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Cluster Report 6: Traffic Management and Control

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THE CIVITAS INITIATIVE
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Cluster 6: Traffic Management & Control



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1 Introduction

Traffic management and control systems have significant efficiency benefits for both public and private transport and therefore make an effective contribution to the sustainable city goals in CIVITAS. Management and control techniques have been evolving over many years, so the projects describe here include some innovative applications of existing techniques and some new developments.

The 25 measures within this cluster largely form into 2 main sub-groups:

- (a) Public Transport priority (9 measures)
- (b) Monitoring and Control (16 measures)

Table 1.1: Traffic Management and Control measures

City	No.	Measure Title	Outline Description	Success of implementation ¹	Success of outcome ¹
(a) Public Transport priority					
Genoa	12.5	Bus lane control system in Genoa	The use of fixed optical gates for bus lane control and enforcement – a camera to ensure that only buses use the lane	2	2
Krakow	8.3	Clean high mobility corridor	Implementation of tram stations with model character and introduction of environment friendly vehicles	2	-
Krakow	12.6	Public Transport priority system	Design study of 9 corridors with full PT priority	1	-
La Rochelle	8.2	Implementation of dedicated bus lanes	Creation of dedicated bus lanes and accessible bus stops	2	3
Malmö	12.7	Bus priority system	Implementation of Malmö bus priority systems at 42 intersections to improve public transport in the urban and suburban area	3	1
Suceava	8.8	Bus priority measures and other bus improvements	Implementation of supporting measures for improving PT conditions such as special traffic priority for PT, new GPS system for bus location and new public transport safety system	1	1
Tallinn	12.5	PT priority system	Implementation of a number of measures such as Automatic Passenger Counting, public transport lanes, priority signals for public transport, etc.	1	1
Toulouse	6.4	High-quality bus corridors and development of PT segregated and secured lanes in the city centre	Development of two High Quality Corridors on roadways and PT lanes in city centre	3	3
Toulouse	12.2	Implementation of bus priority scheme	Study and implementation of a new radio priority system	3	3
(b) Monitoring and Control					
Burgos	12.4	Traffic visualisation system	Implementation of new visualisation tools for assisting the task of controlling and monitoring traffic	1	3
Genoa	11.14	Monitoring centre for road safety & accident prevention	Implementation of an exhaustive multi-source data warehouse system, a set of elaboration and representation methods, and new methods of data gathering from the field	2	2
Genoa	11.17	Decision support tool for environmental impact assessment of traffic	An integrated set of tools based on simulation packages and models to evaluate the environmental impact of the traffic planning	1	2

City	No.	Measure Title	Outline Description	Success of implementation ¹	Success of outcome ¹
		planning measures	measures		
Krakow	11.16	Monitoring centre for road safety & accident prevention	A new and open system able to integrate the existing system (GestInc) and connected to an exhaustive multi-source data warehouse system of road accident and safety	1	
La Rochelle	12.2	Implementation of a common transport information data base	Creation of databases compatible with the Geographical Information System (GIS) in order to facilitate and optimise the monitoring and management of the public transport network	2	2
Malmö	10.2	Satellite based traffic management for SMEs	Implementation of a GPS based traffic dispatch system	1	1
Malmö	12.2	Traffic monitoring	Installation of an adaptive traffic signal control system (Utopia/SPOT) at 10 traffic signals in Malmö	0	0
Ploiesti	12.11	Development of a GPS system for the PT fleet	Implementation of GPS system on 250 public transport vehicles based on a common database and common communication protocol	3	3
Preston	12.6	Management and control	See 12.8	1	0
Preston	12.7	Data collection	See 12.8	1	0
Preston	12.8	Development of common database	The development of a Strategy Integrator which uses information with preset strategies as part of the Common Database (a single and standard database) to improve capability in detecting traffic incidents	3	1
Stuttgart	12.7	Event-oriented traffic management in Stuttgart	Development and demonstration of traffic control in case of events (e.g. sports event, incidents) for the strategic traffic network in Stuttgart	3	3
Toulouse	12.1	Demonstration of EGNOS/Galileo services use for the PT control and information system	Experimental measurements and analysis of current GNSS performances and simulation study over the urban bus network for GPS, Galileo and EGNOS	3	3
Venice	6.9	Electronic control of restricted access zone	Installation of electronic vehicle access control systems at optimal points for intercepting traffic along the main access points of the city	2	2
Venice	12.5	Satellite control (GPS-GPRS) for water PT services	Creation of a GPS-GPRS system which enables the location of all vessels for monitoring and communication between waterbuses and control centre and gives real time information to the public on board and at the waterbus stops	2	2
Venice	12.6	Management decision support system for waterborne traffic	Development of a dynamic waterborne traffic management decision support system as a prototype for the management and control of boat traffic circulation in the Venice lagoon in both ordinary and extraordinary situations	2	2

Note 1: Rating of success: 0=not successful, 1=moderately successful, 2=successful, 3=very successful

Table 1.1 also shows the ratings of success of the measures in relation to the implementation process and the outcome. The estimated ratings were made by the CIVITAS projects themselves and collected at the end of the project. In relation to other clusters, cluster 6, Traffic management and control related measures, is characterised by a moderately successful implementation process and an above average success of the outcome.

