



Transport Research Knowledge Centre

RAIL TRANSPORT THEMATIC RESEARCH SUMMARY

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**European Commission
DG Energy and Transport**

**Transport Research
Knowledge Centre**

**Thematic Research
Summary:**

Rail Transport

Prepared by **Batool Menaz and
Tony Whiteing**

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Foreword

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

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

This particular Thematic Research Summary deals with rail transport. The aim is to provide the reader with a synthesis of results of completed European projects related to the theme of rail transport. 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.



Summary

This Thematic Research Summary on rail transport aims to provide the reader with a synthesis of results of completed European research projects related to that theme. It consists of two main parts.

The first part includes a brief overview of the scope of the theme and summarises the main policy developments at EU level relevant to the theme.

The second part contains a synthesis of the main findings and policy implications from research projects and identifies the implications for further research. This is done separately for three sub-themes identified as important in the rail-related research reported in this summary.

The first sub-theme is concerned with the development, planning and organisation of rail services in Europe for both passenger and freight, and covers aspects such as the adoption of more suitable transport vehicles, better allocation of scarce network capacity, harmonised systems and greater interoperability as well as the potential impacts of liberalisation of the rail sector.

The second sub-theme covers rail management systems, focusing on ICT-based tools for the management of maintenance and safety.

The final sub-theme looks at research into improved technology for the rail industry, including technologies relating to rail vehicles, rail infrastructure and train identification, location and control systems.

The research projects for which the synthesis is provided are European (EU-funded and national) projects that are completed and with results publicly available. The EU projects have been funded by the Fourth, Fifth and the Sixth Framework Programmes. Projects that had been reviewed in the related paper produced within the predecessor project EXTR@Web are only briefly summarised in the background section for each sub-theme.



Acronyms

AG	High level Advisory Group (to the EXTR@Web project)
BG	Benchmark Group (associated with the EXTR@Web project)
CEC	Commission of the European Communities
CEEC	Central and Eastern European Country
DfT	Department for Transport (UK)
DGTREN	Directorate General Transport and Energy
EC	European Commission
EEA	European Environment Agency
ERA	European Research Area (EU, EFTA and CEECs)
ERRAC	European Rail Research Advisory Council
ETDN	European Technical Documentation Network
EU	European Union
EXTR@Web	Exploitation of Transport Research Results via the Web (DG TREN FP 5 Accompanying Measure project)
FP 4 (5, etc)	EC Fourth (Fifth, etc) Framework Programme
ICT	Information and Communication Technologies
ITS	Intelligent Transport Systems
PAG	Programme Analysis Group (part of EXTR@Web project)
PTA	Priority Thematic Area
RTD	Research and Technological Development

SRRA	Strategic Rail Research Agenda
TEN	Trans-European transport Networks
TRKC	Transport Research Knowledge Centre; TRKC website available at europa.eu.int/comm/transport/extra
TRS	Thematic Research Summary



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1. Introduction

This paper is the first version of the Thematic Research Summary (TRS) on Rail Transport produced within the TRKC project. It provides a structured review of the research relating to rail transport, carried out in European transport research projects. The theme “rail transport” is one of the thirty themes in the classification scheme adopted by the TRKC project. The full scheme is shown in the table below.

Table 1. The classification scheme adopted in TRKC

<i>Sectors</i>	
✓	passenger transport
✓	freight transport
<i>Geographic</i>	
✓	urban transport
✓	rural transport
✓	regional transport
✓	long-distance transport
✓	EU accession issues
<i>Modes</i>	
✓	air transport
✓	rail transport
✓	road transport including walking and cycling
✓	waterborne transport
✓	innovative modes
✓	intermodal freight transport
<i>Sustainability policy objectives</i>	
✓	economic aspects
✓	efficiency
✓	equity and accessibility
✓	environmental aspects
✓	user aspects
✓	safety and security



Tools

- ✓ decision support tools
 - ✓ financing tools
 - ✓ information and awareness
 - ✓ infrastructure provision including TENs
 - ✓ integration and policy development
 - ✓ Intelligent Transport Systems ITS
 - ✓ regulation/deregulation
 - ✓ land-use planning
 - ✓ transport management
 - ✓ pricing and taxation
 - ✓ vehicle technology
-

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

In the predecessor project EXTR@Web, TRSs have been produced for 28 of the 30 themes (the reduced number of TRSs resulting from merging of some themes into a single TRS). The TRKC project had planned to produce first versions of TRSs for a sub-set of themes for which a critical mass of results from projects is available by July 2008. The preparation of final versions of TRSs for the full set of themes is planned by the end of the TRKC project in June 2010.

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

The research reviewed in this paper does not represent the whole gamut of research dealing with rail transport carried out in the ERA. The paper focuses on research from those projects which have made documentation on results available to the TRKC team after the issue of the EXTR@Web paper (Extr@web, 2006). A summary of the research

reported in the EXTR@Web paper is also included to make the reader aware of a wider range of research relevant to the theme.

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

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

The following three sub-themes have been considered:

- Sub-theme 1: Development, planning and organisation of rail services in Europe - passenger and freight;
- Sub-theme 2: Rail management systems
- Sub-theme 3: Development of rail technology.

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

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



2. Scope of the theme “Rail Transport”

Rail transport consists of all land passenger and freight transport which runs on both dual and single fixed rails. This principally involves heavy rail, light rail and tram but might also include funicular and monorail rail modes.

Railways deliver economic, social and, particularly, environmental benefits. The last of these is particularly relevant with the current policy emphasis on sustainable transport. Rail travel has pronounced environmental benefits over road and air transport. It helps to relieve road traffic congestion and reduce the number of road accidents. With continuing growth in air transport, it also provides congestion-free surface access to airports.

Rail freight transport in Europe suffered a major decline in the period from the 1970s to the early 1990s. Since then there has been a recovery in the EU15 countries, with a 15% increase in rail freight tonne-kilometres over the period 1990-2007. In the wider EU27, however, decline has continued with a 14% decrease between 1990 and 2007 (CEC, 2006b, CEC, 2009a).

Passenger traffic by rail (passenger-kilometres) km by rail has increased by 28% in the EU15 countries over the period 1990-2007, against the backdrop of a 32% increase in car travel. Rail passenger growth in the EU15 countries has not been matched in the wide EU27, where a 6% fall has been recorded over the same time period (CEC, 2009a).

The topics included in this theme are:

- Fixed infrastructure for rail lines (planning, costing, evaluation, construction, financing, operation, maintenance and renewal) and related infrastructures, including stations, depots, etc. Infrastructure improvements are aimed particularly at improving efficiency and safety and removing bottlenecks. EU support is directed particularly towards the Trans-European Road and Rail Networks (TEN-T budget) and to improving transport links in peripheral or disadvantaged areas (ERDF budget);
- rolling stock, including planning, design, costing, evaluation and financing;
- service planning, including capacity allocation, infrastructure charging, timetabling, pricing (fares and freight charges);
- rail demand forecasting;
- rail system evaluation;
- rail freight (Whilst Europe’s railways focus mainly on providing passenger services, freight is also important in many countries and it is important to distinguish the role for freight services, how this might be facilitated and how it might change over time);

- industrial organisation, including regulation, ownership and competition, degree of vertical and horizontal separation, operations, leasing and franchising;
- interoperability between rail networks (track gauges, electrical systems and signalling, as well as staff issues). Lack of this can create inefficiencies, particularly at border crossing terminals;
- rail-related issues, including competition and cooperation with other modes. A key focus in Europe is the promotion of intermodal freight transport, so as to create a door to door transport chain, and multimodal passenger transport. This aims to increase overall efficiency of the transport system by using the comparative advantages of each mode, and making the best use of existing infrastructure; and
- the promotion of clean vehicles, Intelligent Transport Systems, traveller information, harmonisation of standards and regulations, open access, and the use of pricing and taxation as a tool to correct market failures are also research priorities in land transport.

