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FREIGHT TRANSPORT
THEMATIC RESEARCH SUMMARY

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Thematic Research Summary:

Freight Transport

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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 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.

The particular Thematic Research Summary deals with freight transport. The aim is to provide the reader with a synthesis of results of completed EU-funded projects related to the theme of freight 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.

Executive summary

This Thematic Research Summary on freight 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. The research projects for which the synthesis is provided are European EU-funded projects that are completed and with results publicly available. The EU projects have been funded by the 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.

Freight Transport addresses issues related to the movement of all kinds of goods from raw materials to finished goods and waste products. It makes use of local, regional, national and international transport systems and is increasingly adopting intermodal and multimodal solutions. It is also concerned with the organisation and management of the supply chain and logistics activities as they dictate the quantity and quality of freight transport demanded and the nature of the commercial relationships between shippers and transport service providers.

EU policy has long supported the promotion of intermodality, with the Marco Polo programme providing funds to freight operators that accomplish a shift of traffic from road to rail and sea. Another main policy development relates to the promotion of the Trans-European networks which cover all modes and include the motorways of the sea. Recently the idea of having a freight-oriented railway network has received support following the former idea of freight freeways. The promotion of inland waterway transport is the objective of the NAIADES programme. Legislative initiatives at EU level have addressed the opening of rail freight services to competition and the establishment of a framework for charging of international heavy goods traffic on roads. A policy objective today is to set out a framework for differentiated charging to improve the efficiency and environmental performance of road freight transport.

Four sub-themes are considered in the synthesis of the findings from research projects. The main achievements in each sub-theme are summarised below.

In the sub-theme concerning **trends in freight transport, logistics and supply chain management**, research has identified the main hindrances to the development of rail freight transport, and has provided recommendations to improve the interoperability of railway systems. Research has also investigated the main drivers of supply chain development and the tools supporting its evolution. The establishment of a thematic network on e-Logistics and e-fulfilment to provide inputs to EU research and policy development has been reported.

In the sub-theme concerning **logistics and supply chain management tools**, research has developed tools for port and terminal operators, for enhancing the waterborne mode, for tracking and tracing (T&T), and for fleet management.

More specifically, a terminal simulation system to support managers, planners and designers of small to medium ports and terminals has been developed, as well as a software tool to support them in designing terminals and in selecting the more appropriate transhipment system complying with the main rail and maritime terminal operations.

Tools developed by research specific to waterborne transport are: a concept of flexible container liner services, which integrates an application for door-to-door supply chain management; an Internet-based platform which provides a set of low cost and easy to use applications to streamline the exchange of information and data between partners and authorities working in the waterborne transport; a tool, which calculates the costs of multi-modal transport chains, and compares them with those of unimodal road transport; an internet based platform to encourage the use of the waterborne mode.

In the area of T&T tools, besides enhancing the CESAR tool with additional services and information, research has developed new tools specifically designed for T&T of individual items using innovative technologies such as “thinking tags”, or which specifically address security aspects and the transport of perishable goods. Technologies, processes and services to improve safety and security in intermodal cargo transport have been developed. Finally, research has also developed tools for small haulage companies and small and medium railway undertakings. These tools are a virtual fleet management application, and a customer information system for monitoring in real time cross border train movements.

In the sub-theme concerning **intermodal transport**, a research paper on the role of collaborative business models for the success of intermodal solutions has been produced. Furthermore, two platforms and an advisory council with a view of enhancing the competitiveness of intermodal transport have been established. The first platform,

specifically targeted to Central European Countries, was created to disseminate and exploit results from FP5 and FP6 projects on logistics and transport; the second platform focused on freight terminals and offered opportunities for all relevant stakeholders to discuss research and policy issues; the European Intermodal Research Advisory Council (EIRAC) was responsible for the development of a strategic research agenda on intermodal transport.

Achievements have also been obtained in the area of intermodal transport between EU and neighbouring countries by identifying, demonstrating, and validating possible intermodal solutions to improve terminal operations at borders crossings between MSs and CEECs, and studying the possibility of creating a Euro-Mediterrenean intermodal network.

Results have also been achieved in the area of intermodal transport technologies. More specifically, innovative horizontal transhipment systems have been developed and demonstrated, and the MOCONT system (which automatically tracks the containers inside a terminal) has been further developed and tested. A system to simplify the handling of combined transport semi-trailers has been identified and further developed. Furthermore, a contribution to the development of standardised small containers to be used Europe-wide has been made, and aspects relating to safety and security of intermodal transport have been investigated for the purpose of developing appropriate procedures.

In the sub-theme concerning **urban freight transport** a number of best practices has been identified in the areas of city access restriction, enforcement and control, waste transport, environment-friendly vehicles, and freight distribution management. Research has also developed a methodology for evaluating the feasibility of interventions in the city logistics field. Finally, research has developed a prototype of an automated shuttle linking sea ports and hinterland depots in order to increase the capacity of ports when this is limited by the city.

Abbreviations and acronyms used

3PLP	Third Party Logistics Provider
ACARE	The Advisory Council for Aeronautics Research in Europe
AIS	Automatic Identification System
ASCII	American Standard Code for Information Interchange
B2B	Business to Business
B2C	Business to Customer
CEC	Commission of the European Communities
CEEC	Central and Eastern European Countries
CEP	Courier, Express, Parcel Service
CIS	Commonwealth of Independent States
CT	Combined Transport
CTP	Common Transport Policy
DG TREN	Directorate-General for Transport and Energy
DSS	Decision Support System
EC	European Commission
EDI	Electronic Data Interchange
EDP	Electronic Data Processing
EFV	Environment-friendly Vehicle
EIRAC	The European Intermodal Research Advisory Council
ERA	European Research Area
ERRAC	The European Rail Research Advisory Council
ERTRAC	The European Road Transport Research Advisory Council
ETA	Estimated Time of Arrival
EU	European Union
EXTR@Web	Exploitation of Transport Research Results via the Web (DG TREN FP5 Accompanying Measure project)

FP	Framework Programme
FP4	Fourth Framework Programme
FP5	Fifth Framework Programme
FP6	Sixth Framework Programme
GDP	Gross Domestic Product
GSM	Global System for Mobile Communications
GPRS	General Packet Radio Service
GPS	Global Positioning system
ICT	Information and Communication Technology
ILU	Intermodal Loading Unit
IM	Infrastructure Manager
IMO	International Maritime Organisation
ISDN	Integrated Services Digital Network
IT	Information Technology
ITS	Intelligent Transport system
ITU	Intermodal Transport Unit
IWT	Inland Water Transport
LEZ	Low Emission Zone
LSP	Logistics Service Provider
MEDA	Mediterranean non-Member countries
MS	Member State
NAS	Newly Associated States
NMS	New Member State
O/D	Origin / Destination
R&D	Research and Development
RFID	Radio Frequency Identification
RIS	River Information Service

Ro-Ro	Roll-on Roll-off
RTD	Research and Technical Development
RU	Railway Undertaking
SIRA	Strategic Intermodal Research Agenda
SME	Small and Medium-sized Enterprises
SMS	Short Message Service
SRA	Strategic Research Agenda
TEN-T	Trans-European Network for Transport
T&T	Tracking and Tracing
TRKC	Transport Research Knowledge Centre; TRKC website at http://ec.europa.eu/transport/extra
TRS	Thematic Research Summary
TSIs	Technical Specifications for Interoperability
VAT	Value Added Tax
VHF	Very High Frequency
UMTS	Universal Mobile Telecommunications System
VTS	Vessel Traffic Services
XML	Extensible Markup Language
WSRA	Waterborne Strategic Research Agenda

Table of Contents

FOREWORD **2**
EXECUTIVE SUMMARY **3**
1. INTRODUCTION **10**
2. SCOPE OF THE THEME **13**
3. POLICY CONTEXT **16**
3.1 INITIAL STEPS OF THE COMMON TRANSPORT POLICY 16
3.2 THE 2001 WHITE PAPER AND ITS MID-TERM REVIEW 18
3.3 SPECIFIC POLICY INITIATIVES 20
4. RESEARCH FINDINGS **24**
4.1 INTRODUCTION 24
4.2 SUB-THEME 1: FREIGHT TRANSPORT, LOGISTICS AND SUPPLY CHAIN MANAGEMENT TRENDS 27
4.2.1 BACKGROUND 27
4.2.2 RESEARCH OBJECTIVES 27
4.2.3 RESEARCH RESULTS 28
4.2.4 POLICY IMPLICATIONS 32
4.3 SUB-THEME 2: LOGISTICS AND SUPPLY CHAIN MANAGEMENT TOOLS 36
4.3.1 BACKGROUND 36
4.3.2 RESEARCH OBJECTIVES 36
4.3.3 RESEARCH RESULTS 38
4.3.4 POLICY IMPLICATIONS 44
4.4 SUB-THEME 3: INTERMODAL TRANSPORT 46
4.4.1 BACKGROUND 46
4.4.2 RESEARCH OBJECTIVES 47
4.4.3 RESEARCH RESULTS 48
4.4.4 POLICY IMPLICATIONS 56
4.5 SUB-THEME 4: URBAN FREIGHT TRANSPORT 59
4.5.1 BACKGROUND 59
4.5.2 RESEARCH OBJECTIVES 59
4.5.3 RESEARCH RESULTS 60
4.5.4 POLICY IMPLICATIONS 65
4.6 IMPLICATIONS FOR FURTHER RESEARCH 68
4.6.1 IMPLICATIONS FOR FURTHER RESEARCH FROM PROJECTS REVIEWED 68
4.6.2 SUMMARY OF FURTHER RESEARCH RECOMMENDED BY STRATEGIC RESEARCH AGENDAS 70
5. REFERENCES **76**
ANNEX: LIST OF PROJECTS BY SUB-THEME **82**

1. Introduction

This paper is the first version of the Thematic Research Summary (TRS) on Freight Transport produced within the TRKC project. It provides a structured review of the research relating to freight transport, carried out in EU-funded transport research projects. The theme "freight 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

Sectors
• passenger transport • **freight transport**
Geographic
• urban transport • rural transport • regional transport • long-distance transport • EU accession issues
Modes
• air transport • rail transport • road transport including walking and cycling • waterborne transport • innovative modes • intermodal freight transport
Sustainability policy objectives
• economic • efficiency • equity and accessibility • environmental aspects • user aspects • safety and security
Tools
• decision support tools • financing tools • information and awareness • infrastructure provision including TEN-T • 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 out of the 30 themes (the reduced number of TRSs resulting from merging of some themes into a single TRS). The TRKC project has planned to produce final versions of the TRSs for all themes by June 2010. This is the final version of the TRS on Freight Transport and substitutes the first version issued in May 2009.

A high number of research projects have been related to the theme addressed by this paper. The TRS “Freight Transport” produced in the predecessor project EXTR@Web (EXTR@Web, 2006a) had reviewed research from European projects belonging to the Fourth and Fifth Framework Programme (FP4, FP5) and selected national projects. The paper here adds new projects to the analysis that have reported since that paper, including various European projects from the FP5, FP6 and INTERREG III programmes and the COST research initiative.

The research reviewed in this paper does not represent the whole gamut of research dealing with freight transport carried out in the ERA. 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 (EXTR@Web, 2006a). A summary of the research reported on in the EXTR@Web paper on freight transport and intermodal transport is also included to make the reader aware of a wider range of research relevant to the theme. For completeness, FP6 projects, either on-going or for which results are not yet publicly available, have also been considered.

The paper is organised as follows. Sections 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, etc - 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 freight transport more manageable.

The following four sub-themes have been considered:

- Sub-theme 1: Freight transport, logistics and supply chain management trends;
- Sub-theme 2: Logistics and supply chain management tools;
- Sub-theme 3: Intermodal transport;
- Sub-theme 4: Urban freight transport.

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

The research projects listed under each of the four 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 other project deliverables.

2. Scope of the theme

Statistics show that in 2007 a total of 2650 billion tkm were produced in the EU-27 only considering the four land transport modes (road, rail, inland waterways and pipelines). More than two thirds of the total (72,7%) were attributed to road transport, while rail, pipelines, and inland waterways accounted for, respectively, 17,1%, 5,3%, and 4,9%. If we also consider intra-EU maritime transport[1] and intra-EU air transport[2], then road transport accounts for almost half the total (45,6%), while rail and inland waterways contributions decrease respectively to 10,7% and 3,3% (the intra-EU maritime transport share is 37,3%). The average annual growth rate of freight transport between 1995 and 2007 has been 2,7% (in 2006-2007 it has been 2,6%). It is also worth mentioning that the number of tkm run using road transport has increased by 49,6% during the period 1995-2007, while, in the same period, the rail freight transport trend has been fluctuating, but since 2002 it has increased by 17,7% (EU, 2009). Freight transport is expected to grow at roughly similar rates of GDP (2,1%) for the period 2000-2020. Modal split is expected to roughly stabilise in the longer term (CEC, 2006a).

Freight Transport is primarily concerned with the movement of raw materials, of work in-process inventory, and of finished goods from supplier to consumer. Also, it is concerned with the movement of agricultural products and animals, of new and used consumer products back to suppliers, and of waste to disposal and recycling plants. Freight movements utilise local, regional, national and international transport systems and are increasingly intermodal and multimodal. Indirectly, this theme is concerned with the organisation and management of the supply chain and logistics services as they dictate the quantity and quality of freight transport demanded and the nature of the commercial relationships between shippers and transport service providers.

Main topics in the domain of markets and logistics include the following:

- The trade sphere shows a shift from national to global markets. This brings about a growth of congestion along trade corridors and at ports, airports and border crossings and poses challenges in terms of infrastructure capacity and harmonisation of trade and regulatory policies.

[1] In 2007, the demand for intra-EU maritime transport has been estimated to be about 1575 billion tkm (EU, 2009).

[2] The demand for intra-EU air transport in 2007 has been about 3,4 billion tkm. Calculations based on the data available in the statistical pocketbook 2009 (EU, 2009).

- The economic environment shows a shift from a manufacturing to a service economy with decline in manufacturing employment but increase in manufacturing output. This is accompanied by an increase of small shipments of light, high-value goods, and the emergence of e-commerce and e-business. As a consequence, there are increased needs for packaging, air freight and customer oriented door-to-door truck services. The economic development is becoming more dependent on high-quality, multimodal trans-port services which need to be reliable and predictable.
- The business logistics regime shows a shift from push to pull systems. Logistics is increasingly less manufacture-to-supply and inventory based and more manufacture-to-order and replenishment based. This brings about lower inventory levels and smaller order quantities. The transport system thus faces increasing demand for flexible, timely, reliable and visible door-to-door services. The search for cost effectiveness leads to the growth of third party logistics providers and currently even fourth party logistics providers. At the same time there is an increasing concentration of supply chain control through shipper consortiums and alliances. Main challenges for the transport system include the management of potential service disruptions for either unanticipated peaks in supply and demand or system failure, the impacts of e-commerce on local pick-up and delivery truck services, and the security of cargoes.

Main topics in the domain of carriers and transport systems include the following:

- The shift from modal fragmentation to co-ordinated logistics is accompanied by the development and adoption of technologies for tracing shipments and managing vehicles and fleets, and an increasing carrier concentration and consolidation. At the same time this trend poses challenges in terms of:
    - harmonisation of practices;
    - standards;
    - government regulation and information technology across modal boundaries (as well as national boundaries);
    - investment in information technology particularly for SMEs;
    - barriers to market entry and competition because of economies of scale and scope.
- The shift from system construction to system optimisation is driven by the need for cost-effective provision of more capacity. Road transport faces increasing congestion while intermodal transport suffers from bottlenecks at interchange points with ports and air-ports, again related to congested landside access. Capacity increases can be obtained from infrastructure projects, limited capacity increases from larger lorries and trains, and moderate increases from faster, larger ships and wide-body aircraft. On the other hand, increases in operational capacity are expected from IT and ITS-enabled freight transport systems if interoperability limits are tackled successfully.

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

3. Policy context

3.1 Initial steps of the Common Transport Policy

The development of efficient and integrated transport systems has long been recognised as a priority of the Common Transport Policy, both in the former White Paper on the CTP (CEC, 1992) and in the Action Plans which translated policy objectives into actions (CEC, 1995a; CEC, 1998a). From the general policy priorities which were set in the Action plans those which were most relevant to freight are:

- market access in the railway and port sectors; and
- the promotion of integrated transport systems with the development of the Trans-European Transport Networks, the development of intelligent transport systems including the satellite navigation system and the deployment of traffic management for the different modes, and the development of intermodality.

In the rail sector, following the launch of the freight freeways (CEC, 1997a) and the implementation of Directive 96/48/EC on the interoperability of the Trans-European high-speed rail system further steps were taken on the basis of the Commission's 1996 White Paper on revitalisation of Community railways (CEC, 1996). The infrastructure package concerning charging, capacity allocation, separation of infrastructure management and operation and licensing proposed in 1998 (CEC, 1998b) led to the approval of the three Directives in 2001 which have opened the main rail axes to international freight traffic and have defined the role of the rail infrastructure manager as far as access provision to rail service operators is concerned.

In the waterborne sector, following the 1997 Green Paper (CEC, 1997b), the Commission has supported the liberalisation of port services. The integration of ports more closely into the Trans-European Transport Network taking into account the transhipment function has been stressed in the 1999 Communication on short-sea shipping (CEC, 1999). It is recognised that there is a need for a better understanding of the role of governments in infrastructure planning and the respective role of public and private sector operators in financing infrastructure for both seaports and the inland terminals linked to them.

Intermodality is a main priority of the European transport policy. The 1997 Communication has set the general strategies and actions (CEC, 1997c). The objective is to develop a framework for an optimal integration of different modes so as to enable an efficient and cost-effective use of the transport system through seamless, customer-oriented door-to-door services whilst favouring competition between transport operators.

A number of obstacles have been identified which prevent the extensive use of intermodal transport. These include the lack of a coherent network of modes and interconnections, the lack of technical interoperability among and within modes, a variety of regulations and standards for transport means, data interchange and procedures. There are uneven levels of performance and service quality between modes, different levels of liability and a lack of information about intermodal services. As a result, mode-independent door-to-door transport is underdeveloped.

