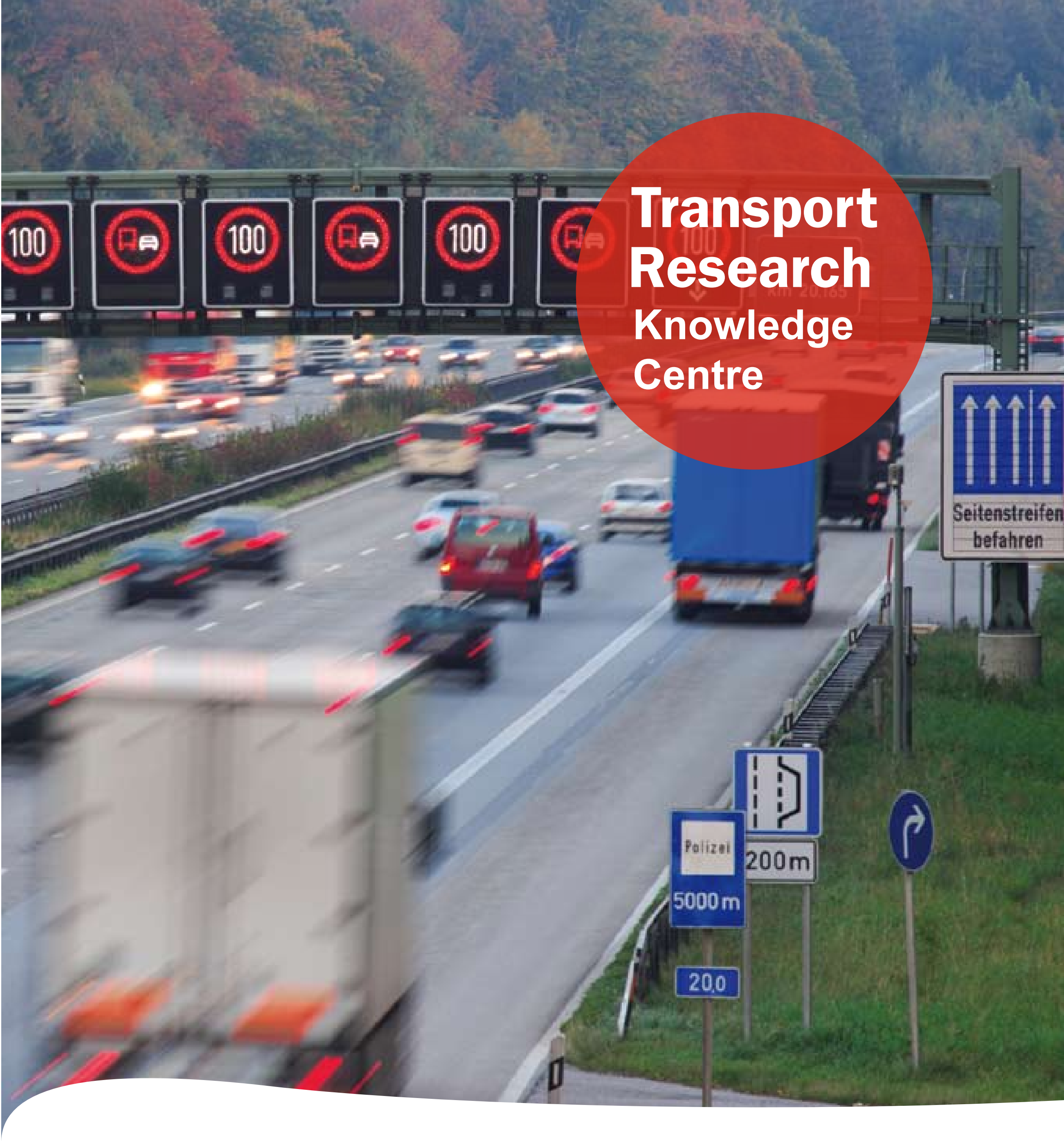


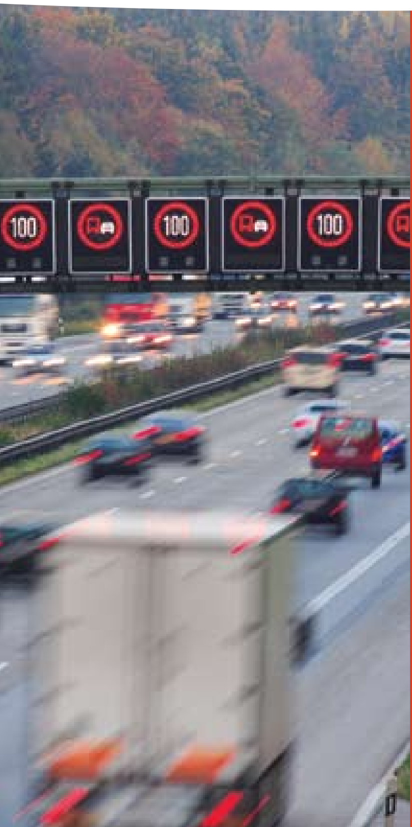
Transport Research Knowledge Centre

TRAFFIC MANAGEMENT FOR LAND TRANSPORT

Research to increase the capacity, efficiency, sustainability and safety of road, rail and urban transport networks

Directorate-General for Energy and Transport
EUROPEAN COMMISSION

Contents



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Additional information on transport research programmes and related projects is available on the Transport Research Knowledge Centre website at **www.transport-research.info**

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Executive summary

This Policy Brochure focuses on **traffic management for roads and railways** – the two main land transport modes in Europe. Traffic management has long existed in one form or another, from the early days of railway signalling or traffic lights on city streets, but the development and implementation of sophisticated integrated applications based on **Intelligent Transport Systems** (ITS) has grown apace in recent years, as a result of successful research and technological advances. This has been pushed by realisation of the need to manage transport networks more effectively in order to maximise the use of existing infrastructure, provide a reliable service to the end user and increase safety, while reducing negative environmental effects.

Urban and **interurban** traffic management research and applications are covered in this publication, including aspects such as network management, public transport priority, safety, punctuality and international traffic. As safety is a very broad area, it is only covered very selectively where it directly relates to traffic management, for instance speed management. Similarly, although infrastructure pricing is a form of transport management, it is a distinct topic and not covered in this Policy Brochure.

The focus is on recent **European research projects**, although some national initiatives have been included on a very selective basis where relevant and where information has been made available. Such a publication can only include a selection of projects; it therefore concentrates on those that contribute to policy goals. Considerable technical research and innovation also exists in the industrial arena, however, with many companies offering marketable solutions and devices for traffic management and control.

1

Traffic management: The scope of the topic

Traffic management is the planning, monitoring and control or influencing of traffic. It aims to:

- maximise the effectiveness of the use of existing infrastructure;
- ensure reliable and safe operation of transport;
- address environmental goals; and
- ensure fair allocation of infrastructure space (road space, rail slots, etc.) among competing users.

It is therefore an essential element in increasing the efficiency and safety of transport networks and operations.

This Policy Brochure focuses on traffic management for **land transport modes**: road and rail. The types of traffic management covered are limited to **strategic and operational measures**, as described below, and do not include pricing or ”softer” measures such as mobility management or traveller information services, although these can also be incorporated into a transport management strategy in order to influence demand.

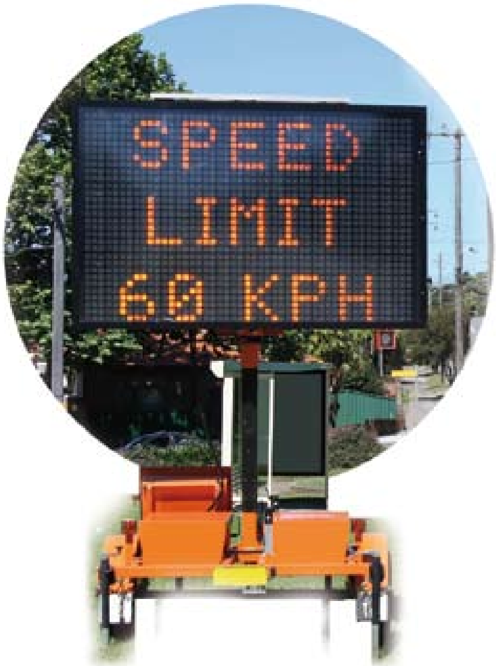
Management of traffic in the aviation and waterborne sectors follows very different principles and organisational and operational characteristics to land transport, and is therefore not included in this publication. Air Traffic Management, for example, is strongly controlled by both EU and international norms and procedures, and is covered in a parallel Policy Brochure on the SESAR (Single European Sky) Initiative (EXTR@Web, 2006a). Related publications in the same series, on Motorways of the Sea (EXTR@Web, 2006b) and River Information Systems (EXTR@Web, 2005), cover waterborne traffic management issues.