With such a diverse set of topics it has been important to identify important sub-themes within the overall theme of rail transport. Three of these have been identified, which are as follows:

- *Development, planning and organisation of rail services in Europe – passenger and freight.*
This covers research into many aspects of how passenger and freight services can be improved, including the adoption of more suitable transport vehicles, better allocation of scarce network capacity, harmonised systems and greater interoperability as well as the potential impacts of liberalisation of the rail sector.
- *Rail management systems*, with most focus on ICT-based tools for the improved management of maintenance and safety related activities.
- *Development of rail technology*, including technologies relating to rail vehicles, rail infrastructure and train identification, location and control systems.

Chapter 4 of this document therefore presents research according to these sub-themes.

As well as the research identified and summarised in Chapter 4, further developments are constantly being sought, and so further research requirements arise across the range of rail research topics. The European Rail Research Network of Excellence (EURNEX) has grouped research requirements as follows:

- Strategy and Economics – Research that develops and supports the business case for railways.
- Operation and System Performance – Research to understand and to evaluate the complex nature of the railway system and to assist its operational management.
- Rolling Stock – Research to develop innovative solutions to the challenges of tomorrow's rolling stock.
- Product Qualification Methods – Research to improve the effectiveness of testing and modelling and to develop product qualification methods for new techniques and technologies supporting the implementation of TSIs throughout the enlarged Europe.

- Intelligent Mobility – This area covers new communication, navigation and surveillance (inside or outside the vehicle) technologies able to answer the needs for lean, clean and clever transport systems.
- Safety and Security – Research to monitor safety, develop new technology and to promote safe and secure systems of operation that reduce risks with diminishing costs.
- Environment and Energy Efficiency – Research to address a number of environmental aspects, including: energy consumption and saving in electrified and diesel traction systems; electromagnetic pollution; noise and vibration; and influence of weather conditions on railway operation.
- Infrastructure and Signalling – Research to optimise the cost, reliability and availability of railway infrastructure.
- Human Factors – Research to enhance the understanding of roles, capabilities and needs of all stakeholders in the rail system.

3. Policy context

European policy objectives related to theme

The EU transport policy White Paper (CEC, 2001) placed major emphasis on shifting the balance between modes, eliminating bottlenecks and ensuring rigorous pricing and safety regimes in the transport sector. This document remains the latest comprehensive statement of overall European transport policy, though the Mid-Term Review of it (CEC, 2006a) provides a useful update with some changes of emphasis, notably placing a greater emphasis on co-modality. The European Commission is expected to publish a new transport policy White Paper in 2010, and has embarked on initial pre-consultation on this as of 2009.

The particular policies towards rail in the 2001 White Paper can be categorised into three groups:

- Increasing competition within rail;
- Promoting socially efficient competition between rail and other modes; and
- Creation of new rail infrastructure.

Progress made since the White Paper in terms of the three policy groups has mainly been in intra modal competition. There has been little progress on efficient competition between modes, because legislation to allow internalisation of external costs for heavy goods vehicles has still not been passed. Also in terms on creation of new infrastructure, adequate investment and financing, whilst provided for in legislation, has still not been implemented in practice. Therefore, the overall targets set out in the White Paper, particularly on modal split, have not been met and the overall objectives in terms of rail have not been achieved.

Competition within rail

Policy in relation to increasing competition within the rail sector focuses primarily on the implementation of the first railway package – enshrined in directives 2001/12, 2001/13 and 2001/14 – and the agreement and adoption of subsequent packages of proposals.

The first railway package, adopted in 2001, already made provision for accounting separation of freight passenger and infrastructure, set the rules for infrastructure charges and provided a timetable for opening up the market for international freight services. However, the Commission has concerns both with its implementation (it has warned 24 of

the 25 member states with rail systems that they have not adequately imposed the legislation) and with whether the package needs amendment, where it is reviewing the case for a recast of the package. One specific issue it has raised as part of the Greening Transport package in 2008 (CEC, 2008a) is whether more specific requirements regarding the treatment of noise in track access charges is required. Consideration is given to strengthening the legislation regarding regulation and multi-annual contracts, and access to associated services such as terminals and maintenance depots.

Following the first railway package, agreement has been reached on a second railway package, presented by the Commission in early 2002, which focused on safety, interoperability and domestic freight services, leading to the adoption of a regulation and three further directives in spring 2004.

The second railway package contained five key legislative proposals:

- An amendment of directive 91/440 on the development of the community's railways;
- a safety directive;
- an amendment to the directive on the interoperability on the trans-European conventional rail system;
- a proposal for a regulation to create a European Rail agency (Regulation No 881/2004); and
- a recommendation on the COTIF (COM2002/24) arrangements for international traffic.

The amendment to Directive 91/440 extends infrastructure access rights to freight services within any Member State and speeds up the opening up of the market. The opening up of the international rail freight market was completed in 2006, whilst the opening up of the market for domestic (or cabotage traffic) – and hence full market opening in relation to rail freight traffic throughout the EU – was completed in 2007. In 2008, the commission put forward a draft regulation (CEC, 2008b) requiring member states to designate freight priority corridors, including a network of strategic terminals, and set out an implementation plan with economically justified investment.

Subsequently, a third railway package was presented in spring 2004 encompassing a further four legislative proposals:

- A proposal to amend directive 91/440;
- a proposal for a directive on the certification of locomotive drivers;
- a proposal for a regulation on the rights and obligations of international rail passengers; and
- a proposal for a regulation on compensation in cases of non-compliance with contractual quality requirements for rail freight services.

As amended, railway operators with a licence and the required safety certificates will, from 1 January 2010, be able to operate international passenger services in the Community, creating the potential for competition with existing international services such as Thalys

and Eurostar. Operators would be permitted to pick up and set down passengers at any station on an international route, including stations located in the same Member State, unless to do so would affect the financial stability of services operated under a public service obligation. The proposals are in line with the European Parliament's call, in 2003, for all rail passenger services, whether national or international, to be opened up to competition as of 1 January 2008, the Commission is now considering how best to open up the domestic passenger sector to competition.

Socially Efficient Competition between rail and other modes

Policy relating to the promotion of socially efficient competition between rail and other modes falls into two areas:

- Infrastructure charging – relating to all modes;
- Fuel taxation – relating to road and to aviation.

The centrepiece of the White Paper proposals on infrastructure charging was a Framework Directive, designed to implement marginal social cost pricing on all modes of transport. This was to have been accompanied by a methodology paper, setting out methodologies for calculating the components of the common infrastructure charge. It was anticipated that the methodology paper and Framework Directive would be followed by a series of four separate Directive proposals dealing in detail with the practical implementation of pricing for road, sea, rail and air modes. However, this was not proceeded with, and whilst the Greening Transport package of 2008 contained a clear restatement of the policy of marginal social cost pricing for all modes of transport, it does not contain a clear implementation plan.

In both the rail and road sectors there has been some progress on infrastructure charging. Directive 2001/14, on allocation of railway infrastructure capacity and levying of charges, enshrined the proposals on railway infrastructure charging emerging from the 1998 railways package. The directive has been implemented throughout the EU and has been incorporated into member state law since Spring 2003. In summary, the directive determines that charges must be based on 'costs directly incurred as a result of operating the train service'. These may include:

- Scarcity, although where a section of track is defined as having a scarcity problem, the infrastructure manager must examine proposals to relieve that scarcity, and undertake them unless they are shown, on the basis of cost benefit analysis, not to be worthwhile;
- environmental costs, but these must only lead to an increase in the average level of rail access charges where these are levied on other modes;
- recovery of the costs of specific investments where these are worthwhile and could not otherwise be funded;
- discounts but only where justified by costs; large operators may not use their market power to get discounts;

- reservation charges for scarce capacity, which must be paid whether the capacity is used or not;
- compensation for unpaid costs on other modes is permitted but only in the form of explicit time limited subsidies; and
- non-discriminatory mark ups are permitted but these must not exclude segments of traffic which could cover direct cost.