It is recognised that implementing a European intermodal transport system requires coordinated development of transport policies at European, national and regional level. The four key strategies to provide the necessary impetus to the development of intermodal transport:

- A European strategy on infrastructure: Trans-European Transport Networks and nodes;
- the single transport market: harmonisation of regulation and competition rules;
- identification and elimination of obstacles to intermodality and the associated friction costs;
- implementing the Information Society in the transport sector.

The action areas where intermodality depends on co-ordination at European level are identified in the following:

- Integrated infrastructure and transport means
    - intensification of intermodal design of the Trans-European Transport Networks;
    - enhancement of design and functions of intermodal transfer points;
    - harmonisation of standards for transport means;
- interoperable and interconnected operations
    - integration of freight freeways in an intermodal context;
    - development of common charging and pricing principles;
    - harmonisation of competition rules and state aid regimes on an intermodal basis.

- mode-independent services and regulations
    - harmonisation and standardisation of procedures and EDI;
    - intermodal liability;
    - research and demonstration;
    - benchmarking;
    - intermodal statistics.

3.2 The 2001 White Paper and its mid-term review

The new White Paper “European Transport Policy for 2010: Time to Decide” (CEC, 2001) identifies a number of priorities specifically relevant to freight transport.

In the road sector it is recognised that there is a need to modernise the way freight transport services are operated while complying with the social and safety legislation.

In the rail sector it is proposed to open up national markets for cabotage, and to further push harmonisation in the field of safety and interoperability and the dedication exclusively to freight services of a network of railway lines.

The 2001 White Paper recognises that 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.

The new Community support programme Marco Polo will help shift more freight from roads to short-sea shipping, rail and inland waterways with the launch of freight services and facilities of strategic cross-border European interest.

Short-sea shipping is mentioned in the White Paper as one way to improve the competitiveness and sustainability of Europe's transport.

Given the saturation of certain major arteries and resulting pollution, the 2001 White Paper recognised that it is essential for the EU to complete the Trans-European projects already decided. For this reason a revision of the Community guidelines is needed which concentrates on removing 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 remote areas. The review of the Trans-European Network must aim at introducing the concept of 'Motorways of the Sea', developing airport capacity, linking remote regions on the European continent more effectively and connecting the networks of the new 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. Projects to clear bottlenecks still persisting on the borders of new member 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 first operating revenues, it must be possible to constitute national or regional funds from the tolls, and 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 seen as a textbook example.

In the infrastructure charging area, the White Paper follows the principles set out in the 1995 Green Paper (CEC, 1995b) and in the 1998 White Paper (CEC, 1998c). It is generally acknowledged that not always and not everywhere do the individual modes of transport cover the costs they generate. The situation differs enormously among Member State and modes. 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, especially railway lines offering a more environmentally-friendly alternative.

The Mid Term Review of the 2001 White Paper (CEC, 2006a) restated a few basic principles of transport policy. First it abandons the principle that growth of transport should be decoupled from economic growth. It recognises that in the years 1995-2004 the growth of goods transport has been broadly in line with economic growth. Transport is an important industry in its own right and mobility of goods and persons is an essential component of competitiveness of European industry and services. Rather mobility must be disconnected from its negative side effects.

It is stated that the future policy will have to optimise each 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 especially on long-distance, urban areas and congested corridors. Each mode must become more environmentally-friendly, safe and energy efficient. “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. Alternatives to congested road corridors involve co-modal logistic chains which optimise the use of transport infrastructure within and across the different modes. This includes transalpine tunnels, rail corridors and intermodal nodes for rail, sea or air transport.

The Mid Term Review also announces the development of a framework strategy for freight transport logistics in Europe. While the industry is developing sophisticated logistics chains in order to use the existing vehicles and infrastructures more efficiently, public policy should enable the optimal use and combination of different modes of transport. Actions include removing regulatory obstacles to co-modality, stimulate learning and exchange of best practice, and promote standardisation and interoperability and investment in transhipment hubs.

3.3 Specific policy initiatives

In the railway sector, Directive 2004/51/EC, which is part of the second railway package, has opened up both national and international freight services on the entire European network from January 2007. 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.

In the maritime transport sector, the Commission has set out a programme for promoting short sea-shipping (CEC 2003a), including harmonising standards for intermodal loading units (ILUs). Within Europe many goods are shifted by road, rail and sea in ILUs, often referred to as "swap-bodies". The Commission's draft Directive would provide for harmonisation.

The priorities set in the White Paper in the Trans-European Network area have been followed up by the revision of the guidelines for the development of the TEN-T which have led to the definition of the new layout of the TEN-T and the identification of 30 priority axes and projects. These priority projects include the Motorways of the Sea.

The priorities as set out in the White Paper in the infrastructure charging area have been followed up by the 2001 Directive on rail infrastructure charging and the proposals for amendment of the Eurovignette Directive on the charging of heavy goods vehicles and the rules for the cross-financing of transport infrastructures (CEC, 2003b). In early 2006 the EU has finalised the approval of the new Directive on road infrastructure charging (Directive 2006/38). It lays down rules for tolls or user charges on the trans-European network. The Directive applies to freight vehicles over 3.5 tonnes. The new Directive represents the first step towards taking account of external costs: it will allow a greater variation in tolls to reflect congestion, and toll variations to reflect the pollution caused by vehicles will be mandatory from 2010. It also makes provision for Member States to be able to increase tolls with a "mark-up" on roads in particularly sensitive mountainous regions. The income from these mark–ups must be used to fund alternative transport infrastructure.

As a result of the request of the Parliament in 2006 to set up a strategy for internalisation of external costs, the Commission has proposed amendments to the directives on infrastructure charging for heavy goods vehicles (Directives 1999/62 and 2006/38). According to the existing directives toll rates may be varied according to vehicle emission standards or congestion levels but under a constraint of revenue neutrality. Except for Germany and Czech Republic this option has not been exerted because of the complexity for infrastructure operators to adjust their charging structure to the demand response in a way that keeps revenues constant. Thus the existing directives do not enable Member States to apply optimal pricing. This means that sufficient incentives cannot be put in place for operators to modernise their fleet with cleaner vehicles and to adapt their route planning and logistics towards more sustainable practices.

The proposal for amending the existing directives (CEC, 2008b) enables Member States to integrate in tolls an amount which reflects the cost of air pollution and noise pollution caused by traffic. During peak periods it also allows tolls to be calculated on the basis of the cost of congestion imposed upon other vehicles. The current scope of the existing directives is extended beyond the TEN-T to avoid inconsistent pricing schemes between major corridors and other inter-urban roads.

The Commission adopted a Communication in 2006 on the promotion of inland waterway transport (CEC, 2006b). The NAIADES Action Programme is intended for the period 2006–2013 and focuses on five strategic areas for a comprehensive Inland Waterway Transport policy: market, fleet, jobs and skills, image and infrastructure. Issues being addressed under NAIADES include working time arrangements, professional qualification requirements, the examination of administrative and regulatory barriers, the adoption of

innovative technologies, such as the River Information Services (RIS), and infrastructure improvements.

The Marco Polo programme has been implemented with the main aim of fostering combined transport and achieving a shift of freight traffic from road to rail and to sea. The programme offers Community funds to support the start-up of new services that accomplish this shift of traffic. The programme subsidises the service in the initial operating period when the service would make a loss and would be not profitable for the operators. For the following periods the proponents need to show that the service will be profitable and will be operated without the Marco Polo funds. Several services of the Motorways of the Sea have been funded under the Marco Polo I and II.

As a follow up of the Mid Term Review of the 2001 White Paper the Commission presented in 2007 a Freight Logistics Action Plan (CEC, 2007), which includes the following:

- e-freight and Intelligent Transport Systems (ITS):
  - develop a roadmap for implementation of e-freight;
  - develop standards for information flows;
  - develop standard data set to describe freight;
  - establish a framework for ITS development;
  - develop standards for on-board units;
  - develop interoperability of electronic fee collection.
- sustainable quality and efficiency:
  - carry out bottleneck identification exercise;
  - develop qualification and training requirement for freight transport logistics personnel;
  - develop indicators of freight transport logistics chain performance;
  - develop benchmarks for terminals;
  - promote exchange of best practice;
  - improve collection of statistical information on freight transport logistics.
- simplification of transport chains:
  - simplify administrative compliance;
  - establish a single transport document irrespective of mode;
  - introduce standard liability clause;
  - develop standards for security.
- vehicle dimensions and loading standards:
  - study the options for modifying standards for vehicle weights and dimensions;
  - establish a mandate for standardising an optimal European Intermodal Loading Unit (ILU).
- green transport corridors for freight:
  - reinforce green corridors in TEN-T and Marco Polo priorities;

  - develop a freight-oriented rail network;
  - promote establishment of Motorways of the Sea;
  - implement the NAIADES programme for inland waterway transport.
- urban freight transport logistics:
  - encourage exchange of best practice;
  - recommend commonly agreed benchmark indicators;
  - reinforce the freight part of CIVITAS[3].

[3] CIVITAS (CIty-VITAlity-Sustainability) is an EC initiative, which aims at supporting and evaluating the implementation of integrated sustainable urban transport strategies in European cities (for more information visit: www.civitas-initiative.org).

4. Research findings

4.1 Introduction

The research which is synthesised in this paper is reported according to four sub-themes (see table 2).

The first sub-theme is concerned with the trends in freight transport, logistics and supply chain management. These trends provide information on issues affecting the evolution of the quality and quantity of freight transport demand.

The second sub-theme deals with logistics and supply chain management tools. It provides an overview of the tools and services developed by research to enhance the quality and efficiency of logistics and supply chain activities.

The third sub-theme relates to freight intermodal transport. Intermodal transport is a key factor for developing a competitive and sustainable transport system and a valid alternative to road-only transport.

The fourth sub-theme reviews research on urban freight transport. Freight movement in cities significantly contributes to negative environmental impacts, energy consumption, and traffic congestion. This sub-theme reports on the research initiatives carried out to improve and optimise urban freight transport activities by reducing its negative impacts.

The TRS on freight transport produced in Extr@web (EXTR@Web, 2006a) included an additional sub-theme “Efficient market place” related to issues such as benchmarking, quality level certification, market tools for shippers, integration of environmental issues, fair and efficient pricing and training in logistics. However, since currently there are no new contributions from research projects (with available results), this sub-theme is not considered in the present paper.

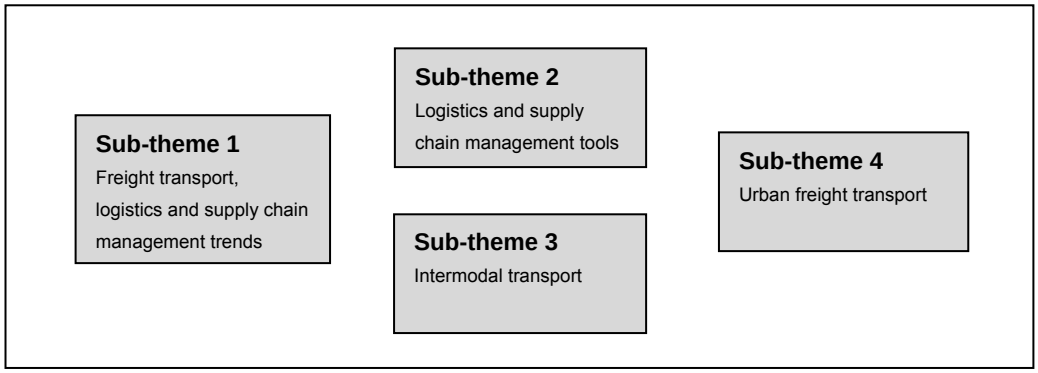

Figure 1: Sub-themes considered in the synthesis of findings from research projects

Table 2 below 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 TRSs on freight transport and intermodal transport 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. EU-funded projects relevant to the theme

Sub-theme	Contributing projects
Freight transport, logistics and supply chain management trends	Projects covered in this paper: e-THEMATIC; NEW OPERA; REORIENT; TREND. Projects covered in the EXTR@Web paper "Freight transport": LOGICAT; PROTRANS; SULOGTRA; Logistics and transport for local production systems: methods and models applied to North-East of Padana valley (IT). Other FP6 projects with results not yet available: CREAM; RAILSERV; RETRACK.

Logistics and supply chain management tools	Projects covered in this paper: ALSO DANUBE; ASAP; BRAVO; CESAR II; iBoS; IP; ITIP; ParcelCall; REALISE; REMARCC II; SIMTAG; SPIN-TN; TRAPIST; TROP. Projects covered in the EXTR@Web paper "Freight transport":: BESTLOG; D2D; FIRE; GAUSS; GIFTS; RECORDIT; SPIN; TASKU (FI); Supply chain resilience (FL0123) (UK). Other FP6 projects with results not yet available: MEDICASE; ROLLING STOCK; SESTANTE; VRSHIPS-ROPAX.
Intermodal transport	Projects covered in this paper: BRAVO; CAESAR; CENTRAL LOCO; COST 339; EUTP II; In.Ho.Tra; INTERFACE; MOCONT II; PROMIT; REMOMED; SIT-TN. Projects covered in the EXTR@Web paper "Freight transport": CARGOSPEED; D2D; F-MAN; INTEGRATION; INTERMODESHIP; MD/DD/17 (BE); MOSCA; ROLLING SHELF; THEMIS. Projects covered in the EXTR@Web paper "Intermodal transport": CARGOSPEED; CO-ACT; INTERMODA; INTERMODESHIP; MOCONT; PREDIM; SAIL ; SPIN; THEMIS; Analysis of the research-studies-orders interface regarding transport interchanges (FR); Efficient terminals for intermodal transport (SE); European sea transport and intermodalism – Consequences for Switzerland (CH) ; Feeder systems in combined transport (CH); Railport-Linz (AT); Road to rail: open access intermodal gateway to the UK – TDG European Chemicals (GPCS 399) (UK); Systems for combined transport between road and railway (SE); The attractiveness of multimodal transport (CH). Other FP6 projects with results not yet available: EFFORTS ; FREIGHTWISE ; GILDANET ; INTERGAUGE; ISTU; LOGBASED; MOBILMED; MOSES; TRIMOTRANS.
Urban freight transport	Projects covered in this paper: ASAPP ONE; BESTUFS II; CITY PORTS; eDRUL; START. Projects covered in EXTR@Web paper "Freight transport": BESTUFS; CITY BOX (NL); CITY FREIGHT; GIFTS; IDIOMA; MOSCA. Other FP6 projects with results not yet available: CHINOS; FIDEUS; MEROPE.

Efficient market place	Projects covered in this paper: - Projects covered in the EXTR@Web paper "Freight transport: FIT (STP 14/6/11) (UK); HISPEEDMIX; WATERMAN-TS; Costs imposed by heavy goods vehicles (UK); Key performance indicators for non-food retail distribution (BG 77) (UK); Market analysis in trans-Alpine freight transport (CH); Multi-modal freight model for distance-based HGV charging (UK); Truck aerodynamic styling (GPG308) (UK). Projects covered in the EXTR@Web paper "Intermodal transport": COST 340; RECORDIT; Intermodality between high-speed rail and air transportation: linkage between networks and populated areas (FR); Market analysis in trans-Alpine freight transport (CH). Other FP6 projects with results not yet available: TOOLQIT.

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: Freight transport, logistics and supply chain management trends

4.2.1 Background

Research reported in the Thematic Research Summary on Freight Transport produced in EXTR@Web (EXTR@Web, 2006a) carried out an analysis on the importance of intermodal transport for Third Party Logistics Providers (3PLP) strategies at European level. It also investigated the effects of supply chain and logistics trends on the transport system, as well as the relationship between logistics activities and economic development, and between supply chain management and integrated intermodal systems.

4.2.2 Research objectives

In the past years, the increase in volumes of international freight transport has resulted in an increase of road transport to the detriment of the more environmentally and energy

efficient railway transport. This is because of its insufficient competitiveness mainly ascribable to the low levels of interoperability. In order to reverse this trend and encourage the use of railway freight transport, a first set of research objectives concerned initiatives to improve and/or assess the interoperability of European railway systems. Research has pursued these objectives gathering all necessary information to assess general progress in the establishment of a European Railway Area (TREND, 2006), and has analysed the prerequisites for innovative concepts for Trans-European rail freight services (NEW OPERA, 2008) as well as the progress made with the implementation of the new rail legislation on interoperability (REORIENT, 2008) in order to give a contribution to the creation of a European rail freight oriented network.

Another strand of research focused on encouraging the use of e-fulfillment by providing market players, research organisations, experts and public authorities with the opportunity to exchange knowledge on innovative technologies, research results and policy recommendations on this area (e-THEMATIC, 2006). Research was motivated by the fact that a trend in supply chain management is the use of e-fulfilment. A successful commercial activity requires an effective and efficient order fulfilment system[4], which in the old economy were paper-based activity. In the e-commerce world with Internet-based sale channels, e-fulfilment performs functions that replace the need for paper-based activities.

4.2.3 Research results

4.2.3.1 Freight Railway transport trends

Rail freight transport can compete with road transport only if the barriers to seamless interoperability are overcome. By assessing general progress in the establishment of a European railway area, research has identified a number of challenges, which have not been exhaustively addressed yet, such as removing administrative and technical barriers to cross-border traffic, and providing sufficient ”good quality” infrastructure capacity for rail freight services. Furthermore, commercial relationships between railways undertakings and shippers have improved, but have not yet reached the quality level of road transport.

The main hindrances to the development of rail freight transport on the basis of analyses carried out in six European freight corridors are (TREND, 2006):

- Border crossing bottlenecks. Main causes are, for example, too many locomotive changes due to different railway equipment, lack of operational co-ordination,

[4] A fulfillment system must, among other things, respond quickly and correctly to orders, maintain customer records, send invoices and record payments, respond to customer inquiries and complaints, etc.

administrative burdens, inefficient transport data management, insufficient infrastructure, specific problems due to special geographic situations.