2 Implementation

Elements to be considered in the implementation processes are outlined and discussed below.

2.1 Public transport priority

- Definition of the network and corridors

For the definition of an overall network for prioritised public transport and high mobility corridors certain priority areas should be identified and analysed. There is the possibility to turn normal traffic lanes into reserved bus lanes or to define eco bus routes to be operated only by clean buses (e.g. when crossing residential areas). An example of dedicated bus lane is shown in Figure 1. Secondary routes of the network could be operated by minibuses when streets are narrow or the demand is less significant. There is the option of closing some road links and transforming them into one-way routes. It is important however to consult bus operators as they know the situation best and to take into account the special requirements of the bus route (e.g. vehicle size or bus lane alignment).

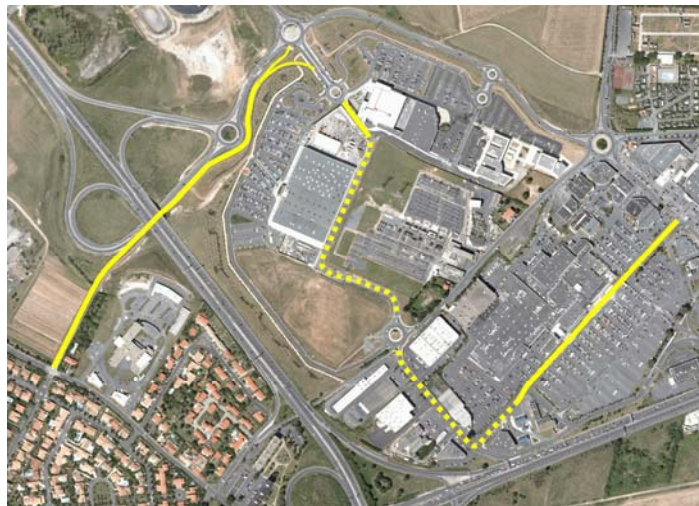


Figure 1: Dedicated bus lane (firm yellow line) route running through commercial centre at La Rochelle

- Consultations with stakeholders and negotiations with the municipality

Consultation with the public and other stakeholders is important to gain support for the measure, as e.g. shop-owners and retailers might fear a loss of their costumers. Negotiations with the municipality can identify existing plans and measures in this area and can provide the necessary support.

- Provision of infrastructure for priority and control systems

The goal of prioritising public transport is to reduce journey times and to ensure a certain regularity of the service for passengers. Basic measures on the road can be the building of roundabouts instead of unsignalised crossroads (e.g. measure 12.6 at Krakow). Crossroads with traffic lights can be equipped with a public transport priority system by either radio call at traffic lights or a loop priority system based on the activation of an electromagnetic loop under the road's surface. The provision of an automatic passenger count system on buses can be linked with these systems and prioritise certain buses according to their load factor. This is a valuable tool for providing system planning and management information, as well as for real time prioritisation of bus access.

If there is a control centre to supervise and manage the traffic in real time, the vehicles can be tracked by “road modules” or odometers (counting the distance travelled) or by using GPS. Traffic sensors along the route can provide data about the number of vehicles in a certain section.

CCTV can monitor the general traffic situation on road segments and congested junctions, so the control centre can react immediately and restore timetable compliance. The control of prioritised lanes and the fining of unauthorised vehicles on the reserved lanes are important to avoid misuse of the lane and can be done via gates and automatic vehicle monitoring systems (cameras) linked with the real time information, e.g. fixed gate for bus lane control at Genoa, as shown in Figure 2.



Figure 2: Fixed gate for bus lane control at Genoa

There is also the possibility to provide communication between buses based on GSM/GPRS technology, so that drivers can inform each other about incidents along the route.

- Improving passengers' convenience

E-ticketing equipment (electronic tickets, top-up of credit, on-board tickets, control and validation of the tickets, wireless network for communication regarding daily transactions, trip fees and lines) can improve passengers' convenience by allowing them a cashless, system-wide means of payment.

- Providing information for public transport users

The information for public transport users should be installed at the public transport station and on the vehicles themselves. Smart devices, such as real time variable message signs at bus stops, can show the remaining waiting time or current route changes. Static signs can indicate the frequency, time schedules, details of the route, points of interest in the area and possible interchange connections. Dynamic travel information devices on the vehicles indicate the next stop and general service information in both audible and visual formats. For example, at Tallinn, electronic displays and equipment for automatic stop-calls have been installed on public transport fleet. The automatic message for the name of the next stop and connections are given in audio format.