In terms of intermodal competition between road and rail, the 2006 Directive on charges for heavy goods vehicles, amending Directive 1999/62 on charges for heavy goods vehicles represents something of a step forward. Under this directive, member states can introduce charges for heavy goods vehicles on roads throughout their jurisdiction. The charges must be, on average, tied to the costs of construction, operation, maintenance and development of the network, but can be differentiated according to levels of congestion, environmental and accident costs. Tolls must be allocated to vehicle types on the basis of stipulated equivalence factors based on objective evidence. In exceptional circumstances a surcharge of up to 25% will be permitted, to fund alternative rail infrastructure.

Further proposals to allow full internalisation of the external costs of noise, congestion and local air pollution, up to stipulated maximum values, were presented in 2008 together with a handbook based on extensive research in the field and showing how these costs are to be calculated.

In relation to the taxation of fuel, Directive 2003/96 on restructuring the Community framework for the taxation of energy products and electricity, adopted in autumn 2003, allows Member States to tax kerosene on domestic flights and, on the basis of bilateral agreements, intra-EU flights. Thus policy to permit the harmonisation of the terms of competition between modes regarding fuel tax does exist, although it has had no effect in practice as yet, and the position where air transport remains free of VAT, whilst in many countries rail transport bears VAT, remains unresolved.

A further major development regarding internalisation of the external costs of air transport is the proposal that air transport should be included in the European emissions trading scheme in respect of its contribution to greenhouse gases from 2012.

Improving Rail Infrastructure

Policy relating to improving transport infrastructure again falls into three key areas:

- Revisions of the Trans-European Network (TEN);
- public funding for infrastructure; and
- linking user charges with infrastructure investment.



The relevant actions, set out in the White Paper's Action Programme, are:

- Support the creation of new infrastructure, and in particular rail freight freeways;
- Revise the Trans-European Network guidelines in order to eliminate bottlenecks by encouraging corridors with priority for freight, a rapid passenger network and traffic management plans for major roads, and adding projects to the “Essen” list;
- Increase to 20% the maximum funding under the Trans-European Network budget for the main bottlenecks, including those still remaining on the Union's frontiers with the accession candidate countries, and then introduce conditionality rules;
- Present a more extensive revision of the Trans-European Network aimed in particular at integrating the networks of the accession candidate countries, introducing the concept of “motorways of the sea”, developing airport capacities and improving territorial cohesion on the continental scale;
- establish a Community framework for allocating revenue from charges on competing routes to the construction of new infrastructure, especially rail infrastructure;
- link the future Member States to the EU's Trans-European Network by means of infrastructure of quality with a view to maintaining the modal share of rail transport at 35% in the candidate countries in 2010 by mobilising private-sector finance; and
- make provision in the Community's future financial perspective for adequate public funding of infrastructure in the new member countries.

In the Mid-Term Review of the 2001 White Paper (CEC, 2006a), renewed emphasis is placed on:

- Completion of the internal market for international rail freight transport and progress with that for international rail passenger transport;
- Tackling structural obstacles to competitiveness, such as “low levels of interoperability, the lack of mutual recognition of rolling stock and products, the weak coordination of infrastructure and interconnection of IT systems and the problem of single wagons loads” (CEC, 2006a);
- Progressing the implementation of the priority TEN-T projects (most of which are rail projects), including the ERTMS rail traffic management system; and
- Legislating for rail passenger rights, similar to those introduced for air passengers.

Progress with implementation of the TENs has been slower than anticipated. Funding has proved to be problematic. EU budgets are only able to fund a minority proportion of project investment costs, with the majority to come from national budgets. The funding position in a number of the New Member States is of particular concern, as funding from national government is scarce, placing greater financial burdens on infrastructure managers and incumbent operators.

The idea of railway network of exclusive use of freight trains which had been proposed by the 2001 White Paper has been superseded by the idea of developing a network with priority to freight (a freight-oriented rail network), thus retrieving the freight freeways concept (CEC, 2008a). The aim is to promote competitive international rail freight to

counter its long term loss of market share, mainly to road. Freeways combine unitary route planning and management with the development of faster train paths offered by a single sales point. A range of complex commercial and legal issues are involved with the concept.

The Commission has now produced a Green Paper on the TEN-T (CEC, 2009b), suggesting more emphasis be placed on whole networks rather than on priority projects, and a specific proposal for a regulation governing the development of freight priority corridors.



4. Research findings

4.1 Introduction

The research which is synthesised in this paper is reported according to three sub-themes as defined earlier in Section 2 of this paper:

- *Development, planning and organisation of rail services in Europe – passenger and freight*
- *Rail management systems*
- *Development of rail technology.*

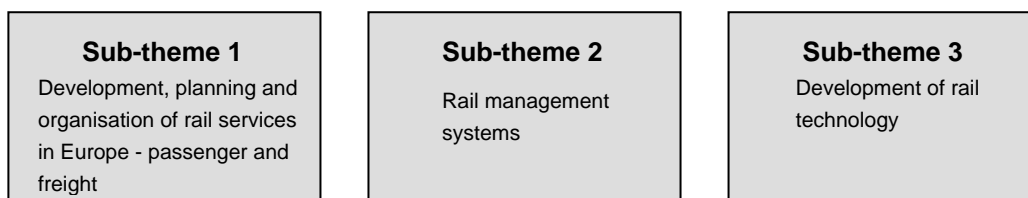


Table 2. EU-funded projects relevant to the theme

Sub-theme	Contributing projects
Development, planning and organisation of rail services in Europe - passenger and freight	<p><u>Projects covered in this paper:</u> BRAVO, CREAM, CroBIT, DEREGULATION OF CARGO TRAFFIC ON THE FINNISH RAILWAYS, ELODIT, EURNEX, FLEXIBLE RAIL INTERIOR DESIGN, INTERFACE, NEW OPERA, PARTNER, REORIENT, SUSTAINABLE BRIDGES, UG 331D</p> <p><u>Projects covered in the EXTR@Web paper:</u> ADVISOR; B6; BAHN.VILLE; CROSSRAIL; D2; ESCUGIBRI; F4; FACT; FIRE; F-MAN; H102N; HISPEEDMIX; IMPROVERAIL; LIBERTIN; Passenger rail services and economic performance; Road to Rail;</p>



	<p>ROLLING SHELF; Strengthening of the competitive environment of rail passenger transport</p> <p><u>Projects where results are not yet available in TRKC:</u> CATIEMON, EUDDPLUS, MODURBAN, RAILCOM, RAILENERGY, RRTC, TREND, SPURT</p>
<p>Rail management systems</p>	<p><u>Projects covered in this paper:</u> EUROMAIN, InteGRail, RAIL, SAMRAIL, TRAINCOM,</p> <p><u>Projects covered in the EXTR@Web paper:</u> PROMAIN; SAFET; SAMNET</p> <p><u>Projects where results are not yet available in TRKC:</u> INFRACLEAR, INNOTRACK, TRACK, SAFEDMI, SAFEINTERIORS, TRANSFEU, URBAN, 2TRAIN</p>
<p>Development of rail technology</p>	<p><u>Projects covered in this paper:</u> ALJOIN, CHECKPOINT, MODTRAIN, R.E.W.I. - R.O.S.E, TRAPOLO, TURNOUTS, WIDEM</p> <p><u>Projects covered in the EXTR@Web paper:</u> HVB2; LOCOPROL; SISMODCOMPROT</p> <p><u>Projects where results are not yet available in TRKC:</u> EUROPAC, GREEN, HI-CEPS, MODBRAKE</p>

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



4.2 Sub-theme 1: Development, planning and organisation of rail services in Europe – passenger and freight

4.2.1 Background

Research reported in the Thematic Research Summary on Rail Transport produced in EXTR@Web (the predecessor of the TRKC project) highlighted the potential detrimental impacts of poor rail performance, with evidence of significant harm, both directly and indirectly, to various groups including businesses, commuters, leisure travellers and tourism. Hence considerable research attention was placed on the need for improved quality and performance, identifying that rail infrastructure managers needed to find ways to optimise the use of railway capacity and to allocate scarce capacity more efficiently. In the light of the need to develop longer distance, international traffic (both passenger and freight), a need for a more integrated approach to infrastructure provision across EU Member States was identified, and most especially in the freight sector, a greater commitment towards intermodality and interoperability, calling for the development of much improved information systems as well as for a culture of continuous improvement and for identification and widespread implementation of best practice.