- Inadequate infrastructures. In general, scarce capacity and quality of stations, nodes, terminals, or along lines lead to expensive operational procedures increasing total costs and negatively affecting the market position of rail freight traffic. More specifically, impediments are high traffic volumes resulting in capacity limitations for additional rail freight, tunnel sections limiting the intermodal gauge, speed restrictions due to line layout, single track line sections, insufficient length of tracks in stations limiting the train length, congested intermodal freight terminals.
- Lack of interoperability. Many factors contribute to interoperability problems, such as different energy systems, different widths of the pantograph, incomplete electrification, different permitted train parameters (length, load, line category, intermodal gauge), and different signalling systems[5], different track gauge, different wagon coupling modes.
- Resource problems. The main resource problem concerns the rolling stock, especially multi-system locomotives. In many cases interoperable engines for different signalling systems are regarded too expensive by Railway Undertakings, and the poor quality of the wagons causes delays in the border crossing procedures.
- Operational problems. These include operational priority of passenger trains over freight trains in infrastructure bottlenecks, controlling of cross border train operations (currently mostly carried out by national dispatching systems), inefficient operations in marshalling yards, and lack of EDP solutions or different EDP standards.

For what concerns interoperability of railway systems, research has produced the following general conclusions (TREND, 2006):

- The transport market does not seem to be prepared to pay the higher costs for rail freight services. The added value of full technical interoperability will not compensate the huge investments required for achieving it.
- It is very important to harmonise freight train operations by removing profile, weight, and module limitations in the European network, although it requires significant investments on some lines.
- There is a need of infrastructure to facilitate terminal access, as well as investments on terminal equipment to ensure the future growth of intermodal services.
- The reform of the railway sector implies that governments will be responsible for the development of the infrastructure. Member States should therefore concentrate their efforts also on cross-border international traffic problems rather than only on domestic transport issues.

[5] The new European ETCS (European Train Control System) levels 1 and 2 have been implemented in dedicated corridor parts

Research has also been carried out to contribute to revitalise the role of rail in freight transport and logistics chains, and to develop international corridors able to ensure smooth and free movement of freight trains in the internal borders of the European Union. A deeper insight into these issues has been provided through a number of research activities (NEW OPERA, 2008):

- State of innovative experiences. A first group of activities aimed at carrying out an analysis of the market variables, which outline the scenario, which future freight mobility must confront with. There are a number of findings, such as substantial changes in trade patterns, faster growing trade with NMS and between NMS, and trade with extra EU countries growing faster than intra EU ones. There is a strong attraction for trade with EU but also a strong impact is noted on non EU trade particularly between CIS and MEDA countries excluding oil. Also the exchanges with China and South East Asia are very rapid and very substantial (however there is a huge trade imbalance in tons or units imported into the EU).
- Future Trends within Supply Chain Development and Philosophy. A survey has been carried out to examine the drivers of supply chain development and the tools supporting its evolution, as well as to assess the infrastructure role (in terms of rail network) in a market driven by supply chain trends. The survey found that there are many drivers pushing towards globalization. Trade and service companies are synchronising their supply chains strategies and structures through a collaborative approach and information sharing. The organisations structure is changing from vertical to horizontal, focusing more on processes than functions. Furthermore, most European companies consider rail and intermodality a viable cost effective alternative to road, but the level of service quality is still unsatisfactory. If rail or intermodality starts offering services in line with market expectations, these companies would use rail instead of other modalities. Finally, the existing rail business model based on sharing the rail infrastructure between passengers has proved to be unable to meet market expectations resulting in a decline in rail freight volumes. To reverse this negative trend it is necessary to rethink the rail business model which allows rail freight to exploit the many development opportunities.
- Rail Freight Traffic Operational Management. Research has shown that different categories of trains (with their own characteristics and priorities) negatively affect the corridor productivity, generate delays, offer little scope for improvement and do not offer long term solution to the European freight mobility requirements. The solution is to progressively separate train categories through either a rail freight dedicated infrastructure, primary rail freight network, or an effective implantation of rail freight windows.
- Operating rules. Research has performed an evaluation of current prevailing operating rules in selected European countries. The main research findings are that

countries developed their own operating rules and national networks, which differ in terms of equipment, operating methods, safety rules and priorities (this has resulted in a lack of interoperability).

Research activities have been carried out to assess the progress made with the implementation of the new rail legislation along a freight corridor (the REORIENT corridor), which provides sea-land connections between the Nordic region and the countries in Central and South-eastern Europe (covering 11 countries). It has been found that practically all countries are making reasonable efforts to comply with the requirements of the Directives on interoperability[6], except for the implementation of the technical specifications for interoperability for which no substantial progress has been assessed in any country within the corridor. Among the identified categories of barriers to the implementation of the EU's interoperability Directives (political; administrative; socio-cultural; technical; financial; market perspective; institutional and organizational), the financial one was considered to be the most important. More specifically, the main financial barriers are the potential of both the railway sector and the national government to accommodate required investments and the willingness of the railway sector to invest in technological improvements and new business concepts (REORIENT, 2008).

Although the rail deregulation directives expected that intra-rail rivalry would improve the railways' competitiveness versus road (with a consequent transfer of freight volumes from road to rail), the analysis of the up-to-now- implementation outcomes in the countries along the REORIENT corridor have shown that there appears to be no clear relationship between completeness of market deregulation and the types of competition. Operators in some countries established strong intermodal competition without intra-sector rivalry. Some others developed fierce intra-rail rivalry despite incomplete market deregulation and without any transfer of freight volumes from road to rail (REORIENT, 2008).

Furthermore, the analysis of current freight flows (drawn on a variety of EC and international data sources) and expected growth (based on EC research project models) combined with survey results of flows in the New Member States (carried out by the REORIENT project) shows that a new rail service could attract a considerable amount of freight from road to rail-based solutions (REORIENT, 2008).

[6] The considered Directives are (REORIENT, 2008): 2001/12/EC (access rights for international freight services; independence between RUs and IMs; separation of accounts for passenger and freight operations; separation of transport operations from capacity allocation, infrastructure charging, and licensing); 2001/13/EC (licensing of RUs); 2001/14/EC (allocation of railway infrastructure capacity; levying of charges for the use of railway infrastructure; safety certification); 2001/16/EC (technical specifications for interoperability (TSIs).

Finally, new types of service for trans-European rail freight transport have been explored and business models of these new service concepts along the REORIENT corridor have been developed. Factors that both hinder and foster an uninterrupted flow of goods along international and/or trans- European corridors have been assessed. The analysis has focused on infrastructure incompatibilities, speed profiles, sidings, etc., as well as on the reasons for border crossings delays, and their effects on total transit times, operations of terminals and transfer points (REORIENT, 2008).

4.2.3.2 Supply chain management trends

New trends such as demand-driven supply chain management and supply chain integration have significantly affected the way of organising logistics activities. This led to the implementation of many different process management systems, which has shifted their focus from the front-end of the supply chain (suppliers) to the back-end of the supply chain (customers). e-fulfilment applications can integrate these process management systems by integrating back-office and front-office processes (e-THEMATIC, 2006). Unfortunately, the currently available e-fulfilment applications generally lack integration with other existing software suites, and there is often substantial variability in their use. Research has established the e-Thematic network to cluster existing European research projects in the field of e-Logistics and e-Fulfilment and identify emerging applications and technologies, as well as examples of good practice. The objectives of this network were to put e-fulfilment on the RTD-agenda and provide inputs for EU research and policy development related to e-fulfilment. A result of these research activities was the production of a report on the state of the art of e-fulfilment, including aspects such as market, technologies, applications, organisations, and integration (software, standards, and technology). On the basis of this analysis, bottlenecks and barriers in e-fulfilment were identified, but also best practices.

4.2.4 Policy implications

4.2.4.1 Freight Railway transport trends

The market demand on freight rail corridors requires different (intermodal) freight service offers with respect to time and cost. Besides solutions involving new infrastructures dedicated to rail, where possible it would be better to offer road-rail-sea connections. Therefore it is recommendable to (TREND, 2006):

- analyse the market requirements for typical supply chains along corridors identifying the potential for modal shift by addressing O/D relations, requirements in terms of performance indicators such as total transit time, need for consolidation, cost, regularity, etc.;
- develop an advanced business model for integrated, road competitive service offers characterised by co-operation with other mode operators and co-operation in international rail freight transport.
- implement interoperability and improved border crossing procedures;
- research in the particular markets of temperature controlled cargo logistics and transport of semitrailers in order to provide technical-operational concepts that allows to facilitate the modal shift of these still road dominated transport to intermodal rail-road transport.

In order to revitalise the role of rail in freight transport and logistics chains, it is recommendable to take into account the following points (NEW OPERA, 2008):

- The new rail freight economy must be based on a new rail freight business model, which places the customer and its needs at the centre of any logistics service providers' activity.
- The mono-product rail freight transport service culture must be replaced by a multi-products marketing oriented culture, which is able to meet the more and more complex customers' needs. However, this change requires new skills, techniques, competences, marketing knowledge, new tools and technologies, management and training.
- Competition on rail tracks is possible if all actors are allowed to access the network on equal terms. Therefore EC must ensure that the rules of an equal level playing field are universally applied.
- The transition into this new service culture will only be possible if two everlasting problems are solved: the conflict with passenger transport; the capacity of lines. The only solution seems to be a rail freight dedicated network approach.

With regard to rail freight competitiveness, research has highlighted the following issues (REORIENT, 2008):

- more intra-rail competition between national and international rail freight operators will increase intermodal rivalry;
- the opening of rail market for financial capital inflow from private investors will increase service quality, and chances for intermodal rivalry;
- the harmonisation of rail infrastructure charges along trans-European corridors will increase operational profitability and application of ICT solutions for enhanced rail competitiveness.

4.2.4.2 Supply chain management trends

The analysis of B2B and B2C markets has identified important differences, especially between North America and Europe (e-THEMATIC, 2006):

- European companies have a more local view of e-business in comparison to North America. This is a consequence of the greater difficulties they must face in the administrative, cultural, taxation, legal and financial area.
- The European market is characterised by a strong specialization in products. Supply chains differ according to the type of products, creating a fragmented logistics market, higher costs, and more expensive back-office activities in comparison to North America. Therefore, it is recommendable to find ways of enhancing the competitiveness of the European logistics systems in Europe by lowering its costs and integrating and standardising the back office activities.
- Europe provides more payment options compared to other regions resulting in heavier back-office activities.
- Europe offers less track and trace options in the B2C market compared to the North America (81,3%). The implementation of e-Fulfilment applications should be encouraged, because they make it easier to provide reliable order status information by integrating processes.

It is recommendable to find solutions to enhance the competitiveness of Europe in e-business, otherwise it will continue to accumulate an international competitive disadvantage. The research performed in e-Thematic has also led to a number of recommendations in six key areas that cover the B2C- and B2B market (e-THEMATIC, 2006).

For what concerns ICT issues, in general it is necessary to encourage the standardization of business processes as much as possible. More specifically, it is recommendable to:

- facilitate research and development on the standardisation of processes in e-fulfilment (B2B and B2C) by mapping common processes[7], identifying those which can be standardized, and optimising the use of standards within ICT systems;
- encourage knowledge sharing and exchange between companies by initiating an e-fulfilment Forum;
- dissemination of ICT innovation in companies;
- encourage RTD on e-fulfilment (which is a new area of study) as a driver for ICT integration and value creation;

[7] Eight main processes are common to any e-Fulfilment cycle. These are order entry, stock management /advice, pricing, payment, order entry to transport, transport monitoring, billing, and reporting

- examine the impact of e-fulfilment on SMEs, and facilitate the development of appropriate applications for e-fulfilment.

As to organisational issues, to accelerate and increase the number of excellent e-fulfilment implementations, it is recommendable to:

- exchange knowledge on organisational and planning issues for e-fulfilment by disseminating best organisational practices, organizing workshops and using the e-fulfilment forum;
- foster openness in information sharing via regulatory policies and suitable technical ICT solutions.

In the area of Logistics, integration problems among LSPs result in an increase in costs and a decrease in the level of service a customer receives. Therefore it is recommendable to:

- continue to encourage research on the standardization of cross company Track&Trace systems;
- optimise pick-up systems and last mile logistics solutions in both B2B and B2C market, which are the two points of the e-fulfilment that impose the most severe inefficiencies on transporters;
- encourage research on last mile logistics and its impact on efficient energy use.

For what concern taxation issues, many businesses are attracted by e-Business because it allows very cost effective entry and operation in new markets. However, there are a number of barriers, such as different tax and customs regulations in EU member states. It is then recommendable to:

- harmonise taxation policies and regulations across EU member states;
- define a European VAT limit (each company, independent of its origin should primarily be facing the same costs of VAT).

Finally, in the financial area, e-Business stakeholders are still concerned about frauds and lack of payment security, and this prevents the development of e-Business in Europe. Therefore, it is recommendable to:

- create an Internet taskforce at European level to monitor Internet fraud and propose appropriate actions;
- to improve the Internet payment methods and associated security mechanisms (The EU, together with banks, credit card companies and software developers should drive this process);
- develop an EU quality system for e-business and e-commerce to create trust and boost e-commerce in both the B2B and B2C market.

4.3 Sub-theme 2: Logistics and supply chain management tools

4.3.1 Background

Research reported in the Thematic Research Summary on Freight Transport produced in EXTR@Web (EXTR@Web, 2006a) developed a set of systems and tools that can provide innovative services and enhance the quality and efficiency of logistics and supply chain management. More specifically, a system that provides reliable and effective location-based services for freight and fleet management, and a fully interoperable and integrated ICT web platform of services for the logistics and freight transport industry have been developed. Furthermore, research also developed:

- a high level methodology for the identification and management of supply chain risks;
- a software to simulate the impact of transport policies on the competitiveness of intermodal transport services;
- a toolbox to assess the intermodal transport potential.

4.3.2 Research objectives

One cluster of objectives has concerned the development of tools for supporting port and terminal operators. More specifically, research has focussed on enhancing the efficiency of port and terminal operations and optimising the planning, management and use of their resources (TRAPIST, 2004), as well as on supporting the selection of appropriate technologies for operations (ITIP, 2002).

Another cluster of objectives has focused on developing concepts and tools to enhance the waterborne mode. Research was motivated by the need of improving efficiency and competitiveness of this environmentally friendly and cost effective mode with respect to road transport. Some tools were specifically created to encourage the use of inland waterway as a key mode within intermodal door-to-door transport chains (ALSO DANUBE, 2006); other tools were designed to improve the integration of ports into intermodal transport chains by offering information and communication services for managing data and information flows (IP, 2002).

Furthermore, a prototype of a tool for making pricing comparisons between multi-modal transport chains (including at least one short sea shipping leg), and unimodal transport chains (road only) has been developed (REALISE, 2005). Research has also investigated shortcomings in transport chains with short sea shipping and sea river transport legs, identifying tools that integrate information to improve the efficiency of the transport services (SPIN-TN). Finally, activities have been carried out to promote competitive and sustainable intermodal transport in the North Sea Region with waterborne transport (short sea shipping and inland navigation) as main leg (REMARCC II).

A third cluster of objectives has concerned the development of tools and concepts for Tracking and Tracing of goods and fleet management. Research was motivated by the fact that supply chains are involving more and more multiple carriers and transport modes, and the demand for accurate and updated information exchange across different carriers and modes is more and more stringent. Since many currently used tracking and tracing systems are typically proprietary solutions, research has focused on establishing a common and harmonised tracking and tracing system (CESAR II, 2003), as well as developing T&T systems characterised by interoperability, open interfaces, and standardization (ParcelCall, 2002), and which ensure transparency and security during transport (ASAP). Research efforts were also made to increase the transparency of information in the logistic chain of perishable goods (iBoS, 2004). Finally, research has been carried out for the development and commercialisation of technologies, processes and services to improve safety and security in intermodal cargo transport (SIMTAG, 2005).

Finally, research has also developed tools to improve the efficiency of small and medium enterprises. The haulage industry in Europe is characterised by many small and medium sized businesses, which have difficulty in competing with larger companies that can offer lower prices exploiting economies of scale and using ICT to improve the efficiency of their fleets. Research has developed a tool which allows individual small transport enterprises to participate in a ‘virtual fleet’ and achieve the economies of scale usually associated with much larger operators (TROP). Research has also developed a tool which allows small and medium railway enterprises to monitor in real-time the position of their trains running on international corridors (BRAVO, 2007).

4.3.3 Research results

4.3.3.1 Tools for port and terminal operators

Small to medium ports (SMP) are generally regional in nature and they bring employment, social and economic benefits to the communities they serve. However they experience difficulties in achieving efficiency goals, especially in servicing unitised cargo movements. In order to support managers, planners and designers of SMPs and terminals, research has developed a terminal simulation system (TRAPIST, 2004).

This simulation system supports strategic planning in establishing the most suitable terminal layout on the basis of the user's inputs, tactical planning in allocating resources on the basis of operational requirements, and safety planning in reducing the probabilities through the reduction of the numbers of encounters (considering vehicles and people) with probabilistic calculations based on industry accident data. This system has been tested in an operational container terminal and the terminal manager considered it to be a valuable operational tool, and decided to adapt the terminal's Container Management System for inserting inputs on container data directly into the simulation system to improve its effectiveness.

Research has also developed the "ExTip" software tool which can support terminal operators in designing terminals[8] and in selecting the more appropriate transhipment system complying with the main rail and maritime terminal operations. The user can use different selection criteria, such as terminal type, ITU compatibility, compatibility with conventional transport mode, compatibility with conventional handling equipment, degree of automation, and others.

4.3.3.2 Tools for enhancing the waterborne mode

The integration of inland waterway transport on the Danube is of key importance for achieving an efficient and sustainable multimodal transport system in the industrial axis from Central Europe to the Black Sea. Research has developed a concept of flexible container liner services[9], which integrates an application for door-to-door supply chain

[8] This modelling part incorporates parts of other EU research projects, among which SIMET, IMPULSE, TERMINET, and IQ.