- Promotion and marketing of the priority system

It is important to promote the use of the corridors by wide media campaigns and door to door marketing activities (brochures, leaflets, etc.) to make people aware of their existence and purpose. The integration of P&R-facilities and existing public transport support measures in the concept can gain additional customers and further justify the project. Information boards on the vehicles and eco-route sign posts along the route can gain attention of road users and promote the (clean) public transport vehicles. An example is shown in Figure 3.



Figure 3: Onboard PT plans display at Suceava

2.2 Monitoring and Control

Within CIVITAS II a range of measures is included under the topic of “monitoring and control” including:

- The provision of a database by developing a common database and setting up guidelines for data collection (Preston, La Rochelle, Venice)
- The work on a satellite based traffic management system (Malmö, Toulouse, Ploiesti, Venice)
- The definition of an area-restricted or event-oriented traffic management system (Stuttgart, Venice)
- Management of traffic flows through adaptive traffic signal control to reduce traffic emissions (Malmö) and
- Monitoring traffic for road safety and accident prevention (Krakow).

The following implementation steps can be identified:

- Acquisition of basic data according to the target areas and objects of interest

By defining the area, the corridors, the routes as well as the road furniture of interest (La Rochelle) it is easier to restrict the analysis of existing traffic data dealing with traffic times and emissions, journey conditions and accident data. Existing traffic models and databases can support the process by allowing simple upgrading, updating or integration of the system for individual needs.

- Profit from and collaboration with existing control organisations

Collaboration with existing control organisations such as police (Venice), fire department, emergency services and public transport demands staff training and the production of a manual for daily and unexpected maintenance of the system. Awareness training with the existing staff is necessary, especially if the system has been enlarged.

In combination with a CCTV system, a synoptic panel can transmit the state of traffic in real time, allowing visualisation and identifying moving traffic offences. For such a measure, it is advised to set up a local working group or steering committee with the relevant stakeholders.

- Provision of a user oriented database and access tools

Once a database has been set up, it is necessary to ensure easy access for the different user groups. Sometimes it is helpful to allow up- and downloads for the users. Ensuring reliability of the data is particularly important. Such a database can support bus drivers for example by delivering real-time data about the traffic situation on a user interface.

If the database is combined with a geographical information system (GIS) it can be used as a tool for an operating transportation system by taking inventory of all bus and coach stops, geo-referencing relevant road furniture, entering characteristics of bus stops and various equipment surrounding each, providing information about accessibility and gathering statistics issued from telematics systems in the vehicles (La Rochelle).

The use of mobile terminals (mini PC) can require the preparation of new software and new architecture of an existing database (e.g. for the police department to record data about accidents such as traffic flow and speed, weather data, health information of people involved in the accidents). The data can be used for statistical analysis afterwards. The devices can be PDAs or tablet PCs with a GPS tool.

- Developing a GPS- based vehicle tracking system

One innovation is the adaptation of logistics software for public transport use. The implementation of fleet tracking and data management systems designed for small and medium sized enterprises can be achieved by installing computers with existing logistics programmes within public transport vehicles. The positioning can be done by GPS and is transmitted by GPRS to a transport control centre that shows the location of all vehicles on a map including the status of every vehicle of the fleet, its history,

current tasks, etc. The communication can work via PDA, which also handles orders or other information. The use of data can show the environmental impact and benefit of a co-ordinated transport system (Malmö). For the use of GPS it is important to identify the areas not available for signals (Toulouse) first. GPS has to automatically stop and start acquiring data without intervention from the bus driver or any other operator. In addition a 3D-model and visualisation can run simulations and can be used as a performance visualisation tool. A typical visualisation output is shown in Figure 4, where the measured and simulated satellite coverage was shown in close agreement.

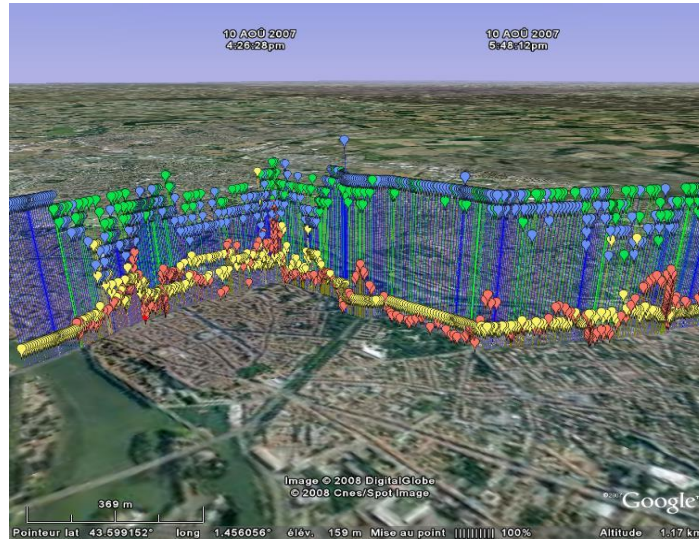


Figure 4: Comparison of number of satellites measured (green bullets) and simulated (blue bullets) at Toulouse