Further research examined the role of infrastructure pricing and charging, including Marginal Cost pricing, in relation to service liberalisation.

Specifically in the freight sector, cost-effective opportunities for rail were identified in the medium to longer term for much greater penetration of the premium freight market, especially if international high-speed freight services could be implemented, though this would be a major challenge requiring step changes in international co-operation and interoperability. Other research focusing on transalpine routes identified considerable technical, bureaucratic and managerial challenges in achieving faster international rail freight transits on such routes.

4.2.1 Research objectives

Much recent research in the rail transport field has been to support the recent and expected growth in the use of rail transport, in line with the economic and environmental objectives of transport policy. Hence key objectives have been to improve the efficiency and hence the competitiveness of rail transport in both passenger and freight markets and to maximise the utilisation of capacity which in many places is under pressure due to increasing demand. (ELODIT, FLEXIBLE RAIL INTERIOR DESIGN, NEW OPERA, PARTNER, SUSTAINABLE BRIDGES). Research was undertaken in the UK aimed at

assessing the compliance of improving rail vehicles to provide better access for disabled people (UG 331D).

A further important objective is to develop a more integrated European rail network with much greater interoperability as a result of standardisation and harmonisation, as well as greatly reduced delays at political borders and transfer points where traffic is switched from one national railway system to another (BRAVO, CREAM, CroBIT, INTERFACE, NEW OPERA, REORIENT).

European railway reform aims to create enhanced competition within the rail market as well as improved competitiveness of rail against other modes. A further research objective is therefore to gain understanding of the likely impacts of liberalisation and greater competition in the market, for both passenger and freight services (DEREGULATION OF CARGO TRAFFIC ON THE FINNISH RAILWAYS, EURNEX, PARTNER, REORIENT).

4.2.2 Research results

Improved passenger and freight rail operations

Efficient use of rail networks calls for resolution of many problems. Increased traffic levels are resulting in bottlenecks in rail network capacity at key locations. Many such bottlenecks are exacerbated by different speeds for different types of train; hence more homogenous speeds would be advantageous. New dedicated High Speed Train routes offer scope for better flow of local passenger and freight trains on pre-existing routes, but this calls for an overview approach to be taken to traffic allocation. Reduction in such bottleneck problems could make a major contribution to cost reduction by increasing the rotation of rolling stock and increasing the productive working hours of drivers. Such measures, perhaps coupled with the use of longer trains may allow costs reductions of between 30% and 50% of operating costs (NEW OPERA).

Given the difficulties in achieving significant expansion of rail infrastructure in the short term, longer train lengths offer perhaps the best option of using existing capacity more effectively. The balance of the argument between electric and diesel traction is moving more in favour of electric traction as technical improvements are made. When new infrastructure is being designed, consideration should be given to loading gauge to allow double-stack freight container operations (NEW OPERA).

Better utilization of capacity also requires better route management. An independent European body could ensure that there is no discrimination between different types of train and that priority rules must be the same throughout the various Pan-European freight

corridors. Management of train paths must be undertaken in a consistent and transparent manner based on 'one-stop-shop' principles (NEW OPERA, PARTNER).

Research looked at improving the capacity of railway bridges without compromising the safety and economy of the working railway. The guidelines produced will help European railways to meet the ever increasing demand in rail transport capacity (stressing on bridge structural performances), extend the residual service lives of existing bridges, enhance management, strengthening and repair systems (SUSTAINABLE BRIDGES).

A demonstration project has shown how train slot allocation and charging can be implemented effectively on international rail freight priority corridors. The proposed system allows for more transparent charging, standardisation of bidding process for train paths across EU railways and moves towards a 'one-stop-shop' for short term requests for paths. It also provides for interfaces between the proposed system and existing national rail timetabling systems (PARTNER).

Better use of rail route capacity requires an increase in speed of freight trains so that better integration of passenger and freight traffic is possible. This requires higher-powered locomotives for freight trains, which is a particular problem on non-electrified routes. Hence research been conducted into alternative technologies (diesel or gas turbine) to achieve such higher power in a cost-effective and environmentally friendly way on a twin bogie 4-axle design providing 3000kW power at the wheels with an axle load of 21 tonnes. The locomotive design envisages a twin-bogie 4-axle wheel arrangement, with 3000kW power at the wheels and an axle-load of 21 tonnes (ELODIT).

Simulated operation of such a locomotive on a major French rail corridor indicates that a gas turbine version is likely to emit significantly lower levels of pollution as well as better reliability characteristics and a lower overall cost over a 30-year life cycle the turbine solution is cheaper. A diesel version would offer lower energy consumption, however. (ELODIT)

Highly specialised railway rolling stock leads to reduced overall vehicle utilization and hence higher costs and lower competitiveness of rail. Greater flexibility in rolling stock use is therefore preferred but can involve significant design challenges. New interior design concepts are needed in order to use passenger coaches in a more flexible way and to ensure that this flexibility does not interfere with the attractiveness of the vehicles in individual segments of the overall rail market. One example of this is the need for separate coach types for day and night passenger services. Research has been undertaken to develop innovative vehicle design concepts for combined night and day coaches with flexible interior designs for night travel which can also be converted for use during day travel with good utilisation of available space. Another example is coaches allowing a more

flexible division between first-class and standard-class accommodation (FLEXIBLE RAIL INTERIOR DESIGN).

Economic evaluation under various operational scenarios has demonstrated very large improvements in rolling stock productivity for both the flexible day and night coach and for the more flexible composite seating class coach. Moreover, such productivity benefits could be reaped either through new builds to such designs or by incorporating such changes in refurbishment of existing vehicles (FLEXIBLE RAIL INTERIOR DESIGN).

Developing a rail system that could be used safely and conveniently by disabled people is undoubtedly important. The original Rail Vehicle Access Regulations in the UK did specify the necessary design standards but they did not include a date by which all rail passenger vehicles should comply with these requirements. Where the vehicles concerned have a long operational life - conventionally 30 years in the case of rail stock - the absence of an end date would mean an unacceptably long time before the rail system is fully accessible for disabled people. The results of UK research show that there is a trade-off between an early compliance date and the costs to the rail industry. If the earliest date considered had been used, the costs to the industry would have been just over twice those for a 2020 end date. Delaying the end date by five years would have reduced the costs considerably, but the additional delay to the creation of a fully accessible rail system was not considered acceptable. As with much of the work needed to enable disabled people to travel easily, there has to be a balance between their reasonable expectations, technical feasibility and costs (UG 331D).

Interoperability

A study of the barriers to interoperability along a major international rail freight corridor towards the east of Europe has identified considerable variation in interoperability status between the countries and much lower impediments to achieving interoperability in some countries (e.g. in Scandinavia) than in others such as new member states and Greece. Given that many of the barriers to interoperability relate to technical issues, the biggest barrier to implementing the EU's interoperability Directives is clearly the high cost of making the required technical changes (REORIENT).