[9] Scheduled service provided by a member of a conference liner. A conference liner is an agreement between shipping companies for providing scheduled cargo services on a specific route at uniform rates and common terms.

management. The most important innovative aspect, which has not been realised yet in any other land transport mode, is that this application for transport logistics planning and tracking/tracing of vehicles and goods is linked to a traffic management system on the Danube, and, as a consequence, can access real time transport data. The application and demonstration of this concept has proved that inland navigation is (ALSO DANUBE, 2006):

- is competitive if it is integrated in managed logistics chains;
- is also attractive for short distances (< 100 km);
- is a transparent mode of transport (security relevance);
- is an appropriate means of transport for intermodal container services;
- gains significant savings in logistics costs.

European waterborne transport has not yet achieved a desirable market share. Missing integration of information is identified as one of the key impediments for increasing its use. Research has developed and tested a set of low cost and easy to use Internet based applications that provide an IT environment[10], which permits and streamlines the exchange of information and data between partners and authorities. This environment ensures the reliability and security of all data transmissions within the system. These applications are (IP, 2002):

- The Waterborne Single Desk, which streamlines and harmonises administrative procedures to be followed when ships are calling at ports in Europe. This application has been developed in line with the European Directive on implementation of FAL forms[11], and it has set up a common interface between port authorities, maritime agents and shipping lines. The testing phase has demonstrated how easily voyage data can circulate within the EU eliminating the administrative procedures in each port of call and thus improving Short Sea Shipping inside Europe.
- Intermodal Waterborne Node, which supports the organisation of intermodal transport considering ports as natural important interfaces. This application includes the portorder@online, which allow users to book a port transaction via a web-based interface, and ETA (Estimated Time of Arrival) function, which enables the user to detect the ETA that will have to be applied. The onward or pre-carriage[12] is supported by an Internet-based Transport Order module, which can be integrated into any operative IT system via XML interfaces.
- HAZMAT Dangerous Goods. This application streamlines and intends to harmonise the declaration of any dangerous cargo and the transfer of the relevant information, maintaining the required level of attention.

[10] The name is intermodal portal available at: www.intermodalportal.com

[11] IMO has produced standardised forms for some documents, which public authorities can demand from ships defined by the Convention on Facilitation of International Maritime Traffic (FAL Convention). For further information visit the link http://www.imo.org/Facilitation/mainframe.asp?topic_id=396.

[12] Usually freight charges for port or airport delivery arising before the principal international carriage.

Research has also developed a prototype of a tool which calculates the costs of multi-modal transport chains, and compares them with those of unimodal road transport (REALISE, 2005). This tool is an Excel-based application and makes price and environmental comparisons along pre-selected transport routes. A large number of existing route segments, along broad European freight transport corridors, has been used as basis for the price comparisons. The comparison in most cases showed that multi-modal chains involving short sea legs were lower in price than equivalent unimodal road-only chains. However, research also showed that other than price factors are key modal choice drivers (e.g. reliability, measured by the percentage of deliveries within the specified time-windows, quality, travel time, cultural factors, etc.).

The integration of Inland Navigation in intermodal door-to-door transport is important for increasing the use of the waterborne mode, accessing new markets, and gaining new market shares of the growing transport volumes. Research has pointed out that there is a number of already available tools to share and monitor information relating to key waterborne mode stakeholders' activities (SPIN-TN, 2005). These tools are of different forms: technical, administrative, regulatory, and procedural. The SafeSeaNet system, which could support the implementation of the Directive 2002/59/EC[13], has improved data exchange concerning vessel traffic monitoring, dangerous cargo details, results of ship inspections, and so on, by better standardisation. The PortNet system offers information on traffic to and from the port to all stakeholders, and a cost effective and efficient way to perform administrative tasks. River Information Services integrate information services to support traffic and transport management in inland navigation, including interfaces to other transport modes, while Vessel Traffic Services improve the safety and efficiency of vessel traffic and protect the environment. The Helsinki Commission (HELCOM) has developed and launched an automatic VHF radio-based AIS for monitoring maritime traffic in the Baltic Sea.

Furthermore, there are some well established information protocols in use within the Maritime Short Sea Shipping and Inland Navigation communities. However, some tools are still restricted to national coverage, and others are restricted to specific domains. As a consequence, there is already the potential to build a multidiscipline information network for serving the short sea shipping and inland water transport, but it is necessary to put all pieces together to create a pan European system (SPIN-TN, 2005).

Finally, an internet based platform has been created to encourage the use of the waterborne mode (short sea shipping and inland navigation) in intermodal transport in the

[13] This Directive aims at establishing a vessel traffic monitoring and information system to enhance the safety and efficiency of maritime traffic.

North Sea Region and increase awareness of waterborne transport as an environmental and economic alternative to road transport (REMARCC II). Furthermore, the characteristics of maritime regions (availability of ports as nodes in transport chains, interface function for deep sea and short sea feeder services, port and ship operators, logistics and value added services) have been investigated.

4.3.3.3 Tools for Tracking and Tracing and fleet management

In response to the need of common and harmonised tracking and tracing systems, research has enhanced a tool for T&T already developed in a previous FP4 project[14] rather than developing a new one (CESAR II, 2003). The original tool, named CESAR, allows road hauliers and freight forwarders using combined transport (CT) to get status information of loading units at terminals and on trains. The enhancements consist in:

- Additional services, such as timetables, service offers and prices for unaccompanied traffic[15]. Customers usually get timetable information from operators in different formats and EDI systems, as a consequence, when dealing with international shipments he has to combine different information. This tool provides customers with direct access to a centralised consolidated European timetable with the information sent by different operators, adopting a common exchange format. The tool now also offers services (display of timetables and display of prices and conditions) for the other great market of intermodal services, i.e. the accompanied intermodal transport[16], through the Rolling Motorway section.
- Additional status events. An important addition to the tool is the real time reporting about any irregularity in transport. It was a challenge because it required the adaptation of different national information systems to a harmonised European approach[17], and the establishment of the amount of details to be communicated. The possibility of accessing such information through one single Internet access increases the level of the service offered by European intermodal transport and its competitiveness, considering that road transport cannot offer – such a feature.
- Integration of further specific intermodal transport areas. Three main areas were considered: intermodal transports between Great Britain and the continent using the Eurotunnel; from ports to inland transport by interconnecting to ship services; intermodal transport operators outside the European Union.
- Establishment of a computer-based data flow between the tool and the clients systems. The adopted solution enables clients to automatically treat data without

[14] CESAR (Co-operative European System for Advanced Information Redistribution). FP4 Transport Programme.
[15] It means that the driver of the lorry is not on the train.
[16] The driver of the lorry is on the train.
[17] Information on irregularities comes from many organisations, which use different sources. As a consequence, it was necessary to harmonise the structures and rules of the different organisations involved in the same transport.

investing too much to adapt their in-house system by using ASCII or Excel format type interfaces.

Research has also pointed out how cooperation to establish common and harmonised tools can raise risk or fears in transport service operators (CESAR II, 2003), namely:

- The equalisation of their level of service with those of competitors with consequent loss of competitive advantage.
- Their dependence on an external central system in an area of strategic importance.

Another developed tool for T&T permits to acquire, store, and manage detailed information of individual transport items (parcels) (ParcelCall, 2002). As a consequence, it is possible to track goods also in case part of a large shipment gets lost, damaged, or takes a different route. This tool is characterised by interoperability, open interfaces, and standardization in order to allow seamless tracking and tracing across the entire logistics and transportation chain. The architecture of this tool (the ParcelCall system) is open and scalable to permit to easily add new server components. Users, who can be small trucking companies as well as huge multinational integrators, can access tracking & tracing information using Cellular networks (GSM, GPRS, UMTS), ISDN and the Internet. Radio-Frequency Identification (RFID) tags are used besides existing automatic identification methods using bar codes and labels.

For the transport of perishable, sensitive and high-risk goods, research has developed “Thinking Tags” which replace passive RFID tags (ParcelCall, 2002). These Thinking Tags are compact reusable devices, equipped with sensors, processing power, memory, and capable of active, two way radio communication. Differently from the traditional transmission of static identification information, these tags offer the possibility of introducing new and value added services in the area of transportation and logistics, such as:

- continuous measuring and monitoring of environment conditions (temperature, humidity, shock) for sensitive shipments (e. g., food) for each transport item;
- active transmission of messages of alert to the owner of a shipment in case of an alarm (e.g., deviation from the planned transport route, inadequate environment conditions, etc.);
- recording of the history (location, environment conditions, status) of a shipment in order to provide evidence in liability issues (e. g., for security transports).

Issues concerning security aspects and perishable goods have been considered by other tools developed by research.

A first tool is a wireless, info-mobility system based on location and security information which makes use of end unit devices, sensors, system infrastructure and inter-connected

databases (ASAP). This tool has been designed to make surveillance and protection of goods more affordable, accurate and user-friendly. In particular the very low consumption of energy (in comparison to currently used systems) increases the availability of end units and considerably reduces operational costs. The system can monitor information concerning temperature, movement, door status (open or closed), and also the presence of specific gases (important when transporting hazardous goods). This information, accessible via the internet or with mobile devices, is available to all stakeholders (end user, transportation operators, insurance companies, etc.).

The other tool consists in a new transport crate (info-Box) equipped with RFID transponder device (moulded in the box) and a new open standard, internet based supply chain management system to manage and control the information flows related to the use of the info-Box (iBoS, 2004). This tool permits secure, efficient, and easy T&T of perishable goods such as food like meat. Every stakeholder can easily access the information stored in each info-box. Extensive field trials have been performed to demonstrate the system and its benefits, involving logistics chain for selling meats. The final result of these demonstrations was that all system components turned out to be reliable and well performing, and generated substantial advantages to the users. More specifically this tool has (iBoS, 2004):

- fulfilled without any errors the requirements of paperless documentation of data for proof and origin;
- led to significant reductions in work activities (hand written entries into joint packing lists, data input into data processing systems, etc.);
- led to a reduction of work load by 8 to 10 hours a week at the butcher in the supermarket and permitted to employ 4 workers instead of 5 at the refrigerated areas in the meat company.

Research has also developed the platform for a commercially viable web-enabled portal (SIMTAG Portal), providing services for safe and secure intermodal cargo transport such as a web-based application for on-line tracking, security monitoring and management of cargo containers and their contents and other assets at nodal points in transit. This tracking methodology is based on a Registered Journey Plan for each container (being shipped). An Event Log monitors and records any deviations from the registered plan (e.g. location, security-seal status, temperature or other selected attributes), and in case of an emergency, a strongly practicable process permits to alert and facilitate the response. This methodology permits to reduce or even eliminate the need to re-key data relating to the cargo during the cargo transport journey and consequently cumulative cost savings to the benefit of all parties in the supply chain. The accessibility to specialised services for hazardous goods (e.g. their characteristics, proper handling requirements, clean-up guidance and risk alerts) and the information about the exact location and status of the cargo provided by the SIMTAG Portal will allow authorised emergency services to make

more informed choices. This portal has been tested with two demonstrators, one involving chemical tank containers and the other reefer and dry containers, but it might also be used to register journeys involving other logistics units (e.g. swapbodies, truck semi-trailers and trailers, railway wagons) (SIMTAG, 2005).

As to fleet management, research has developed and tested a system which allows small haulage companies to take part in a 'virtual fleet'. Based on Virtual Factory technology, this system consists of (TROP):

- a Planner, which plans the work of the Virtual Fleet;
- the Work Flow Manager, which synchronises the overall behaviour, interacting with monitoring devices on board the individual vehicles;
- a database containing information about missions in progress, orders from customers etc.; a map server and cartography manager, which produce images showing the current position of all the vehicles.
- a LINUX based web server, which permits to communicate with the individual companies using a user-friendly, browser-based interface;

The system communicates with individual vehicles using the Short Message Service (SMS), but some vehicles may also have GPS location devices or route planners, which allow the exact positioning of a vehicle and the calculation of the most efficient route for the driver. An important feature is that the system offers companies independent control of their businesses, because they can choose whether to accept offers of work from the system or use the system to manage their own orders.

Finally, research has also developed a customer information system (CIS) targeted to small and medium sized railway undertakings. This system allows to monitor cross border train movements in real time (BRAVO, 2007), providing their location, relative delay, reasons of delays and statistical analysis of past train runs. Therefore small and medium enterprises can monitor their trains running on different infrastructures through one single system, and can also communicate with their customers in an efficient way.

4.3.4 Policy implications

4.3.4.1 Tools for enhancing the waterborne mode

To enhance the competitiveness of inland navigation, it is recommendable to (ALSO DANUBE, 2006):

- support an extensive use of ICT-solutions to simplify and improve administrative
- and logistical processes;

- stimulate the application of IWT based door-to-door supply chains as long as it reaches a good level of commercial competitiveness;
- support the development of container liner services on inland waterways;
- implementation River Information Services (RIS);
- create harmonised regulations for the implementation and use of RIS;
- provide funding for innovative inland waterway development projects;
- use synergy effects between information technology (logistics, telematics) and the upgrading of waterways.

The main policy implication of the applications integrated in an IT environment developed by research (IP, 2002) is that they make use of inter- and intra-organizational working procedures that fully supports the implementation of a European Transport Policy oriented towards the rationalization of intra-European procedures. Furthermore, the streamlined dangerous cargo reporting tool, whose use has resulted in substantial savings for companies and organizations, demonstrates how ICT can significantly help to facilitate the implementation of directives that are, otherwise, very difficult to enforce (IP 2002).

The pricing of logistics supply chains is generally recognised as a key driver of modal choice, but not the only one nor the principal factor. In practice in modal choice selection processes it is necessary to take into account a number of variables. This does not mean that policies to influence modal shift by increasing the price of road transport may not be effective at all, but it must be considered that there are limits to the impact of such measures on modal shift (REALISE, 2005).

At present many of available tools are used at national level, but to maximise the efficiency of Short Sea Shipping, River Sea Shipping and Inland Navigation, there is a need of a network that shares traffic information between Member States (SPIN-TN, 2005).

4.3.4.2 Tools for Tracking and Tracing

The development of the CESAR tool is an example of how European collaboration may be organised in order to develop common and harmonised tools. It is recommendable that also European railways can find similar models of cooperation to inform the combined transport operators. This would result in more accurate data input, better use of the CESAR tool and, as a consequence, benefits for all stakeholders: railways operators and transport and logistics companies. Logistics companies would make a more extensive use of combined transport, if railways and operators could provide better and more reliable services (CESAR II, 2003).

The spread of T&T system based on standards like those of the project ParcelCall can greatly reduce the costs of moving towards inter-organisational information exchange.

However, policies and regulations are important drivers for this process and can avoid possible diffusion of incompatible proprietary solutions (ParcelCall, 2002).

For the exploitation and a widespread use of the info-boxes system in the European market, standardised rules for processes, inputs and documentation from all stakeholders must be decided and developed (iBoS, 2004).

Finally, the virtual fleet management tool has shown how shared use of ICT technologies can help small companies to make use of advanced services and enhance their competitiveness. The development of a commercial product based on the TROP prototype could benefit small haulage companies in many parts of Europe. This tool could be operated by an industry association or a co-operative representing a regional group of such companies (TROP).

4.4 Sub-theme 3: Intermodal transport

4.4.1 Background

The research results illustrated in the former Thematic Research Summaries on freight transport and intermodal transport (EXTR@Web, 2006a; EXTR@Web, 2006b) have addressed issues concerning intermodal network efficiency, technical improvements of intermodal transport, and applications of ICT to intermodality. More in detail, technical improvements had concerned the development of pallet and suitable wagons for travelling at high speed, an innovative solution for transferring semi-trailers, and conceptual terminal designs with fully automated loading and unloading systems, as well as a system to trace container within the terminal yard in real time, reducing the intervention of human operators.

For what concerns the intermodal network efficiency, research has particularly focussed on investigating existing technologies and their applications to enhance the efficiency of intermodal and maritime operations and increase their volume by improving and facilitating cargo flows between inland and sea. An innovative waterborne transport concept for inland/short-sea operations was developed, which can replace the currently fragmented and traffic jams sensitive road, rail and waterborne transport. Furthermore, tools for improving the efficiency of door-to-door transport of goods in urban areas were developed, as well as a Freight Transport Monitoring System (FTMS) for intermodal transport chains, which can monitor the status of the delivery and provide real-time information. Research has also provided an overview of the potential and limits concerning the use of semi-

trailers in intermodal transport chains in Europe, together with recommendations to enhance the use of semi-trailers in intermodal transport.

In the area of intermodal modelling and planning, research has specified technical performance indicators, market determinants and parameters for regulatory framework conditions, and has developed a tool for identifying opportunities and barriers for modal shift in freight transport.

4.4.2 Research objectives

The intermodal transport can significantly help Europe to enhance its competitiveness and at the same time to cope with the ever increasing demand for transport and the necessity to minimise environmental impacts. Substantial research has been developed in past years, but it is necessary to bring together all stakeholders and decision makers (terminal handling, freight villages, port, and intermodal operators, modal transport operators, forwarders, equipment suppliers, cargo owners, high educational institutions, authorities,...) to provide and exchange advices and experiences, and to coordinate planning activities concerning research and technology programmes. To this aim, research has pursued the objective of setting up a number of networking and knowledge transfer activities (CENTRAL LOCO, 2007), and creating the European Intermodal Research Advisory Council (EIRAC), whose mission is the creation of a co-ordinated intermodal research strategy for Europe (CAESAR). Research has also focused on activities to create awareness on innovations, collect best practices, and identify intermodal transport opportunities (PROMIT), as well as on encouraging a more efficient use of intermodal transfer points (EUTP II, 2004).

