during periods of bad visibility (SAFE-AIRPORT).

Furthermore, the increasing air traffic on the one hand, and the environmental concerns which make it more difficult to expand existing airports or build new ones, on the other hand, urge to develop new tools to airport operators. These tools must enhance the ability to handle more aircrafts with the same or better level of safety. Efficiency can also be improved during take-off and landing with a better utilisation of available ground and air space. Research has developed an acoustic system, which can contribute to a better efficiency in managing airport operations by alerting controllers when a plane leaves its flight path up by over six nautical miles (SAFE-AIRPORT).

### 4.4.2.2 Airport decision support tools

A second cluster of objectives concerned the development of a user-friendly decision-support system for airport stakeholders and policy-makers. This user-friendly and fully integrated set of tools can support strategic level and operational level decision making concerning airport planning, development and operations. It also provides an integrated impact analysis.

\textsuperscript{11} The A-SMGCS project has identified four implementation levels for A-SMGCS forming a coherent series of increasing system complexity (www.eurocontrol.int): level 1 provides surveillance, display systems and procedures to permit comprehensive Air Traffic Control Officer situation awareness; level 2 consists of Level 1 functions together with automated monitoring and alerting functions, initially including the prediction of conflicts on active runways or incursions into restricted areas; levels 3 and 4 correspond to the introduction of routing, automatic guidance and planning functions, but have yet to be clearly defined.

\textsuperscript{12} Any circumstance in flight where the degree of separation between two aircrafts is considered by either pilot to have constituted a hazardous situation involving potential risk of collision.
4.4.3 Research results

4.4.3.1 Airport capacity

Research has extended the A-SMGCS concept by adopting an holistic, integrated air-ground approach that considers aircraft equipped with advanced systems for pilot assistance and controllers supported by A-SMGCS ground systems (EMMA, 2007). This extended technical and operational concept increases the efficiency of operations by:

• defining procedures as well as roles and tasks of the onboard and ground operators;
• ensuring consistency of traffic information given to controllers and pilots.

Furthermore, the operational concept was demonstrated and validated in three different European airports: Milano-Malpensa, Prague-Ruzyne, and Toulouse-Blagnac. Controllers and pilots actively participated and contributed to the results (EMMA 2). The results of this test phase provided a feedback on the A-SMGCS ICAO Manual (Doc. 9830) and constitute a reference for:

• proposing standards for future implementation of common operational procedures, common technical and operational system performance, common safety requirements, and common standards of interoperability with other ATM systems;
• supporting the regulation and standardisation bodies as well as the industry in early and efficient implementation of A-SMGCS in Europe.

Research has developed an innovative acoustic system (SAFE-AIRPORT). It is based on two Passive Phased Array Microphone antennas capable to discover and track aeroplanes up to at least six nautical miles distance in air and on ground. The system can be fully integrated with airport air traffic management procedures and it is an effective air control system for ATZ (Aerodrome Traffic Zone). It can work autonomously in smaller airports and integrated with standard control systems in greater airports. It consists of two acoustic sensors, to be used in open environments, and a control unit linked to the sensor with fibre optics connection. It can be managed by an operator with a control console to be installed inside the airport structure.

This system does not produce electromagnetic radiation (like radar or any noise pollution), so multiple arrays can be used to detect aircraft from their engine and aerodynamic noise with very high precision. Also, unlike radar, it can detect aircraft with composite, non-metallic bodies that are likely to be used widely in civil aviation in the future. Moreover, the cost of the technologies used by the system is in such a range that small airports will be able to make the necessary investments, thus improving safety and increasing capacity. The system has been tested at the Rome airport for three months, and successively in a more extensive validation trial of 18 months.
4.4.3.2 Airport decision support tools

Research has developed a decision making tool-set which can address, through integrated impact and trade-off analyses for a variety of performance measures (e.g. capacity, delay, level of service, safety, security, environmental impact and cost-benefits), a number of important decisions (or "use cases") regarding airport development, planning and operations (SPADE, 2006). This tool-set is equipped with a pre-structured, pre-specified and guided "wizard-type" human-machine interface in a single run, and in a back-office routine.

Demand and supply-side analyses were conducted regarding tools for assisting airport-domain experts. The supply-side analysis prepared a list of state-of-the-art decision-support tools. Each of the identified tools was described, addressing its capabilities, integration constraints and requirements, as well as its potential contribution to the SPADE system. The demand-side survey and the supply-side analysis was then matched and analysed to determine existing tool combinations that can be used and integrated in order to perform the elicited use cases. This resulted in a list of 18 use cases for possible implementation in the SPADE system. They were subdivided into the following.

- Strategic use cases, which provide decision-support for a medium or long term time horizon through the use of macroscopic, low level-of-detail tools (Expanding airport landside infrastructure; Airside infrastructure development; Airport capacity management; New equipment, technology or procedures; Sharp traffic increase; Change in operating conditions; Identification of capacity bottlenecks and shortages).
- Operational use cases, which provide decision-support for a short or medium term time horizon through the use of microscopic, high level-of-detail tools (Impact of fleet characteristics; (Re-)allocation of flights; Impact of new airport equipment and procedures; Analysis of impact of new procedures; Weather forecast in capacity; Airport capacity determination; New security devices and/or procedures; Taxiing methodology; Airport capacity versus air-side factors; Resources workload and its impact on airport capacity; Trade-off airport capacity versus environmental capacity/airport performance).

The decision-making support tool-set was designed and a prototype of the SPADE system was developed in order to validate the concept. The Concept developed by SPADE consists of the following tools, which were designed, implemented and tested:

- a traffic generator (TRAFGEN);
- a runway occupancy planner (ESTOP);
- two exchangeable fast-time air-side simulation (aircraft flows) (TAAM and RAMSPlus);
- fast-time land-side simulation (passenger flows) (ED-PAX/-BAX);
- noise model around the airport (INM);
- cost benefit model for both airside and landside (ED-PAX/-BAX);
- a flight schedule generator (FLASH);
• an air-side capacity and delay analysis tool (MACAD);
• a land-side capacity and delay tool (SLAM).

SPADE will solve a key problem that airport stakeholders have with current information and software support tools: their complexity. SPADE can support airport modelling decisions and identify potential sources of inefficiency in airport operations. Furthermore specific safety/risk assessment analysis will be possibly by SPADE, helping to improve safety and security of air transport. Finally, SPADE will also be able to specify noise exposure of the area around the airport.

4.4.4 Policy implications

4.4.4.1 Airport capacity

Research has strengthened the European position in the global ATM market by setting standards for A-SMGCS systems and their operational usage. The EMMA consortium has set up this frame of consolidated accepted standards for operational and technical concept, procedures, safety and interoperability by joining forces of highest A-SMGCS excellence from users, industry and R&D organisations. Extensive operational live trials proving the usefulness and completeness of the operational and technical requirements frame will form the basis for efficient A-SMGCS production and implementation throughout Europe.

The acoustic system developed by research is a valid alternative to ground radar and is conceived to enhance efficiency and safety. It is very innovative and it is likely to have a vast impact on the future of air traffic control at airports, because it can be a cheap alternative to ground radar. It is expected to be launched on the market within two to three years (SAFE-AIRPORT).

4.4.4.2 Airport decision support tools

Research contributed to improve airport decision-making process quality through integrated and systematic impact analyses. It also contributed to harmonise and rationalise the decision-making process at European level by addressing a standard set of questions or use cases related to airports (SPADE, 2006).
4.5 Sub-theme 4: multi-modal networks

4.5.1 Background

Research reviewed in the related EXTR@Web paper (2006) has addressed in the area of freight:
• the analysis of the management of supply chains with particular regard to the potential of ICT (Information and Communication Technologies);
• the development of an operational platform for the management of intermodal and unimodal door-to-door freight transport;
• the feasibility of a European high-speed rail freight network;
• new delivery solutions in urban freight distribution.

In the area of passenger transport, research reviewed in the EXTR@Web paper has addressed:
• the modelling of multi-modal networks for the use of European policy makers;
• strategies to enhance the attractiveness of rail transport;
• the specification of a Pan-European intermodal public transport network.

4.5.2 Research objectives

Research objectives focussed on the promotion of innovative intermodal freight transport and the improvement of the competitiveness of rail freight services.

4.5.2.1 Intermodal freight transport

A first research objective was to promote innovative intermodal freight transport and modal shift by raising awareness of innovations, best practices and intermodal transport opportunities for potential users, politicians and research community. An objective was also to contribute to a faster improvement and implementation of intermodal freight transport technologies and procedures (PROMIT).

Another research objective was to increase intermodal traffic volumes. More specifically, research aimed at developing and demonstrating an action strategy on intermodal rail-road transport services involving major scientific and technological activities in order to lay the foundations for achieving a significant and sustainable increase in intermodal volume on the Brenner corridor. This action strategy was designed with a view to be applicable to other pan-European freight corridors. At the heart of the Brenner corridor, the link München – Kufstein – Brenner - Verona is functioning like a pipeline “absorbing” practically all individual transport flows on one side and “ejecting” them on the other. This pipeline
ensures pan-European goods transport between all countries North and South of the Alps. However, the corridor primarily is serving the trade between Germany and Italy (BRAVO, 2007).

Owing to this pipeline effect there is particular pressure on the transport infrastructure and the environment, that is the sensitive Alpine eco system and its residents. Pollution is particularly severe because some 70% of all Brenner freight volume, i.e. 25 million tonnes, is carried by road. So requests on rail to relieve road transport are massive. In fact, in the period 1989 to 2001, while rail single-wagon traffic has been stagnating at 3.5 million tonnes, intermodal transport volume more than quintupled to 11.1 million tonnes. Out of that, 5.9 million tonnes are accompanied rolling highway services, 5.2 million tonnes are logistically demanding long-distance unaccompanied intermodal services designed for the transport of containers, swap bodies and semi-trailers.