For **road transport**, tactical traffic management involves monitoring the actual traffic situation in real-time (including volumes, speeds, incidents, etc.) and then controlling or influencing the flow using that information in order to reduce congestion, deal with incidents and improve network efficiency, safety and environmental performance, or achieve other objectives. On a broader scale, strategic traffic management involves managing whole networks at a macro level (overall operational policy), as well as integrating or linking different networks. For **public transport** – whether by road or rail – the scope includes fleet management and timetabling, matching services and vehicles to meet demand and providing socially essential services while also fitting in with (or finding ways to improve) constraints caused by network capacity, driver shift patterns and technical aspects. Other aspects of **rail traffic** management exist on three broad operational levels:

- the bottom operational level of signalling systems and systems for train location;
- the intermediate level, consisting of the management of rail operations to enhance both the level of service to users and safety; and
- the higher strategic level, dealing with network access terms and capacity allocation.

Traffic management involves the allocation of infrastructure (road space or train slots on a railway network) according to **strategic operational and policy goals**. These include efficiency, safety, environmental, economic and equity objectives. In real terms, meeting them may encompass measures that include giving priority to buses, trams or other vehicles such as emergency services or high occupancy vehicles, increasing space available for pedestrians and cyclists, or providing shared road space. For rail, rules for market opening, network capacity allocation and pricing also constitute policy-level strategic management.

Traffic signals and **railway signalling** are perhaps the earliest form of ”intelligent” traffic management, aimed primarily at safety but also at managing priorities at junctions. The phasing and coordination of road traffic signals in urban areas via a control centre is still the most widespread tool for the



effective management of street networks. More recent applications of traffic signalling include dynamic lane allocation (for tidal flow, or reserved lanes for buses or other authorised vehicles) and ramp metering (signalised access control to motorways). Rail traffic management, and particularly signalling, is as old as rail operations themselves. Rail traffic, due to its own physical characteristics, is based on a controlled flow density, as opposed to road traffic, which is based on free flow. Rail signal systems therefore do not only protect junctions but also ensure safe spacing between trains running on the same lines. Some of them, in addition to transmitting information about movement to authorities and speed limits from track to train, can also effect automatic braking if the train ignores certain limits through Automatic Train Protection (ATP). In stations and yards these functions are realised by interlocking systems which ensure that trains run safely across the many conflict points.

While this level of control does not extend to road traffic management, recent road applications of Intelligent Transport Systems (ITS) add some functionalities which already existed for rail traffic, for example systems to manage inter-vehicle distance (primarily in tunnels) to maintain safe headways, or tidal flow schemes on highways which partially replicate the concept of bi-directional signalling on multiple track railway lines. Variable speed limits on roads can also increase both capacity and safety.

At an intermediate operational level, between stop-go signalling at the lower level and policy-oriented macro-management at the higher level, are the concepts of **routing and route guidance**. For both modes, the aim is to optimise capacity - including alternative routes - and direct drivers. For railways, systems range from a simple dispatcher, who coordinates traffic on a rail line, to Automatic Route Setting (ARS) which provides for the automatic setting of the desired routes when a train approaches a signal. These systems also include train location and conflict solving devices. Related aspects of rail traffic management include scheduling, as well as operation rules, in particular when it is necessary to optimise line utilisation.

While standard road traffic signs provide routing guidance, dynamic rerouting by road authorities on major interurban corridors is primarily done by Variable Message Signs (VMS), often coordinated according to different scenarios so that a series of coherent messages on different signs can be displayed according to the location and nature of any incident. Broadcasting, websites, text messaging services (SMS) and in-vehicle systems are also important telematic tools in this respect. The main difference is therefore that routing for rail traffic is highly prescriptive whereas for road users it is primarily informative.

2

Policy background: Environmental, social and global trends

The White Paper on Transport, the Lisbon Strategy and Trans-European Networks

Traffic congestion on major overland road and rail corridors and in urban areas, the need to improve the balance between different transport modes, and the needs to improve safety and mitigate the impact of transport on the environment are some of the key challenges set out in the European Commission's White Paper on Transport **"European Transport Policy for 2010: time to decide"** (CEC, 2001). Traffic management and control are key tools with which to address these problems, alongside infrastructure investments, transport pricing, regulatory and fiscal measures and smart transport applications.

More recently, the renewed **Lisbon Strategy** (CEC, 2005) highlighted the need to develop and improve economic and resource efficiency. This will enable a reduction in transport costs. Objectives of the Lisbon Strategy with relevance to traffic management include improved utilisation of existing networks, tackling congestion and increasing accessibility, developing urban transport opportunities, developing charging policies, increasing synergies between modes and improving logistics.

According to **"Keep Europe moving - Sustainable mobility for our continent"** (CEC, 2006), the mid-term review of the 2001 White Paper on Transport, there is no reason in the long run why sophisticated communication, navigation and automation should be restricted to aircraft and not be available to land transport modes, in particular road transport. The review expects that new technologies will provide new services to citizens and allow improved real-time management of traffic movements and infrastructure capacity use, as well as the tracing and tracking of transport flows. In addition to providing benefits for transport operators and users, new systems can provide public administrations with rapid and detailed information on infrastructure maintenance and renovation needs. Traffic management applications can increase the efficiency of networks, reduce the need to build new infrastructure, enhance driving and travelling comfort and also help to increase safety and security, as well as tackling wasteful and socially harmful transport patterns in the interests of environmental and social sustainability.

Approaching the end of the 10-year period of the 2001 White Paper on Transport, it is time to define a vision for the future of transport and mobility, preparing the ground for later policy developments. A reflection process identified six main trends that will shape the future of transport policy over the coming decades: aging, migration and internal mobility, environmental challenges, the availability of energy resources, urbanisation and globalisation. Accelerating the introduction of innovative technologies and the full integration of the different transport modes is crucial to meeting those challenges (CEC, 2009).

EU policy is to promote integrated traffic management and control on the **Trans-European Networks (TEN-T)**, which cover all transport modes, to enable them to fulfil their function of offering high-quality core networks and corridors linking all countries and regions of Europe. This includes Air Traffic Management and waterborne applications, outside the scope of this Policy Brochure, as well as open access and interoperability of rail systems, infrastructure and rolling stock, and integration of road traffic management and related services such as traveller information, payment and ticketing systems.

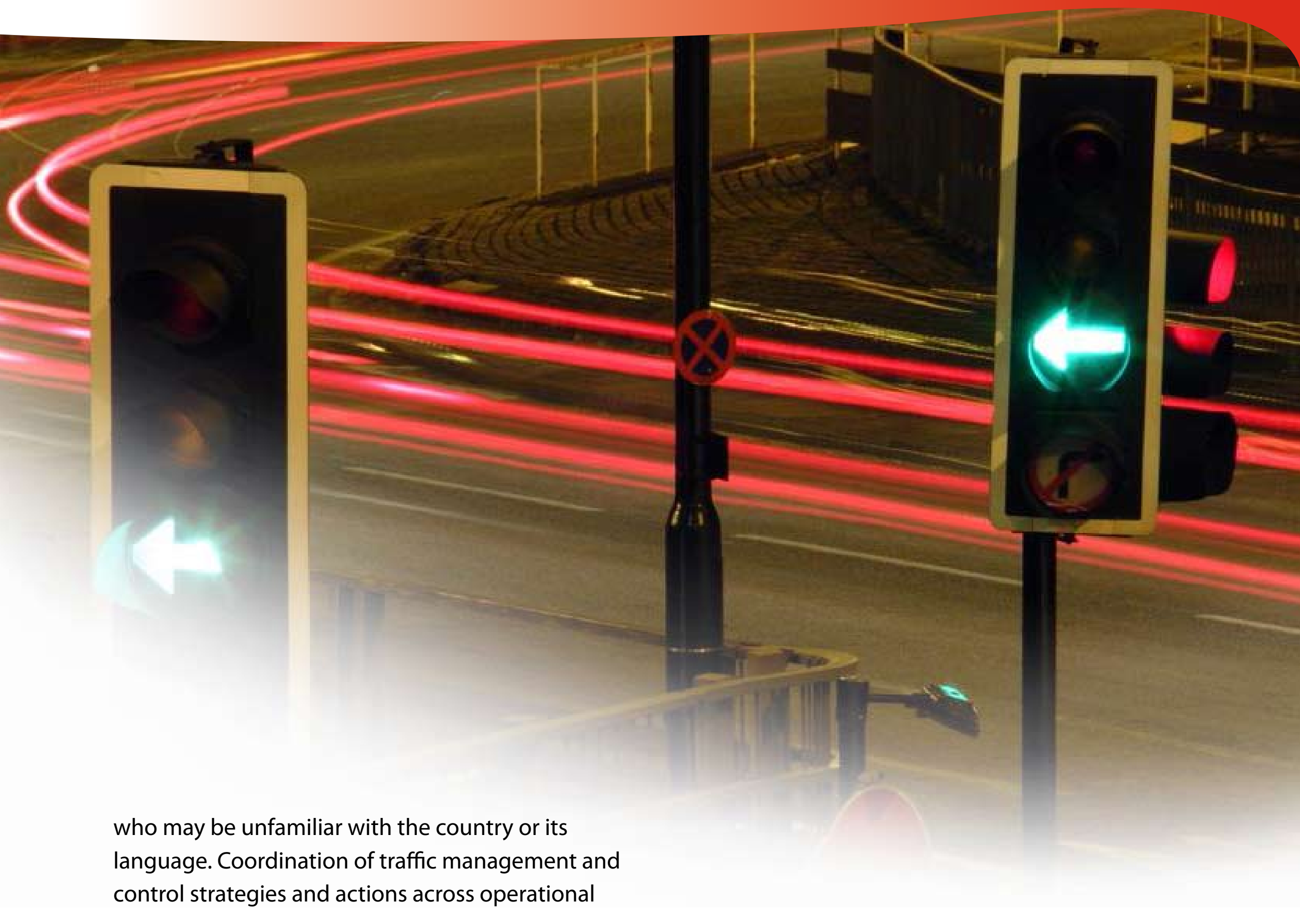
Road and urban transport policy: Local, regional and trans-European levels

Roads account for most inland passenger and freight transport in the EU. Road capacities in urban areas are reaching saturation or even 'gridlock' in some cities, while interurban passenger and freight transport by road is increasing as a result of socio-economic and political changes that are increasing personal mobility and intra-EU trade.