- Installation of necessary road infrastructure
Construction work may be required, such as the drilling and laying of cable pipes for the detector cables and the installation of other equipment, such as a parking and traffic guidance system or a lane signalisation system for traffic-actuated control of in- and outgoing traffic (Stuttgart).
- Information and promotion of the measure
Information for users can be provided by setting up an internet platform (e.g. in combination with a navigation system or an online carpooling system) or via broadcast and mobile networks (on-trip). Communication of the traffic-controlling measures can be made by display systems in the street space (guidance systems and collective traffic control at traffic lights). Cooperation with the local media from the very start of the project can help to set the correct goals of the project and can make the public transport user's opinions and wishes visible.
- Round table discussions and stakeholder meetings
The involvement of politicians, local organisations and public transport operators is essential to assure the successful delivery of the project.

3 Drivers and strategies to overcome barriers

The tables below show, by sub-cluster, the drivers (Table 3.1) and barriers (Table 3.2) encountered, as reported by the individual project teams.

3.1 Drivers

Drivers were asked about in an open question format. They were asked to be reported only if they were recognized as being more than what would normally be expected. To give a better overview and to compare the different measures with each other, categories have been created. A tick mark indicates that the specific driver was indicated at least once in the evaluation for the measure.

The drivers which particularly assist and strengthen the measures are outlined below. They particularly profited from acting according to current needs and meeting existing demands as well as from the commitment of political stakeholders and public involvement (see Table 3.1). In detail, the drivers were described as follows:

3.1.1 Public transport priority

- Acting according to the stakeholder's interests and needs

Regular passengers as well as people with short distance trips are interested in public transport measures and especially public transport priority. Prioritisation makes travelling by public transport much more attractive because of higher reliability. Without an increase in the number of public transport vehicles, mode switch and environmental benefits can be achieved.

- Existing plans and projects supporting public transport priority

Ongoing public transport measures can support the idea of improving linked public transport. The implementation of the measures in time improves reliability and service quality.

- Political support

Political support for the project is very often based on the willingness to improve the life of the citizens and to support the economy by reducing congestion to/from commercial areas.

3.1.2 Monitoring and Control

- Profit from existing experience and knowledge

Cooperation and exchange of experiences with other cities dealing with the same traffic (signal) control issues can support the project, as misinterpretations and misconceptions can be avoided. The knowledge of other stakeholders can also be expanded as they benefit from complementary skills and expertise. Linkage to existing developments can encourage the motivation of all stakeholders and provides political support and positive feedback from stakeholders and public.

- Information and promotion

Adaptive traffic signal control systems can reduce traffic stopping and traffic queues, reduce emissions and bring environmental benefits. To communicate these benefits for users and the environment it is necessary to hold workshops and regular stakeholder meetings e.g. to demonstrate the usefulness of the GPS system both for drivers (bus, trolleys and trams) and the public transport users. Furthermore the data acquired can be used for statistical purposes.

Table 3.1: Drivers

City	Measure	Driver related to above expected...				
		engagement / commitment of organisation or persons involved	experience and know-how of persons involved	support from outside the project team to implement measure	good structures / cooperation / management within project team	unsatisfying situation before and/or need to improve the situation
(a) Public transport priority						
Genoa	Bus lane control system in Genoa (12.05)	✓				
Krakow	Clean high mobility corridor (8.03)	✓				
Krakow	PT priority system (12.06)					
La Rochelle	Implementation of dedicated bus lanes (8.02)			✓		✓
Malmö	Bus priority system (12.07)					✓
Suceava	Bus priority measures and other bus improvements (8.08)	✓		✓		
Tallinn	PT priority system (12.05)	✓				
Toulouse	High-quality bus corridors and PT segregated secured lanes in city centre (6.04)				✓	
Toulouse	Implementation of bus priority scheme (12.02)		✓			
(b) Monitoring and control						
Burgos	Traffic visualisation system (12.04)				✓	
Genoa	Decision support tool for environmental impact assessment of traffic planning measures (11.17)				✓	
Genoa	Monitoring centre for road safety & accident prevention (11.14)	✓		✓	✓	
Krakow	Monitoring centre for road safety & accident prevention (11.16)		✓			✓
La Rochelle	Implementation of a common transport information data base (12.02)	✓				
Malmö	Satellite based traffic management for SMEs (10.02)			✓	✓	
Malmö	Traffic monitoring (12.02)					✓
Ploiesti	Development of the GPS system for the PT fleet (12.11)				✓	
Preston	Management and control (12.06)			✓		
Preston	Data collection (12.07)					✓
Preston	Development of common database (12.08)			✓		
Stuttgart	Event-oriented traffic management in Stuttgart (12.07)				✓	✓
Toulouse	Demonstration of EGNOS/ Galileo services use for the PT control and information system (12.01)			✓		
Venice	Electronic control of restricted access zone (6.09)	✓		✓		
Venice	Satellite control (GPS-GPRS) for water PT services (12.05)				✓	
Venice	Management decision support system for waterborne traffic (12.06)		✓		✓	

3.2 Strategies to overcome barriers

Barriers can often occur during the planning, installation and operation of measures, so being aware of the potential of such barriers and the means to avoid or overcome them is important. Measures dealing with public transport priority, monitoring and control dealt with acceptance issues, technical barriers and organisational difficulties (see Table 3.2) so the following strategies to deal with them were identified.