The main weak points are as follows.

- Deficiencies in cross-border coordination and in the quality of service, in particular low rate of punctuality, clearly limiting the competitiveness in logistically demanding market segments. Even though the setting-up of the joint Brenner Servicestelle (Brenner service agency) has improved train monitoring, customer information, and the appreciation of problems, it lacks of a corridor process organization and management which aims at avoiding deficits.
- Deficiency in interoperability of equipment, particularly as regards locomotives.
- Lack of efficiency of the resources used (locomotives, wagons, staff), contributing to non-competitive freight rates as regards the transport of general cargoes.
- Infrastructural capacity bottlenecks on rail networks (main lines and junctions), at key intermodal terminals, and at border stations.
- Economic-technological gap: out of the some 4,000 freight trucks which, on the daily average, use the Brenner corridor in long-distance traffic some 90% are articulated vehicles. And according to the SAIL project funded under the FP5, the share of semi-trailer-based traffic in pan-European transport is continuously increasing. It exists a gap in the supply of a viable and self-sustaining intermodal technology capable of capturing conventional road-based semi-trailers for unaccompanied intermodal services.

Against this background, representatives of the Ministries for Transport of Austria, Germany, Greece, and Italy as well as all relevant stakeholders of the rail and intermodal transport industry engaged on the Brenner corridor, elaborated the "Brenner 2005" action plan. It contains a list of activities required to organize the short- to medium-term enhancement of intermodal services in this corridor. Advancing from this action plan, a more comprehensive Brenner corridor action strategy was scheduled to be developed. It consists of a set of coherent technological components (BRAVO, 2007).
4.5.2.2 Competitiveness of rail freight services

Another cluster of research objectives concerned the improvement of rail freight service competitiveness. In fact, the growing international freight transport is increasing the market share of road freight haulage for the low competitiveness of rail in international freight transport because of the low level of interoperability between the member states railway systems, which directly affects the efficiency of the intermodal chain. The low level of interoperability can be ascribed to a number of factors, such as:

- different legal and administrative conditions for building, financing and operating local rail infrastructures;
- inadequate cross-border co-ordinations between rail freight operators;
- different level of performance of national infrastructure;
- bottlenecks in important international rail corridors in relation to technical capacity;
- regulations which give priority to passenger service to the detriment of freight, and which are not harmonised on international services.

Furthermore, there is a significant difference in the progress achieved towards the internationalisation of rail services between the Member States and Accession Countries.

On the one hand, the new European regulatory framework for the rail sector has laid an important foundation stone for this structural change process. On the other hand, expected growth in demand points to the foreseeable dynamic development of the European freight transport market. It is now necessary to accelerate the development of predominantly nationally aligned systems into a single, integrated Pan-European system approach which will result into a more competitive rail freight service offer compared to road transport.

As a consequence, research aimed at gathering all necessary information to assess the general progress in the establishment of a European Railway Area, providing an "evaluation scheme for integration". It also aimed at developing a coherent conception of individual actions as a "break down" of the White Paper's general framework. If these actions are implemented in a co-ordinated way and according to a reasonable scheduling, the concept should enable to achieve a quantum leap for Trans-European rail services in quality, efficiency, and in volume (TREND, 2006).

4.5.3 Research results

4.5.3.1 Intermodal freight transport

Research has examined all kinds of organizational and business models within intermodal transport chains, identifying best practice cases. As a result, it was found that it is difficult to collect information about how intermodal transport solutions are organized in detail, and
which business models were used to make the service successful. However, result of this research has so far shown that sustainable solutions are only those when collaboration between chain partners is organized to share huge investments and reach critical mass (PROMIT).

An inventory of projects and operational solutions for intermodal infrastructures and equipment was produced, as well as the description of 11 projects demonstrating best practices in ICT applications in intermodal transport (including different levels of IT penetration, low compatibility of existing systems, differences in standards, lack of interoperability and integration). The developed systems provide solutions that cover a wide array of services (tracking and tracing of cargo, fleet management, electronic administration procedures, advanced navigation and communication, and intermodal door-to-door management) (PROMIT).

It was also found that among other problems, operational and service related barriers are the reason for not choosing intermodal transport. In fact, intermodal transport does not always meet the market demand related to lead times: reliability, frequency, flexibility, added value services, and price. The quality requirements of shippers have increased over the years. Road Transport has many advantages with regard to quality and price (PROMIT).

Finally, documents and data collection about intermodal transport and an inventory of the various kinds of incentives at the national level has been organized. The information collected creates a broad basis for analysis of the differences between countries of the various European regions, determining similar or opposing strategies and discovering good common practices or extraordinary examples (PROMIT).

The action strategy to increase intermodal traffic volume in the Brenner corridor consisted in (BRAVO, 2007):

- development of a coherent Brenner corridor management scheme which shall meet the requirements as a sustainable system – maintained beyond the project period - and an open system enabling the access of new entrants;
- development of an improved train path availability and allocation process;
- development of an interoperable rail traction scheme involving the employment of multi-current locomotives;
- development of an EDP-supported corridor quality management system (QMS) including quality agreements;
- development of an advanced customer information system (CIS) generating an “estimated time of availability (ETA)” information in the event of delays based on the development of a real-time train location system;
- elaboration of a time-schedule (short-, medium- and long-term perspectives) for extending intermodal transport services, e.g. to Southern Italy and Greece;
• development of a self-sustained intermodal technology to capture the growing market of conventional road-only semi-trailers for intermodal transport.

The application of this strategy should result in (BRAVO, 2007):
• an enhancement of the quality and efficiency of intermodal services thus inducing an increased customer retention;
• development and demonstration of innovative system technologies suitable for broadening the intermodal market base;
• raising of awareness of benefits of intermodal services with customers (i.e. freight forwarders and shippers) and interested parties on the Brenner corridor;
• increase of intermodal rail transport volume on the Brenner corridor by 50 % within a three years.

4.5.3.2 Competitiveness of rail freight services

The assessment of general progress in the establishment of a European railway area, led to the identification of significant best practices encountered within the analysis, as well as some highlights on particularly critical situations (TREND, 2006).

Although licensing no longer seems to be an issue causing potential barriers to integration, while safety certification procedures, as well as the performance and efficiency of the safety authority vary greatly from country to country. Romania appears to show a best practice, since the guidelines for safety certification and authorisation are reported to be very clear, thus allowing rapid application (less than one month).

The right of access is the legislative principle on which market access for different types of transport is based. Italy also allows cabotage, in the form of passenger and freight rail transport between two stations in the network, to Railway Undertakings (RU) from a Member State, though only after granting a "Titolo Autorizzatorio". This certificate is issued to RUs based in Member States that have already opened their market to competition.

The Track charging system appears to be clear and fair to users in most of the countries. The calculation of charges in Slovenia may be more complicated due to the difficulties in obtaining the Network Statement (in any case in the local language only) from the infrastructure manager.

The ways in which framework agreements are used in order to allocate rail capacity differ greatly in the countries analysed. However, almost all countries have implemented the European regulation on the matter. The procedures for capacity allocation, both for train paths and terminal capacity, are reported in general terms to be fair and clear. However, the management by the incumbent RU of the "last mile" for terminal access is sometimes reported as a potential factor for discrimination in some countries. In these countries, some
applicants may feel discriminated against when access to public terminals and marshalling yards is refused on the grounds of lack of capacity. Best practices in this area are reported where delays in allocation are minimised, and justifications for refusals are very clear: this happens in Romania (no refusals), Austria and Switzerland.

The access to electricity, and in particular the liberalisation of energy supply to RUs, appears to be one of the most important topics for successful liberalisation of rail service markets in the forthcoming years. No best practices have been reported for overall aspects in the topic of approval and safety authorisation of rolling stock. In almost all countries the procedures and time span for approval have proved to be unsatisfactory for RUs. In Hungary the absence of justification for refusal has been reported. Concerning single evaluation criteria (in which the aspect has been broken down), 7 countries show a responsible body fully independent from the IM (Austria, Bulgaria, France, Germany, Poland, Romania, Switzerland) and in these countries – except Germany – procedures for safety authorisation are reported to be very clear.

- In terms of the availability of drivers for international operations, Poland appears to have the best practice since PKP Cargo, as well as some private RUs, are training their locomotive drivers for international operations, in particular in the East-West traffic with Germany. Some private RUs even see business opportunities due to the high differential in personnel cost between Germany and Poland.

### 4.5.4 Policy implications

#### 4.5.4.1 Intermodal freight transport

Research has found that no comprehensive intermodal transport policy strategy has been elaborated by the EU so far (PROMIT). The Swiss transport policy is based on distinct objectives for modal shift and shows clearly the power of policy tools. Protection against negative effects due to heavy traffic includes measures such as transfer of transalpine freight transport from road to rail and denial of road capacity. There is an explicit modal shift target in the traffic transfer act; namely, to reduce the number of heavy goods vehicles crossing the Alps by road to a maximum of 650,000 per year until 2009.

Intermodal terminals and transfer points are important interfaces within intermodal transport chains. There is no common view of financing of intermodal terminals at the European level. Every country has different financing systems. Furthermore, intermodal terminals are not included in the TEN-networks today. In case the terminals will be a part of TEN-network, also financial aid from EU should be introduced as a part of TEN financing policy. German subsidies can be up to 85% of the investment including land acquisition, necessary infrastructure, buildings, equipments and costs of planning. Another promoting trend is the integration of ports and intermodal terminals, based here on experience in
northern Germany (PROMIT).

Key issues to make intermodality successful are (PROMIT):

- concentrated traffic (a critical volume is necessary);
- high quality of service along the whole chain;
- efficient transfer points;
- standardisation of equipment, operating procedures, documentation, etc;
- suitable organisational structures through partnerships;
- efficient information systems;
- legal and regulatory promotion.