EU policy is to promote integrated traffic management services and traffic control on the key European roads and motorways which make up the **Trans-European Road Network (TERN)** – the road aspect of the TEN-T. The aim is to ensure that a similar minimum level of service is provided, that there is continuity of services such as information and road charging systems across borders, and that - where different services are provided - they should have a common "look and feel" so that they are, as far as possible, understandable to users

Intelligent Transport Systems (ITS)

Research and deployment of **ITS** are strongly supported at the EU level as a key tool for traffic management and control, improving safety and user services and reducing the environmental impact of traffic on the TERN, particularly at infrastructure bottlenecks. ITS applications for traffic management and control include rerouting using VMS, Variable Speed Limits (VSL) with automated enforcement, lane control, dynamic use of the hard shoulder on motorways or access control measures such as ramp metering, as well as specific measures for freight such as information on Heavy Goods Vehicle (HGV) parking and "stacking" of lorries in the case of disruption. Cooperative systems, whether vehicle-to-vehicle (V2V) or vehicle-to-infrastructure (V2I,) will play an increased role in traffic management and control in the future; coordination across countries and regions, as well as with vehicle and equipment manufacturers, is required in order for systems to succeed in meeting traffic management objectives.



who may be unfamiliar with the country or its language. Coordination of traffic management and control strategies and actions across operational and jurisdictional boundaries is an important part of the TEN-T policy, including coordination between Member States, but also within countries, for example between urban and interurban road network operators, road authorities in neighbouring regions or integration with other transport modes (park-and-ride, car ferries, etc).

Road-related traffic management research and implementation are supported at the EU and national level due to their considerable benefits in improving traffic flows, increasing safety and improving services to road users, for relatively little cost compared to that of building new infrastructure. ITS, for both urban and interurban road transport, was the subject of a recent EU policy initiative: the **ITS Action Plan** (CEC, 2008), which sets out a clear vision and proposes a roadmap for implementing ITS in a coordinated way in order to achieve seamless pan-European ITS services and contribute to efficiency, safety and environmental goals.

Traffic control in **urban areas** principally involves traffic signal management and coordination, congestion reduction, prioritisation and improvements to public transport. EU policy and action has historically been weaker in this area, due to the principle of **subsidiarity**, whereby Member States and their respective regional and local administrations determine local and regional transport policies. The EU has competence in setting or influencing transport policy at the trans-European level, both for road and rail, where there is "common European interest", but for the most part, tackling local and regional transport issues is not within its competence. The EU does, however, promote the study and exchange of **best practice** at local and regional level with respect to urban traffic and public transport management. The European Commission has recently become more proactive in this area by launching a **Green Paper "Towards a new culture for urban mobility"** (CEC, 2007).

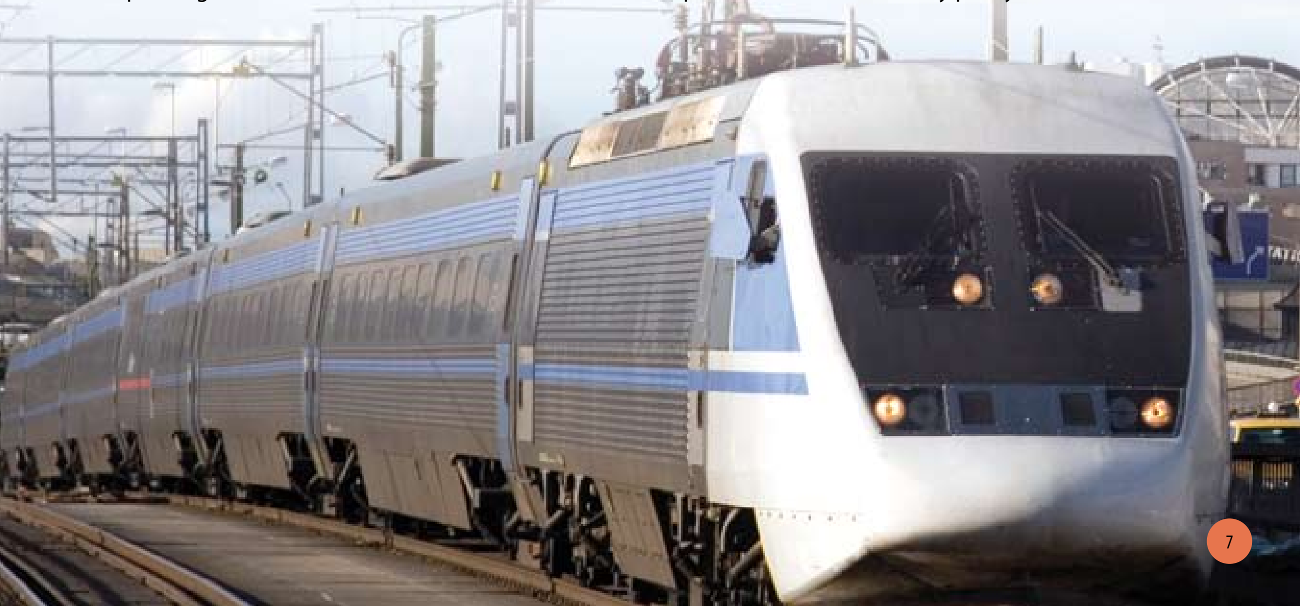
Railway policy: Open markets and interoperability

European policy has long promoted the use of rail in order to rebalance modal shift and encourage the use of this more environmentally friendly and safer transport mode. European rail policy has been developed in the last twenty years along two main lines: market opening and interoperability of European railway systems.

One aim has been to **open the market** for rail services, first in freight, then in passenger transport, and allow **competition**. This is expected to transfer more goods and passengers to rail, at a lower price and with better quality. The separation between infrastructure management and rail operation services has been supported since 1991 (Directive 91/440). This concept was further developed in the following years with the definition of criteria for licensing of railway undertakings and of principles and rules for network capacity allocation (Directives 95/18 and 95/19). Other milestones have been the **Second Railway Package** in 2004, opening the market for national and international rail freight services (Directive 2004/51), and the **Third Railway Package** in 2007, opening the market for international rail passenger services (Directive 2007/58).

Another aim of EU policy has been to reduce, and in the future to eliminate **technical and operational differences** among national railway systems and achieve harmonisation in terms of technical specifications for infrastructure, signalling, telecommunications and rolling stock, as well as certain operational rules. The concept of interoperability was introduced with the Maastricht Treaty which provided for the implementation of Trans-European Networks in transport, energy and telecommunications. The First and Second Railway Packages fixed the harmonisation of technical specifications for interoperability of lines, rolling stock and operational rules under the oversight of the European Rail Agency. The development of a European Rail Traffic Management System / European Train Control System **(ERTMS/ETCS)** has been a major effort in this respect.

Besides market opening and interoperability, but strictly linked to them, the EU has developed a common approach for railway **safety policy** (Directive 2004/49) which includes fixing a common base for safety indicators and safety methods, and consolidating the national safety authorities and safety regimes. The European Rail Agency is responsible for the implementation of this safety policy.



3

Research context: Data and tools for traffic management

Road traffic management

Road traffic management research at the **urban level** covers aspects such as intersection-based traffic management in urban areas, real-time traffic signal management and public transport priority. Elsewhere, the main requirements are research and experimentation in **tactical (ITS-based) traffic management and control techniques and more high-level traffic management strategies.** There are thus distinct approaches to traffic management and control at the urban and interurban level to reflect the different challenges faced. Chapter 5 therefore structures the research results for road transport to reflect this split.

With the increasingly widespread use of many traffic management measures the focus of research has changed in the last decade from, for example, "architectural" issues, such as methods with which to effectively monitor traffic and provide increased user information through extensive use of VMS and planning of management strategies, to issues involving **data acquisition and control or enforcement**. The more extensive the information available on the operational state of a network, and how it is changing over time, the more accurate and effective any management policy can be, through for example Variable Speed Limits (VSL) and Hard Shoulder Running (HSR); where choosing appropriate speeds and/or operational lane strategies may depend on fluctuations in traffic patterns which are not easy to discern and system effectiveness is conditional on being able to appropriately enforce speed and access.

Provision of adequate data for traffic management is particularly important in the **urban context** where the needs of passenger cars and freight are increasingly in conflict with those of public transport, and priority systems are required, such as Automatic Vehicle Identification and Location

(AVI/AVL) and Automatic Number-plate Recognition (ANPR), in order to ensure full use can be made of traffic management and enforcement strategies. Indeed existing Automatic Incident Detection (AID) measures can be supplemented by, for example, "probe" (or "floating") vehicle systems.