3.2.1 Public transport priority

- Round table discussions and stakeholder meetings

There can be a lack of support by the public and other stakeholders. Examples include motorcycle drivers (as they use the lane now reserved for public transport and are not fined), shop owners (as they fear the loss of customers) and local politicians who have to deal with dissatisfaction. Moreover, when streets are compact and narrow it is a political decision which transport mode to support and prefer. Public transport priority signals can affect and delay other modes of transport in the system, so it is necessary to provide information about the measure's goals and give the stakeholders the opportunity to speak their mind. The time between the consultations and the start of work should not be too long, as the stakeholders might lose their trust and refuse support.

- Setting up a schedule control group

Delays in existing projects linked to the measure, or problems with the tender process or delivery of products from various private companies, can delay the measure itself, it is necessary to have a control group in charge of keeping the time schedule and dealing with unforeseen problems.

- Providing alternative routing and by-passes during construction work

Due to intensive road constructions during the project phase, inconvenience can occur for other road users, so it is important to provide alternative routing and by-passes during construction work.

3.2.2 Monitoring and Control

- Round table discussions and stakeholder meetings

It is important to hold regular meetings with the stakeholders and the relevant departments to communicate the benefits of the project and to find common solutions acceptable to all stakeholders. The exchange of knowledge with the urban community can reach a high-quality and user-friendly final product.

The use of GPS may initially be rejected by drivers as it monitors the exact location and the drivers' activity in traffic. It has to be made clear though, that it supports the drivers in time-keeping and satisfying the public transport users. There is also a risk that departments may not want to use new equipment to collect data as they fear an increase of work. It is therefore important to ensure direct involvement of the departments and early training of key-personnel.

- Setting clear competences and responsibilities within the project team

As there are various project partners involved and the complexity of the database and system can be high, there should only be one person in charge of updating the database but all the operators should be involved to avoid lack or mix of data. In addition there should be training of the staff and users of the various systems.

- Acting according to technological possibilities

Where high-end technology is involved, the implementation can be planned over a long period of time (>10 years). The integration of the measure's conclusion and recommendations now and for future systems might not be possible. It has to be considered, that some technical issues can turn out to be more complex than expected.

- Stringent contractual conditions for quality, deadlines and budget control group
- Lack of financial resources can lead to postponements of important project steps that trigger further delays themselves. The lack of suppliers of the system technology can delay the start of the project with possibly serious impacts on stakeholder support. It has to be taken into account, that accompanying measures have their own timetables and their own constraints. It is therefore necessary to set up a budget control group as well as stringent contractual conditions concerning quality and deadlines.

Table 3.2.1: Barriers

City	Measure	acceptance barrier	delays during the project	financial barrier	institutional barrier	lack of labour resources	legal barrier	management barrier	market barrier	organisational barrier	political barrier	spatial barrier	technical barrier
(a) Public transport priority													
Genoa	Bus lane control system in Genoa (12.05)	✓					✓				✓		
Krakow	Clean high mobility corridor (08.03)			✓						✓			✓
Krakow	PT priority system (12.06)			✓							✓		
La Rochelle	Implementation of dedicated bus lanes (08.02)	✓									✓		✓
Malmö	Bus priority system (12.07)						✓						
Suceava	Bus priority measures and other bus improvements (08.08)	✓										✓	✓
Tallinn	PT priority system (12.05)										✓		✓
Toulouse	High-quality bus corridors and development of PT segregated and secured lanes in the city centre (06.04)	✓	✓		✓					✓			
Toulouse	Implementation of bus priority scheme (12.02)									✓			✓
(b) Monitoring and control													
Burgos	Traffic visualisation system (12.04)			✓							✓		✓
Genoa	Decision support tool for environmental impact assessment of traffic planning measures (11.17)									✓			✓
Genoa	Monitoring centre for road safety & accident prevention (11.14)	✓		✓									
Krakow	Monitoring centre for road safety & accident prevention (11.16)									✓			
La Rochelle	Implementation of a common transport information data base (12.02)	✓				✓		✓					✓
Malmö	Satellite based traffic management for SMEs (10.02)							✓		✓			✓
Malmö	Traffic monitoring (12.02)									✓			
Ploiesti	Development of the GPS system for the PT fleet (12.11)												✓
Preston	Management and control (12.06)												
Preston	Data collection (12.07)												
Preston	Development of common database (12.08)					✓				✓			