The collection and analysis of extensive data on national transport policies supporting intermodality through infrastructure, R&D, services, environment, taxation, legislation and transport policy, led to the identification of many strategies available to support sustainable transport (PROMIT).

- Most support actions dealing with intermodal transport are directed to rail investments and connections, access to the railway system, intermodal terminals, handling equipment, inland waterway connections, and IT systems (mostly waterborne).
- Services include setting up of rolling-motorway services and intermodal and combined transport services. SMEs have also been taken into consideration (the aim, more or less, has been to shift freight from road to rail and waterways).
- Typical taxation measures are rail track price reduction, tax exemption in pre- and on-carriage, and refunds for vehicles or boxes being used in combined transport.
- Typical legislative measures are exemptions from weekend driving restrictions for pre-and end-haul carriers and exemptions from maximum weight.
- Transport policy support deals with many types of actions such as scanning modal shift potential, national or regional transport plans, national plans for logistics centres and freight villages, programs for developmental support for combined transport, development schemes for combined traffic, logistics competence centres, and integration of rail into European transport corridors.

4.6 Sub-theme 5: commercial fleet and public transport operations

4.6.1 Background

Research reviewed in the related EXTR@Web paper (EXTR@Web, 2006) has addressed in the freight area:

- the state of tracking and tracing systems;
- the development of planning tools for the distribution of goods in urban areas;
the development of an information and communication system for the management of fleets, including navigation, info-mobility and dangerous goods monitoring capabilities.

In the passenger area, research reviewed in the EXTR@Web paper has addressed:
- European harmonisation and standardisation issues in light rail and light metro;
- best practice as well as demonstrations of car sharing systems;
- state of methodologies tools supporting the planning of local public transport;
- issues of quality and real-time information in bus transport.

4.6.2 Research objectives

Research has focussed on finding best practices for the application of ITS technologies to support freight transport operators to efficiently planning and managing delivery trips (eDRUL) (BESTUFS, 2003). Research was motivated by the fact that urban freight transport is more and more a key issue for the sustainable development of cities, which are facing problems such as high level of traffic congestion, high energy consumption and environmental impacts. Recent developments of ITS can offer freight transport operators the opportunity to manage and operate their fleets more efficiently by supporting them with technologies such as Global Positioning Systems (GPS), Geographical Information Systems (GIS), advanced software for vehicle scheduling and routing, and various telecommunication devices.

4.6.3 Research results

Research has investigated, developed and validated an innovative e-logistics platform, and supported service models, for improved management of freight distribution processes in urban area (eDRUL). The platform is strongly based on integration with e-Commerce/e-Business architectures and concepts. The developed solutions enable the management of available resources of the logistics system (fleets and available capacity, logistics platforms, goods collection and unload areas, routes, etc.) in a way to realise flexible, demand-driven freight distribution schemes integrated within the ITS urban scenario.

The implementation of the eDRUL architecture involved a number of advanced ITS applications and enabling technologies, including:
- web-enabled information and booking services for the customers (B2C segment), information exchange, resource sharing for e-logistics operators (B2B segment);
- delivery notification and information through mobile phones and SMS;
- goods dispatching software for trip planning and resource (i.e. vehicle capacity) optimisation;
• in-vehicle display units and hand-held devices (palmtops, PDAs, new generation mobile phones based on WAP and GPRS) to support vehicle drivers and goods delivery operators tasks;
• GPS-based or GSM/GPRS-based vehicle location systems;
• long-range, wireless communications (GSM, GPRS) to support interactions and information exchange among the logistics planning/management platform and vehicles/goods delivery operators.

Different city distribution scenarios and service models can benefit from the developed solutions:
• city distribution services in limited traffic areas under various access restriction measures;
• consumer-driven goods delivery services through the use of dedicated infrastructures such as pick-up points or take-away stations;
• optimisation of deliveries and reduction on city impacts through cooperation of networked transport service providers;
• door-to-door delivery services to special user categories such elderly and disabled consumers.

The eDrul concept has been successfully tested in four European cities: Aalborg, Eindhoven, Lisbon, and Siena.

A concept named “Commercial Vehicle Fleet Management System” has also been developed (BESTUFS, 2003), which permits fleet owner to take advantage of advanced logistics services made available on-line. This concept increases the efficiency of activities related to fleet management. The system consists of:
• on-board vehicle units, whose functions are acquiring data from on-board sensors (state of motion or stop, road or traffic information, etc.), pre-processing and storing them, as well as exchanging information with the fleet management centre.
• the fleet management centre, which evaluates data sent by on-board units, and communicates with fleet owners in order to send instructions to the on-board units for optimising purposes;
• the users (fleet or vehicle owners) who can access on-line information on their vehicles or about certain traffic situations or road conditions.

Operators and fleet owners can use only the services they really need, choosing the corresponding software packages, which become available by connecting to the central server at the headquarters. Six software packages have been designed: basic, safety, diagnostics, financial, consignment-safety and administration.
4.6.4 Policy implications

Main conclusions from research are that the application of ITS to provide logistics services such as fleet management and route planning can significantly contribute to make logistics more efficient and customer-friendly, as well as to reduce environmental impacts. A significant part of traffic in metropolitan areas is generated by freight transport activities (pick-ups and deliveries). Furthermore, the number of individual deliveries is meant to further increase because of the development of e-commerce and orders made on the Internet. As a consequence, resources should be made available to further investigate possible use of ITS for creating new logistics services and concepts to optimise goods delivery processes, as well as for refining and integrating the existing ones (BESTUFS, 2003).

4.7 Sub-theme 6: transport demand management

4.7.1 Background

Research reported on in the EXTR@Web paper (EXTR@Web, 2006a) has addressed mainly pricing issues. UK research has reviewed the urban pricing scheme in Durham and developed a national model able to forecast the impacts of HGV (heavy goods vehicle) charging. Research in Switzerland has analysed how to reform the pricing of road and rail transport in the country. Another topic addressed is the investigation of the mechanisms underlying urban sprawl and strategies to tackle this.

4.7.2 Research objectives

Research objectives focussed on interoperability of payment systems, facilitating and accelerating transport pricing reforms, and developing scenarios to describe trends in transport and energy supply systems.

4.7.2.1 Interoperability of payment systems

A research objective concerned the investigation of issues concerning cross-border interoperability of Electronic Fee Collection (EFC) systems with a view of defining a future shared standard, and building consensus in the Member States and among operators.

Research has already developed the CARDME concept for a common interoperable payment service, which can be added to existing systems or provide the basis for new
systems. Furthermore a detailed design of a transaction for use in dedicated short-range communication (DSRC) systems was completed. In CARDME-4 research aimed at building consensus among operators and Member States on the data required for the CARDME transaction and preparing an agreed set of specifications. It also further investigated areas where previous research showed to be technological problems such as the use of interoperable electronic purses. Finally efforts were made to disseminate CARDME concepts to a wider audience.

4.7.2.2 Transport pricing reforms

Research efforts were dedicated to facilitate and accelerate pricing reforms.

Pricing of transport infrastructure use has been identified since the Green Paper of 1995 on fair and efficient pricing (EC, 1995) as a pillar of the strategy towards a more sustainable transport system. Visible progress has been made since then both in the scientific area and in the policy making field. However, pricing reforms are still hindered by the existence of specific, critical gaps in the available body of knowledge, and by the insufficient level of consensus currently achieved within the transport community of stakeholders. Furthermore, the state of advancement of research and policy making on the issue of a more fair and efficient pricing system is uneven between modes: this implies that a differentiated approach has to be taken for rail/road and air/maritime.

Research has provided a discussion platform for policy makers, transport operators, researchers and other stakeholders to exchange views on the implementation of new pricing regimes, cost calculation methods, and derivation of tariffs to be levied. The platform aims to improve and enhance the transfer of research findings to policy makers and stakeholders involved in the formulation and implementation of transport pricing reforms. It also aims to stimulate the debate among stakeholders in order to build consensus on the principles and the practice of transport pricing, thus facilitating and accelerating the implementation of pricing reforms and contributing to the implementation of the EU transport policy (IMPRINT-NET).

Particular emphasis was laid on the air and waterborne modes, for which the state of knowledge is less advanced, links between infrastructure charging and investment needs, and pricing reforms in NAS, in the perspective of EU enlargement.

4.7.2.3 Transport and energy supply systems

The future framework of the transport system is intimately linked with the general energy supply of the future. The nature of the fuel technology and economy has been a major influence of the transport system and mobility patterns of today.
However, circumstances are changing. There is an increasing concern about the environmental consequences of the fuel technology used on the one hand, and the future availability of the fuel required on the other hand. Driven by these issues, a wide range of new or improved fuel technologies are being proposed and developed.

Each alternative fuel technology brings with it issues over the wider consequences of its adoption. These issues include the autonomy and security of the fuel supply, the infrastructure requirements of the fuel technology, the implications for the possible pattern of use of the vehicles, and so possible changes in the patterns of mobility with its impact on land use. There will also be political, social and environmental issues to be considered with the assessment which technologies should be encouraged and invested in.

There are technological risks with all new technologies, combined with the uncertainties in the energy, social and economic future. The implications of the various futures are best considered by investigation of a series of scenarios reflecting a range of ‘best’ estimates of future conditions in the energy, transport, economic and social fields.

Research aimed to develop, compare and assess possible scenarios for the transport system and energy supply of the future. These scenarios take into account the state of the art of relevant research within and outside of the Sixth Framework Programme (FP6), and such criteria as the autonomy and security of energy supply, effects on the environment and economic, technical and industrial viability (including the impact of potential cost internalisation and the interactions between transport and land use) (STEPS, 2006).