Additionally with Urban Traffic Control (UTC) systems becoming more flexible, traffic control strategies are now focusing on the fusion of real-time data while also addressing differing impact criteria such as emissions and noise in tandem with congestion. These strategies may increasingly be modelled in real-time through the use of simulation models, allowing proactive traffic management to be undertaken.

With an increasing number of traffic management and control techniques and products available, the place of traffic management within sustainable mobility itself is of vital importance. Indeed its use as a **transport planning tool** is now of increasing importance and this is the focus of research in itself. Another more recent focus is on the evaluation of traffic management measures and systems, both prior to implementation (cost-benefit and business case issues) and after implementation (actual contribution towards policy goals and lessons learned for the future).

Rail traffic management

In rail traffic management one area of research addresses tools used to enhance the availability of **paths and location of trains**. Tools include new concepts for timetable development and location systems for more reliable traffic management. Another area is the development of tools for business process reengineering aimed at companies working in the railway service sector.

- the identification and acceptance of common safety performance criteria;
- the implementation of safety management systems able to monitor the achievement of safety target levels;
- the development of a framework for harmonisation of safety assessment; and
- hazard mitigation approaches.

Investigation of how to increase **punctuality** also contributes to the availability of paths and to the improvement of service quality. **Safety and security**, in particular for mass transit, is another aspect of quality of service and is also part of traffic management. The main aim here is to prescribe and implement a common rail safety policy in Europe. This includes:

Another area of research relates to traffic management solutions for **international railway corridors**. A coherent management system needs to meet the requirements of increased network capacity for combined (national and international) and mixed (passenger and freight) utilisation, at the same time overcoming the traditional difficulties in harmonised infrastructure capacity management and access charging. Co-modality and intermodality aspects, such as rail traffic in ports and inland terminals, are additional research areas.

4

Research programmes: Focus on implementation

European programmes

Road and rail traffic management issues have been addressed in a number of EU research projects. However, given that traffic management and control is now very much a mainstream subject with many mature applications and widespread deployment, most research takes the form of the implementation of experiments and trial systems as a precursor to full-scale deployment. Pure scientific R&D is therefore much less common, with current and future implementations and improvements being guided by past experiences and the sharing of best practice on an EU and international level.

The **Fifth Framework Programme (FP5)** sub-programme on **"Competitive and Sustainable Growth"** (GROWTH) included several traffic management related projects within its key action "Sustainable mobility and intermodality". Results highlighted in this Policy Brochure cover speed adaptation policies on European roads (PROSPER), traffic management strategies for secondary road networks (SENSOR), allocation of rail capacity and charging on international railway corridors (PARTNER), measures for cross-border rail traffic (INTERFACE), business process reengineering in rail infrastructure management (IMPROVERAIL), and the development of a European approach to rail safety (SAMRAIL).

The FP5 **"User-Friendly Information Society"** sub-programme (IST) funded more technical traffic management projects, covering topics such as intersection-based traffic management and traffic signal management in urban areas (OMNI and SMART NETS) and bus priority strategies (PRISCILLA).

The **Sixth Framework Programme (FP6)** sub-programme on **"Information Society Technologies"** (Priority Thematic Area 2: IST) included projects on ramp metering (signal-controlled access to motorways – EURAMP), as well as projects on road safety and enforcement, which are related to, but not included in the traffic management theme.

The FP6 sub-programme on **"Sustainable Development, Global Change and Ecosystems"** (Priority Thematic Area 6: SUSTDEV) included projects on intelligent road infrastructure for traffic management and safety (INTRO), visions and strategic research agendas for road and rail research (ERTRAC and ERRAC respectively), and projects on interoperability for rail transport and intermodality, such as an action strategy for intermodal transport on the Brenner axis (BRAVO) and a project on management measures aimed at promoting international rail traffic services (NEW OPERA). This sub-programme also included InteGRail, a major project on integrating railway systems.

Research in the **Seventh Framework Programme (FP7)** is currently underway, therefore results are not yet available for this Policy Brochure. FP7 research relevant to traffic management is included in the sub-programmes on **"Sustainable Surface Transport"** and on **"Information and Communications Technologies"** (ICT). Relevant projects can be found on the Transport Research Knowledge Centre (TRKC) website, with links to the project websites for further information.

The **CIVITAS Initiative** started under FP5 and continued into FP6 and FP7, bringing together cities in different countries to research, implement and share urban transport and traffic solutions. CIVITAS I (2002-2006) comprised four projects under FP5 with actions in a total of 19 cities, CIVITAS II (2005-2009) is also made up of four projects under FP6, bringing together 17 additional cities. Five new FP7 projects under CIVITAS PLUS (2008-2012) include a further 25 cities.

From the mid 1990s the European Commission's budget line for **Trans-European Networks for Transport (TEN-T)** has supported a number of "Euro-Regional projects" to study and deploy systems on the TERN to improve traffic management and user services. EU support has focused on systems and services with European added-value, such as trans-European and in particular cross-border corridors. Due to this support there have been significant advances in cross-border traffic management and cooperation between neighbouring countries and road operators, for example cross-border Traffic Management Plans, which now exist in several parts of Europe. Most TEN-T funding, which is now channelled through the European Commission's **TEN-T Executive Agency**, is however oriented towards network expansion and improvements (for road and rail, as well as other modes), for example, through rail ERTMS implementation and studies for new or upgraded railway lines.

The **EUREKA Programme** co-funds numerous industrial R&D projects. One such project (covered in this brochure) was the TRAPOLO project on train location technology.

National research

Although the focus of this publication is on European research projects, some national research initiatives have been included on a very selective basis where relevant and where information has been made available.

At national level there are a wide range of government-led programmes that have provided funding for collaborative research on transport, from **PRIN** in Italy, **PROFIT** in Spain, **PREDIT** in France, **IV2Splus** in Austria and **FITS** in the UK, along with specialised major research initiatives in the Netherlands such as **TRANSUMO**, and research work undertaken by specialist industrial groups such as the European Association of Tolled Motorways, Bridges and Tunnels (**ASECAP**). Several national initiatives are coordinated across the European Research Area (ERA) through the ERA-NET projects, which are linked to FP6 and FP7. **ERA-NET Road** and **ERA-NET Transport** include activities related to traffic management.

National road and rail administrators and network operators throughout Europe also conduct or procure their own research to meet their traffic management needs, but this is mainly focused on developing, testing, deploying and monitoring software and other tools, as well as systems and operating practices. As an example, the French railway operator (SNCF) conducts traffic management research across four themes: network capacity, processing information to improve traffic management, safety and regularity of traffic, and efficient and prompt maintenance (SNCF, 2009).

5

Research results and benefits

This chapter looks separately at road traffic on the urban and interurban level, due to the different techniques and approaches adopted for both. Rail traffic management approaches are more integrated between local and intercity lines, so this area is covered in one sub-section. Finally, projects dealing with international traffic management issues are considered, for both road and rail.

Urban traffic management and public transport priority

Road traffic management in urban areas

An open model for network-wide heterogeneous intersection-based transport management (**OMNI**, 2003) demonstrated the feasibility of integrated deployment of advanced ITS and applications for urban street networks, overcoming the legacy constraints imposed by existing infrastructure. Research developed a network-wide intersection-driven model, able to achieve tasks such as managing information exchange among all the components of the model and monitoring the status of the fixed devices used to control traffic (local controllers, sensors and sub-systems). A related project, **SMART NETS** (2004), provided an easy-to-implement and easily transferable Urban Traffic Control (UTC) strategy. The performance of this system was evaluated in three cities and compared to the existing UTC systems in those cities. It was demonstrated that SMART NETS is a valid and credible UTC strategy.