Rail border crossings entail an interchange of traffic between Infrastructure Managers (IMs) and often also involve a transfer of haulage from one Train Operating Company (TOC) to another. Border crossing delays are a major factor impeding the timeliness and cost-effectiveness of international rail freight movement. Demonstration projects involving various border transfer stations (including some involving a change of track gauge) have shown that significant reductions in border waiting times and delays at borders can be achieved, largely by the introduction of better and more integrated data management and

transfer systems rather than through changes to physical operating systems (INTERFACE). Research has been undertaken to develop, test and evaluate ICT-based solutions for cross border freight trains in the Trans European rail freight network corridors, with a particular view to using advanced ICT to provide efficient data exchange that will facilitate improved service reliability. Data exchange and information integration can be facilitated by using a state of the art message broker. Through the development of effective system interfaces, rail operators can continue to use their existing data formats and protocols whilst still benefitting from a more integrated management of the end-to-end freight transport corridor (CroBIT).

Research has been undertaken into how to provide customer-driven rail freight services on the long corridor between the Benelux countries and Turkey. Effective service provision to allow the innovative use of rail for supply chain operations depends on solving a set of complex interoperability and other issues including streamlined border crossings, integrated telematic solutions for train control, tracking & tracing of shipments and customer information, effective ways of handling temperature-controlled cargoes and new technology for the transport of unaccompanied semi-trailers. Integration of the new Betuwelijn in the wider European rail network has also been investigated (CREAM).

The busy Brenner corridor is a particularly challenging rail operating environment which would benefit from improved interoperability, especially for rail combined transport services, and this has been the subject of both research and demonstration projects. Aspects covered by such research have included the provision of interoperable rail traction involving multi-voltage locomotives, the development and testing of specialised wagons suitable for the carriage of conventional road semitrailers for unaccompanied intermodal transport, improved information systems providing for online train monitoring including estimated time of availability (ETA) information accessible for all parties involved in rail transport, including infrastructure operators, train operators, combined transport companies and terminal operators and the specification of a coherent and transparent corridor management scheme (BRAVO).

Research has continued into the development and implementation of the European Rail Traffic Management System (ERTMS) and associated train control systems (ETCS), including research into their impacts on the development of improved interoperability along major rail corridors. Results show that implementation of the early technological stages of the system would yield modest benefits in terms of increased capacity, but the so-called ETCS level 3, which involves replacing traditional fixed block signalling sections with a “moving block” system, could lead to capacity increases of up to 50% (NEW OPERA).



Market competition and liberalisation

European research has tried to contribute to improving the competitiveness and economic stability of the railway sector and industry, as well as promoting the railways contribution to a sustainable transport policy (EURNEX).

When considering the likely impacts of rail service liberalization on rail traffic, freight traffic has received considerable attention. A study of the barriers to interoperability along a major international rail freight corridor towards the east of Europe has identified that whilst technical issues are the biggest single barrier, the different rates of progress between countries in rail market deregulation and the emergence of intra-modal and inter-modal competition are also a significant impediment to improving the effectiveness of such rail corridors (REORIENT).

Increased competition within the rail industry calls for transparent approaches to both infrastructure slot allocation and pricing for the use of slots. Research has led to the development of a demonstrator to show how such transparent slot allocation and charging can be implemented, most particularly in international rail freight corridors (PARTNER).

The likely implications of competition in national rail freight in Finland have also been investigated. It was found that any increase in supply due to more liberal access to the rail market is not expected to generate large amounts of additional rail freight, or increase the total size of the domestic freight market or significantly change modal shares. Greater choice of supplier may improve the position of shippers in price negotiations, putting downward pressure on freight transport prices. Competition is unlikely to occur quickly because there are significant barriers to entry and all players would have time to adjust to the new market environment as a result (DEREGULATION OF CARGO TRAFFIC ON THE FINNISH RAILWAYS).

4.2.3 Policy implications

This research has significant implications for railway infrastructure operators and train operating companies, in terms of recommendations on investment requirements for many aspects of railway operation including infrastructure and rolling stock as well as information systems, including provision of information to the travelling public. It provides guidance on pricing and allocation of infrastructure capacity as well as on terminals provision and specification and on ways of achieving enhanced interoperability.

Perhaps more important are the lessons for national governments regarding how they can provide for the required liberalisation of rail markets as well as for intermodality and the

much needed interoperability between different railway networks, most particularly in the international freight sector.

4.3 Sub-theme 2: Rail management systems

4.3.1 Background

Research reported in the Thematic Research Summary on Rail Transport produced in EXTR@Web (the predecessor of the TRKC project) included work towards the development of a self-assessment management toolkit, based on Business Process Re-engineering (BPR) principles, for use by railway infrastructure managers across various aspects of their responsibilities.

In the rail freight sector, considerable research effort was reported into the creation of innovative tools for use by fleet managers in the location, control and positioning of wagons, allowing much improved information to be made available both within the rail industry (allowing better routing of empty wagons, provision of the most suitable wagons for work, understanding maintenance status etc) and to customers, allowing better information on traffic status and estimated time of arrival.

4.3.2 Research objectives

Improved management systems offer major potential benefits to railways and hence considerable research effort has been focused in this field. Rapid improvements, greater standardisation and cost reduction in information and communication technologies (ICT) offer many opportunities which have been researched in the context of the rail industry. A major application area is in the management of maintenance (EUROMAIN, RAIL, TRAINCOM) and safety regimes (SAMRAIL), with the objectives of improved safety and of improved reliability of rail operations, in support of the objectives of improved operations and enhanced interoperability discussed in the previous section of this summary. A more recent objective has been to move forward from compartmentalised management systems in the fields of maintenance and safety to the development of much more integrated railway management information systems (INTEGRAL).



4.3.3 Research results

Safety management

The large amount of European legislation on railways, coupled with the continued existence of different sets of national rules, has led to difficulties in ensuring that safety requirements are complied with. Moreover, for potential new entrants in a liberalised market, safety approval has become a significant barrier to entry in many cases. Hence research has been conducted towards the development of a common safety management system for European railways, to establish a consistent and common set of criteria for safety performance and to provide guidance for setting safety and performance targets, for assessing risks and for specifying duties, rules and regulations. A key aim of such research is to develop a comprehensive and consistent safety management programme for European railways which could provide a basis for developing and implementing the European Railway Safety Directive and interoperability requirements for both high speed and conventional railways (SAMRAIL).

Maintenance management

Work has progressed towards the definition and specification of a complete maintenance support system for railways. This research will provide tools that will allow remote monitoring and diagnosis of complex systems both aboard trains and inside fixed plant, automatic linking of real-time data with suitable technical documentation, retrieval of such data in standard format from a distributed database, and presentation of appropriate information to final users in a suitable format, by means of a complete set of tools. This work includes the development and validation of prototype hardware and software modules, integrated within the communication infrastructure developed in previous research projects. A European Diagnostic Data Network (EDDN) is under development with the aim of providing immediate diagnostic information to ground systems, so that operators know the status of each device and the maintenance workshop can plan in advance the resources needed for maintenance operations. Documentation is a primary resource for maintenance and a European Technical Documentation Network (ETDN) aims use computer and web technologies to improve the benefits and usability of technical manuals and documents (EUROMAIN). Another project has defined a standard communication infrastructure, which is able to seamlessly connect train equipment and ground facilities, so as to support a wide range of applications, including improved train fleet management based on remote diagnostics and maintenance (TRAINCOM).

Reliability Centred Maintenance (RCM), a technique originally developed for maintenance in the aircraft and nuclear industries, has been applied to the case of railway infrastructure, most particularly in the monitoring of the maintenance status of track circuitry, axle

counters, point machines, signals and interlocking devices. The technique has performance benefits through reduction of faults on such infrastructure components which account for a large number of train delays, as well as safety benefits for railway personnel through reduction in the need for visual inspection of busy rail routes. The creation of maintenance databases allows more accurate information on repair costs and the costs of preventive maintenance, and facilitates the development of a Life Cycle Costing approach to items of rail infrastructure concerned (RAIL).