4.7.3 Research results

4.7.3.1 Interoperability of payment systems

Since users in some countries demanded for greater privacy than that offered by the central account method of payment adopted by the CARDME concept, previous research investigated the possibility of using credit cards through a DSRC link, and the introduction of a European electronic purse suitable for EFC applications for toll payment. The conclusions were that solutions seemed to be not available in the short term. Research in CARDME-4 has further investigated these issues.

As to the electronic purse, the transfer of real money over a DSRC link require costly level of security, and the processing speed of currently available IC cards are still low and take a second or two to complete a transaction. As a consequence the application of this technology is possible only for single lane systems where barriers can be kept closed until a transaction is complete, or for free flow systems with an additional structure to provide a second communication zone for completing the transaction. In the case of credit cards, the
processing time is similar, and the issuers are financial institutions who have no particular interest in offering cards with faster chips (a processing time of a second or two is acceptable for retail transactions). However, even if the speed of chips could be increased, it would remain the problem of reading credit card details. The use of an onboard unit (OBU) with a credit card account number would provide the necessary transaction speed for free flow operation but, on the other hand, would not permit to use different cards (CARDME-4, 2002).

No definitive conclusions can be drawn on how VAT for international traffic will be calculated when using the concept proposed by CARDME. A general rule seems to be that tax is payable at the rate prevailing for the country in which the service is received, but when a single invoice is provided by the users’ home operator it is not clear how this would apply. It is possible that the procedure could be similar to that used by telephone companies for roaming users. Finally, the use of a hand-held cellular telephone as a payment device has been investigated (CARDME-4, 2002).

4.7.3.2 Transport pricing reforms

The platform permitted to reach consensus among stakeholders on recommendations about how to implement pricing reforms in the transport sector. Furthermore, the platform has developed methods for ensuring the harmonization between the GRACE tool for external costs evaluation and the IMPACT Handbook recommended values (IMPRINT-NET).

4.7.3.3 Transport and energy supply systems

Research has also developed a basic set of scenarios to describe trends in transport and energy supply systems. Two main variables marked the scenario framework. The first was fuel price increase, which is directly related to energy scarcity. In the coming decades the fuel price increase may be as generally accepted in current times, or energy may be subject to more severe scarcity (so pointing to a faster increase in the fuel price). The second variable is represented by the policies that various authorities deploy in response, such as ‘business as usual’ (not specifically meant to target transport system and its energy supply), or more targeted policies (e.g. technology investment to adapt with the use of innovative technologies, or use of more stringent demand management) (STEPS, 2006).

The scenarios were simulated with existing integrated land use – transport models, both on the European scale and on the regional scale. The regional models covered five diverse regions in Europe: Edinburgh, Dortmund, Helsinki and Brussels with their respective surrounding regions, and the region of South Tyrol in Northern Italy. Partly, the scenarios worked together to produce the input needed to calculate all parameters needed. In some cases, results from the European models could be used as input in the calculations within
the more detailed regional models. The prognosis year was typically 2030 (in some cases 2020). The outcomes were described in an extensive overview of their impacts. The modelling exercise provided indications about the development of several variables (transport demand, economy, energy consumption, emissions, etc.) over the period 2005 – 2020 / 2030 under the different scenarios.

From the analysis of scenarios it was concluded that energy and environmental criteria improve in all scenarios and models. Demand management appears to be more effective than technology investments in the long term, but this is quite sensitive to the actual policy package selected, its efficiency, and the way fuel prices will develop. The predicted effect on social criteria is not simple. Both fuel price increases and policy measures tend to result in higher transport costs, mobility constraints and reduced accessibility. Economic development for large parts of Europe could be at stake because of this, and investment in new, sustainable technologies might be a preferable option for a better future for transport systems and their energy supplies.

4.7.4 Policy implications

4.7.4.1 Transport pricing reforms

Research has drawn the following conclusions (IMPRINT-NET).

In the interurban road sector there are current evidences that a traditional allocation of road maintenance and renewal costs based on standard axle kilometres in the most congested areas appears reasonable. There is good evidence that technology is improving over time, while successive implementations help to build up acceptability. Some form of independent regulation of charges and use of revenues may also increase acceptability. It may be simpler and more necessary to charge larger vehicles such as HGVs rather than passenger cars. This leads to a need for a kilometre based charge varying with the characteristics of the vehicle (gross weight and axle load) for heavy goods vehicles, buses and coaches. Relatively simple technology can implement such a charge, with varying levels between countries.

In the rail sector the starting point for rail infrastructure charges should be a charge per gross tonne km to reflect marginal wear and tear costs. In the absence of specific evidence for the country concerned, this might be approximated as 30% of average track maintenance and renewals cost. Where there is a wide variety of types of rolling stock in terms of axle weights, speed and unsprung mass, engineering formulae may be used to weight the different types of rolling stock according to the equivalent damage per gross tonne km they do. Where data exists, it may also make sense to segment charges according to the type of track (e.g. high speed, other main lines, secondary lines, low
density lines), as there is evidence that marginal costs are lower the higher the quality of the track.

In the maritime sector, it should be examined if there is a net benefit from the implementation of SMCP (Social Marginal Cost Pricing). A Cost-Benefit Analysis (CBA) is needed, together with a regional impact analysis and a socio economic impact analysis in order to properly establish if the introduction of pricing is needed. The probable impact will be increased transport costs for the end user. In the case of road transport different outcomes of the CBA were predicted in the case of the Stockholm, from net benefits to losses to society. It is not the question of the perfect SMCP scheme, but what is a good scheme of pricing. Road pricing has in general a goal to reduce congestion, and this is different from maritime transport.

In the waterways transport sector, transparency, and easy implementation of the system (introduction of pricing regimes for other modes at the same time) is the main focus to get the pricing scheme accepted by the users of the system. The group is not sure about possible lobbying from e.g. the railway lobby (especially in central Europe) or the road sector (especially in Western Europe). Therefore the inland waterway sector needs to be proactive to arrange the introduction of pricing.

In the air sector there is the need to improve the evaluation and the impact assessment of the external costs of air transport, with particular reference to global warming, noise, congestion and scarcity. To reach a common agreement on methods and order of magnitude of the monetary evaluation of the external costs of air transport (both “en route” and at airport level) represents an important precondition for carrying out pricing reforms. Evidences form research need to be strengthened, and research streams need to be promoted at international and national level by policy makers and regulators.

Concerning the use of revenues, for all modes the Expert Group sees benefits in being a regulator, independent from day-to-day government intervention, to oversee charges and use of revenue. Such a regulator would have specific duties, to prevent abuse of monopoly power, to investigate efficiency and to examine use of revenues, working within a policy framework set by the government.

4.7.4.2 Transport and energy supply systems

The results of research constitute a valuable synthesis of the main findings on trends and policy scenarios and their predicted effects. They serve as a basis for the development of a view on future policy and give insight into research requirements in the area of transport and energy scenarios.

Research has created a valuable contribution in the hugely complicated trade-off between
energy and the energy sustainability of our transport networks on the one side, and economic development on the other (STEPS, 2006).

4.8 Implications for further research

The information on implications for further research illustrated in this section has been collected from the projects reviewed in this report, and from European Strategic Research Agendas (SRA) developed by the European technology platforms\(^\text{13}\) on Air Transport (ACARE, 2004), Rail Transport (ERRAC, 2007), Intermodal Transport (EIRAC, 2005), Waterborne Transport (Waterborne, 2006), and Road Transport (ERTRAC, 2004). The characteristics of a strategic research agenda for air transport (ACARE 2006) can be extended to the other technology platforms. A SRA:

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

4.8.1 Implications for further research from projects reviewed

As to the sub-theme 1 concerning Infrastructure and vehicle development and maintenance, the “Vision 2040” has identified, comparing the future situation with the present situation, research areas for developing each of the four key concepts as follows. “Reliable infrastructure” requires the development of new materials and products, fast, hindrance-free maintenance techniques, and good asset management tools to support decision-making by road authorities with respect to maintenance strategies. As to “Green Infrastructure”, an important contribution of road engineering to the green infrastructure concept involves the saving of natural resources. For what concern “Safe & smart infrastructure”, easy and cheap data acquisition along with communication between the smart road systems and the cars will be crucial to the success of system optimisation. Research is required to develop real Dynamic Road Information Panels with the ability to

\(^{13}\) Technology platforms are framework to unite stakeholders around: a common “vision” for the technology concerned; mobilisation of a critical mass of research and innovation effort; definition of a Strategic Research Agenda (EC 2004). The rationale behind them is to contribute to competitiveness, boost research performance, concentrate efforts and address fragmentation (ibidem).
integrate common traffic signs, static and real time information. Finally, as to “Human infrastructure”, society’s demand for liveable surroundings requires a new design concept: human design, the harmonisation of the dimensions of the built environment and infrastructure with human dimensions.

In the sub-theme of traffic management and control, although research has developed a useful tool for ATM operational concept validation (through the development of the Validation Best Practices Manual in CAATS), it is necessary to further investigate alternative solutions, resource requirements, technology performance and availability. This will permit to further refine the process of successfully identify stakeholders requirements concerning the performance and behavioural capabilities of an ATM concept.

Research has shown that airspace users are convinced that ASAS and ADS-B applications will be an integral part of the future ATM systems. Although benefits of these applications are promising, it is necessary to carry on further work on validation, safety, certification, benefits versus costs, etc.

Additional research should be performed to ensure that the Super Highway is operated within the SESAR airspace and planning environments, with precise descriptions of how the Super-Highways would be activated as part of planning activities and how they would be exploited.

As to the sub-theme concerning terminals, the decision-making tool set developed by SPADE has been object of extensive validation by airport stakeholders, from technical and end-user perspectives. Airport stakeholders expressed a positive attitude towards the SPADE system, and perceived it as user-friendly, however a need was expressed to pay more attention to clarifying how it would fit within an organisation and on business models for its operation.