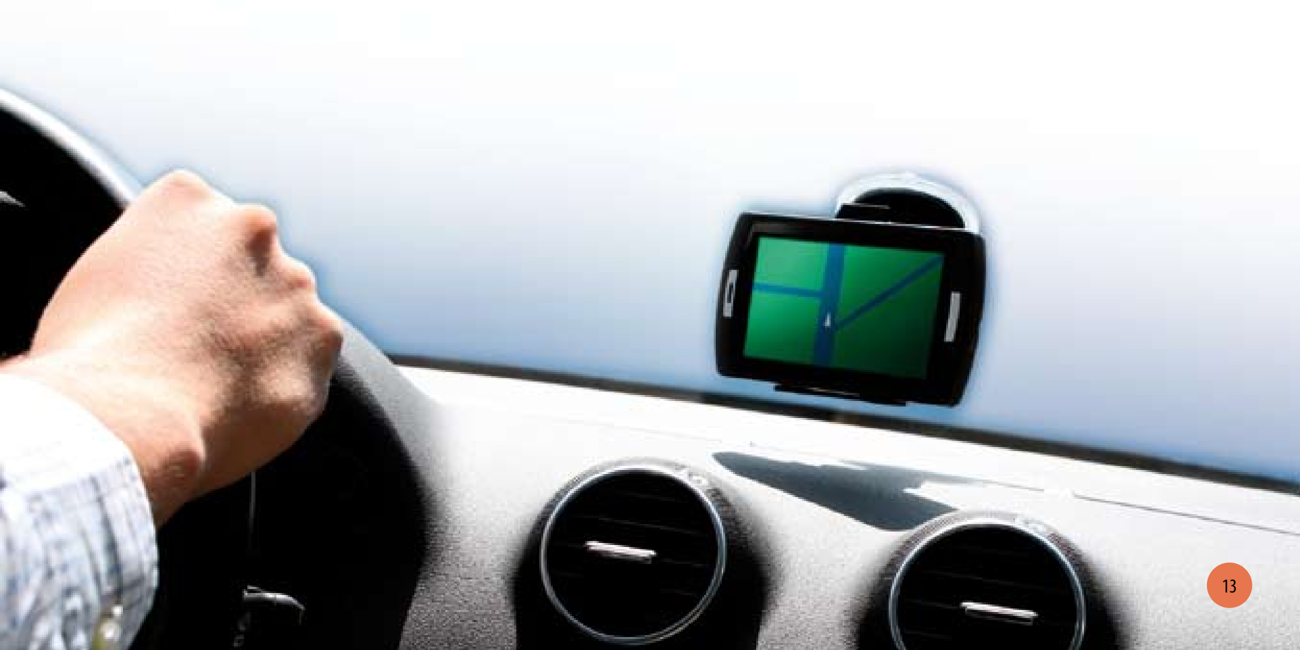
One of the most well established systems or protocols for traffic management in the UK has been **Urban Traffic Management and Control (UTMC**, 2006), conceived by the UK Department for Transport (DfT) in 1997, taking an open approach to ITS and aiming to provide cost-effective tools and solutions for urban traffic control that could not be achieved through the isolated proprietary products. The initiative has defined a set of standard components, communication protocols, interfaces and operation guidelines. Since then, a large number of traffic management solutions have been developed revolving around the standard and system architecture. In addition to network management and more efficient use of existing capacities, the UTMC approach also provides an integrated platform for addressing issues such as the environment, multi-modal transport, and traveller information, which are also an important part of transport policy. UTMC has now become the standard for UK local transport authorities to design and implement urban traffic management systems.

More recently in the UK the **Reading Area Transport Information Network** investigated the opportunities offered by emerging wireless communication technologies (e.g. WiMAX, WiFi and 3G) for better managing traffic flow on local networks. The project allows drivers to access the latest traffic information, either from their home or from their cars, helping them to better plan their journeys and avoid traffic jams (RBC, 2007). The project not only proved the concept of using advanced communication technologies to save costs and provide more reliable infrastructure, but also set an example of how local transport policies could be delivered through public-private partnerships without the exposure to commercial risks.

Traffic management measures themselves, however, can vary greatly, for example the **Travolution** project in Germany, developed by Audi and supported by the Bavarian Government, aimed at streamlining urban traffic flow through the interactions between cars and traffic lights to improve the fuel economy of vehicles. Following the successful test trials, Travolution is to be expanded to include more vehicles (Baker, 2008). Again, this shows how the private sector can be involved in helping to improve local transport policies.

On-street public transport priority

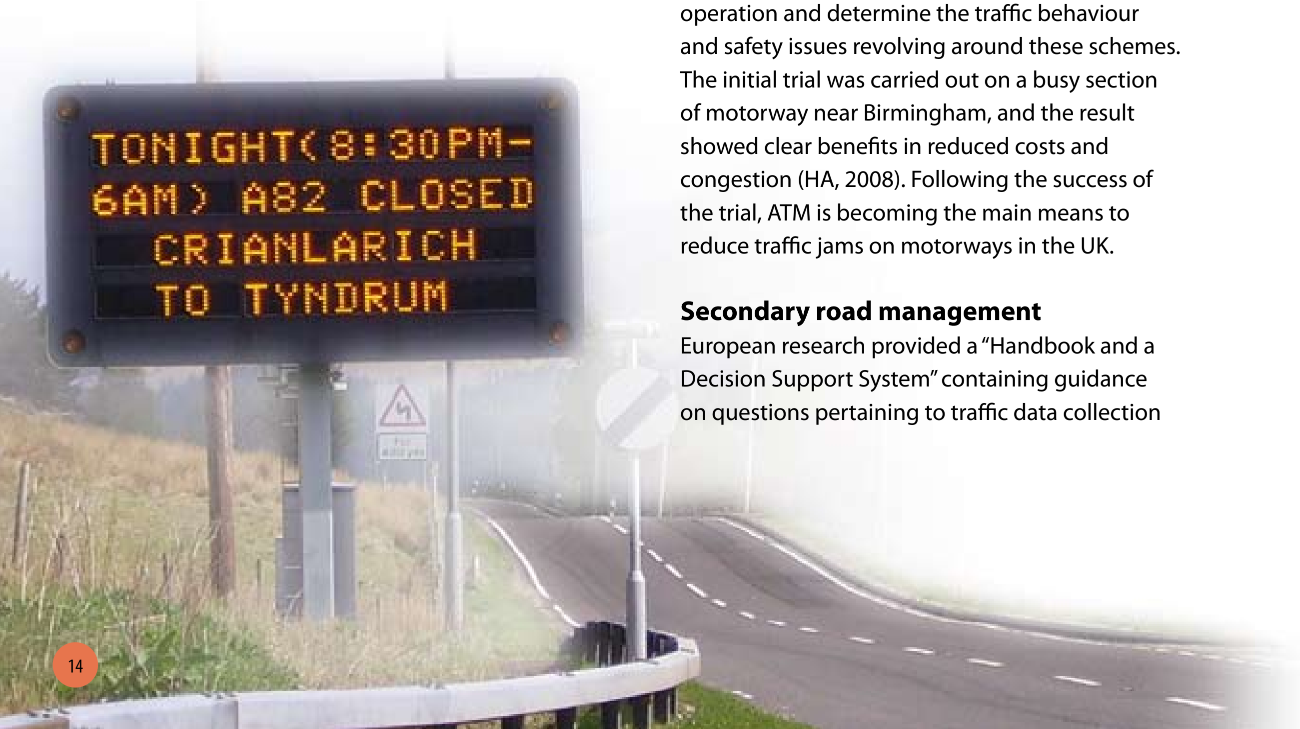
Research on bus priority strategies and impact scenarios (**PRISCILLA**, 2002) showed that the benefits of bus and tram priority strategies, in terms of travel times and punctuality, are favourable and deliver a real improvement in the service quality offered to users. An improvement in commercial travel time of between 5% and 15% can be achieved for priority given at traffic signals only. This improvement contributes to a modal shift in favour of public transport. In cases where UTC exists and buses or trams are equipped with Automatic Vehicle Location for providing real-time passenger information, the main tools for providing bus priority at traffic signals are already present. Different priority strategies can be adopted, for example allocating priority based on the punctuality of the bus or tram at the time. Bus priority strategies should however not only consider time savings at signals or through the use of bus lanes or bus gates, but also time lost at bus stops, and careful consideration of factors such as bus design and ticketing systems as well as bus stop location can speed up boarding and alighting at stops.



Tools for road traffic and safety management

Speed management

PROSPER (2006), studied speed adaptation policies for European roads, looking at how ITS applications for speed management, such as Intelligent Speed Adaptation (ISA), compare with traditional physical means in terms of efficiency, as well as the reaction of road users to such developments and future implementation strategies. Driving simulators and field experiments were used. It was confirmed that while physical speed management measures are suitable for spot-based speed reduction, they are inefficient in generating network effects. They should be seen as complementary to ISA. Safety and subsequent network management benefits are increased not just by reducing speeds, but by reducing speed variation: in this respect ISA can reduce accidents by 20-40% without increasing travel time. Reduced noise and emissions are other benefits of the system and user acceptance was positive, particularly among those who were given live experience of the system.



Tactical management for motorways

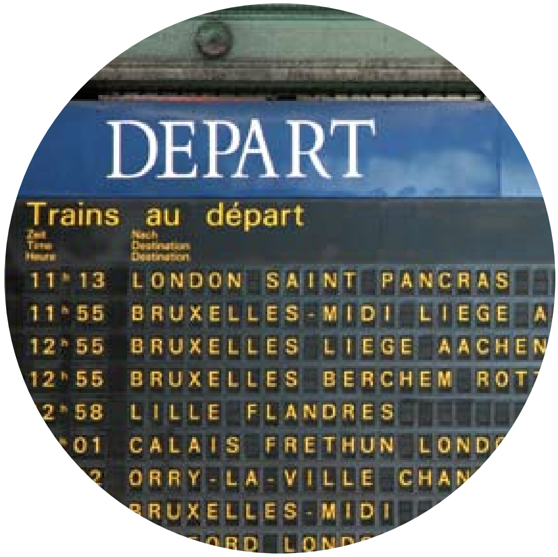
Ramp metering (motorway access control using traffic signals) was considered at four test sites as well as a "no control" situation (**EURAMP**, 2007). In two sites, the impact and socio-economic assessment showed that ramp metering could improve travel times and benefits over the "no control" base cases, with the best results showing a 17% reduction in congestion. However in one other case, delays on the motorway ramp outweighed the travel time benefits achieved on the motorway itself. Where benefits were achieved, they were high in relation to costs (cost-benefit ratios of between 2.2 and 10.3). A "Handbook of Ramp Metering" was also produced, targeted at those interested in designing, developing, implementing and operating such a system.