Research towards integrated railway management systems

Whilst European railways have made substantial progress has been made in the development of information systems for particular important aspects of their operations, different elements of information management systems within organizations often do not interface effectively. Moreover, there are many difficulties in exchanging information in a timely manner. Hence research is now underway in an attempt to create a holistic, coherent rail information management system which will integrate major railway sub-systems. The basic information system requirements for train control and monitoring, maintenance, management and communications will be redefined, paving the way for widespread introduction of innovation in the management of infrastructure, traffic management (including the European Rail Traffic Management System ERTMS), train operations and rolling stock (InteGRail).

4.3.4 Policy implications

Whilst such management systems are designed to be implemented at national or operator level, there are major implications for the achievement of interoperability between countries. Hence there are important lessons to be learned from this research in terms of how such information systems must be implemented to achieve maximum compatibility and ease of information transfer across company and national boundaries. This is particularly challenging when systems are designed to be complementary to existing information systems, calling for considerable attention to how different information sub-systems must be interfaced. In the longer term systems will need to be replaced by new systems with much greater scope and functionality and this will raise continuing questions about the design of such systems as well as their costs.



4.4 Sub-theme 3: Development of rail technology

4.4.1 Background

Research reported in the Thematic Research Summary on Rail Transport produced in EXTR@Web (the predecessor of the TRKC project) had identified very significant potential of technology for rail to develop its market position, most particularly in the longer distance passenger market. Important cost reduction and quality enhancement opportunities were identified in both infrastructure and rolling stock, with the introduction of new kinds of tracks, optimisation of maintenance and increased standardization and modularisation. Looking further ahead, opportunities were identified in the fields of automation, ticketing and train control, including the adoption of radio technologies which could lead eventually to driverless operation. Research was also reported into the development of innovative cost-effective satellite based fail-safe train location systems, which would allow the extension of the ERTMS/ETCS system (covering high density lines only at that time) to more lightly trafficked routes, with the potential for considerable cost reduction.

4.4.2 Research objectives

There is still large potential for the application of new and improved rail transport technologies as well as for the application of technologies used in other fields in the rail industry. Hence there is a need for continued research for development, testing and application in all engineering and technical aspects of the rail industry, including track technology (R.E.W.I. - R.O.S.E., TURNOUTS) and train detection (TRAPOLO), to achieve improved performance and enhanced safety. There is the need to improve efficiency and competitiveness through a fundamental re-examination of wheelset design, which in turn will facilitate improved maintenance practices (WIDEM).

Further research objectives are concerned with achieving cost reduction through the application of new technologies to replace existing high cost (often labour-intensive) practices such as train inspection (CHECKPOINT), designing cost effective aluminium rail vehicle bodies that will not fail by catastrophic joint failure under extreme loading (ALJOIN) and the use of interchangeable modules (MODTRAIN) to achieve greater standardisation. The use of advanced technology can increase railway competitiveness and interoperability.

4.4.3 Research results

Research continues into rail track technology, to ensure safety standards, to comply with environmental requirements in terms of for example noise reduction and to reduce the life cycle costs of track maintenance and renewal. Examples of such research include

Austrian national research into the advantages and disadvantages in such respects of different types of track sleepers, including those for use in marshalling and freight yards and those on for use on bridge structures. Research has also been conducted into the relative merits of aggregate foundations and concrete track bases (R.E.W.I. - R.O.S.E.). Turnouts (points) have also received attention, including those used on metro rail lines and urban tramways where conditions and requirements are very different from those on mainline rail routes. A range of technologies have been tested for possible use in such light rail applications, with mixed results (TURNOUTS).

Electronic tags or transponders and radio communication are required for determining the precise positioning of trains, which is necessary for traffic management and for the provision of reliable real time information to passengers. There are particular technical challenges of developing these for use of the electrified railway sections. Research has led to the development of state-of-the-art, low frequency battery-less RFID (radio frequency identification) tags which are reliable, accurate, very cheap, need no maintenance and easy to install. These have now been turned into marketable products by ensuring that they can be interfaced with a variety of existing systems in Europe (TRAPOLO).

Improved train inspection offers the prospects of improved safety, better service quality and reduction in operating costs, but traditional labour-intensive inspections need to be replaced by technical solutions. Automated checkpoints have been developed and installed on the railway line between Vienna and the Austrian-Hungarian border to check the status of passing trains, for example for the incidence of overheating axleboxes. Such methods are seen as essential in a more liberal track access regime where the use of a wide range of rolling stock types from different operators could prove problematic (CHECKPOINT).

Research highlighted the economic efficiency and competitiveness of rail can be affected by safety, availability and maintenance of its individual highly loaded structure components such as railway wheelsets. Combining inputs from reliable service measurement of wheel-rail forces carried out by innovatively instrumented wheelset and an extensive assessment of actual material properties, an endurance strength design concept was developed and validated through a comprehensive testing programme on full-scale wheelset prototypes. A flexible numerical tool was developed to serve to enhance existing knowledge. Research allowed development and evaluation of alternative NOT (non-destructive testing) techniques that allow significantly increased detection probability and a size estimation of cracks to set up a schedule for NOT periodic inspection. The research work led to the definition of wheelset design procedures and maintenance methods that could be implemented into existing standards for a quick and easy optimisation of the process (WIDEM).

Research has provided the high speed market a set of specifications that allow for better inter-changeability of key components for maintenance, as well as for a higher level of standardisation at the interfaces of the main train subsystems. This was achieved through the identification of the main interfaces subject to possible standardisation and the drafting of the related standards (MODTRAIN).

The ability to accurately model the collision behaviour of a rail vehicle has been a major output of some research. Results were found that demonstrably improved the structural integrity of rail vehicles and their crashworthiness (ALJOIN).

4.4.4 Policy implications

Increased interoperability and exchange of traffic between European networks will mean that there is a need to ensure compatibility between technical systems used in each country. Recent research expands on the EU's previous legislative packages that were set out to support the rail sector and increase its competitiveness. It is also paving the way for cooperation between the different actors of the sector.

4.5 Implications for further research

The rail industry is very wide ranging and this presents widespread opportunities for further research into many aspects of rail technology, safety, economics and management. The major strides now being taken to liberalisation of the rail market to boost competition both within the rail industry and between modes also call for further research, including work in the field of efficient pricing. The progress towards implementation of liberalisation will also need to be monitored and lessons drawn from the process.

Whilst rail is increasingly seen as a solution to the need for more environmentally friendly transport, both for passenger and freight and for local (e.g. city region) mobility as well as for long distance travel, there is considerable concern about the high costs of rail operation which have impacts on competitiveness. Hence much future research will need to focus on how new technologies (including ICT technologies) can be harnessed and effectively implemented to reduce industry costs.

Further major developments in the world of ICT can be expected in the coming years and this will call for further work into how such technologies can be implemented to the benefit of the European rail industry. More research is also required into how the pace of ICT development and implementation in the rail sector can be accelerated.