4.8.2 Summary of further research recommended by Strategic Research Agendas

4.8.2.1 Infrastructure and vehicle development and maintenance

The ERTRAC Strategic Research Agenda has identified a number of research topics to improve the efficiency of maintenance operations in road transport (ERTRAC, 2004):

- Infrastructure monitoring and maintenance management systems. They should be upgraded using advanced software, sensors and data transmission, responding to real-time local needs and reducing the impact of road works on travel time. Low cost, autonomous sensors for road condition monitoring have to be further developed.
- Introduction of quicker, more effective and durable road maintenance techniques.
• Development of new technologies for maintaining underground utilities (cables, pipes for water, gas, electricity and communication technologies) with a minimum of traffic disturbance in particular in urban areas.
• Improvement of maintenance operations through application of digital techniques like virtual factory and augmented reality. Systems and materials capable of self-diagnostics and repair should also be developed.
• Development of new materials and components for fast and low cost road infrastructure maintenance.
• Development and implementation of new road construction and maintenance management and rapid construction and maintenance techniques to avoid capacity reduction, road closures and coordinate with public utility work.

The Strategic Rail Research Agenda (SRRA) has identified in innovative materials and production methods an effective way of reducing costs for building new products and for their operation and maintenance, as well as for improving rolling stock availability and productivity. It also suggests developing more energy efficient train control systems. Priority research areas identified are (ERRAC, 2007):
• Introduction of new lightweight materials and more efficient construction methods to encourage the development of a better track-train interface resulting in further cost reductions.
• Development of new technologies for vehicle structures and components and definition of new performance standards for structural materials.
• Investigations into coating and surface treatments, production technologies and support logistics.
• Innovative design of systems and components for the automation of existing rail systems and the development of operating systems with new technology.
• Development of track train and track designs to maximise the reliability of both, maximise capacity and minimise maintenance cost.
• Reduction in infrastructure failures causing delay.
• Automated track and structures inspection and maintenance ultimately leading to zero maintenance through the use of high reliability equipment.
• Improvement in maintenance. Efficiency can be improved through optimising the split between the cost of initial investment and maintenance on infrastructure and rolling stock. The increasing scarcity of maintenance skills will result in the development of innovative low labour technologies (e.g. remote monitoring of the integrity of bridges and tunnels; track-train interaction models to aid predictive maintenance; degradation modelling of infrastructure to support predictive maintenance; and the use of embedded devices to check tolerances and displacements). Innovative predictive maintenance methodologies for fleet management must be developed using automated remote workshop technologies. Meanwhile the increasing demand for cross border operation requires the development of technologies able to support the concept of major open workshops for dispersed fleets.
The ACARE SRA has identified a number of features aircraft should have for a highly time and cost efficient air transport system (ACARE, 2004):

- Aircraft should be planned to have adequate margins of performance (especially on long haul) to allow trajectory schedules to be met.
- ATM compatible capability for zero-visibility surface movement on the airfield.
- Streamlined boarding patterns for multi-door embarkation.
- Communications that allow the aircraft crew to be part of the aircraft/airport/ATM loop whilst in the airport area and able to send and receive voice and data.
- A maximised standardisation of the aircraft and its systems for cheaper manufacturing, operation and maintenance.
- Designs aiming to zero maintenance with in-flight monitoring allowing increased aircraft utilisation and leading to lower operating costs.
- Automation for route keeping and separation, which allow more versatility in operation, and gives optimised planning and dispatching characteristics for the operator (reduced requirements for flight crew in the cockpit further lowers the cost base for operating the airplane).

The Waterborne Strategic Research Agenda (WSRA) has pointed out the necessity to develop innovative vessels and ship systems. It has identified the following research areas (Waterborne, 2006):

- **The energy efficient ship.** The design for new propulsion systems need to be developed and optimised into new hull forms with integrated design tools. Electric propulsion can offer new propulsion system configurations providing increased ship design flexibility, with lower build and operating costs.
- **New Materials and Production Methods.** A key RD&I task is to investigate emerging new materials, structure types, technologies and production methods to determine their potential benefits for the maritime industry. New, more cost efficient vessels will require the development of lighter and stronger engineering materials such as advanced composites, alloys and sandwich structures. New production techniques must be developed to satisfy the demand for speed and cost efficiency and to ensure a safe, clean and efficient working environment.
- **Optimum Vessel Utilisation.** Waterborne transport maximises its economic and environmental benefit when each vessel carries as much cargo as possible. Individual experience and manual methods dominate commercial operation of vessels. Improved control and decision-making requires introduction of a new breed of management tools to ensure the maximum utilisation of vessels at all times.
- **Effective waterborne operations.** Tools for modelling LCC will have to be developed to assess and optimise the impact of improvement measures in LCC reduction, e.g. properties of the new vessel and maintenance schedules. Energy demand for functions other than propulsion is high for many vessel types. Advanced power management systems, in combination with intelligent power generation concepts that adapt to the demand profile, will contribute to substantial cost and resource savings.
• **Intelligent Maintenance Planning and Optimisation.** Improved and optimised maintenance scheduling is a key factor for competitiveness. It will be enhanced by the further development and implementation of emerging technologies such as embedded Equipment Health Monitoring (EHM) to provide an enhanced and reliable predictive maintenance support. Development of in service performance databases and innovative intelligent pattern recognition tools will deliver robust maintenance planning information. This will maximise the availability of the ship.

• **Automation and Platform Management.** New developments in process automation, computer technology, sensors, smart components and communication must be applied to the maritime industry to enable the safe and efficient operation of increasingly complex vessels with a minimum of crew. The individual systems need to be designed to standardise hardware and software interfaces within a holistic platform management concept. The on-board decision support systems should be linked to shore based control centres for technical back up and incident management support.

### 4.8.2.2 Traffic management and control

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

- Development of real-time traffic information systems, in combination with a European digital road map database, including traffic restrictions, road condition data, and parking availability, to allow reliable travel time prediction and better route selection.
- Integration of intelligent transport management and infrastructure systems into broader networks (e.g. food distribution, energy, industrial production) to allow a more responsive multi-modal transport system capable of resisting and recovering from shocks.
- Development of robust indicators on freight transport efficiency, journey time reliability, and network efficiency.
- Development of applications of navigation and positioning systems for tracking the position of vehicles and for collecting real-time traffic information. Investigate potential for improved and more accurate localisation to enable new functions such as parking slot identification, lane keeping, distance relative to other vehicles (platooning) based on vehicle-vehicle and vehicle-infrastructure communications combined with the GALILEO satellite system.
- Development of network level systems to support the transit of heavy vehicles. This should consider the issues of restrictions for bridges, tunnels, steep gradients and congested or environmentally sensitive areas. Real-time and seasonal effects will need to be examined to maximise the effectiveness of the system in all weather conditions.
- Development of solutions using new dynamic traffic management and infrastructure technologies in order to improve the use of the existing infrastructure and reduce bottlenecks.
• Investigation of systems for platooned trucks in dedicated lanes.
• Develop new technologies for cost effective traffic data collection on all networks (urban, rural, main roads and motorways) with improved performance over existing technologies. Communication with the navigation systems in the vehicles, Traffic Dialog Systems (TDS), Floating Car Data (FCD) and anonymous data transmission should be further developed. Mobile communication may enable the collection of data from distributed, moving vehicles in real time and could allow more comprehensive assessment effects of traffic effects.
• Development of measuring methods for congestion, travel time reliability, network performance monitoring and service level indicators.
• Development of real-time travel time prediction methods and increased reliability of short-term traffic forecasting models to improve information and management.
• Further research on the implementation and the assessment of New Information and Communication Technologies (ICT) and ITS technologies for application in road transport.
• Development of assessment tools for traffic management strategies, based on dynamic capacity optimisation models, taking into account dynamic lane allocation, tidal flows, two-way communication with the users, ICT and ITS, and electronic parking management services.
• Creation of dynamic, information led traffic management and control models utilising embedded information, real-time data transmitted from the vehicles (position, speed, origin, and destination), individual route planning, and access control to routes, lanes, and parking. More automation in traffic flow control should be developed.
• Development of methods for intelligent, dynamic lane allocation considering the effects of variable lanes and speed limits for different traffic flows, taking into consideration all types of vehicles (trucks, cars, busses, two-wheelers) private or public.
• Improvement of the links between traffic control centres across Europe in order to enable traffic management on long stretches including alternative routes, incident management and congestion management.
• Development of methods for mobility and traffic management in case of special events, man-made and natural. Strategies based on risk evaluation should be developed.
• A better understanding of removing bottlenecks in order to provide the required capacity. Harmonised decision indicators and standards for the level of service of the road infrastructure for all road users have to be established.
• Pilot studies and validation projects for the practical installation of ICT and ITS, intelligent pavements enabling dynamic traffic management, allowing dynamic allocations of lanes, intelligent merging systems, speed control, guidance systems, and lane prioritising for collective transport, high occupancy and emergency vehicles. These pilot studies should include new technologies for electronic road markings, pavement surface colouring and dynamic lane barriers.
• The overall effectiveness of separate lanes for road operations should be evaluated, as well as the need for upgrading the secondary road network (safe alternative and escape routes).
• Further research on Automatic Vehicle Guidance (AVG) (in particular speed and distance management systems, is needed to evaluate its potential to increase road capacity).
• Evaluation of systems enabling platooned vehicles for safety and capacity increase.
• Research on interactive functions (vehicle-vehicle, vehicle-infrastructure) in support of methods to improve the capacity of the road infrastructure.
• Telematics communication systems must be developed for real-time information transmission between the infrastructure, vehicles, and individuals for:
  ♦ Infrastructure monitoring, maintenance and operating activities,
  ♦ Suitable management and operative processes for emergencies,
  ♦ Improved safety and avoidance or reduction of congestion

The SRRA has also stressed on the fact that efficiency can be increased by enhancing railway interoperability, through a continuous improvement of the conditions for operational and technical integration of the different national railway systems in the European Union and Accession Countries. More specifically, further research is needed to (ERRAC, 2007):
• Develop the use of new train control technologies such as ETCS (European Train Control System) level 3 to increase capacity.
• Develop specifications and hardware for a new generation of interlocking systems to facilitate the introduction of ERTMS (European Rail Traffic Management System).
• Development of new technologies for staff training and traffic management such as virtual reality and simulation tools.
• New methods and tools for train configuration management and for train/infrastructure interaction management.
• Availability of fleet management and train deployment information should across Europe.
• New management techniques to enable more efficient use of infrastructure (e.g., through improved management and integrated long, medium and short distance clock-face rail services14).
• Tools that can predict deterioration of both track and train as traffic levels increase, leading to scientifically based track access charges including classification of vehicles and track that reflect the damage inflicted on track and train.