In the UK the Highways Agency's **Managed Motorways** project is developing the concepts of Controlled Motorways and Active Traffic Management (ATM) with considerable research currently being performed to optimise their operation and determine the traffic behaviour and safety issues revolving around these schemes. The initial trial was carried out on a busy section of motorway near Birmingham, and the result showed clear benefits in reduced costs and congestion (HA, 2008). Following the success of the trial, ATM is becoming the main means to reduce traffic jams on motorways in the UK.

Secondary road management

European research provided a "Handbook and a Decision Support System" containing guidance on questions pertaining to traffic data collection

system design on secondary (non-highway) roads (**SENSOR**, 2004). The project studied what data to collect, how, and where. This responds to the increased interest by local road authorities in traffic management tools which match their needs and budgets, and the exploitation of the results of this project is a process that can be carried out over the next decade, as the nature of the results enables the incorporation of new technologies without substantial additional effort.



Tools for rail traffic and safety management

Timetable planning and quality of service

INTERFACE (2005) developed a concept for integrated timetable planning, aiming at a single track international axis. The tool includes two approaches: one for short-term and one for medium-term planning. The short-term approach gives priority to one direction in some hours of the day. The dispatcher supervises traffic flows by simply coordinating station inspectors without directly managing the station interlocking systems. Conversely, the medium-term approach foresees the introduction of a centralised train control which provides the dispatcher with remote control of station interlocking systems.

The **TRAPOLO** project developed a Train Position Locator system based on an odometer or tachometer, a tag placed in the infrastructure and radio communication for interaction with different signalling equipment along the line. The system uses battery-free, low-frequency tag/transponder technology. Compared with existing systems the system developed has low costs for investment in hardware and software technology and low maintenance costs. It can lead to better utilisation of the existing infrastructure because of the possibility of upgrading and extension of the density of positioning at low costs. It is an attractive solution for low traffic lines, branch lines, or metro and urban rail systems.

In Sweden, **a study on railway punctuality** was conducted as a result of a slight tendency towards poorer punctuality in Swedish public transport in 2002. Increased use of capacity, which led to increased sensitivity to incidents and disturbances, was identified as the main reason for declining punctuality. Another reason was the lack of maintenance of both infrastructure and rolling stock. The potential for increasing punctuality by a system of bonuses and penalties was assessed. The interviewed operators showed interest in this approach and believed that incentive systems have a potential to be effective. The main problem of the existing incentive systems was reported to be the identification of the party responsible for the delay.

Rail infrastructure management

Business Process Reengineering (BPR) for railway infrastructure managers was addressed in the **IMPROVERAIL** project. It provided a roadmap for BPR which takes a holistic approach to the management of infrastructure. It covers functional and technical issues as well as the institutional issues between the infrastructure manager and other agents. The tool has identified representative processes in three areas: operational, commercial and managerial. The framework includes prospective network capacity management, short and long-term planning, life-cycle cost assessment for infrastructure investment evaluation, and railway infrastructure benchmarking.

In France, research by SNCF has developed several software tools for rail traffic management, including **Exalibur**, which is a prototype decision-support system to monitor and manage traffic in the event of disruption, **Lipari**, which is a simulation system to help manage networks nearing saturation, and **Demiurge**, a program designed to assist in making rail network capacity studies.

Research has also addressed the enhancement of interactions between terminals and the network. A demonstration was carried out in the Novara Intermodal Goods Centre at the border between Italy and Switzerland within the **INTERFACE** project in order to reduce train delays from the terminal to the rail network. It consisted of harmonising the interface of the information systems of CEMAT (the main intermodal operator at Novara terminal) and train operator Trenitalia, and creating a common wagon database. This measure, together with Integrated Timetable Planning (ITP), has produced positive impacts on train punctuality along the transport chain, capacity increase for intermodal transport on the line and at the terminal, and optimisation of transhipment movements at the terminal.

In another demonstration (**PROMIT** project) at the Bologna Interporto freight terminal, the implementation of an Intelligent Automation System (IAS) has permitted improvements to the management of traffic in the existing shunting system by minimising the number of wagon movements and maximising the number of trains operated within the terminal.

Safety management

The development of a Safety Management System (SMS) for European railways was the aim of the **SAMRAIL** project. The structure and requirements of the different elements of the SMS, such as safety policy, risk management and incident/accident reporting, have been specified and guidelines provided. The steps which could be taken by the European Commission and by the European Railway Agency to develop a SMS certification standard have been identified. A risk management approach has been proposed. The project also proposed the adoption of two types of safety targets: global targets for measuring performance of Member States and specific targets for measuring performance of individual railway functions.

Managing international road and rail traffic: Strategies and solutions

Trans-European Road Network (TERN)

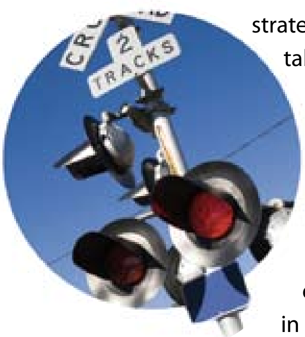
On the TERN, a series of "Euro-Regional" projects have developed coordinated traffic management, in particular in cross-border areas. This includes the **CENTRICO** project, which studied and implemented cross-border Traffic Management Plans (TMP) over major interurban routes between Belgium and the Netherlands, Germany, Luxembourg and France, and the **SERTI** project which researched and implemented trans-Alpine cooperation and traffic management between road and motorway operators in France, Italy and Switzerland. Data exchange between regions and countries has been a key element in international road traffic management, and standard language-independent protocols have been developed by all Euro-Regional projects using the DATEX II standard. Although the Euro-Regional projects, which are now part of the Europe-wide **EasyWay** project, are mainly focused on ITS deployment, a significant part of their work has been applied research and studies of systems and operational techniques.

Trans-European Network – Rail (TEN-Rail)

Solutions for efficient management of rail services on international corridors have been dealt with in the **NEW OPERA** project. The first concern was the increase in network capacity. The project also addressed the signalling and rail operation management systems needed to achieve a more homogeneous speed of trains as well as longer and heavier trains. The utilisation of new infrastructure for High Speed Trains (HST) together with former railway lines was considered as a means to remove existing bottlenecks and increase speed on the main European corridors. The project identified a range of management and bureaucratic barriers which interfere with optimisation and prevent the rail system from becoming one uniform rail space in Europe. Harmonisation in operating rules and in training was also tackled. Specifically on interoperability the project provided a cost-effectiveness assessment of ERTMS levels 1, 2 and 3.

The allocation of rail capacity on international routes, in particular for freight corridors, was the focus of the **PARTNER** project. First, state of the art European timetable planning together with the identification of user requirements and technical specifications were provided. A prototype, the PARTNER demonstrator, has been developed which includes a conflict detection module and a conflict solving part, with a capacity allocation module and a user interface using data standards according to RailML open formats. The project has shown that it is possible to achieve a better support in Infrastructure Manager (IM)-to-IM cooperative planning by use of more advanced methods for capacity allocation and consequent reformulation of track access fees, based on standardised European methods.

An action strategy to promote intermodality along the Brenner axis was developed and tested in the **BRAVO** project. The strategy centres around the development of a new corridor management scheme based on an open platform at the strategic level, consisting of a round table open to all stakeholders in the corridor (with the aim of coordinating infrastructure development, technical and administrative issues) and a restricted platform at operational level, that ensures quality management in daily operation. This approach is in line with the European policy goals of liberalisation and interoperability, and integrates infrastructure, technical, legal and operational aspects due to more flexible timetable management. Other aspects of the strategy are improvement in train path availability, promotion of use of interoperable locomotives, development of a corridor-based quality management system and a customer information system.



On the Brenner corridor BRAVO demonstrated that combined transport develops well if quality and efficiency is improved: a growth of 57% in unaccompanied combined transport was registered in the period 2003-2006. A factor for success was the close cooperation of intermodal operators and railway undertakings, including both incumbents and new entrants.

The **InteGRail** project has developed a new general platform for exchanging data between Infrastructure Managers and railway undertakings across Europe. This allows easy integration and management of different solutions and systems, and improves cooperation among rail subsystems as well as their performances.

This platform is middleware, providing a common interface between new applications and the existing network infrastructure. It can support many applications in key fields such as monitoring, system management and maintenance. Each application can exchange data with the others based on this common platform, both at national and international levels. In addition to the platform the project has developed several application prototypes. Among these are:

- the Traffic Re-scheduler, which allows the traffic manager to view planned and actual train timings and to reschedule selected trains in order to reduce overall disruption;
- the Operational Decision Support System, which provides a procedure to be manually or automatically executed when an unplanned event occurs; and
- the Infrastructure Availability Checker, a web-based tool which allows online access to a national IM's infrastructure database of actual and planned availability.