The European Rail Research Advisory Council (ERRAC), the advisory body to the EU Commission representing Member States and all stakeholders in the rail sector, has developed its 'Strategic Rail Research Agenda (SRRA) 2020' to inform the planning of research programmes across the EU. This agenda identifies key research objectives to ensure that the ERRAC vision of the increased role of rail in the future of Europe is achieved by providing seamless and integrated high speed passenger services and door-to-door freight services as well as efficient metropolitan and urban mass transport. There are seven research priority areas for the next decade, covering the following themes:

- *Intelligent mobility*, essentially to work towards a European-wide intelligent infrastructure with compatible technology between member states and across transport modes, to support improved customer information systems,
- *Energy and environment*, to work towards new standards and regulations which improve environmental performance and reduce dependence on fossil fuels without detriment to the commercial competitiveness of the rail mode,
- Combatting terrorism and vandalism in order to achieve *improved personal security* for rail customers and staff,
- *Faster implementation of new technologies*, to improve the spread of European homologation, calling for streamlined testing and acceptance procedures without compromising safety regimes,
- *Enabling technologies for increased rail competitiveness*, through the creation of more attractive products for customers and the reduction of life cycle costs through modern technology in all aspects of railway operation,
- *New accounting and planning models* are required to provide a better understanding of the costs of operating and maintaining rail infrastructure and how these costs vary with changes in types of train used and in service frequency, in order to improve rail economics and strategy.
- *Infrastructure developments*: there is a need to develop infrastructure systems that can deliver interoperability, increased capacity, increased axle weights and track stability whilst at the same time having low maintenance costs or be maintenance-free.

Finally, EU enlargement, particularly to the east, brings opportunities and a need for further research into the rail infrastructure investment requirements to promote mobility and to enhance integration and development. A clearer view of the strategic network requirements is needed, and the technical and managerial issues impeding the development of intermodality and interoperability also require further attention.



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Annex: List of projects by sub-theme

Sub-theme 1: Development, planning and organisation of rail services in Europe – passenger and freight				
Project acronym	Project title	Programme	Project website	Coverage
	Passenger rail services and economic performance	DfT - Rail - Department for Transport - Rail	N/A*	Covered in EXTR@WEB paper
	Strengthening of the competitive environment of rail passenger transport	HARMONISATION - Transformation and harmonisation of the transport and communication services and system	N/A*	Covered in EXTR@WEB paper
	Deregulation of cargo traffic on the Finnish railways	MinTC R&D - Ministry of Transport and Communication's R&D Projects Supporting Transport Policy	N/A*	Covered in this paper
ADVISOR	Annotated Digital Video for Surveillance and Optimised Retrieval	FP5 - IST - KA1 - Systems and services for the citizens	www-sop.inria.fr/orion/ADVISOR/	Covered in EXTR@WEB paper
B6 (NRP 41)	Integration into the European network: passenger transport	NRP 41 - Transport and Environment (internal research plan)	www.nfp41.ch	Covered in EXTR@WEB paper

Sub-theme 1: Development, planning and organisation of rail services in Europe – passenger and freight				
Project acronym	Project title	Programme	Project website	Coverage
Bahn Ville	Promoting a rail oriented urban development approach for urban regions in Germany and France	DEUFRAKO - German-French cooperation for land transport research	N/A*	Covered in EXTR@WEB paper
BRAVO	Brenner Rail Freight Action Strategy Aimed at Achieving a Sustainable Increase of Intermodal Transport Volume by Enhancing Quality, Efficiency, and System Technologies	FP6-SUSTDEV-2 - Sustainable Surface Transport	www.bravo-project.com/home/index.shtml	Covered in this paper
CATIEMON	Catenary Interface Monitoring	FP6-SUSTDEV-2 - Sustainable Surface Transport	N/A*	Project results are not yet available on TRKC
CREAM	Customer-driven Rail-freight services on a European mega-corridor based on Advanced business and operating Models	FP6-SUSTDEV - Sustainable Development, Global Change and Ecosystems - Priority Thematic Area 6 (PTA6)	N/A*	Covered in this paper
CroBIT	Cross-Border Information Technology	FP5 - GROWTH - KA2 - Sustainable Mobility and Intermodality	www.crobit.org/	Covered in this paper
CROSSRAIL	Integrating Local and Regional Rail Including Cross Border Aspects	FP5 - GROWTH - KA2 - Sustainable Mobility and Intermodality	N/A*	Covered in EXTR@WEB paper
D2 (NRP 41)	Railways: Competition and Basic Mobility	NRP 41 - Transport and Environment (internal research plan)	www.nfp41.ch	Covered in EXTR@WEB paper

Sub-theme 1: Development, planning and organisation of rail services in Europe – passenger and freight				
Project acronym	Project title	Programme	Project website	Coverage
ELODIT	High-powered locomotive for non-electrified lines	PREDIT 3: G.O.6 - Technologies for goods transportation (Operational Group 6)	N/A*	Covered in this paper
ESCUGIBRI	ESC UserGroup and InfoBank to support Rail Interoperability	FP5 - GROWTH - KA3 - Land transport and marine technologies	www.esc-usergroup.org	Covered in EXTR@WEB paper
EUDDPLUS	European Driver's desk advanced concept implementation	FP6-SUSTDEV - Sustainable Development, Global Change and Ecosystems - Priority Thematic Area 6 (PTA6)	N/A*	Project results are not yet available on TRKC
EURNEX	European Rail Research Network of Excellence	FP6-SUSTDEV-2 - Sustainable Surface Transport	www.eurnex.net	Covered in this paper
F4 (NRP 41)	Technical perspectives of rail transport	NRP 41 - Transport and Environment (internal research plan)	www.nfp41.ch	Covered in EXTR@WEB paper
FACT	Fast and Comfortable Trains	FP5 - GROWTH - KA2 - Sustainable Mobility and Intermodality	N/A*	Covered in EXTR@WEB paper
FIRE	Freight Information in the Railway Environment	FP4 - TRANSPORT RTD - Transport Research and Technological Development	N/A*	Covered in EXTR@WEB paper

FLEXIBLE RAIL INTERIOR DESIGN	Flexible usable rail passenger cars for efficient long distance travel	ISB - Innovative System Railway	N/A*	Covered in this paper
F-MAN	Rail Car Asset Management	FP5 - IST - KA1 - Systems and services for the citizens	www.fman.org	Covered in EXTR@WEB paper
H102N	Integrated National Rail Model Development	DfT - Strategy Economics and Mobility - Department for Transport - Strategy Economics and Mobility	www.dft.gov.uk/rmd/project.asp?intProjectID=9124	Covered in EXTR@WEB paper
HISPEEDMIX	High Speed Freight	FP4 - TRANSPORT RTD - Transport Research and Technological Development	N/A*	Covered in EXTR@WEB paper
IMPROVERAIL	IMPROVED tools for RAILway capacity and access management	FP5 - GROWTH - KA2 - Sustainable Mobility and Intermodality	N/A*	Covered in EXTR@WEB paper
INTERFACE	Improvement of intermodal terminal freight operations at border crossing terminal	FP5 - GROWTH - KA2 - Sustainable Mobility and Intermodality	w3.uniroma1.it/interface/	Covered in this paper
LIBERTIN	Light Rail Thematic Network	FP5 - GROWTH - KA3 - Land transport and marine technologies	www.libertin.info	Covered in EXTR@WEB paper
MODURBAN	Modular Urban-guided Rail Systems	FP6-SUSTDEV-2 - Sustainable Surface Transport	www.modurban.org	Project results are not yet available on TRKC

NEW OPERA	New European Wish: Operation Project for European RAil network	FP6-SUSTDEV-2 - Sustainable Surface Transport	www.newopera.org/	Covered in this paper
PARTNER	Path Allocation Re-engineering of Timetable Network for European Railways	FP6-SUSTDEV-2 - Sustainable Surface Transport	N/A*	Covered in this paper
RAILCOM	Electromagnetic Compatibility between Rolling Stock and Rail-infrastructure Encouraging European Interoperability	FP6-SUSTDEV-2 - Sustainable Surface Transport	N/A*	Project results are not yet available on TRKC
RAILENERGY	Innovative Integrated Energy Efficiency solutions for railway rolling stock, rail infrastructure and train operation	FP6-SUSTDEV-2 - Sustainable Surface Transport	www.railenergy.org	Project results are not yet available on TRKC
REORIENT	Implementing Change in the European Railway System	FP6-SUSTDEV - Sustainable Development, Global Change and Ecosystems - Priority Thematic Area 6 (PTA6)	N/A*	Covered in this paper
Road to Rail	Open Access Intermodal Gateway to the UK - TDG European Chemicals (GPCS 399)	DFT - FREIGHT LOGISTICS - Department for Transport: Freight Logistics	www.transportenergy.org.uk/downloads/GPCS399.pdf	Covered in EXTR@WEB paper
ROLLING SHELF	Palletised Rail Goods	FP4 - TRANSPORT RTD - Transport Research and Technological Development	N/A*	Covered in EXTR@WEB paper
RRTC	Regional Railway Transport research and training Centre foundation	FP6-SUSTDEV-2 - Sustainable Surface Transport	N/A*	Project results are not yet available on TRKC