City	Measure	acceptance barrier	delays during the project	financial barrier	institutional barrier	lack of labour resources	legal barrier	management barrier	market barrier	organisational barrier	political barrier	spatial barrier	technical barrier
Stuttgart	Event-oriented traffic management in Stuttgart (12.07)			✓									
Toulouse	Demonstration of EGNOS/ Galileo services use for the PT control and information system (12.01)		✓							✓			
Venice	Electronic control of restricted access zone (6.09)	✓			✓					✓	✓		
Venice	Satellite control (GPS-GPRS) for water PT services (12.05)		✓		✓					✓			✓
Venice	Management decision support system for waterborne traffic (12.06)				✓					✓	✓		

4 Impacts

A summary of the outputs and impacts of the measures is given in Table 4.1.

Table 4.1: Achieved Outputs and Key Impacts for Traffic Management & Control measures

City	No.	Main Outputs	Key Impacts
(a) Public Transport Priority			
Genoa	12.5	15 fixed gates for bus lane control installed	Illegal transit significantly reduced; bus average travel time reduced slightly.
Krakow	8.3	Two "Model" tram stations built and strategies to improve PT security and safety implemented	Accessibility, safety and passenger service time improved at two model stations; average traffic speed at model stations reduced by 10 km/h as a result of adjusted street level to the height of platforms.
Krakow	12.6	Full priority for PT implemented on two routes	For the majority of the working day, PT running time decreased. About 70% of passengers felt that PT running times reduced after separated PT lanes implementation.
Toulouse	6.4	Two high quality corridors developed on RN126 and RN113	Substantial improvements on PT services in terms of travel time, reliability and comfort.
Toulouse	12.2	Radio priority system tested at two junctions; loop priority system equipment installed on the buses travelling on two high quality corridors.	Waiting time at traffic signals reduced by 52%; dispersion of bus travel time decreased by 3.5 points. Bus drivers have no difficulties using the system; attractiveness of bus to users improved.
Malmo	12.7	Introduction of bus priority system at 42 traffic lights	Bus priority increased bus travel speed without more delay for other traffic.
Suceava	8.8	Improve PT service, reduce traffic emission promote alternative fuel vehicles	Increase the number of PT passengers by 757%; the average delays of the bus trips reduced by 31.8%
Tallinn	12.5	A public transport management and control system was implemented, including traffic priority on 26 intersections and around 10km of PT priority lanes	Speed of public transport increased marginally by 0.1 km/h. the steady decline in the modal share of public transport has been halted in 2008
La Rochelle	8.2	Dedicated bus lanes equipped with rising bollard system and accessible bus stops implemented	Standard deviation of trip times significantly reduced although gains in travel times were limited because of the increase of length of the bus route and the addition of new stops.
(b) Monitoring and Control			
Burgos	12.4	New visualisation system added to control room	The quality of service and acceptance level expressed by the operators in the Traffic Control Room was very positive
Genoa	11.14	Monitoring centre of Genoa was created	Acceptance level for computerised accident data collection raised.
Genoa	11.17	A fully integrated decision support tool for environmental impact assessment based on simulation produced	Each tool of the platform has been validated and can be used to evaluate environmental impact of traffic planning measures.
Krakow	11.16	A new road safety monitoring system developed	Changes in road accident did not show a clear pattern.
Stuttgart	12.7	Incident management system, parking and traffic guidance system and lane signalisation system were implemented	Significant reduction of congestion in case of big events achieved.
Toulouse	12.1	Cartography of the performances of EGNOS system in Toulouse urban area tested and a Galileo performance simulation conducted	Simulation revealed that with the use of several constellations such as GPS and Galileo, GNSS receivers will be able to use about 15 to 20 satellites at anytime and in all parts of the city.
Venice	6.9	Tele-camera based access control at 12 control points established	Total vehicle volume decreased by 10% during peak hours between 2005 and 2008.

City	No.	Main Outputs	Key Impacts
Venice	12.5	GPS-GPRS systems were installed in waterbuses which enable the integration of the ACTV system with the City of Venice System	ACTV and municipal police joint operations centre came into operation.
Venice	12.6	A waterborne traffic management decision support system based on web-GIS technologies was established	Not defined.
Malmo	10.2	A satellite based GPS system for vehicle dispatches in SME	Task coordination increased slightly.
Malmo	12.2	Adaptive traffic control system installed at 10 traffic signals	Before-after comparisons did not shown significant changes.
La Rochelle	12.2	WIFI system for downloading bus on-board data implemented and databases on public transport compatible with GIS created	Not yet available.
Ploiesti	12.11	GPS system was installed on 169 public transport vehicles and integrated with the information management system	Quality of traffic information improved; the accuracy of time keeping by public transport improved.
Preston	12.6	See 12.8	See 12.8
Preston	12.7	See 12.8	See 12.8
Preston	12.8	"Strategy Integrator" function within the Common Database developed	Cost £185,421 between 2005 and 2008 Operators satisfied with functions.