A second group of objectives has concerned the technical improvement of intermodal transport technologies and procedures. In particular, research has investigated the technical and operational capabilities of horizontal transhipment technologies to improve the efficiency of transfer operations of loading units between different modes (In.Ho.Tra, 2003). Research has also developed a self-sustained intermodal technology to capture the growing market of conventional road-only semi-trailers for intermodal transport (BRAVO, 2007), and has encouraged the application of ITS technologies to support the management of containers inside terminals (MOCONT II, 2003). Another research objective has been concerned with the development of standardised small containers to be used Europe-wide (COST 339). Another research objective has been to investigate aspects relating to safety and security of intermodal transport and to develop appropriate procedures (SIT-TN).

Finally, a group of objectives was focused on the development of intermodality between EU and neighbouring countries. It has investigated solutions to strengthen intermodal transport between EU member states and the CEEC (INTERFACE, 2005), and has carried out a study for the creation of a Euro-Mediterranean intermodal network with a view to enhancing the competitiveness of the Mediterranean basin regions (REMOMED, 2006).

4.4.3 Research results

4.4.3.1 Competitiveness of intermodal transport

An important achievement of research has been the establishment of the European Intermodal Research Advisory Council (EIRAC) in 2005 to support the European Commission in directing European and national resources to targeted research (CAESAR). The EIRAC mission is "to foster innovation and change in Intermodal Transport and Logistics in order to enable the growth of the European Economy through competitive and sustainable logistics" (EIRAC, 2009).

The main tasks of EIRAC are the formulation of a vision of intermodal transport in 2020, and the production of the strategic documents to achieve the vision. These documents are:

- the Strategic Intermodal Research Agenda 2020 (SIRA), which contains the drivers for change (i.e., research and innovation accompanied by proper policies, codes of conducts and supporting instruments);
- the Implementation Plan (IP), which translates the SIRA elements into practical topics for achieving the vision.

Naturally, considering the current evolving economic, social and environmental, the SIRA, and consequently the implementation plan, needs to be updated and priorities redefined.

Research has also promoted the dissemination and exploitation of results of RTD FP5 and FP6 projects among companies and research units operating in logistics and transport by using a number of means, such as organisation of workshops and conferences, cluster meetings, creation of web pages, and producing newsletters, in more general terms (PROMIT), targeting Central-European states (CENTRAL LOCO, 2007), or focusing on intermodal transfer points (EUTP II, 2004), producing interesting results.

At a general level, a number of intermodal transport best practice cases concerning organisation and business models, infrastructure and equipment, operation and service, and ICT have been analysed, identifying their benefits, factors of success, and transferability (PROMIT).

A main achievement has been the production of a research paper on the role of collaborative business models for the success of intermodal solutions (PROMIT). This paper shows that currently there are two successful models in intermodal (rail) transport: one where the risk of filling the capacity lies at the demand side (the anchor model); the other where such risk is at the supply side (the line service model). The main conclusion is that it is necessary to develop advanced collaborative models to exploit the intermodal potential.

Another important finding is that many European countries, among which there are those with the highest volumes in rail-road intermodal transport, are implementing programs to promote the operation of (new) national intermodal connections. Considering that the Marco Polo programs promote border-crossing intermodal transport, national promotional programs and the Marco Polo programs supplement each other, as national connections in many cases feed border-crossing connections and vice versa (PROMIT).

For what concerns the activities mainly targeted to four Central-European New Member States (Czech Republic, Hungary, Poland and Slovakia, known as the Vysehrad Four), the main achievements have been (CENTRAL LOCO, 2007):

- identification of EU RTD projects in the field of logistics and intermodal transport and dissemination of the results;
- collection and presentation of logistics best practice solutions;
- dissemination of current recommendations of the European transport policy concerning re-balancing and integrating different modes of transport;
- exchange of practical knowledge of logistics and transport issues among stakeholders;
- harmonisation of national initiatives in connection with ERA-NET;
- creation of opportunities for new projects among members of research and business communities;
- support for developing safe, secure and efficient intermodal transport according to the recommendations outlined in the EU transport policy.

Finally, research has also carried out cluster meetings to enhance the co-operation between national and European RTD on freight transfer points and to discuss research and policy issues with all relevant stakeholders. The cluster meetings involving public authorities, experts from the research sector, and the transport industry, have been focused on (EUTP II, 2004):

- policy, organisational aspects and network integration;
- infrastructure, transport equipment and transfer means;
- information and communication systems.

In each cluster meeting the participants discussed results from research projects and pilot and demonstration activities, and formulated recommendations in order to provide proposals for actions for policy makers, and inputs to European and national research programmes (EUTP II, 2004) (see § 4.4.4.1).

4.4.3.2 Intermodal transport technologies

Intermodal transport requires at least two intermediate transfers of loading units; this results in additional costs, and, as a consequence, in a competitive disadvantage. In order to limit the negative impacts of intermediate transfers on total costs, research is continuously engaged in finding and developing cheaper and more efficient transfer systems in intermodal transport. More than half of international road transport is made using articulated road vehicles with semi-trailers, which represents a significant potential market for intermodal transport. Semi-trailers can be loaded on wagons vertically or horizontally, but the vertical transfer requires additional mechanical strength features in the construction of the road vehicle, and most companies are not willing to pay these extra costs. As a consequence, research has focused on investigating technical and operational capabilities of horizontal transfer systems to understand if (In.Ho.Tra, 2003):

- it is possible to develop horizontal transfer systems for intermodal transport that permit cheaper transfer in comparison to those currently adopted;
- there is a need to change standards, technical rules and/or legislation to ensure proper application of horizontal transfer techniques in intermodal transport.

This research has produced an updated inventory of the operational horizontal transfer systems existing in Europe. The main finding is that only 20% of the systems invented in the last 25 years are in service today. The main reasons for their failure concern commercial issues. More specifically (In.Ho.Tra, 2003):

- Some technologies require re-designing existing loading units, or designing completely new ones, and commercial actors, who should have been taken all expenses upon them, gave their refusal.
- Some technologies require additional pieces of equipment (adapter) (e.g. an intermediate platform between loading unit and transfer system). Commercial actors refused to accept them, because they would have made too complicated handling operations.
- Some technologies are based on specialised road/rail vehicles, which require large investments without being sure of their success in the long term.

Taking into account these findings, research has developed and demonstrated prototypes of innovative transfer systems using a virtual environment simulating terminals and trains (In.Ho.Tra, 2003):

- The Hungarian prototype (RTS technology). The RTS technology consists in three modular parts, which can work separately or together: the re-loader RTS 500, the staple lifter RTS 300, and the sorting field RTS 100. Since each unit is independent from the others, they can operate in parallel for performing simultaneously transhipment, sorting and stacking. The re-loader, which can work under catenaries, has two independent parts, which permit to handle any length of intermodal loading unit. The staple lifter can enhance the storage capacity of the sorting field by stacking ISO-freight containers and stackable swap bodies. The prototype of the RTS 500 re-loader and the prototype of the RTS 100 sorting field have been installed in the Freeport Budapest, while the RTS 300 staple lifter is erected in the Ganz factory in Budapest. A complete terminal in the Freeport of Budapest and in other sites in Hungary is going to be built.
- The Austrian prototype (the IUT "Innovatives Umschlag-Terminal"). The innovative aspects of IUT is the separation of transhipment, sorting and storage, which can be done in parallel. The IUT has a length of 30 meters, comprises two levels, and can handle all commonly used containers. It consists of a land saving multi-level high-rise shelve for ISO-freight containers and swap-bodies. A vertical operating stacker with a device for loading and unloading shelves handles the intermodal loading units between the shelves and a buffer lane (pre-sorting area) beside the loading track. The system uses a portal crane for unloading and loading rail and road vehicles. The maximum weight the system can handle is 45 tons. Series production IUTs will have a length of up to 700 meters and up to 3 levels. The system is installed at the Wien Northwest terminal since January 2003. The testing phase has demonstrated that all the resources necessary for transhipment (facilities, personnel, energy) can be optimised and a much greater flexibility in terminal operations can be achieved.
- The Swiss prototype NETHS (Neuweiler Tuchschmid Horizontal System). This prototype, designed for small and medium size terminals, can handle ISO-freight container with a weight up to 35 tonnes using two top lift beams hanging on chains. Swap bodies with a weight up to 20 tonnes can be handled by using concertina grapple arms. The system can operate in manual, semi-automatic and fully automatic mode. The prototype, installed in 2001 in a plant of Tuchschmid in Frauenfeld, has been tested and modified within the InHoTra project and is in commercial operation since 2002.

One of the main technical burdens of unaccompanied combined transport (CT) is that semi-trailers must be equipped with particular devices which provide a grip for cranes. In order to solve this problem and open the combined transport to new markets, research has investigated the commercial, technical and operational possibilities of new technologies in this field (BRAVO, 2007). The result of these activities was the identification of the innovative system "Innovativer SattelanhängerUmschlag" (ISU). The advantage of this system are the possibility of using conventional semi-trailers without specific CT-

equipment; the possibility of using multiple common pocket wagon types with only minor adaptations (the technology is implemented in the terminal facility not in the loading unit or wagon); the fact that no additional large scale infrastructure investment in the terminal are required.

Efforts were also made to investigate the development of wagons (multifret wagons) in order to overcome the problems concerning the traditional structure gauge of the Italian rail infrastructure, which only permits the transport of small loading profiles. This condition prevents the further development of combined transport. This new concept is characterised by a lower deck height, which allows gaining 23 coding points (which practically means that containers and swap bodies can be 230 mm higher in comparison to those carried on conventional wagons) (BRAVO, 2007).

Research has further developed and tested in field-trials the system to automatically track the containers inside a terminal designed in a previous RTD project (MOCONT II, 2003). This system improves the efficiency of container terminal operations by continuously and automatically updating the terminal operating system database with the position of each handled container, eliminating time and personnel consuming control activities and optimising yard operations. The field-trials tested the system performances with a view of providing some indications on its potential future market application. From the scientific point of view, the trials results have been positive. Among the benefits produced by this type of technology, there are the reduction of the average time for container handling, the increase of terminal productivity, a better level of service, an improvement of the working conditions and quality of work for terminal workers, and finally a general cost reduction of the operational costs due to the decrease in re-handling operations. Although the performances of the prototype are good, its transformation into a marketable industrial product requires the improvement of some features to match all market requirements. It is also necessary to reduce its overall cost to make it more attractive on the market (MOCONT II, 2003).

Just-in-time transport, which is more and more diffuse, requires smaller load sizes that usually do not completely use the loading space of containers and swap bodies. Consequently, additional loading procedures at collection and distribution points are required. Suitably designed small containers can be a good solution to this problem. However, existing or proposed solutions tend to be isolated and specific to individual carrier companies. Therefore, research has been carried out to develop a standardised small container. More specifically, a comprehensive analysis of existing regional or company specific solutions has been carried out, as well as an analysis of the user needs for the different market segments (both demand and supply side) in order to assess whether it is feasible to develop a transport system using small containers. These analyses have permitted to define appropriate dimensions and the necessary construction elements,

as well as technical requirements for the transhipment and transport of small containers. This research has also analysed existing and planned systems for container identification and assess their applicability to small containers. The outcome of this research has been a proposal for a standardised family of small boxes (that are 1/4 and 1/2 of the 7.45m class C swap body) which specifies outside and inside measures, transhipment elements and transhipment method, full load weight of boxes, and makes recommendations on transport and transhipment processes (COST 339).

Finally, a thematic network on Safe and Secure Intermodal Transport has been created to encourage international cooperation and information exchange on the topic. In particular, risks originated by data transmission and hosting have been analysed, as well as currently used approaches and measures to minimise them (e.g. through appropriate procedures, standards, etc.) in order to identify gaps and propose additional measures (e.g. creation of an international data exchange standard). Furthermore, procedures and standards required for secure data transmission for intermodal freight transport have been examined and issues relating to the establishment of an international data exchange standard and common language have been investigated (SIT-TN).

4.4.3.3 Intermodal transport between EU and neighbouring countries

Starting from an analysis of the state of the art and case studies, research has identified, demonstrated, and validated possible intermodal solutions to improve terminal operations at borders crossings between EU member states and the CEEC (INTERFACE, 2005). More in detail research has carried out the following activities:

- A literature review of different types of border crossings terminals. As result, two families of terminals were identified: the “technical terminal”, and the “techno-commercial”.
- Identification of performance criteria/indicators and their application to case studies. Indicators, as measurable characteristics of four Case Studies (border crossing between Austria and Czech Republic, border crossing between Spain and France, border between Italy and Switzerland and Nordic corridor Stockholm – Helsinki – Finnish/Russian border – Moscow), were selected to identify the main lines of dedicated solutions that were assessed by a multi-criteria methodology (the first level criteria were: quality of service, operations and management of the terminal, security and friendliness, economic impacts).
- Development of selected scenarios to model and simulate the identified intermodal concepts.
- Demonstration of the solutions developed and theoretically assessed within the research phase in order to check the transferability of the results to other conditions and to define pre-conditions and supporting measures for the breakthrough.

The main results obtained are an exhaustive overview of the current development of the intermodal freight transport and suggestions on the actions that can improve the efficiency and the effectiveness of border crossing operations (INTERFACE, 2005):

- optimisation of the management of intermodal procedures;
- tools (optimisation model) for transhipment and loading planning;
- harmonisation of the information systems among the actors of the transport chain;
- planning of specific integrated timetables.

These actions are characterised by the following common features (INTERFACE, 2005):

- the reduction of bottlenecks due to the rail border crossing operations;
- the redesign of the existing information and communication systems;
- the promotion of co-operation among the different players of the intermodal chain;
- the development of a continuous improvement process (long term perspective).

Other general and specific findings are as follows.

- The wide survey conducted on the border crossing terminals aiming at defining the terminal peculiarities and the different operating conditions, allowed to identify the main factors (technical, operational, commercial, legal, etc) influencing the operational performances.
- Significant reductions in operational efficiency of terminals are mainly caused by constraints such as technical, operational, infrastructural, administrative and documentary barriers;
- The harmonisation of the Information Systems among the involved actors and the creation of a Central Database can significantly enhance the efficiency and reliability of data transmission.
- The integration of Information Systems between the Railway Undertakings of the two border countries (in one of the demonstrations performed) and among them and Terminal Operators improved planning capabilities at terminal level, and reduced the waiting times in one terminal up to 30-40 minutes/train.
- The train pre-advice measure (implemented on one of the demonstrations) improved punctuality and accuracy of information, which are essential factors in the intermodal transport operations planning.
- Actors' co-operation by agreements and cross-border alliances as well as standardisation of delivery booking and accounting data exchange represent a useful approach to collect and share commercial and operational data.
- Lack of interoperability of rolling-stock in terms of locomotive power traction, difference in drivers' training of the bordering countries this implies locomotives and drivers' changes at the border station), as well as different standards in rolling stock construction affect timetable reliability. A better knowledge at European level of the

available capacities along selected freight corridors would increase reliability and service quality of rail freight transport.

- Lack of trust among the involved actors causes repeated train technical inspections: to this purpose, possible agreements among Railways Companies regarding duration and typologies of technical inspection as well as standardisation of freight trains configuration (in terms of number and typologies of ITUs) could be useful actions to improve terminal efficiency.
- Usually, inspection procedures are based on visual check and staff expertise. The installation of equipment can improve operational safety at terminal level as well in trains circulation by reducing inspection time and increasing reliability and accuracy of the train inspections.
- The optimisation of the road-rail freight transfer can be supported by the design and implementation of a decision support system for transhipment planning and operation (in one of the demonstrations the reduction of transhipment time was up to 20% and, moreover, the related processes are less dependent on staff expertise).
- When the railway transport chain is composed of many actors, the introduction of roundtables and meetings of involved actors can generate a better co-operation.
- Co-operation among the actors of the supply chain following a common strategy and defining innovative services can produce new “customers - oriented” intermodal services, enhancing the competitiveness of rail freight transport.
- It is important to view the intermodal transport chain as a whole, researching system productivity improvement through new production models at operational level (flows consolidation, block train services) as well as at network level (construction of gateways /hubs).

Research has also investigated the possibility of extending intermodality to the Mediterranean basin countries by creating a Euro-Mediterrenean intermodal network capable of integrating and enhancing efficiency, safety and quality of service of the intermodal distribution system. The distribution of products in the Euro-Mediterranean channel in general, focusing on the aspects of demand and supply, as well as the origin and destination of products has been analysed. This study has proved the possibility of new forms of distribution of products, and has identified models to support the exchange of products between ports; Short Sea Shipping is particularly considered as an optimal solution to ensure an effective distribution of products in the area (REMOMED, 2006; MEDOCC, 2006). More specifically, achievements of this study have been:

- Analysis of the intermodal system in the Southern Euro-Mediterranean channel. In particular, the demand for Road/waterborne combined transport has been analysed, as well as the volumes of transported goods. Furthermore, critical issues of the observed intermodal supply-chains have been identified.
- Definition of strategies for the development of intermodality in the Southern Euro-Mediterranean channel. General principles of interventions for the development of the

intermodal nodes and axes in the region have been defined, as well as the performance indicators.

- Identification of a model for the development of the intermodal system in the Southern Euro-Mediterranean channel.

4.4.4 Policy implications

4.4.4.1 Competitiveness of intermodal transport

For what concerns the activities of the EIRAC (CAESAR), the SIRA and the implementation plan have been completed. They were given to the European Commission, which considered (and considers) the information and indications contained in these documents when defining the content of the work programmes of the FP7 concerning intermodal transport; they have also been given to the Member States through the Mirror Group representatives[18] in order to direct national research and public/private investment programmes on intermodal transport. Furthermore, close contacts have been created between the EIRAC members and the EC for policy development (e.g., EIRAC members participate in the preparation of the new release of the directive for the European Intermodal Loading Unit, and the preparation of the Logistics Action Plan of DG TREN) (CAESAR). EIRAC is still carrying out activities to provide further support to policy development such as (CAESAR):

- preparation of directives/regulations/laws in co-operation with governmental institutions;
- proposal for common codes of conduct to improve the effectiveness of logistics through co-modality and sustainable (intermodal) transport solutions.