The ACARE SRA has identified the following research needs for a highly time efficient air

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14 A clock-face timetable (used in Switzerland) means that trains leave at the same minutes after the hour, every hour. As a consequence, PT users can easily remember the departure times, and railway networks are easier and cheaper to manage because fewer (larger in capacity) trains can used to meet the demand. Finally, less investment in railway infrastructure are needed, because there are less train movements.
Improvement of predictability within the ATM system. Time efficiency is strictly connected to high predictability. The main aspects to be considered are the absorption of non-predictable events especially weather and congestion. Unfortunately, weather will never become fully predictable, nor manageable, but it is possible to mitigate its effects by organising the airspace dynamically in order to minimise its impact on traffic flows. In each airport, all weather landings/take-off equipment must be made mandatory, and pilots or controllers must be equipped with enhanced/synthetic vision systems. The congestion issue can be solved adopting a more rigid organisation of traffic, according to aircraft capability as well as aircraft operators needs.

The increase in predictability is likely to be based on a time and space (4D) trajectory. The “4D trajectory management system” must be supplemented by autonomous separation, in which aircrafts ensure on their own that they are appropriately separated one from another, for instance on express-ways or in low density airspace. In other zones “conventional” ATM, rendered highly efficient by the use of new technologies and automatic support to human controllers will be used. Dynamic Flow Management techniques would need to be integrated into possibly new Air Traffic Control (ATC) operational concepts through a consistent, end-to-end trajectory-based information management system. For example, the integrated (air/ground) 4D trajectory management system is ultra secured, in order to prevent any intrusion in the definition and negotiation of trajectories. Trajectories close to the airports are the most security sensitive, because of their proximity to cities and the ground. Secured trajectories should be therefore defined and strictly respected by the aircraft. Any deviation from the defined trajectory should be immediately detected, and given the ground proximity of the aircraft and the impossibility to launch interception actions, the ground system should take over the control of the aircraft in order to put it back on its planned trajectory.

Improvement of the ATM operations by ensuring that all actors, ATM aircraft operators and airport operators, exchange dynamically information on the exact status of their operations.

Development of models to optimise the efficiency of the whole operational ground/flight/ground cycle (air and ground operation, aircraft/airport/ATM environment). Particular attention must be paid to the modelling of passenger and baggage flows (intermodal, in the airport, boarding).

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

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

4.8.2.3 Terminals

As to rail transport, according to the SRRA, research need to focus on the need for optimising operations at freight traffic nodes. More specifically, migration times need to be reduced by enhancing the interoperability of the existing infrastructure, and the development of new railway equipment. Furthermore, there is a need to improve station design to attract passengers and improve personal security and access and ensure lowest life-time cost (ERRAC, 2007).

ACARE SRA 2 has identified the following topics for developing a highly time efficient air transport system (ACARE, 2004):

• New business models for the allocation of slots to airlines that underpins reliability of schedule.
• A streamlined and automated passenger handling system that makes the arrival at the airport, checking-in, baggage surrender and passage to the departure gate as swift, smooth and automatic as possible. Basic identification, baggage check-in and flight checks are at entry to the airport. Security checks take place immediately before boarding at the departure gate.
• On-schedule aircraft management systems that present the aircraft to the departure gate in enough time to load before departure on schedule.
• Links to the airline information network that allows the airport to supply and obtain information to the network. Airports need to be
• A runway management system able to adjust for weather, with wind-shear and vortex monitors, and able continuously to adapt separation distances to circumstances and to minimise them.
• A surface taxiway system that can be used in all weathers.
• Integrated surface management systems that allow take-offs, landings, taxiing and servicing to be co-ordinated with full A-SMGCS capability to improve predictability.

• Fast and efficient aircraft handling and servicing systems. These must deal with a variety of types working on different flight modes. Increasingly these include underground systems that permit “roll-over” of the aircraft for de-icing and other servicing.

• Systems that are compatible with highly efficient ‘trajectory’ controlled movement across and into and out of the airport.

The WSRA has identified the following research areas for further research concerning maritime transport (Waterborne, 2006):

• **Accelerated Development of New Port and Infrastructure Facilities.** The development of waterborne traffic by new European policies of motorways of the sea and transfer of cargo from the road transport to inland navigation will require the development of new ports, terminals and inland waterways. Research activities are necessary to identify efficient, economic and environmentally friendly technical solutions for building, maintaining and upgrading port and inland waterway infrastructures, as well as navigable canals.

• **More Efficient Ports and Infrastructure.** It is necessary to narrow the gap in the point-to-point delivery time of waterborne transport relative to road transport. RD&I activities should investigate ways of minimising the distance from vessel discharge point to consumer, minimising docking time, minimising transfer time from ship to shore, minimising time to identify, select, transfer and clear individual consignments.

• **Equipment and Systems for Faster Cargo Handling.** Research activities are necessary to identify weaknesses in the existing port systems, including inappropriate and non-standard handling facilities and to propose Europe-wide standard solutions. This must be done in conjunction with new concepts of vessels and innovative loading/unloading systems. Improvements are necessary to trans-shipment methods to reduce trans-shipment time and thus encourage greater use of short sea, coastal and inland shipping. Express, secure port network systems and procedures should be developed to facilitate more rapid and secure transit of goods throughout their entire transportation from door to door, including inter-port trans-shipment. This will reduce containers’ dwell time in ports to only a few hours instead of days.

• **Automatic Operations.** Appropriate and standardised automated docking systems have the potential to reduce point-to-point cargo delivery times. A standardised cost-effective system should be identified and developed. The automation of marshalling areas is already a feature of a few large ports, but has yet to be widely adopted. Research is needed to determine whether automated marshalling can be safely and economically introduced to a wider spectrum of ports sizes and types. Automated control of vessels approaching/departing port using intelligent systems and improved navigational aids could significantly help to increase efficiency and safety of ship handling. The technological aspects of such development should be investigated along with a consideration of the legal and regulatory aspects.
• **Intelligent Transportation Technologies and Integrated ICT solutions.** Innovation in this field is essential. It will enable more efficient planning, booking, simulation, routing and control of cargo along the different transport modes as well as providing other services supporting efficiency, safety and security.

• **Ports Network and Data Exchange.** To maximise the efficiency of the real time transport opportunities and vessel utilisation it is necessary to develop a web-based system of port networking to identify and exchange vessel locations, planned routes, cargo facilities and dates and times of movement.

### 4.8.2.4 Multi-modal networks

For what concern road transport, the ERTRAC SRA has identified the following research areas:

• Promote European level intelligent multimodal transport and routing systems.
• Assess the potential of various forms of Urban Intermodal Transport Management Centres.
• Development of automatic ticketing and fee collection for seamless mobility and goods transport within Europe. This should aim to stimulate an optimal distribution over all modes.
• Development of new concepts for multimodal connection areas that are all-mode friendly, allow seamless links, utilize real-time, multimode information systems, and offer other value-added services to the passengers (meeting place, multimedia, restaurants, shops).
• Further investigation on technologies that can facilitate the transfer between modes (efficient interchange for passengers, people movers, more efficient park and ride).
• Improvement of the global quality (direct and indirect cost, time, physical access, security) of the entire mobility chain, including modal transfer.
• Definition of standards are needed for traffic information and routing systems in a multimodal transport environment, e.g. for location, timing, metadata common referencing systems.
• Development of concepts for the Truck of the future including modular goods carriers and effective road-rail combinations.
• Development of European level intelligent Intermodal Transport Units (ITU) for modular goods movement.
• Development of new solutions, operational throughout the enlarged EU, for long-distance transport combined with efficient modal transfers.

The SIRA and WSRA have identified the following research areas for more efficient intermodality in the maritime and rail sector (EIRAC, 2005) (Waterborne, 2006):

• **Transfer Nodes.** Any real increase in intermodal transport will require a significant additional increase in transfer nodes across Europe. Increased interoperability depends upon access to sufficient transfer nodes. Research is required into the setting
up of a network of transfer nodes around Europe and should encompass the merits of using

- **IT systems.** IT systems are needed to support booking, invoicing, tracking, transhipment and crucially to allow the user to be fully informed. This is essential to maximising interoperability between modes. Research is needed to define the most suitable IT system, which can meet the needs of all stakeholders.

- **Systems of Transfer.** Within the intermodal process, loading units are transferred from one mode to another. Research needs to be carried out into the most efficient transfer methods available and into when and where they should be applied.

- **High Quality and Efficient Intermodal Services.** To be competitive, intermodal transport should deliver a high quality service (seamless, fast, and reliable) and be highly efficient (low costs). Future research should focus on:
  - Integration of Information technology and logistics to form the “smart supply chain”, embedded in a common EU intermodal, cross-border strategy;
  - IT system to control all points in the supply chain (based on harmonised information availability and automated tracking & tracing features), including terminals and transhipment points;
  - Methodologies and tools for global repositioning of loading units;
  - Co-operation and liabilities between transport operators (service quality, reliability, cargo conditions of carriage, legal, competition and insurance issues, loss and damage issues);
  - Harmonisation of document handling, customs procedures, contracting, and permissions.