The impacts of all the Traffic Management and Control measures are considered together under the main areas of economy, energy and environment, society and transport.

4.1 Economy Impacts

Costs for the implementation of Traffic Management and Control measures varied considerably from a few thousands to millions of Euros:

- The investment costs for "High Quality Corridor (HQC)" at Toulouse amounted to €1M (actual cost provided by SMAT), including €24.1M for one corridor (HQC113, 5.5M per km) and €26.9M for another corridor (HQC126, 4.1M per km).
- The costs for the development of a common transportation database were €75251 (average annual net present cost through cost analysis based on actual cost) at La Rochelle and about €37,000 (£33452) (average annual net present cost through cost analysis based on actual cost) at Preston.
- Implementation of dedicated bus lanes at La Rochelle cost €47,000 (net present value calculated using cost effective analysis (CEA)) per year.
- The development of a traffic visualisation system at Burgos cost €11769 (actual).
- The development of a GPS system for Public Transport fleet at Ploiesti cost €22760 (actual).

Total costs for the majority of measures are below €100k, which are determined by the nature of the measure and the scale of the implementation. For example, the cost for each on board unit of radio bus priority system at Toulouse was €2000. The total cost would then be determined by the scale of implementation: the more buses equipped, the higher the cost.

No direct revenues were generated from the Traffic Management and Control measures. In a few cases, economic benefits were achieved or projected as a result of the measure implementation. In Krakow where a public transport priority system was implemented, public transport ticket income increased from 7.52 EEK/vkm (0.481€) in 2005 to 8.31 EEK/vkm (0.531€) in 2008 (actual), an increase of 13.7%. The projected saving on the local economic cost of road accidents could reach €38M (projected) for the 'monitoring centre for road safety and accident prevention' at Genoa if a reduction of 40% of death and 20% of injuries within 2010 can be achieved.

4.2 Energy and Environment Impacts

The majority of traffic management and control measures focused on improving public transport services and traffic monitoring and information services. Despite this, energy and environment impacts were evaluated in a number of implementations. The environmental impacts of traffic management measures were very positive with significant fuel savings and emission reductions achieved.

Fuel savings achieved from two traffic management measures are shown in Figure 5. Bus priority and bus lanes resulted in fuel savings between 1.2~8% (measured). This was mainly caused by improved traffic conditions on the bus lanes and the use of alternative fuel buses.

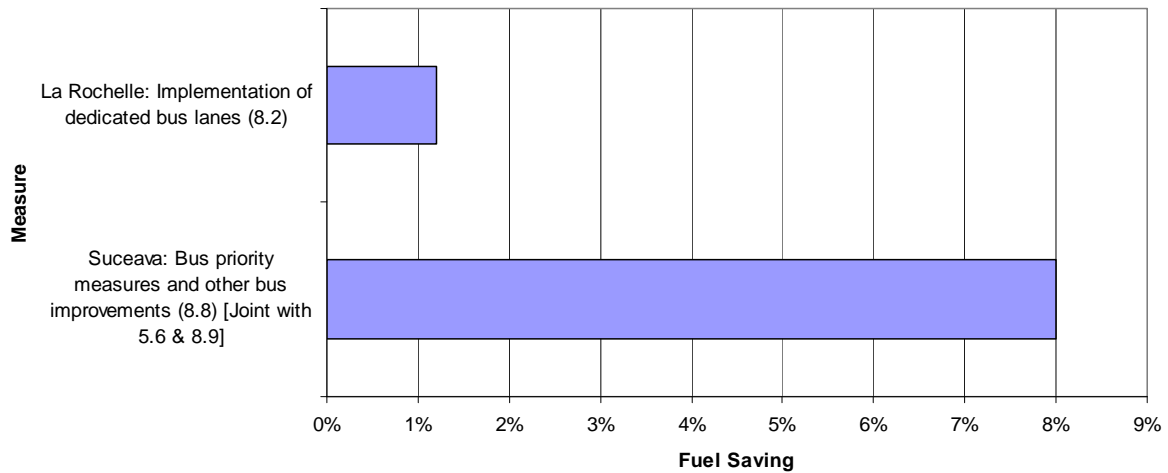


Figure 5: Fuel saving of Traffic Management Measures

Emission reductions from five traffic management measures are shown in Figure 6. Substantial reductions in CO₂, CO, NO_x and PM have been achieved as a result of the event-oriented traffic management measure in Stuttgart. The exemplary impacts were based on the management of out flowing vehicles from a stadium park at Talstrasse on about 20 big stadium events, where the waiting time at the traffic lights reduced from 1800 sec to about 30 sec due to the new measure (modelled).