Research has provided more advanced knowledge and experiences on intermodal transport, as well as EU expertise to support the Polish, Czech, Hungarian and Slovakian industries to conform to the European standards (CENTRAL LOCO). Furthermore, communication and networking activities encouraged the creation of links between new Member States, and promoted SME's and key industrial stakeholders' participation in the EU Framework Programmes, and stimulated international co-operation to create partnerships for collaborating in future European research projects. It would be recommendable to continue to promote the participation of research organisations and SMEs in knowledge transfer activities from research to industry also in the 7th Framework Programme (CENTRAL LOCO, 2007).

[18] The mirror group is a component of the EIRAC, is composed of one representative per Member and Accession Country. Experts of this group promote the endorsement of the SIRA in each Member State (EIRAC, 2009)

Research has shown that there is a scarce knowledge on intermodal terminal network at European level, and very little information on international Origin-Destination flows; moreover, the definition of intermodal traffic appears to be not too clear. Another finding is that countries have different financing systems for intermodal transport, and there is not any harmonisation at European level. Furthermore, freight terminals are not part of TEN-T network (EUTP II, 2004).

Another important point highlighted by research is that the realisation of multimodality requires an EC multimodal policy approach and a new way of viewing inland ports. An innovative use of inland waterways is necessary for the development of intermodality, which currently seems to be too much focused on rail and road modes. In more general terms, intermodal transport can be encouraged not only improving railway services, but also strengthening the role and exploiting the specific advantages of each transport mode, providing initial financial supports, ensuring optimal use of existing infrastructures and capacities and effectively using telematics systems. For what concerns political measures, intermodal transport can be supported by making use of subsidies, investments, taxation, regulations and legislation. In particular, harmonisation/standardisation is an effective tool to promote more efficient transport. History has already shown that the successful introduction of a standard box has reduced prices in international transport (EUTP II, 2004).

Terminals should be considered as one element of the door-to-door intermodal chain, and therefore terminal issues, especially those relating to costs, should be evaluated within the general framework of the complete integrated transport chain (EUTP II, 2004).

For what concerns ICT, one finding is that the basic technology for solving operational problems in freight transfer points and along transport chains is already available, but organisational and legal problems prevent the fast and efficient creation of applicative solutions. In fact, there are too many players and projects in the e-network environment, and the point is how to use and adapt existing technology in the best possible way. To this aim, it is necessary to better understand the real needs of industries and what is happening in the environment. The creation of a reference centre for freight terminals could support these activities this. Furthermore, there is currently a lack of integration and interactive processing between the operating parties within intermodal transport and logistics chains. Intermodal transport could be enhanced by performing harmonisation of information exchange between operators and between operators and customers (EUTP II, 2004).

4.4.4.2 Intermodal transport technologies

One of the findings of research on operational and technical possibilities of horizontal transfer system was that for their commercial success it is necessary that their adaptation to the currently used loading units such as containers, swap bodies and semi-trailers, should be encouraged. As a consequence, it is not necessary to develop a European standard for specific loading units used by horizontal transfer systems (In.Ho.Tra, 2003).

For what concerns the development of technical rules, as long as horizontal transfer equipment is included in "rail equipment" category, national railway safety authority are likely to be in charge of approving them according to their specific national rules. As a consequence, this equipment will be specifically conceived and adapted to national markets. The European Commission should investigate this problem and include this type of equipment into the ongoing activities to create a Pan-European scheme for safety approval in the railway sector (In.Ho.Tra, 2003).

The use of small containers can improve the lead-times because they permit faster transhipment operations at consignors and consignees and avoid or streamline intermediate transhipments. They are particularly suitable for intermodal freight transport over shorter distances. Research has produced a pre-study useful for a follow-on standardisation process, which should be addressed by the EC and standardisation authorities in Europe (CEN TC 119) (COST 339).

4.4.4.3 Intermodal transport between EU and neighbouring countries

The main recommendations have been structured in five macro-groups, highlighting the issues related to the intermodal rail traffic growth (INTERFACE, 2005):

- Functionality of EDI at Terminal level: meaning the capability to improve the efficiency of the Electronic Data Interchange Systems among the actors involved in the terminal operations.
- Functionality of EDI at Network level: meaning the capability to improve the efficiency of the Electronic Data Interchange Systems among the actors involved in the intermodal transport chain.
- Timetable Reliability: meaning the capability to achieve trains punctuality preservation and/or delays recovering, and optimising rail line capacity and border crossing operations.
- Effectiveness of Technical and Commercial Inspections: meaning the ability to improve the reliability and accuracy of train inspections.

- Production of new intermodal services: meaning the capability to enhance the competitiveness of rail freight transport, providing “customers - oriented” innovative services.

4.5 Sub-theme 4: Urban freight transport

4.5.1 Background

Research on urban freight transport reported in the Thematic Research Summaries on freight transport and intermodal transport produced in Extr@Web (EXTR@Web, 2006a; EXTR@Web, 2006b) has been concerned with efficiency of freight platforms and villages, application of ICT, and environmental impacts of urban distribution.

More specifically, a Best Practice Handbook has been produced, which includes detailed examples from all over Europe about urban freight distribution practices and provides recommendations.

Research also developed guidelines on the advantages and drawbacks of some recent innovative initiatives in the field of inter-urban and intra-urban freight distribution systems to be used by stakeholders with the aim of a successful implementation of these initiatives in their local contexts. Moreover, a system for improving the efficiency of door-to-door transport of goods in urban areas was developed. This system enables and supports planning decisions for both private and public operators through services for efficiently managing their logistics operations.

4.5.2 Research objectives

One strand of research has aimed at assessing opportunities for improving the urban transport systems of cities by implementing combinations of measures for making urban freight transport more efficient (START, 2009) and identifying, describing, and disseminating best practices, success criteria and bottlenecks concerning urban freight transport, including city access restriction (Bestufs II, 2006), enforcement and control (Bestufs II, 2006), waste transport (Bestufs II, 2005), environment-friendly vehicles (Bestufs II, 2005), and planning and management of delivery trips (eDRUL). Research was motivated by the fact that the delivery and collection of goods within cities have significant economic, social and environmental impacts, and the economic health and the quality of life of cities can only be achieved through an efficient and environment-friendly transport system.

A second strand of research focused on the development of methodologies for the evaluation of applications of urban logistics with a view to promoting the development of effective and efficient interventions for a sustainable distribution of the goods within the cities (CITY PORTS, 2005).

Another strand of research has continued to pursue the enhancement of the efficiency of freight terminals. More specifically, research has developed solutions to expand the capacity of existing terminals, namely sea-ports, inside cities, where problems of space and traffic significantly limit this possibility (ASAPP ONE).

4.5.3 Research results

4.5.3.1 More sustainable urban freight transport

Research has implemented in a cluster of European cities (Bristol, Göteborg, Ljubljana, Ravenna and Riga) a combination of measures such as access restrictions, consolidation centres and incentives to make urban goods distribution more energy efficient and environmentally friendly (START, 2009).

The implementation of consolidation schemes has been successful in all involved cities (START, 2009):

- In the city of Bristol a reduction of 78% of vehicle movements among the participating companies has been achieved;
- in the demonstration area (Lindholmen) of the city of Göteborg a reduction of 50 % in both vehicle-kms and trips together with a decrease by 50% in CO2, NOx and PM10 emissions has been obtained;
- the consolidation scheme delivering into the historical area of the city of Riga has resulted in a reduction of trips by 9% and an estimated decrease of emissions by 3% to 9%;
- consolidation of deliveries has permitted to obtain a reduction by 4% of trips in the city of Ravenna;
- for the small consolidation scheme serving the historical centre of Ljubljana a decrease in the number of trips by 15% and reduction by 20% of emissions have been estimated.

In the city of Bristol, the development of support, technical guidance and training tools involving 4 fleets and over 40 drivers trained in eco-driving has permitted to achieve fuel efficiency savings by 8% to 13%, while an articulated package of incentives in the city of

Ravenna has resulted in the extension of the fleet of private and commercial CNG vehicles with 3925 additional units. Incentives for clean vehicles have been included in the new local traffic legislation in Ljubljana (START, 2009).

The city of Ljubljana has developed a model for access restrictions and regulations for freight deliveries, while the city of Ravenna has included “access and park in the City Centre regulations” in the new “General Urban Traffic Plan”, has implemented the access monitoring system (named SIRIO) with 5 detecting points with automatic number plate recognition (ANPR) system, and has set up the “Control Centre” which permits the integration of the IT tools for the monitoring and control of urban traffic in a single system of control. In the city of Göteborg time windows and removal of one-way road signs in the inner-city area have been implemented in combination with new pedestrian streets permitting to achieve a reduction by 82% of parked vehicles in the area and a reduction by 73% of pass-through vehicles (START, 2009).

Finally Freight Quality Partnerships have been successfully established in the involved cities. These partnerships allow main freight transport stakeholders (e.g local administrations, businesses, freight operators, environmental groups, local communities, etc.) to collaborate in order to address freight transport problems and achieve a more sustainable freight distribution (START, 2009).

4.5.3.2 City access restriction best practices

The case studies on city access restriction show that in the last years, innovative schemes, new concepts and trials have been done in the field of environment related schemes and access charging schemes (Bestufs II, 2006).

Besides measures that permit the access to central urban areas only to zero-emission, electric, or low emission hybrid vehicles, cities began to implement measures based on the new concept of Low Emission Zones (LEZ) or “Environmental Zones” (Successful examples came from Swedish cities - Stockholm, Gothenburg, Malmö, and Lund. Cities like London, Madrid, Paris, Copenhagen and a number of Norwegian cities have planned to implement this concept). The LEZ may be based on a geographical area, a time period, vehicle emission standards, vehicle types, loading factor / utilisation rate, and, unlike other schemes they are mainly driven by the intent to reduce air pollution and noise (Bestufs II, 2006).

A successful case of implementation of city access charge scheme is the London congestion charging. The main results have been a decrease in overall traffic by 18%, and a decrease in delays by 30% without any shift of congested roads or appreciable impact on overall business performance in the area. Freight operators are satisfied with this

measure, because it brought to them many benefits, such as increased reliability of deliveries (due to less delays), more efficient use of vehicles and drivers, more reliable trip planning, and faster deliveries. However, today's legislation does not allow such schemes everywhere (Bestufs II, 2006).

Case studies also show that the question of night deliveries is still very controversial; some cities are against night deliveries because of noise emissions, others adopt them because they permit to decrease traffic at daytime and increase the efficiency of the delivery process. There are also examples of night deliveries only permitted in a limited geographical area (in non residential areas). Furthermore, a case study was focused on improving the cooperation between operators and authorities well as among municipalities. In the Netherlands, a national committee on urban freight for an increased cooperation of urban freight parties was set up. A first result of this initiative is a harmonisation of time-windows among a number of cities (Bestufs II, 2006).

4.5.3.3 Enforcement and control best practices

Case studies on enforcement and control concepts in urban freight transport identified by research concern the detection of offences in access restriction schemes for the reduction of heavy goods transport within city historic centres. These case studies show that the greater an area or system is, the more it makes sense to carry out check and control activities with the support of electronic equipment (video detection or electronic bollards). Although electronic control technologies are expensive, several countries have begun to use them as a consequence of deficiencies of manual control and enforcement systems or for the lack of human resources for carrying out regular monitor activities. However, the costs of electronic enforcement equipment can be (partly) recovered from the money trespassers pay for the imposed fines and penalties. Furthermore, there are many differences in how countries permit the use of video enforcement; often the national regulation hinders its use, or, when it is allowed, data must be deleted after a certain time period (Bestufs II, 2006).

4.5.3.4 Waste transport best practices

A number of analysed case studies were focused on the disposal of waste, an important aspect of city logistics often overlooked. In fact, the economic development implies more production and consumption, which result in increased volumes of waste (in particular packing material). The problem of waste disposal is becoming more and more urgent, especially in cities, and it is necessary to develop suitable waste management programmes to increase the sustainable development of cities (Bestufs II, 2005). One finding from the analysis of case studies is that waste transport seems to be very suited to inland waterways and railway transport modes, as a successful case study shows.

Moreover, other analysed cases prove that modal shift solutions for waste transport can enhance efficiency and reduce costs, as well as environmental impacts. Positive results can be achieved also using ITS for planning and scheduling trips for collecting waste (Bestufs II, 2005).

4.5.3.5 Environment-friendly vehicles best practices

Urban freight transport must also confront with the negative impact on energy use and environment of motorised traffic, to which urban freight transport naturally gives its contribution. Among possible solutions to these problems, there are those based on the use of environment-friendly vehicles and equipment. The analysis of projects has shown that many municipal and national initiatives have been implemented to encourage the use of EFV in urban freight transport. Some of them (e.g. National programmes like the Dutch PIEK-programme or the French "National Programme on Goods in Cities") led to successful results. However, it seems that private transport operators are not so willing to change their fleets towards environment-friendly vehicles. In fact, private operators only change their fleets and operating concepts if (Bestufs II, 2005):

- there is a clear financial benefit for them;
- there are enough filling stations in the area of operation;
- there are marketing effects and image benefits.

From the analysis of projects emerges that only large courier companies have changed their fleets, since in large fleets it is possible to realise economies of scale and cost savings. Furthermore when the delivery points are very closely distributed, CNG or bio-fuel vehicles are more efficient because in the stop and go process they spent less fuel (Bestufs II, 2005).

However, case studies, in which an assessment of emissions and environmental impacts has been carried out, have shown that the use of EFV in urban freight transport generates high ecological benefits. In general these benefits consist in a reduction of CO_2 emissions, lower noise emissions, and improved energy efficiency. On the other hand, a number of disadvantages have been assessed, such as higher operational costs for EFV, an inadequate filling station network, reliability problems and defects, and high maintenance costs (Bestufs II, 2005).

In general, stricter emission standards and regulations together with tax reductions and financial incentives can encourage operators to change their operation strategy (Bestufs II, 2005).

4.5.3.6 Freight distribution management best practices

Research has identified a best practice to improve the management of freight distribution in urban areas, which consists in an innovative e-logistics platform (eDRUL, 2002). A number of ITS applications (e.g. web-enabled information and booking services, delivery notification and information through mobile phones and SMS, trip planning and resource optimisation, GPS-based or GSM/GPRS-based vehicle location systems, long-range, wireless communications, and others) enable the user to manage its logistics resources to realise flexible, demand-driven freights distribution schemes. This system, which has been validated in four European cities (Aalborg, Eindhoven, Lisbon, and Siena), can be used to efficiently manage different city distribution scenarios, such as:

- 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.

4.5.3.7 Methodologies for evaluating city logistics interventions

Research has developed a methodology in terms of analysis tools and assessment procedures for evaluating the feasibility of an intervention in the city logistics field (CITY PORTS, 2005). This methodology consists of three phases. During the first phase key information is collected and the critical issues relating to the delivery of goods in the urban context where an intervention is to be done is analysed. In the second phase an integrated solution is identified, which takes into account all main aspects, such as technical/logistic aspects, political/administrative aspects and involvement of stakeholders. In the third phase a cost-benefit analysis is carried out to assess external costs and benefits and how stakeholders share them. Apparently, research has not devised a new procedure, it has developed a patchwork based on several relevant European experiences, instead. In fact, the methodology aims specifically to build a common vision of the operating mechanisms of urban logistics, of the modelling criteria, and of the evaluation criteria; it also provides guidelines and tools for the study of the haulage of goods, determination of solutions coherent to the context, and the development of feasibility studies.

4.5.3.8 Sea ports in cities

Research has developed a prototype of an automated shuttle linking sea ports and hinterland depots in order to test the possibility to increase the capacity of terminals limited by physical constraints (such as terminal in cities surrounded by built-up areas). From the hinterland depot where road vehicles unload, freight is transferred to the port via the electrically-powered shuttles will run either individually, or in convoy mode. These computer-controlled shuttle, which can transport each up to six container units, run either on a dedicated railway line or on a concrete pathway. This solution avoids congestion at the quayside and improves the rate at which freight is transferred to the ship. This system allows also smaller ports to accept freight, and, as a consequence, additional sea and inland waterway routes can be created, which will contribute to reduce road traffic. This solution avoids congestion at the quayside and improves the rate at which freight is transferred to the ship (ASAPP ONE).

4.5.4 Policy implications

4.5.4.1 More sustainable urban freight transport

The importance of urban freight appears to be still underestimated in Europe. It is necessary to support initiatives (at the local, national and EU level) aiming at raising awareness of the role played by freight delivery in the sustainability of urban areas and in particular the drastic reduction in urban traffic which can be achieved with more efficient freight flows and increased load factors. Furthermore, cooperation between all stakeholders in the distribution chain based on mutual trust and understanding permits to efficiently implement changes and restrictions for achieving a better sustainability (START, 2009).

Effective schemes for goods, such as consolidation schemes run the risk of being closed down as soon as the support from public authorities is withdrawn if they are not economically profitable. However, criteria other than gained money should be considered when assessing the profitability of such schemes, like “increased attractivity” of a city centre or other specified areas (START, 2009).

The main recommendations concerning access restriction schemes are the following (Bestufs II, 2006):

- To ensure a high level of acceptance of an access restriction scheme, it is recommended to have consultations with stakeholders (particularly businesses in the city centre and their transport operators) in an early stage of the planning process.
- To increase acceptance it is also recommendable to make an information campaign upon the introduction or change of a scheme, and encourage cooperation between cities for certain schemes (same environmental standards, weight and size restrictions, etc.).
- To improve transport efficiency and the quality of life in cities it is recommendable to also make use of innovative schemes based on environmental zones or charging approaches, besides the traditional access regulation schemes based on weight, size, and time restrictions
- To successfully implement a scheme it is crucial to consider the local context, making the required adjustments to the scheme according to the characteristics of the local industry and businesses. It is also necessary to develop enforcement concepts during the planning of a scheme, especially their costs.
- Finally, it is also recommendable to measure and evaluate the effects of a scheme for monitoring its success or failure and for making further improvements and adjustments.