Overall, research on transport management in both modes has been primarily of a technical nature, including the development and testing of systems and strategies and fostering interoperability and open systems. Many road applications have been based around data management, an essential tool for traffic management, whereas for rail the timetabled structure of the networks means that the required data is generally available in an exploitable form. Interoperability, planning and path allocation issues are the focus of many rail projects. Many advanced traffic management applications (for both modes) are now technically mature and the challenge lies in fostering the implementation of the necessary systems on road and rail networks in a harmonised way.

6

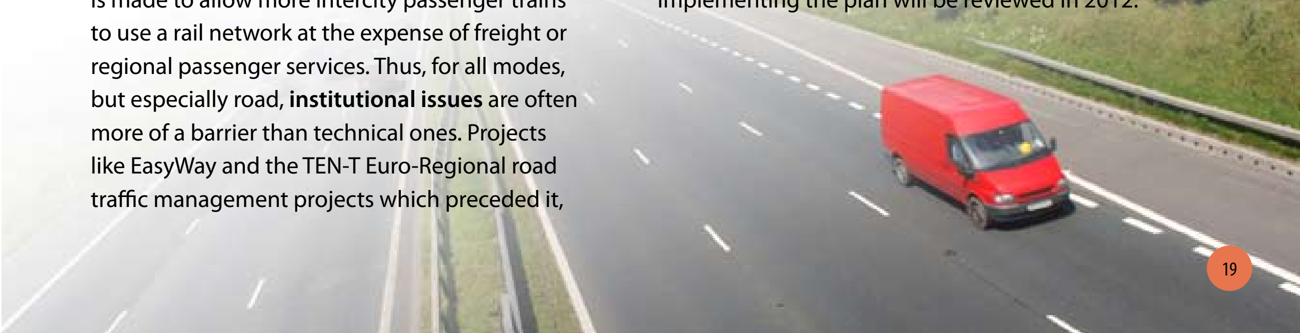
European policy implications: What to do now?

New innovative solutions are needed to reach the objective of sustainable mobility while reducing energy consumption and air pollution. In urban areas, for instance, **public transport priority strategies** can significantly reduce travel time and have been shown to encourage modal shift in favour of public transport, although buses or trams need to run at sufficient frequency to justify the business case for priority measures. **Cost-effective use of public money** is an issue clearly addressed by urban and interurban traffic management. Increasing the punctuality of public transport and the reliability of networks depends on providing an improved service level with the same system cost.

Many intelligent systems for traffic management depend on **data** having levels of accuracy, timeliness and coverage (both geographical and temporal) appropriate to the application. For example, despite the benefits and user acceptance of Intelligent Speed Adaptation (ISA), its deployment is hampered by a lack of Europe-wide coverage of high quality speed limit information and the absence of a functioning method for collection and distribution of speed limit information for cross-border applications.

Traffic management has some political implications, such as perceived discrimination against certain users, and public and political outreach is important in explaining the overarching benefits of management strategies adopted and gaining public acceptance. At operator level, there can also be conflicts, for example, if traffic is diverted from a motorway operated by one authority to a network operated by another or if a political decision is made to allow more intercity passenger trains to use a rail network at the expense of freight or regional passenger services. Thus, for all modes, but especially road, **institutional issues** are often more of a barrier than technical ones. Projects like EasyWay and the TEN-T Euro-Regional road traffic management projects which preceded it, have gone a long way towards addressing such institutional issues by deploying practical systems and services on a cross-border level, requiring close coordination between stakeholders. Such practical actions are essential in ensuring that research results can be implemented in a harmonised way in order to reap maximum benefits.

Nevertheless, many research and demonstration results in road traffic management have been at the national level, and even successful cross-border or regional implementations have not included a pan-European element, whereas this is present in the case of rail traffic management (ERTMS) or indeed traffic management for air or waterborne transport. The **European Commission's ITS Action Plan** (CEC, 2008) was thus borne out of the implications of past research in order to address **post-research implementation issues**. These include the current fragmented uptake of many research results, and the slow deployment of intelligent systems for traffic management and related applications, such as traveller information, safety, freight services, etc. Actions and measures are proposed in the plan for **short- and medium-term implementation of ITS** for clean, efficient, safe and secure road transport, as well as interfaces with other transport modes. It draws on research results as the 24 actions proposed in the plan cover areas where technologies and processes are sufficiently mature and interoperable to be capable of having a catalytic effect on road transport across Europe. The measures will be implemented by a range of actors, including the European Commission, Member States and industry, and progress made in implementing the plan will be reviewed in 2012.



In order to increase market share and competitiveness, rail transport needs to improve its level of service. As the transport sector becomes more international, deregulated rail transport in Europe should be able to take actions looking at the **EU dimension** rather than the national one. Research results have contributed to these high-level policy objectives.

A common feature of rail research projects with a significant policy implication is that they involve **several rail transport actors**. Therefore the projects have contributed to promoting cooperation among these subjects and between them and regulatory authorities, both at the national and European level.

Research relating to more flexible, responsive and accurate path allocation and enhanced coordination in timetable planning has contributed to the objective of increasing the capacity of the existing infrastructure. The tools proposed allow a better allocation of infrastructure capacity, **allowing for easier infrastructure access** and **reduced transport costs**.

One stream of research, which dealt with localisation and forecasting of traffic flows and flow simulations, contributed to the development of the concept of a **freight-dedicated rail** network where bottlenecks are overcome by harmonisation of operation rules. This concept is today an EU policy priority.

Other contributions have been offered on the development of **common technical standards**. Research helped to define an approach to develop common technical standards from existing practices, including consultation with stakeholders for a smooth migration from national to common standards. In the context of the development of the **common safety management system**, research proposed a rule management framework which can be used to set up and maintain operational safety rules. As an example, the framework foresees achieving a preventive consensus among involved organisations on accident scenarios and on hazards and risk assessment methods.

Research on Business Process Reengineering (BPR) has contributed to the enhancement of coordination between key railway processes. BPR allows **high standards of efficiency** in different components of the rail system. By making rail transport more easily available, affordable, safe and with a quality level that fulfils the needs of people and enterprises, it contributes to the achievement of improved European competitiveness and sustainable growth, as well as economic and social cohesion.

7

Future research developments: What next?

Traffic management is one of the most industrialised topic areas within transport research, comprising of industrial sectors with interests in infrastructure, systems and vehicles. For this reason R&D is increasingly led by industry and many advances are made as part of implementation projects, with management systems being researched, defined, and fine tuned as part of installation and service contracts. This means that this research area is very dynamic and fast moving, and will continue to be so.

Road Transport

Key examples of systems for road traffic management that are developing rapidly include Hard Shoulder Running (HSR), Section (or Average) Speed Enforcement and floating vehicle traffic information systems, which are now available commercially in many countries. Many of these systems are restricted in their effectiveness and transferability, however, by a lack of timely and accurate information or the ability to exercise suitable control over traffic. To that end there is a need for an increasing research focus on issues such as distributed sensing or "data nets" potentially using data fusion, or developing low cost sensor equipment. For example, in the UK these issues have increasingly been focused on by

- the FREEFLOW project, which generated transport intelligence in a proactive way through "intelligent decision support" (EPSRC, 2009); and
- the MESSAGE project, which investigated ways in which to allow vehicles and people to act as mobile, real-time environmental probes (Imperial College, 2009).

Increasingly, it is seen that traffic management can be implemented at a microscopic level (e.g. i2010) through the use of Cooperative Vehicle Highway Systems (CVHS). Information from vehicles could be used individually to provide accurate network conditions and aid in the detection and early warning of accidents and the selection of appropriate management strategies, with these implemented by giving early warning of network or road conditions ahead, so that vehicles will be able to communicate with each other and modify speed, headway and route in order to optimise conditions. On the other hand there are ITS projects on the infrastructure side, such as the FP7 project SARTRE (starting in September 2009), which will develop a vehicle platoon that targets operation on public highways.