The SIRA has also identified the following additional themes for research on intermodality:

- **Simulation of Logistic Chain.** To maximise the expansion and efficiency of waterborne transport it is necessary to develop user friendly programs that simulate the total point-to-point transport chain so as to quickly determine the most cost effective and rapid combination of transport modes that are available at a given, or required time.

- **Ship/shore interface design and logistic chain integration.** A major challenge in reducing the cost and time of marine transport compared to road and rail is cargo handling. Innovative approaches to the design of vessels as a logistic chain component need to start with the cargo and the most effective way to move it from one transport mode to another. The design of the vessel needs to simplify its mooring, loading and unloading and the use of the latest automated shore side facilities. State of the art automated and robotic systems, with computerised process management are required to meet this challenge. This has to be combined with strategic infrastructure planning.

- **Standardised intermodal equipment.** A standard loading unit is the core of an efficient intermodal transport. Euro pallets are not fully compatible with ISO containers used for intercontinental transport. Research is needed for understanding how to quickly agree on the design features of a standard loading unit for Europe, and for designing and developing a worldwide compatible loading unit.
• **Development of consistent regulations.** Throughout Europe, there are different national regulations applied across many areas of transport, which impede seamless and flexible interoperability. Research is required for harmonising regulations across Europe.

• **Harmonisation of transport documentation.** Research is needed for harmonizing documentation/e-documentation and reducing the number of transport documents to enhance interoperability.

• **Awareness of Intermodal Transport.** The complexity of intermodal transport induces people to think that it is difficult and ineffective. Such beliefs are reflected in assumptions about the interoperability between modes. Thus, investing in infrastructure, equipment and information systems to improve interoperability will only be effective if efforts are made to increase the level of awareness among stakeholders. Research must be conducted into the best way to promote intermodal transport in all its aspects.

• **Harmonised Framework Conditions for all Modes.** Equal opportunities should be created for all modes. The barriers for changing to equal conditions for all modes are first to be identified, by economics and behavioural research. Once barriers are detected, a roadmap for the implementation of equal conditions for all modes must be produced, identifying those conditions to be implemented at the EU level, along with others that might be implemented by private investors.

4.8.2.5 **Commercial fleet and public transport operations**

The ERTRAC SRA has identified for the road transport the following research areas to improve efficiency:

• Systems for high-speed bus and taxi corridors in dedicated lanes.

• Development of new transport services that fill the gap between private and public transport (car pooling, collective taxis, bus on demand). Explore new car ownership systems.

• Further research in the longer term on “cyber cars” with highly automated driving capabilities, available on call at any location and time, offering new solutions for door-to-door services.

• Development of new forms of collective transport. For example, community-based transport pooling for repetitive activities (leisure, shopping, trips to work or school) through information and communication technology (ICT) tools for local organisations (sport clubs, businesses, schools, community centres).

• Development of innovative urban delivery systems that are tailored to the local needs of individual urban areas.

• Development of new systems for greater efficiency for street-based loading and unloading. This should take into account vehicles, goods transport units, street design, traffic management, etc.
• Studies into the complexities of urban freight transport which should develop solutions for overcoming difficulties of loading and unloading, parking and planning. Methodologies and systems for the designation of specific urban truck routes, which may be variable in time, need to be developed.
• Development of city logistics solutions for transhipment to quieter, lower-emission vehicles of appropriate size, or to other transport systems (conveyors, tubes).
• Investigations on new solutions for underground, automated freight transport. The feasibility of full driving automation on dedicated infrastructures for commercial vehicles should also be evaluated.
• Development of new modular vehicle systems and load carrier concepts for all portions of the logistics chain.
• Development of new innovative optimised delivery systems.
• Creation and testing of concepts for multi-purpose vehicles (e.g. passenger/freight carrying vehicles).
• Development of business processes to support multi-functional operation.
• Creation and testing of concepts for multi-modal vehicles.
• Studies on alternative delivery scheduling in order to reduce congestion in streets.
• Development of tracking technologies in order to establish a seamless information chain to increase planning efficiency.

For what concern rail transport, the research topics which were given the highest priority by the SRRA are both for passenger and freight (ERRAC, 2007):

• **Seamless transport.** In particular research needs consists in improving information flows for a more fluent door-to-door travel, and in capturing passenger and freight information to improve public transport offer. The implementation is expected to improve attractiveness of PT for all categories of users (including disabled, and elderly people) and provide more reliable and precise information for trip planning.
• **Compatible ticketing systems across borders** (including urban transit legs through the development of e-tickets and contact-less electronic purses using common interface protocols). The growth of urban transit will depend on its ability to respond to individual travellers needs through the spread of e-ticketing, interoperability and journey planning information. To improve the attractiveness of public transport it is advisable to provide passengers with a service that is easy to book, pay for and use (including people with disabilities and those with luggage) and provide up to date information before and during the journey. In the freight sector, all necessary information should be made available in real time covering possible delays, charging systems, train numbering and terminal management.
• **Development of new concepts in ticket selling, validation and control.** This will permit to maintain the protection of revenue and easy access to public transport while reducing costs. Public acceptance of contact-less passes will require investigation into customer acceptance and cross border interchange-ability. Personalised and advanced booking reservation services should be developed for a wide range of customers through the
web, mobile phone and voice recognition systems and will be accompanied by the introduction of innovative devices for improving passenger information, comfort and personal security in on trains and at stations.

4.8.2.6 Transport demand management

The ERTRAC SRA has identified the following research areas related to road transport (ERTRAC, 2004):

- Models to simulate the demographic development and the entire mobility chain under multiple scenarios to thoroughly test and optimise the system before making costly investments. These include the economical and social evaluation of the transport system and the economics of multimodal transport.
- A better understanding of social values and how they influence the choices people make relative to housing, schools, work, family and friends, and leisure activities and how they are related to mobility. The real individual criteria for transport decisions should be examined, taking account of the expected demographic changes, the influence of flexible working hours and holiday periods, and the impact of greater mobility and freedom of movement between member states.
- New methods for data collection and treatment for demographic, mobility and transport demand patterns including origin, destination, time slot and energy consumption. These must be harmonised and interrelated/aggregated at the EU level to provide the basis for understanding, modelling, and decision-making on demand management and land planning.
- Development of simulation models to link the cause and effect of mobility and transport demand in relationship to land use and to accurately predict outcomes of alternative choices for optimising liveability, economic viability, and sustainability.
- Development of methods for short, medium and long term traffic forecasts and for the measurement of social and economic impact of transport.
- Development of forecasting methodologies, impact models and benchmarking indicators.
- Understanding of the root causes of mobility demand and the relationship to social values and the dynamics of communities.
- Simulation of mobility and transport flows based on reliable and accessible data.
- Efficient pricing tools and fee collection systems to optimise travel and transport of goods over all modes, based on social, economic and environmental criteria.
- Development of network-wide strategies and technologies for demand management.
- Study of the role of pricing in all its forms (road pricing, taxes, parking costs, subsidies, incentives) as a demand management tool. The effect of transport pricing policies and contribution of pricing practices towards accessible, equitable and sustainable transport systems goals should be measured.
- Assessment of impacts of further developments and implementation of electronic fee collection and dynamic road pricing on traffic and demand.
• Analysis of the impact of transparent transport charging on individual choice and collective interests.
• Development of new business models to meet the changing consumer demand and at the same time contribute to more sustainable transport solutions.

The ERRAC SRRA has identified as research priority area “Strategy and Economics” to establish how economic, institutional and social changes might affect the future of the railways in order to enable decision makers establish a long term direction for rail. More specifically for what concerns accommodating the expected increases in demand, the main topics identified are (ERRAC, 2007):
• Analysis for long term projections of passenger travel and freight traffic by rail.
• Options for managing increases in demand (which include: increases in the capacity of both trains and infrastructure; improved train operations, scheduling and signalling; the use of fares and pricing to reduce overcrowding; scarcity charges to train operators);
• Analysis of the contribution of rail to local, regional and national economic development and a method of identifying, quantifying and valuing these benefits.
• Creation of a system approach based on a thorough knowledge of cost drivers, customer needs and non-fare box revenue obtained through the development of models covering infrastructure, finance, maintenance, and capacity. It should then be possible to undertake an analysis of theoretical capacity available for increased passenger and freight traffic.
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## Annex: List of projects by sub-theme

### Sub-theme 1: Infrastructure and vehicle development and maintenance

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<td>Development of new intermodal loading units and dedicated adaptors for the trimodal transport of bulk materials in Europe</td>
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<td><a href="http://www.zaft.htw-dresden.de/trimotrans/index.php?lang=en">www.zaft.htw-dresden.de/trimotrans/index.php?lang=en</a></td>
<td>if reports become available</td>
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</table>
## Sub-theme 4: Multi-modal networks

<table>
<thead>
<tr>
<th>Project acronym</th>
<th>Project title</th>
<th>Programme</th>
<th>Project website</th>
<th>Coverage</th>
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<tbody>
<tr>
<td>WORLDNET</td>
<td>European Transport Network Model Refinement Regarding Freight and Intermodal Transport to and from the Rest of the World</td>
<td>FP6 – Research for Policy Support - &quot;The development of tools, indicators and operational parameters for assessing sustainable transport and energy systems performance (economic, environmental and social)&quot;</td>
<td><a href="http://www.worldnetproject.eu">www.worldnetproject.eu</a></td>
<td>if reports become available</td>
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## Sub-theme 5: Commercial fleet and public transport operations