4.5.4.2 Enforcement and control best practices

For what concerns the introduction of an enforcement and control scheme, it is recommendable to do it according to the function of a regulative measure and the area size. In fact, for a small city area that want to control forbidden loading activities it would make no sense to introduce a high technology control system. As a consequence, a planning and consultation process is recommendable before implementing an enforcement and control scheme. It is also recommendable to inform all involved parties about the enforcement and control mechanisms trying to raise an understanding of the necessity of such measure (Bestufs II, 2006).

4.5.4.3 Waste transport best practices

Recommendations for improving waste transport and logistics are as follows (Bestufs II, 2006).

- There is a lack of integrated logistics solutions. It is recommendable to develop integrated solutions and strategies, for example combining intermodal transport concepts, ITS-use and environment-friendly vehicles for the waste collection.

- It is recommendable to plan the location of landfill facilities in order to reduce negative impacts (vehicle kilometres, noise and exhaust emissions etc.). Spatial planning and transport activities, especially waste transport should be planned with a common approach.
- City authorities are often responsible for waste management, and they often outsource waste activities to private operators. As a consequence they have the opportunity to define in the tendering processes standards for collecting waste and technologies that can be used taking into account not only the operation costs, but also the environmental impacts, creating a sustainable approach in waste management and waste transport in their cities.
- Application. European countries should encourage and finance in co-operation with private operators national but also regional research activities in this field waste transport and logistics in order to find new sustainable solutions.

4.5.4.4 Environment-friendly vehicles best practices

The following recommendations have been produced for encouraging the use of EFV:

- National authorities must take over a leading role in supporting EFV and the use of alternative fuels. They should support, with financial incentives, private operators and private industry to start-up initiatives, who in their turn should continue these initiatives investing their own resources.
- It is recommendable to exploit the synergetic effects deriving from the combination of measures and incentives. In fact, on the one hand, restrictive measures certainly force private transport operators to renovate their vehicle fleet; on the other hand, the higher operation costs due to necessity of renovating their fleet result in higher prices for customers.
- Programs which encourage the use of more environment-friendly vehicles should be further developed at European and national level. It is very important to involve also the New Member Countries in EU projects with focus on the use of EFV in urban freight transport. Considering the restricted financial municipal and national budgets, it is recommendable that EU contributes to the financing of these projects.
- Although also smaller projects with few vehicles can be successful, financial support should be especially given to operators with big vehicle fleet, which produce a high number of vehicle-kilometres. Therefore, the negative impacts can be reduced more significantly in comparison to small projects.

4.6 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[19] on Intermodal Transport (EIRAC, 2005), Waterborne Transport (Waterborne, 2006), and Road Transport (ERTRAC, 2004).

4.6.1 Implications for further research from projects reviewed

For what concerns the sub-theme 2 "logistics and supply chain management tools", further research is required for developing tools for increasing competitiveness of waterborne mode. In particular, actions should be taken to (SPIN-TN, 2005):

- Expand services such as PortNet to cover European Ports at a regional level, and through interregional exchange to achieve pan-European interoperability.
- Carry out surveys to identify all information requirements that can impact directly or indirectly on inland and short sea shipping. Then survey all currently available information tools to check whether the above identified requirements are included, and create a list of missing information. Finally, identify way for obtaining the missing information.
- Design a strategy for awareness raising and training key stakeholders of short-sea shipping, river-sea shipping, and inland navigation to encourage the exchange of commercial information, and how to best use such information for maximizing the efficiency of their processes and operations.

Further research on short sea shipping issues should be specific and targeted towards key issues, such as (REALISE, 2005):

- To investigate the decision-making process of shippers and freight forwarders concerning modal choice options;

[19] Technology platforms are frameworks 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).

- To carry out a broad analysis of trade and transport flows over the next 10 years within Europe, with special reference to the link between the carriage of specific commodities and the corresponding structure of logistic chains;
- To study the environmental impacts of particulates' emissions from short sea shipping, with special emphasis on Ro-Ro vessels;
- To investigate the impact of port charging based on the gross tonnage on the choice of ship type in relation to the use of open-hatch vessels to provide faster and safer loading and unloading of containers.

For the sub-theme of intermodal transport, clustering meetings and networking activities have identified a number of recommendations for future policy and research development. More specifically, the following priority topics have been identified for improving intermodal freight transport, with particular focus on freight terminals (EUTP II, 2004):

- Support to policy making process for public and private investment strategies finalised to improve organisational aspects and network integration (inland waterways, trans-European transport corridors, logistics integration of the entire chain, interoperability issues between NAS and EU, funding mechanisms for financing terminals, and planning principles for developing a terminal).
- Standardisation of loading units and for improving interoperability.
- Improvement of the integration of existing and future ICT systems, preferably based on internationally agreed process and message standards. Furthermore, there is a need for logistics management tools covering the whole transport chain. The distribution of costs and benefits of ICT implementation and operation should be also addressed.
- Intermodal nodes as a part of TEN-T network.
- Security in terminals and along the whole chain. There is a need for an integrated approach to the implementation of security measures for freight transport, and for risk assessment along the whole chain. This requires a comprehensive research of existing regulations at European and international level.
- Improvement of co-operation between actors, which can result in higher competitiveness (e.g. lower costs, shorter lead times, better quality of service). Co-operation implies collaboration, creation of partnerships, sharing of information, processes and resources.

Research on horizontal transfer equipment has produced a state of the art on this kind of technologies and developed prototypes, but it is still necessary to further develop or investigate the following points (In.Ho.Tra, 2003).

- The main advantage of horizontal transfer systems is that they can perform their operations remaining under the catenaries. It is recommendable to carry out surveys and studies for calculating all benefits that can be achieved with the application of horizontal transfer systems.

- Basically two methods of handling operations in terminals exist: the first method consists in removing all loading units from the train transfer them into a sorting field or directly onto a truck (this method normally optimises productivity of cranes and is appropriate for terminals with large-scale operations); the other method consists in selecting specific loading units for transfer and leaving the others on the wagons. The second method can be efficiently applied by exploiting the specific ability of horizontal equipment to single out a specific loading unit and transfer it from (or on to) the wagon while the train remains on a track under catenaries. So it is recommendable to assess how efficiently use horizontal transfer systems for selected transfer in cases like liner train operations or priority treatment of certain road vehicles. This would permit to extend intermodal transport to new markets that currently he cannot serve.
- After the privatisation of railways, some new actors have demonstrated that even low scale solutions in intermodal transport can be commercially feasible (annual throughput of about 15000 to 30000 loading units per year). The traditional gantry crane is oversized in such cases (it can handles about 50000 to 80000 loading units per year), while horizontal transfer equipment would be suitable. It is recommendable to analyse in detail the possible development of these "small terminals" with low investment needs and low personal costs. A possible development could lead to the case of a "do-it-yourself terminal", i.e. a transfer facility without staff in which the truck driver himself operates the transfer equipment.

Research on horizontal transfer facilities has shown how this technology can be successfully applied to small transfer facilities. A specific case of small terminal might be a downtown transfer facility in order to use rail mode also in the inner city. The wagons containing the loading units could be separated from the intermodal train before it is shunted into the crane area of the large intermodal terminals situated outside of the city, and a small locomotive could be used to transport these wagons to the downtown transfer facility. Horizontal transfer facilities would suitably perform the kind of operations required by these downtown transfer facilities (low scale operations at competitive cost level with low noise levels). Therefore, a possible further topic for R&D projects could be a feasibility study and a demonstration of this kind of small terminals (In.Ho.Tra, 2003).

4.6.2 Summary of further research recommended by Strategic Research Agendas

4.6.2.1 Road and waterborne modes

The Strategic Research Agenda on road transport has identified the following topics for further research on logistics and supply chain management tools (ERTRAC, 2004):

- Identification of the impacts of information on distribution practices and the effect on improved journey time reliability.
- Development of concepts for modular goods carriers and effective road-rail combinations.
- Development of intelligent Intermodal Transport Units (ITU) for modular goods movement at European level.
- Development of standardised concepts for effective goods movement throughout the entire logistics chain, not just the transport portions.
- Development of network level systems to support the transit of heavy vehicles.
- Development of new tools and models for the efficient infrastructure asset management of both overall network and individual sections to improve the overall life cycle costs.
- Development of new solutions for using new dynamic traffic management and infrastructure technologies in order to improve the use of the existing infrastructure and reduce bottlenecks.
- Development of appropriate road classifications for the efficient operation of modular vehicles and road-train combinations.
- Investigation on systems for platooned trucks in dedicated lanes.
- Investigate and find solutions for issues concerning the security and safety of freight transport (tracking, tracing, monitoring and response technologies to prevent theft of vehicles, or from vehicles warehouse or intermodal node). In particular further research on risk management for the transport of hazard and safety-critical goods, including precise tracking of such goods and specific strategies for emergency scenarios need to be made.

The Waterborne Strategic Research Agenda (WSRA) has stressed on the fact that the optimisation of transport chains featuring waterborne transport, whether by sea, or inland waterway, has the potential to reduce congestion effects in road and rail transport. Therefore, it suggest to carry out further research aimed at developing intelligent planning tools and by reactive and agile real-time scheduling systems to support this optimisation process (Waterborne, 2006).

4.6.2.2 Intermodal transport

By 2020, the European intermodal transport system is expected to account for 40% of freight movements, which will be increasingly unitised. The use of intermodal transport will enable Europe to cope with the increase in transport demand, improve environmental impact of transport, and enhance its competitiveness, but there are a number of challenges to face (EIRAC, 2005). The Strategic Research Agenda on Intermodality (EIRAC, 2005) has identified five areas for further research to improve intermodal transport: interoperability between modes, logistics, security, socio-economics, education

and training. For each area a number of research themes have been proposed. Some of these themes have been also identified by WSRA. For what specifically concerns freight transport, the research themes are as follows (EIRAC, 2005) (Waterborne, 2006):

- Standardised Intermodal Equipment. Research is needed to investigate how to quickly agree on the design features (carrying ability, stackability, handling ease and flexibility) of a European standard loading unit, as well as to design and implement a worldwide compatible loading unit.
- Transfer nodes. Interoperability depends on the availability of enough transfer nodes. Research is needed for creating a network of transfer nodes in Europe possibly using both public and private investments.
- Consistent Regulations. Different national regulations applied across many areas of transport impede seamless and flexible interoperability. Therefore research is required for harmonising regulations across Europe.
- Transport Documentation. To enhance interoperability, there is also a need to simplify and harmonise documentation, and reduce the number of transport documents.
- Systems of transfer. The efficiency of transfer systems from one mode to another is crucial to intermodality. Research needs to be carried out both to improve transfer systems and to establish when and where the currently available transfer methods should be applied.
- Awareness of Intermodal Transport. Potential users of intermodal transport are reluctant to use it because it appears to be too complicated. Therefore, the improvement of infrastructure, equipment and information systems must be accompanied by activities to increase the level of awareness among potential users. As a consequence, research is needed to investigate the best way to promote intermodal transport in all its aspects.
- IT sytems. Open IT systems are needed to support Activities like booking, invoicing, tracking, transhipment must be supported by efficient open IT systems for a timely and precise exchange of information among stakeholders. Research is still necessary to define the most suitable IT system which can serve the needs of all the participants.
- Harmonised Framework Conditions for all Modes. There should be a level playing field in which all modes and price tags are comparable. Also the cost of security measures is not equal for all modes. It is important that a European common policy ensures that all modes have equal conditions and pay for the external costs they create and that the same conditions apply in all countries (and ‘non-European’ suppliers have to comply with this). So economics and behavioural research is needed to identify barriers to changing to equal conditions for all modes, as well as research to define a roadmap for the implementation of equal conditions for all modes, identifying those conditions to be implemented at the EU level, along with others that might be implemented by private investors.
- High Quality and Efficient Intermodal Services. Intermodal transport requires high quality and very efficient services from all modes. Research is needed to: integrate

information technology and logistics to form the “smart supply chain”, embedded in a common EU intermodal, cross-border strategy; develop 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; develop methodologies and tools for global repositioning of loading units; define co-operation and liabilities between transport operators (service quality, reliability, cargo conditions of carriage, legal, competition and insurance issues, loss and damage issues); harmonise document handling and customs procedures, contracting, and permitting; develop and assess different financing schemes.

- European Intermodal Network. Research is needed on the requirements of agile European Transport networks, where many shippers and service providers (and modes) work together. A very important part of this research is cooperation issues (how to define costs and benefits). Another important part of this research is on the ‘last mile’ including city logistics. For intermodal transport this will mainly mean research on the interface between intermodal transport and last mile logistics.
- Security. Although substantial improvements in transport security took place in the last few years, there is still a lack of harmonisation in legislation and regulation at both EU and International levels. It is important to develop a European common policy to secure freight transport accompanied by implementing suitable liability policies, creating a forum for international cooperation and information exchange in the area of transport security, and harmonising security policies of Member States and Accession Countries. One aspect of the harmonisation would be a Common Code of Conduct, containing the rules laid out for Intermodal players, how to behave and which security standards to observe, to become a recognised “Intermodal Secure Economic Operator”.
- Research is needed to develop a common secure IT infrastructure to exchange and record transport related information in a secure IT environment compatible with international customs standards, and using open standards technologies and procedures to reduce investment costs. It should be based on a common language or dictionary of terms applicable to all modes of transport to ease storing, mining, and transfer of information. The solutions are to be envisaged in terms of functions, so that the infrastructure can be configurable and adaptable to technologies resulting from further evolution of ICT. The IT infrastructure will add value to intermodal transport, rather than representing an additional barrier for its development.
- A topic for further research is the development of new technologies for non-intrusive container inspection, characterised by short acquisition time, low cost, and high accuracy, such as the electronic seals, so that scanning delays at Intermodal terminals should be minimised in order to maintain the competition position. Technologies are to be compatible or developed in conjunction with harmonised policies and standard security IT infrastructure.

Furthermore, the Waterborne Strategic Research Agenda (WSRA) has also identified the following research areas (Waterborne, 2006):

- In order to reduce the cost and time of marine transport compared to road and rail is necessary to improve cargo handling. Innovative approaches to the design of vessels as a logistic chain component must start with the cargo and the most effective way to transfer it from one transport mode to another.
- 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. Therefore, research activities are necessary to identify efficient, economic and environmentally friendly technical solutions for building, maintaining and upgrading port and inland waterway infrastructures.
- Simulation of Logistic Chain. To maximise the expansion and efficiency of waterborne transport it is necessary to develop user friendly programs which simulate the entire transport chain so as to quickly determine the most cost effective and rapid combination of transport modes available.

4.6.2.3 Urban freight transport

One of the main concerns in urban freight transport is to reduce impacts of freight traffic on residents, and at the same time to increase or at least maintain overall effectiveness and efficiency. The Strategic Research Agenda on road transport has identified the following topics for further research (ERTRAC, 2004):

- studies to investigate and find solutions to the complex aspects of urban freight transport such as loading and unloading, parking and planning;
- development of innovative urban delivery systems tailored to the local needs of individual urban areas;
- development of methodologies and systems for assigning specific urban truck routes, which may be variable in time;
- development of public-private models for urban freight delivery;
- development of new concepts for cleaner and quieter vehicles for urban delivery and night-time operations ;
- development of new multifunctional vehicles (such as post-buses) to integrate different types of passenger and freight transport.
- development of new vehicle concepts for city logistics, investigating solutions for underground, automated freight transport.
- development of new modular vehicle systems and load carrier concepts for all portions of the logistics chain.

The ERTRAC SRA has also identified the following topics for further research specifically relating to home delivery, which is the final stage of the distribution chain (ERTRAC, 2004):

- development of innovative optimised delivery systems;
- assessment of the impacts of e-commerce on future freight transport, as well as the impacts of home delivery on residential traffic;
- investigations on the relationship between home delivery and car and public transport use;
- development of suitable local area distribution points (e.g. drive-in centres, park and ride facilities).