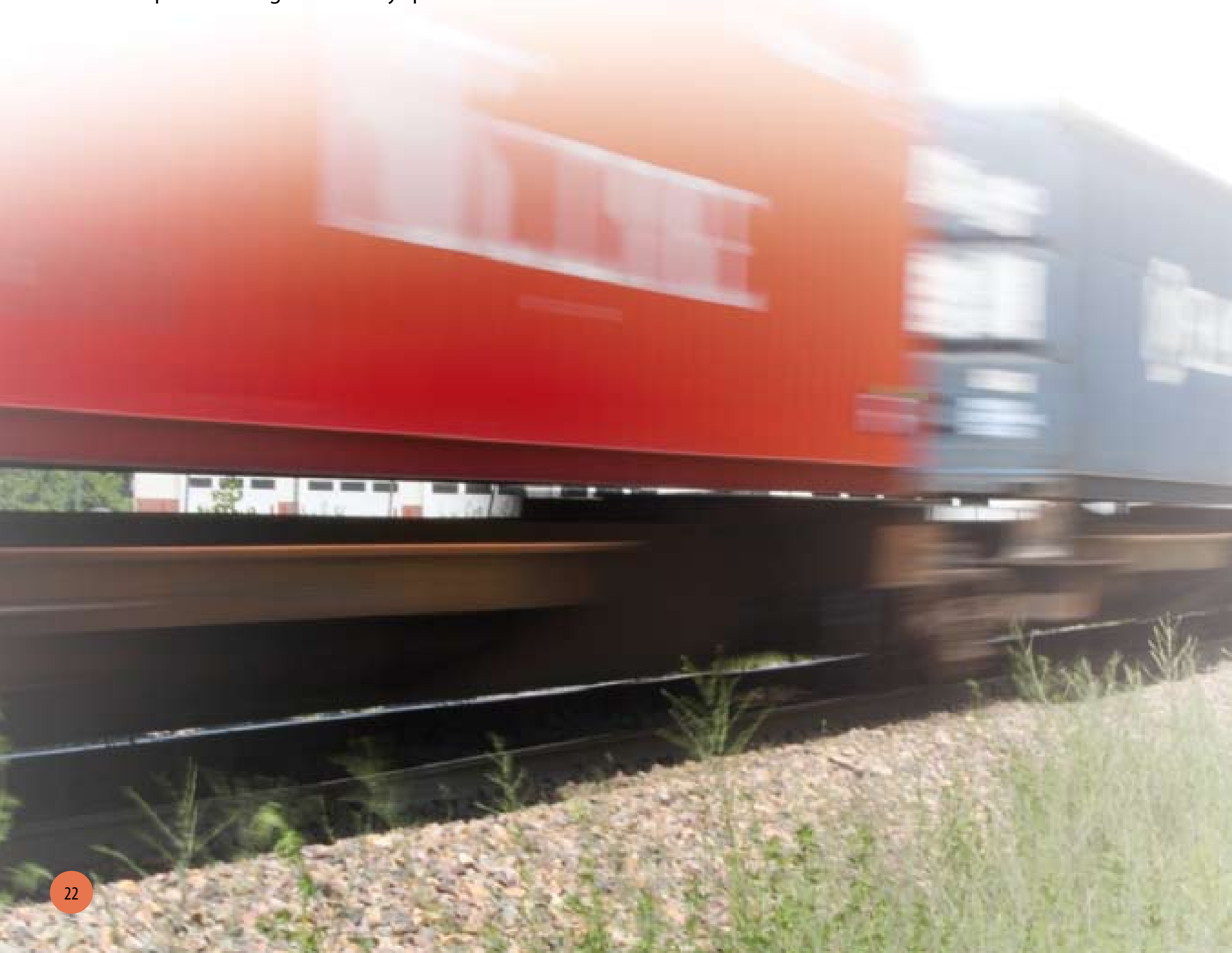
Rail Transport

One of the areas of the Seventh Framework Programme deals with interoperability and safety requirements. One particular aim is to develop specifications and hardware for European interlocking systems aimed at facilitating the introduction of ERTMS. The INESS project is addressing this.

Two technology-related areas deal with new concepts for interoperable rolling stock for European networks, which include information and communication systems, and innovative control and command systems for urban rail transit, with particular regard to safety specifications.

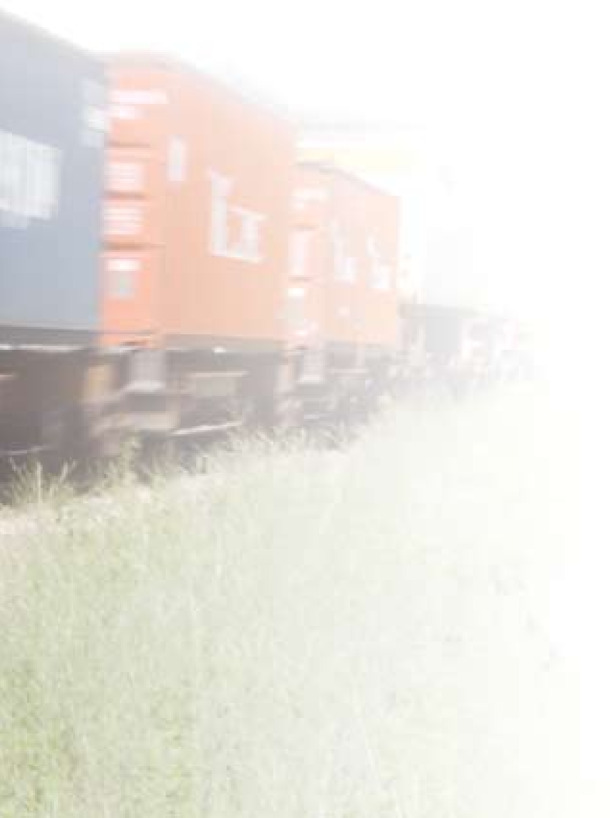
Another area relates to intermodality with the aim of integrating a freight-oriented rail network into logistics chains. This includes aspects such as information flow to the customers and monitoring and management of the quality of services. The KOMODA project within FP7 is currently addressing the issue of optimising the logistics chain through co-modality.

InteGRail has recommended research aimed at improving the standardisation process by developing agreements, rules and procedures for information exchange that can establish new organisational models.



Strategic Research Agendas

European Technology Platforms (ETP) were set up in response to the European Council Lisbon Summit. Led by industry, they aim to define medium- and long-term research and technical development objectives. Two such platforms relevant to this publication are the European Road Transport Research Advisory Council (ERTRAC) and the European Rail Research Advisory Council (ERRAC). Both organisations, supported under FP6, produced Strategic Research Agendas. Available on the respective websites (ERTRAC, 2004 and ERRAC, 2007), these cover a wide range of recommendations, many relevant to traffic management. Under FP7 these platforms are aiming to set their Strategic Research Agendas into action and to jointly develop roadmaps for research and technical development. Other platforms like the European Intermodal Research Advisory Council (EIRAC) and ERTICO - ITS Europe, put similar actions in place.



ERTRAC Strategic Research Agenda (Road)

The recommendations for further research in the road sector provided in ERTRAC's Strategic Research Agenda covered actions related to mobility, transport and infrastructure; safety and security; environment, energy and resources; and design and production. Traffic management related research topics proposed included: integration of vehicle and infrastructure systems; traffic management using ITS; data collection and processing; business models; optimisation of road space to ensure that vehicles (particularly HGVs) adopt routing patterns that minimise adverse impacts; systems for segregating traffic with dedicated infrastructure and prioritised traffic management; and methods to assist the booking of optimised slots for individual freight vehicles.

ERRAC Strategic Research Agenda (Rail)

Concerning rail transport, the ERRAC Strategic Research Agenda 2020 includes intelligent mobility, competitiveness and enabling technologies, and infrastructure as priority research areas related to traffic management. In the area of intelligent mobility, the main issues deal with the definition of new management techniques to enhance infrastructure use. These include timetable optimisation, new fleet management tools, and development of information systems, as well as harmonised information exchange between stakeholders in cross-border traffic. In the area of competitiveness and enabling technologies, priorities include the compatibility of on-board data collection systems and their integration with communication networks, as well as the analysis of passengers and traffic flows in order to reach a more efficient Europe-wide train path allocation. Finally, in the infrastructure area, priorities include the development of train control systems and new operational rules in order to optimise both capacity and service interchange.

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Glossary

3G	Third Generation (of mobile telephony standards)
AID	Automatic Incident Detection
ANPR	Automatic Number-Plate Recognition
ASECAP	European Association of Tolled Motorways, Bridges and Tunnels
ARS	Automatic Route Setting
ATM	Active Traffic Management (combination of hard-shoulder running, incident detection, variable speed limits and other measures integrated as a common system, as trialled and used in the UK)
ATP	Automatic Train Protection
AVI	Automatic Vehicle Identification
AVL	Automatic Vehicle Location
BPR	Business Process Reengineering
CEC	Commission of the European Communities (official title of European Commission)
CO_2	Carbon dioxide
CVHS	Cooperative Vehicle Highway Systems
DATEX II	European Traffic Data Exchange Protocol
DfT	Department for Transport (UK Government department)
ERA	European Research Area
ERTMS	European Rail Traffic Management System
ETCS	European Train Control System
EU	European Union
FP5 / 6 / 7	Fifth / Sixth / Seventh Framework Programmes on Research and Technological Development, funded by the European Commission
HGV	Heavy Goods Vehicle
HMI	Human-Machine Interface
HSR	Hard-Shoulder Running
HST	High Speed Train
ICT	Information and Communication Technologies
IM	Infrastructure Manager (rail)
IAS	Intelligent Automation System

ISA	Intelligent Speed Adaptation
ITP	Integrated Timetable Planning
ITS	Intelligent Transport Systems
R&D	Research and Development
SMS	Safety Management System (railways)
SMS	Short Message Service (mobile telephones)
SNCF	Société Nationale des Chemins de fer Français (French Railways)
TEN-T	Trans-European Network – Transport
TERN	Trans-European Road Network (= Road TEN-T)
TMP	Traffic Management Plan
TRKC	Transport Research Knowledge Centre
UTC	Urban Traffic Control
UTMC	Urban Traffic Management and Control
V2I	Vehicle to Infrastructure
V2V	Vehicle to Vehicle
VMS	Variable Message Sign
VSL	Variable Speed Limits
WiMAX	Worldwide Interoperability for Microwave Access

This Policy Brochure addresses the role of traffic management for land transport, which can be defined as making more effective use of existing infrastructure, for road and rail transport. It considers the need for traffic management from efficiency, environmental and safety standpoints, the role of data and information systems, new technologies, the evidence on their performance and limitations, and the implications for future policy.

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