<table>
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<tr>
<th>Project acronym</th>
<th>Project title</th>
<th>Programme</th>
<th>Project website</th>
<th>Coverage</th>
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<tr>
<td>Guidelines For Programming Local Public Transport Services</td>
<td>Project from Italy</td>
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<td>EXTR@Web paper</td>
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<tr>
<td>UG4231: Bus Real-Time Information – Business Case</td>
<td>Project from the United Kingdom</td>
<td></td>
<td>EXTR@Web paper</td>
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<tr>
<td>BESTUFS</td>
<td>Harmonisation of strategies and highlighting best practice to determine optimum Urban Freight Solutions (Thematic Network)</td>
<td>FP5 – Growth, KA 2 &quot;Sustainable Mobility and Intermodality&quot;</td>
<td><a href="http://www.bestufs.net">www.bestufs.net</a></td>
<td>this paper</td>
</tr>
<tr>
<td>CARAVEL</td>
<td>Travelling Towards a New Mobility</td>
<td>FP6 - SUSTDEV-2 &quot;Sustainable surface transport&quot;</td>
<td><a href="http://www.civitas-caravel.org">www.civitas-caravel.org</a></td>
<td>if reports become available</td>
</tr>
<tr>
<td>eDRUL</td>
<td>eCommerce enabled Demand Responsive Urban Logistic</td>
<td>FP6 – IST – KA1 “Systems and Services for the Citizen”</td>
<td><a href="http://www.edrul.org">www.edrul.org</a></td>
<td>this paper</td>
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## Sub-theme 5: Commercial fleet and public transport operations

<table>
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<th>Project acronym</th>
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<tbody>
<tr>
<td>FIRE</td>
<td>Freight information in the railway environment</td>
<td>FP4</td>
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<td>GAUSS</td>
<td>Galileo and UMTS Synergetic System</td>
<td>FP6 – IST – KA1 “Systems and Services for the Citizen”</td>
<td><a href="http://galileo.cs.telespazio.it/gauss">http://galileo.cs.telespazio.it/gauss</a></td>
<td>EXTR@Web paper</td>
</tr>
<tr>
<td>LIBERTIN</td>
<td>Light Rail Thematic Network</td>
<td>FP5 – Growth, KA 3 &quot;Land Transport and Marine Technologies&quot;</td>
<td><a href="http://www.libertin.info">www.libertin.info</a></td>
<td>EXTR@Web paper</td>
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<tr>
<td>MOSCA</td>
<td>Decision-support System for Integrated Door-to-door Delivery: Planning and Control in Logistic Chains</td>
<td>FP6 – IST – KA1 “Systems and Services for the Citizen”</td>
<td><a href="http://www.idsia.ch/mosca/">www.idsia.ch/mosca/</a></td>
<td>EXTR@Web paper</td>
</tr>
<tr>
<td>TOSCA</td>
<td>Technological and Operational Support for Car sharing</td>
<td>FP6 – IST – KA1 “Systems and Services for the Citizen”</td>
<td><a href="http://www.atc.bo.it/progetti/tosca/default.htm">www.atc.bo.it/progetti/tosca/default.htm</a></td>
<td>EXTR@Web paper</td>
</tr>
<tr>
<td>VOYAGER</td>
<td>A vision for public transport in 2020 (Thematic Network)</td>
<td>FP5 – Growth, KA 2 “Sustainable Mobility and Intermodality”</td>
<td><a href="http://www.voyager-network.org">www.voyager-network.org</a></td>
<td>EXTR@Web paper</td>
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## Sub-theme 6: Transport demand management

<table>
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<th>Project acronym</th>
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<th>Programme</th>
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<th>Coverage</th>
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<tr>
<td>-</td>
<td>Fair and efficient pricing (CH)</td>
<td>Project from Switzerland</td>
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<td>EXTR@Web paper</td>
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</table>

Thematic Research Summary: “Efficiency in Sustainable Mobility”
Transport Research Knowledge Centre
### Sub-theme 6: Transport demand management

<table>
<thead>
<tr>
<th>Project acronym</th>
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<th>Project website</th>
<th>Coverage</th>
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<tbody>
<tr>
<td>-</td>
<td>Multi-modal freight model for distance-based HGV charging (UK)</td>
<td>Project from the United Kingdom</td>
<td>EXTR@Web paper</td>
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<tr>
<td>-</td>
<td>UG346: Monitoring the effects of road user charging in Durham (UK)</td>
<td>Project from the United Kingdom</td>
<td>EXTR@Web paper</td>
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<td>CARDME-4</td>
<td>Concerted Action for Research on Demand Management in Europe: work of CARDME team in support to cross-border interoperability of electronic fee collection systems</td>
<td>FP5 - KA 1, Cluster 1 &quot;Mobility and Intelligent Infrastructure for Transport&quot;</td>
<td>this paper</td>
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<td>CITY FREIGHT</td>
<td>Inter- and Intra-City Freight Distribution Networks</td>
<td>FP5 – EESD, KA 4 &quot;The City of Tomorrow and Cultural Heritage&quot;</td>
<td><a href="http://www.cityfreight.org">www.cityfreight.org</a></td>
<td>EXTR@Web paper</td>
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<tr>
<td>IMPRINT-NET</td>
<td>Implementing Pricing Reforms in Transport - Networking</td>
<td>FP6 - SUSTDEV-2 &quot;Sustainable surface transport&quot;</td>
<td><a href="http://www.imprint-net.org">www.imprint-net.org</a></td>
<td>this paper</td>
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<tr>
<td>STEPs</td>
<td>Scenarios for the Transport System and Energy Supply and their Potential Effects</td>
<td>FP6 - SUSTDEV-2 &quot;Sustainable surface transport&quot;</td>
<td><a href="http://www.steps-eu.com">www.steps-eu.com</a></td>
<td>this paper</td>
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<tr>
<td>CARAVEL</td>
<td>Travelling Towards a New Mobility</td>
<td>FP6 - SUSTDEV-2 &quot;Sustainable surface transport&quot;</td>
<td><a href="http://www.civitas-caravel.org">www.civitas-caravel.org</a></td>
<td>if reports become available</td>
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<tr>
<td>CREAM</td>
<td>Customer-driven Rail-freight services on a European mega-corridor based on Advanced business and operating Models</td>
<td>FP6 - SUSTDEV-2 &quot;Sustainable surface transport&quot;</td>
<td>if reports become available</td>
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### Sub-theme 6: Transport demand management

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<th>Project acronym</th>
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<tr>
<td>CURACAO</td>
<td>Coordination of Urban Road-User Charging Organisational Issues</td>
<td>FP6 - SUSTDEV-2</td>
<td><a href="http://www.curacaoproject.eu">www.curacaoproject.eu</a></td>
<td>if reports become available</td>
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<tr>
<td>FIDEUS</td>
<td>Freight innovative delivery in European urban space</td>
<td>FP6 - SUSTDEV-2</td>
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<td>if reports become available</td>
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<tr>
<td>MAX</td>
<td>Successful Travel Awareness Campaigns and Mobility Management Strategies</td>
<td>FP6 - SUSTDEV-2</td>
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<td>if reports become available</td>
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<tr>
<td>MIDAS</td>
<td>Measures to influence transport demand to achieve sustainability</td>
<td>DG TREN - IEE Intelligent Energy Europe Initiative</td>
<td><a href="http://www.midas-eu.com">www.midas-eu.com</a></td>
<td>if reports become available</td>
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<td>MOSES</td>
<td>Mobility services for urban sustainability</td>
<td>FP5 – EESD, KA 4 &quot;The City of Tomorrow and Cultural Heritage&quot;</td>
<td><a href="http://www.moses-europe.org">www.moses-europe.org</a></td>
<td>if reports become available</td>
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<tr>
<td>MOVE</td>
<td>International cluster for mobility management development and research dissemination</td>
<td>DG TREN - IEE Intelligent Energy Europe Initiative</td>
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<td>if reports become available</td>
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<td>NICHES</td>
<td>New and innovative concepts for helping European transport sustainability</td>
<td>FP6 – SUSTDEV-2</td>
<td><a href="http://www.niches-transport.org">www.niches-transport.org</a></td>
<td>if reports become available</td>
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<td>RCI</td>
<td>Road Charging Interoperability Pilot Project</td>
<td>FP6 - SUSTDEV-2</td>
<td><a href="http://www.ertico.com/ri">www.ertico.com/ri</a></td>
<td>if reports become available</td>
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<tr>
<td>SCATTER</td>
<td>Sprawling Cities And Transport: from Evaluation to Recommendations</td>
<td>FP5 – EESD, KA 4 &quot;The City of Tomorrow and Cultural Heritage&quot;</td>
<td><a href="http://www.casa.ucl.ac.uk/scatter">www.casa.ucl.ac.uk/scatter</a></td>
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## Sub-theme 7: Regulatory framework

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<th>Project acronym</th>
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<tr>
<td>-</td>
<td>Costs imposed by heavy goods vehicles (UK)</td>
<td>Project from the United Kingdom</td>
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<td>EXTR@Web paper</td>
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<td>-</td>
<td>Effects of cycle parking arrangements on bicycle use (FI)</td>
<td>Project from Finland</td>
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<td>EXTR@Web paper</td>
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<td>-</td>
<td>New investment models for infrastructure services (FI)</td>
<td>Project from Finland</td>
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<td>EXTR@Web paper</td>
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<td>-</td>
<td>Optimal Investments (NL)</td>
<td>Project from the Netherlands</td>
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<td>EXTR@Web paper</td>
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<td>UNITE</td>
<td>Unification of accounts and marginal costs for Transport Efficiency</td>
<td>FP5 – Growth, KA 2 &quot;Sustainable Mobility and Intermodality&quot;</td>
<td><a href="http://www.its.leeds.ac.uk/projects/unite">www.its.leeds.ac.uk/projects/unite</a></td>
<td>EXTR@Web paper</td>
</tr>
</tbody>
</table>

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