SPURT	Seamless Public Urban Rail Transport	FP6-SUSTDEV-3 - Global Change and Ecosystems	N/A*	Project results are not yet available on TRKC
SUSTAINABLE BRIDGES	Assessment for future traffic demands and longer lives	FP6-SUSTDEV-2 - Sustainable Surface Transport	www.sustainablebridges.net	Covered in this paper
TREND	Towards new Rail freight quality and concepts in the European Network in respect to market Demand	FP6-SUSTDEV-2 - Sustainable Surface Transport	www.trend-project.com	Project results are not yet available on TRKC
UG 331D	Implications of RVAR (Rail Vehicle Access Regulations) Compliance	DfT Strategy Economics & Mobility - Department for Transport - Strategy Economics and Mobility	N/A*	Covered in this paper

Sub-theme 2: Rail management systems				
Project acronym	Project title	Programme	Project website	Coverage
EUROMAIN	European Railway Open Maintenance System	FP5 - IST - KA1 - Systems and services for the citizens	www.euomain.org	Covered in this paper
InteGRail	Intelligent Integration of Railway Systems	FP6-SUSTDEV-3 - Global Change and Ecosystems	www.integrail.info	Covered in this paper
INFRACLEAR	Rail Infrastructure Clearance Management	FP6-SUSTDEV-3 - Global Change and Ecosystems	N/A*	Project results are not yet available on TRKC

Sub-theme 2: Rail management systems				
Project acronym	Project title	Programme	Project website	Coverage
INNOTRACK	Innovative Track Systems	FP6-SUSTDEV-3 - Global Change and Ecosystems	www.innotrack.eu	Project results are not yet available on TRKC
PROMAIN	Progress in Maintenance and Management of Railway Infrastructure	FP5 - GROWTH - KA2 - Sustainable Mobility and Intermodality	www.promain.org	Covered in EXTR@WEB paper
RAIL	Reliability centred maintenance (RCM) Approach for Infrastructure and Logistics of Railway Operations	FP5 - GROWTH - KA2 - Sustainable Mobility and Intermodality	www.datsi.fi.upm.es/~rail/index.html	Covered in this paper
SAFEDMI	Safe Driver Machine Interface (DMI) for ERTMS automatic train control	FP6-SUSTDEV-3 - Global Change and Ecosystems	www.safedmi.org	Project results are not yet available on TRKC
SAFEINTERIORS	Train Interior Passive Safety for Europe	FP6-SUSTDEV-3 - Global Change and Ecosystems	www.eurailsafe.net/projects.php?id=2	Project results are not yet available on TRKC
SAFET	Safety in tunnels Thematic Network	FP5 - GROWTH - KA2 - Sustainable Mobility and Intermodality	www.safetunnel.net	Covered in EXTR@WEB paper
SAMNET	Safety management and interoperability Thematic Network	FP5 - GROWTH - KA2 - Sustainable Mobility and Intermodality	samnet.inrets.fr	Covered in EXTR@WEB paper

Sub-theme 2: Rail management systems				
Project acronym	Project title	Programme	Project website	Coverage
SAMRAIL	Safety management in railways	FP5 - GROWTH - KA2 - Sustainable Mobility and Intermodality	samnet.inrets.fr	Covered in this paper
TRAINCOM	Integrated Communication System for Intelligent Train Applications	FP5 - IST - KA1 - Systems and services for the citizens	www.traincom.org	Covered in this paper
TRANSFEU	Transport Fire Safety Engineering in the European Union	FP7-SST - Sustainable Surface Transport	www.transfeu.eu	Project results are not yet available on TRKC
URBAN TRACK	Urban Rail Infrastructure	FP6-SUSTDEV-3 - Global Change and Ecosystems	www.urbantrack.eu	Project results are not yet available on TRKC
2TRAIN	Training of Train Drivers in safety relevant issues with validated and integrated computer-based technology	FP6-SUSTDEV-3 - Global Change and Ecosystems	www.2train.eu	Project results are not yet available on TRKC

Sub-theme 3: Development of rail technology				
Project acronym	Project title	Programme	Project website	Coverage
ALJOIN	Crashworthiness of joints in aluminium rail vehicles	FP5 - GROWTH - KA3 - Land transport and marine technologies	N/A*	Covered in this paper

Sub-theme 3: Development of rail technology				
Project acronym	Project title	Programme	Project website	Coverage
CHECKPOINT	The integration of Checkpoint Systems into Solid State Interlockings for automatics train supervision	ISB - Innovative System Railway	N/A*	Covered in this paper
EUROPAC	European optimised pantograph catenary interface	FP6-SUSTDEV-2 - Sustainable Surface Transport	N/A*	Project results are not yet available on TRKC
GREEN	Green Heavy Duty Engine	FP6-SUSTDEV-3 - Global Change and Ecosystems	green.uic.asso.fr/introduction.html	Project results are not yet available on TRKC
HI-CEPS	Highly Integrated Combustion Electric Propulsion System	FP6-SUSTDEV-3 - Global Change and Ecosystems	N/A*	Project results are not yet available on TRKC
HVB2	High Voltage Booster - second phase	FP5 - GROWTH - KA3 - Land transport and marine technologies	N/A*	Covered in EXTR@WEB paper
LOCOPROL	Low Cost Satellite Based Train Location System for Signalling and Train Protection for Low Density Railway Lines	FP5 - GROWTH - KA3 - Land transport and marine technologies	N/A*	Covered in EXTR@WEB paper
MODBRAKE	Innovative Modular Brake Concepts for the Integrated European High-speed Railway System	FP6-SUSTDEV-3 - Global Change and Ecosystems	www.modbrake.com	Project results are not yet available on TRKC

Sub-theme 3: Development of rail technology				
Project acronym	Project title	Programme	Project website	Coverage
MODTRAIN	Innovative Modular Vehicle Concepts for an Integrated European Railway System	FP6-SUSTDEV-3 - Global Change and Ecosystems	www.modtrain.com	Covered in this paper
R.E.W.I. - R.O.S.E	Frame type sleepers - new type of track switches - Optimisation of noise and vibration characteristics	ISB - Innovative System Railway	www.fcp.at	Covered in this paper
SISMODCOMPRO T	A modern system of commutation and protection of the electrical power lines in the railway transport in view of alignment to the requirements of the European system	AMTRANS - Territory Arrangement and Transport	N/A*	Covered in EXTR@WEB paper
TRAPOLO	Train Position Locator for Electric Railways	EUREKA - A network for market-oriented R&D	www.eureka.be/inaction/portfolio.do	Covered in this paper
TURNOUTS	New Concepts for Turnouts in Urban Rail Transit Infrastructures	FP6-SUSTDEV-3 - Global Change and Ecosystems	N/A*	Covered in this paper
WIDEM	Wheelset Integrated Design and Effective Maintenance	FP6-SUSTDEV - Sustainable Development, Global Change and Ecosystems - Priority Thematic Area 6 (PTA6)	www.widem.org	Covered in this paper

Notes:

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