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Annex: List of projects by sub-theme

Sub-theme 1: Freight transport, logistics and supply chain management trends				
Project acronym	Project title	Programme	Project website	Coverage
-	Logistics and transport for local production systems: methods and models applied to North-East of Padana valley	Project from Italy		EXTR@Web paper (Freight Transport)
CREAM	Customer-driven Rail-freight services ona European mega-corridor based on Advanced business and operating Models	FP6 - SUSTDEV-2 "Sustainable surface transport"		If reports become available
e-THEMATIC	Thematic Network on e-Fulfilment	FP5 - IST - KA1 - Systems and services for the citizens		This paper
LOGICAT	Concerted Action on Logistics, Supply and Demand Chain Management in Europe	FP4 - TRANSPORT RTD - Transport Research and Technological Development		EXTR@Web paper (Freight Transport)
NEW OPERA	New European Wish: Operation Project for European RAil network	FP6 - SUSTDEV-2 "Sustainable surface transport"	www.newopera.org	This paper
PROTRANS	Role of third party logistics service providers and their impact on trans-port	FP5 - GROWTH - KA2 - Sustainable Mobility and Intermodality		EXTR@Web paper (Freight Transport)

RAILSERV	Thematic Network on Rail Freight Services	FP5 - GROWTH - KA2 - Sustainable Mobility and Intermodality		If reports become available
REORIENT	Implementing Change in the European Railway System	FP6 - SUSTDEV-2 "Sustainable surface transport"	www.reorient.no	This paper
RETRACK	Reorganisation of Transport networks by advanced Rail freight Concepts	FP6 - SUSTDEV-2 "Sustainable surface transport"	www.retrack.eu	If reports become available
SULOGTRA	Effects on Transport of Trends in Logistics and Supply Chain Management	FP5 - GROWTH - KA2 - Sustainable Mobility and Intermodality		EXTR@Web paper (Freight Transport)
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	This paper

Sub-theme 2: Logistics and supply chain management tools				
Project acronym	Project title	Programme	Project website	Coverage
-	Supply chain resilience (FL0123)	Project from The United Kingdom		EXTR@Web paper (Freight Transport)
ALSO DANUBE	Advanced Logistic Solutions for Danube Waterway	FP5 - GROWTH - KA2 - Sustainable Mobility and Intermodality	www.alsodanube.at	This paper
ASAP	Asset Surveillance and Protection	FP5 - IST - KA1 - Systems and services for the citizens		This paper
BESTLOG	Logistics Best Practice	FP6 - SUSTDEV-2 "Sustainable	www.bestlog.org	If reports become

Sub-theme 2: Logistics and supply chain management tools				
Project acronym	Project title	Programme	Project website	Coverage
		surface transport"		available
BRAVO	Brenner Rail Freight Action Strategy Aimed at achieving a Sustainable Increase of Intermodal Transport Volume by Enhancing Quality, Efficiency and System Technology	FP6 - SUSTDEV-2 "Sustainable surface transport"		This paper
CESAR II	Co-operative European System for Advanced Information Redistribution	FP5 - GROWTH - KA2 - Sustainable Mobility and Intermodality	www.cesar-online.com	This paper
D2D	Demonstration of an integrated management and communication system for door-to-door intermodal freight transport operations	FP5 - GROWTH - KA2 - Sustainable Mobility and Intermodality	www.d2d.no	EXTR@Web paper (Freight Transport)
iBoS	European integrated info-Box System for improved food safety and logistics	FP5 - IST - KA1 - Systems and services for the citizens		This paper
FIRE	Freight information in the railway en-vironment	FP4 - TRANSPORT RTD - Transport Research and Technological Development		EXTR@Web paper (Freight Transport)
GAUSS	Galileo and UMTS Synergetic System	FP5 - IST - KA1 - Systems and services for the citizens	http://galileo.cs.telespazio.it/gauss	EXTR@Web paper (Freight Transport)
GIFTS	Global Intermodal Freight Transport System	FP5 - IST - KA1 - Systems and services for the citizens	http://gifts.newapplication.it/gifts	EXTR@Web paper (Freight Transport)
IP	Intermodal Port	FP5 - GROWTH - KA2 -	www.intermodalportal.co	This paper

Sub-theme 2: Logistics and supply chain management tools				
Project acronym	Project title	Programme	Project website	Coverage
		Sustainable Mobility and Intermodality	m	
ITIP	Innovative Technologies for Inter-modal Transfer Points	FP5 - GROWTH - KA2 - Sustainable Mobility and Intermodality		This paper
MEDICASE	A new concept for fully integrated, quality Assured transportation of Sensitive Medical items	FP5 - IST - KA1 - Systems and services for the citizens		If reports become available
ParcelCall	An Open Architecture for Intelligent Tracing Solutions in Transport and Logistics	FP5 - IST - KA1 - Systems and services for the citizens		This paper
RECORDIT	Real Cost Reduction of Door-to-door Intermodal Transport	FP5 - GROWTH - KA2 - Sustainable Mobility and Intermodality	www.recordit.org	EXTR@Web paper (Freight Transport)
ROLLING STOCK	Supply chain visibility by dynamic consolidation of ROLLING STOCK information	FP5 - IST - KA1 - Systems and services for the citizens	www.eu-rollingstock.org	If reports become available
SESTANTE	Information and communication tools for secure and efficient information exchange in the logistics chains of ports and intermodal terminals	Interreg III – "Cross-border, Transnational and Interregional Cooperation"		If reports become available
SIMTAG	Safe InterModal Transport Across the Globe	FP5 - GROWTH - KA2 - Sustainable Mobility and Intermodality		This paper

Sub-theme 2: Logistics and supply chain management tools				
Project acronym	Project title	Programme	Project website	Coverage
SPIN	Scanning the Potential of Intermodal Transport	DGTREN - Energy & Transport DG - Miscellaneous projects	www.spin-eu.com	EXTR@Web paper (Freight Transport)
SPIN-TN	Thematic network on the development of European strategies to promote short sea shipping, sea-river and inland navigation	FP5 - GROWTH - KA2 - Sustainable Mobility and Intermodality	www.spin-network.org	This paper
TASKU	Tracking and Tracing of Freight Transport	Project from Finland		EXTR@Web paper (Freight Transport)
TRAPIST	Tools and Routines to Assist Ports and Improve Shipping	FP5 - GROWTH - KA2 - Sustainable Mobility and Intermodality		This paper
TROP	Transport Optimiser & Planner	FP5 - IST - KA1 - Systems and services for the citizens		This paper
VRSHIPS-ROPAX	Life-Cycle Virtual Reality Ship Systems	FP5 – Growth, KA 3 "Land Transport and Marine Technologies"	www.vrsproject.com	If reports become available

Sub-theme 3: Intermodal transport				
Project acronym	Project title	Programme	Project website	Coverage
-	Analysis of the research-studies-orders interface regarding transport interchanges	Project from France		EXTR@Web paper (Intermodal Transport)

Sub-theme 3: Intermodal transport				
Project acronym	Project title	Programme	Project website	Coverage
-	Efficient terminals for intermodal transport	Project from Sweden		EXTR@Web paper (Intermodal Transport)
-	European sea transport and intermodalism – Consequences for Switzerland	Project from Switzerland		EXTR@Web paper (Intermodal Transport)
-	Feeder systems in combined transport	Project from Switzerland		EXTR@Web paper (Intermodal Transport)
-	Railport-Linz	Project from Austria		EXTR@Web paper (Intermodal Transport)
-	Road to rail: open access intermodal gateway to the UK – TDG European Chemicals (GPCS 399)	Project from The United Kingdom		EXTR@Web paper (Intermodal Transport)
-	Systems for combined transport between road and railway	Project from Sweden		EXTR@Web paper (Intermodal Transport)
-	The attractiveness of multimodal transport	Project from Switzerland		EXTR@Web paper (Intermodal Transport)
BRAVO	Brenner Rail Freight Action Strategy Aimed at achieving a Sustainable Increase of Intermodal Transport Volume by Enhancing Quality, Efficiency and System Technology	FP6 - SUSTDEV-2 "Sustainable surface transport"		This paper
CAESAR	Coordination Action for the European Strategic Agenda of Research on	FP6 - SUSTDEV-2 "Sustainable surface transport"	www.eirac.net	This paper

Sub-theme 3: Intermodal transport				
Project acronym	Project title	Programme	Project website	Coverage
	intermodalism and logistics			
CARGOSPEED	Cargo Rail Road Interchange at Speed	FP5 - GROWTH - KA3 - Land transport and marine technologies	www.cargospeed.net	EXTR@Web paper (Intermodal Transport) (Freight Transport)
CENTRAL LOCO	Central European Network for Logistics Competence	FP6 - SUSTDEV-2 "Sustainable surface transport"		This paper
CO-ACT	Creating Viable Concepts for Combined Air/Rail cargo Transport	FP5 - GROWTH - KA2 - Sustainable Mobility and Intermodality		EXTR@Web paper (Intermodal Transport)
COST 339	Small containers	COST – "European Co-operation in the Field of Scientific and Technical Research"		This paper
D2D	Demonstration of an integrated management and communication system for door-to-door intermodal freight transport operations	FP5 - GROWTH - KA2 - Sustainable Mobility and Intermodality	www.d2d.no	EXTR@Web paper (Freight Transport)
D4D	Data Warehouse for Danube Waterway	Interreg III – "Cross-border, Transnational and Interregional Cooperation"	www.d4d.info	If reports become available
EFFORTS	EFFective Operation in poRTS	FP6 - SUSTDEV-2 "Sustainable surface transport"	www.efforts-project.org	If reports become available
FastRCargo	Fast Transhipment Equipment and Novel Methods for Rail Cargo in Europe	FP6 - SUSTDEV-2 "Sustainable surface transport"	www.fastrcargo.eu	If reports become available

Sub-theme 3: Intermodal transport				
Project acronym	Project title	Programme	Project website	Coverage
F-MAN	Rail Car Asset Management	FP5 - IST - KA1 - Systems and services for the citizens		EXTR@Web paper (Freight Transport)
FREIGHTWISE	Freightwise - Management Framework for Intelligent Intermodal Transport	FP6 - SUSTDEV-2 "Sustainable surface transport"		If reports become available
GILDANET	Global Integrated Logistics DAta NETwork	Interreg III – "Cross-border, Transnational and Interregional Cooperation"		If reports become available
In.Ho.Tra	Integration of Interoperable Intermodal Horizontal Transhipment Techniques in intermodal transport operations	FP5 - GROWTH - KA2 - Sustainable Mobility and Intermodality		This paper
INTEGRATION	Integration of sea land technologies for an efficient intermodal door to door transport	FP5 - GROWTH - KA3 - Land transport and marine technologies		EXTR@Web paper (Freight Transport)
INTERFACE	Improvement of Intermodal Terminal Freight Operation at Border Crossing Terminal	FP5 - GROWTH - KA2 - Sustainable Mobility and Intermodality		This paper
INTERGAUGE	Interoperability, Security and Safety of Goods Movement with 1435 and 1520 (1524) mm Track Gauge Railways: New Technology in Freight Transport including Hazardous Products	FP6 - SUSTDEV-2 "Sustainable surface transport"		If reports become available
INTERMODA	Integrated Solutions for Intermodal Transport between the EU and the	FP5 - GROWTH - KA2 - Sustainable Mobility and		EXTR@Web paper (Intermodal Transport)

Sub-theme 3: Intermodal transport				
Project acronym	Project title	Programme	Project website	Coverage
	CEECs	Intermodality		
INTERMODESHIP	The intermodal ship	FP5 - GROWTH - KA3 - Land transport and marine technologies		EXTR@Web paper (Intermodal Transport) (Freight Transport)
ISTU	Integrated Standard Transport Unit for Self-guided Freight Container Transportation Systems on Rail	FP6 - SUSTDEV-2 "Sustainable surface transport"		If reports become available
LOGBASED	Logistics-based design	FP6 - SUSTDEV-2 "Sustainable surface transport"	www.logbased.no	If reports become available
MD/DD/17	Inland navigation and sustainable development: analysis of factors that increase its market	Project From Belgium	www.belspo.be/belspo/fedra/proj.asp?l=en&COD=MD/DD/17	EXTR@Web paper (Freight Transport)
MOBILMED	Mobilità sostenibile negli ecosistemi fragili (isole e coste) / Sustainable mobility in sensitive ecosystems (islands and coasts)	Interreg III – "Cross-border, Transnational and Interregional Cooperation"		If reports become available
MOCONT	Monitoring the Yard in Container Terminal	FP5 - IST - KA1 - Systems and services for the citizens		EXTR@Web paper (Intermodal Transport)
MOCONT II	Monitoring the Yard in Container Terminal - Trials	FP5 - IST - KA1 - Systems and services for the citizens		This paper
MOSCA	Decision-support System for Integrated Door-to-door Delivery: Planning and Control in Logistic Chains	FP5 - IST - KA1 - Systems and services for the citizens	www.idsia.ch/mosca	EXTR@Web paper (Freight Transport)

Sub-theme 3: Intermodal transport				
Project acronym	Project title	Programme	Project website	Coverage
MOSES	Motorway of the Sea European style	FP6 - SUSTDEV-2 "Sustainable surface transport"	http://moses-eu-project.org	If reports become available
PREDIM	Research and demonstration platform for multimodal information	Project from France		EXTR@Web paper (Intermodal Transport)
PROMIT	Promote innovative intermodal freight transport	FP6 - SUSTDEV-2 "Sustainable surface transport"	www.promit-project.net	This paper
REALISE	Regional Action for Logistical Integration of Shipping across Europe	FP5 - GROWTH - KA2 - Sustainable Mobility and Intermodality	www.realise-sss.org	This paper
REMARCC II	Network of Regional Maritime Competence Centres - A Regional Maritime Strategy for Promoting Intermodal Transport, ICT and Network Opportunities within the North Sea Region	Interreg III – "Cross-border, Transnational and Interregional Cooperation"		This paper
REMOMED	RE.MO.MED – “Rete Intermodale Mediterranea”	Interreg Programme III		This report
ROLLING SHELF	Rolling Shelf	FP4 - TRANSPORT RTD - Transport Research and Technological Development		EXTR@Web paper (Freight Transport)
SAIL	Semi Trailers in Advance Intermodal Logistics	FP5 - GROWTH - KA2 - Sustainable Mobility and Intermodality		EXTR@Web paper (Intermodal Transport)
SIT-TN	Safe and secure intermodal transport	FP5 - GROWTH - KA2 -		This paper

Sub-theme 3: Intermodal transport				
Project acronym	Project title	Programme	Project website	Coverage
		Sustainable Mobility and Intermodality		
SPIN	Scanning the Potential of Intermodal Transport	FP5 - GROWTH - KA2 - Sustainable Mobility and Intermodality		EXTR@Web paper (Intermodal Transport)
THEMIS	Thematic Network in Optimising the Management of Intermodal Transport Services	FP5 - GROWTH - KA2 - Sustainable Mobility and Intermodality		EXTR@Web paper (Intermodal Transport) (Freight Transport)
TRIMOTRANS	Development of new intermodal loading units and dedicated adaptors for the trimodal transport of bulk materials in Europe	FP6 - SUSTDEV-2 "Sustainable surface transport"		If reports become available

Sub-theme 4: Urban freight transport				
Project acronym	Project title	Programme	Project website	Coverage
				This paper
ASAPP ONE	Intelligent Shuttle Fleet Connecting A Split Container Storage Area For Intermodal Operation Improvement	FP5 – Growth, KA 3 "Land Transport and Marine Technologies"		This paper
BESTUFS	Harmonisation of strategies and highlighting best practice to determine optimum Urban Freight Solutions (Thematic Network)	FP5 - GROWTH - KA2 - Sustainable Mobility and Intermodality	http://bestufs.net	EXTR@Web paper (Freight Transport)

Sub-theme 4: Urban freight transport				
Project acronym	Project title	Programme	Project website	Coverage
BESTUFS II	BEST Urban Freight Solutions II	FP6 - SUSTDEV-2 "Sustainable surface transport"	http://bestufs.net	This paper
CHINOS	Container Handling in Intermodal Nodes - Optimal and Secure!	FP6 - SUSTDEV-2 "Sustainable surface transport"	www.chinos-rfid.eu	If reports become available
CITY BOX	stadsbox -Small loading unit for urban distribution	Project from the Netherlands		EXTR@Web paper (Freight Transport)
CITY FREIGHT	Inter- and Intra- Urban Freight Distribution Networks	FP5 EESD KA4 - City of Tomorrow and Cultural Heritage		EXTR@Web paper (Freight Transport)
CITY PORTS	A City Net Following a Coordinated approach to Develop Feasible and Sustainable City Logistics Solutions	Interreg III – "Cross-border, Transnational and Interregional Cooperation"		This paper
eDRUL	eCommerce enabled Demand Responsive Urban Logistic	FP5 – IST – KA1 “Systems and Services for the Citizen”	www.edrul.org	This paper
FIDEUS	Freight Innovative Delivery in European Urban Space	FP6 - SUSTDEV-2 "Sustainable surface transport"		If reports become available
IDIOMA	Innovative distribution with intermodal freight operation in metropolitan areas	FP4 - TRANSPORT RTD - Transport Research and Technological Development		EXTR@Web paper (Freight Transport)
MEROPE	Telematic instruments for innovative services for mobility and logistic in urban and metropolitan areas	Interreg III – "Cross-border, Transnational and Interregional Cooperation"		If reports become available
MOSCA	Decision-support System for Inte-	FP5 - IST - KA1 - Systems and	www.idsia.ch/mosca	EXTR@Web paper

Sub-theme 4: Urban freight transport				
Project acronym	Project title	Programme	Project website	Coverage
	grated Door-to-door Delivery: Planning and Control in Logistic Chains	services for the citizens		(Freight Transport)
START	Short-term actions to re-organise transport of goods	IEE - Intelligent Energy Europe Initiative	www.start-project.org	This paper

Sub-theme 5: Efficient market place				
Project acronym	Project title	Programme	Project website	Coverage
-	Costs imposed by heavy goods vehicles	Project from The United Kingdom		EXTR@Web paper (Freight Transport)
-	Key performance indicators for non-food retail distribution (BG 77)	Project from The United Kingdom		EXTR@Web paper (Freight Transport)
-	Intermodality between high-speed rail and air transportation: linkage between networks and populated areas	Project from France		EXTR@Web paper (Intermodal Transport)
-	Market analysis in trans-Alpine freight transport	Project from Switzerland		EXTR@Web paper (Freight Transport)
-	Multi-modal freight model for distance-based HGV charging	Project from The United Kingdom		EXTR@Web paper (Freight Transport)
-	Truck aerodynamic styling (GPG308)	Project from The United Kingdom		EXTR@Web paper (Freight Transport)

Sub-theme 5: Efficient market place				
Project acronym	Project title	Programme	Project website	Coverage
COST 340	Towards a European intermodal transport network: lessons from history	COST – "European Co-operation in the Field of Scientific and Technical Research"		EXTR@Web paper (Intermodal Transport)
FIT	Assessing the potential for rationalising road freight operations (STP 14/6/11)	Project from The United Kingdom		EXTR@Web paper (Freight Transport)
HISPEEDMIX	High-Speed Freight on the European High-Speed Railway Network	FP4 - TRANSPORT RTD - Transport Research and Technological Development		EXTR@Web paper (Freight Transport)
RECORDIT	Real Cost Reduction of Door-to-door Intermodal Transport	FP5 - GROWTH - KA2 - Sustainable Mobility and Intermodality	www.recordit.org	EXTR@Web paper (Intermodal Transport)
TOOLQIT	Tools for the Assessment of Level and Quality of Service Across Different Transport Market Segments	FP6 - Research for policy support	www.tis.pt/proj/toolqit	If reports become available
WATERMAN-TS	Waterborne Traffic and Transport Management Technical Secretariat (thematic network)	FP5 - GROWTH - KA2 - Sustainable Mobility and Intermodality		EXTR@Web paper (Freight Transport)

Note. The projects listed in the Annex are those that have had the focus on the theme "Freight", as well as those who have addressed Freight as secondary topics to some extent.
On the TRKC portal (www.transport-research.info) it is possible to use the "advanced search" functionality – with the option "Freight" – and find all research projects, EU-funded and national, which have treated, to a variable extent, aspects that can be related to the theme.