Emission reductions from public transport (PT) priority and restricted access zone measures varied in different cities. The maximum emission reductions were achieved by Suceava bus priority and other measures, e.g. alternative fuel bus fleet measure. Modelling results of the implementation of PT priority system at Tallinn indicated substantial emission reductions per vkm of between 4.1% and 33.3%.

Implementation of the bus priority scheme at Toulouse also resulted in overall improved bus performance and reduced bus delays, bus fuel consumption, and bus emissions because of the relatively high priority given to buses, although these impacts were not quantitatively evaluated.

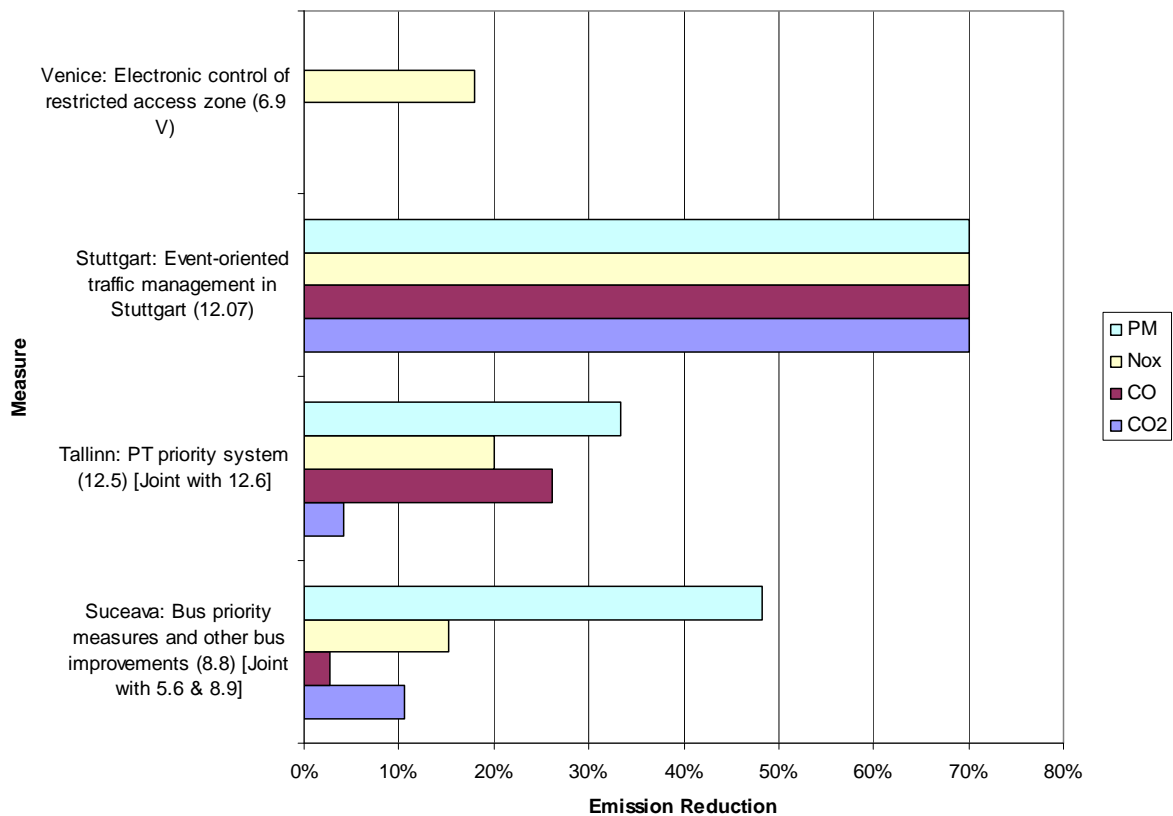


Figure 6: Emission reduction of Traffic Management Measures

4.3 Society Impacts

Social impacts were mainly evaluated using perceived awareness and acceptance levels by concerned user groups, obtained using surveys and interviews.

Awareness referred to whether concerned users or the public have perceived the existence of the new traffic management and control measures in question, whilst acceptance level refers to the degree of satisfaction with the existence and the use of the measures.

As shown in Figure 7, public transport priority measures (8.8, 12.5, 12.6) implemented in different cities all registered quite high levels of awareness and acceptance (survey results), particularly in Suceava where both the awareness and acceptance levels were above 80%. The monitoring centre for road safety and accident prevention measure in Genoa was also well perceived and accepted by policemen who formed the main user group.

The awareness for three traffic management and control measures, the development of GPS system for the PT fleet, the event-oriented traffic management and the traffic visualisation system, was below 20% (survey results). This was mainly caused by the composition of survey population. Unlike public transport measures which were visible to the general public and public transport users, these measures could not be seen directly by the general public so the awareness level would be expected to be low. However, it was felt that awareness for these measures among the general public is not crucial. The acceptance levels by operators for these measures were high, especially for the traffic visualisation measure, where 100% acceptance was achieved. Acceptance levels for the measure of event-oriented traffic management in Stuttgart were not available, so only the awareness level is depicted in the figure.

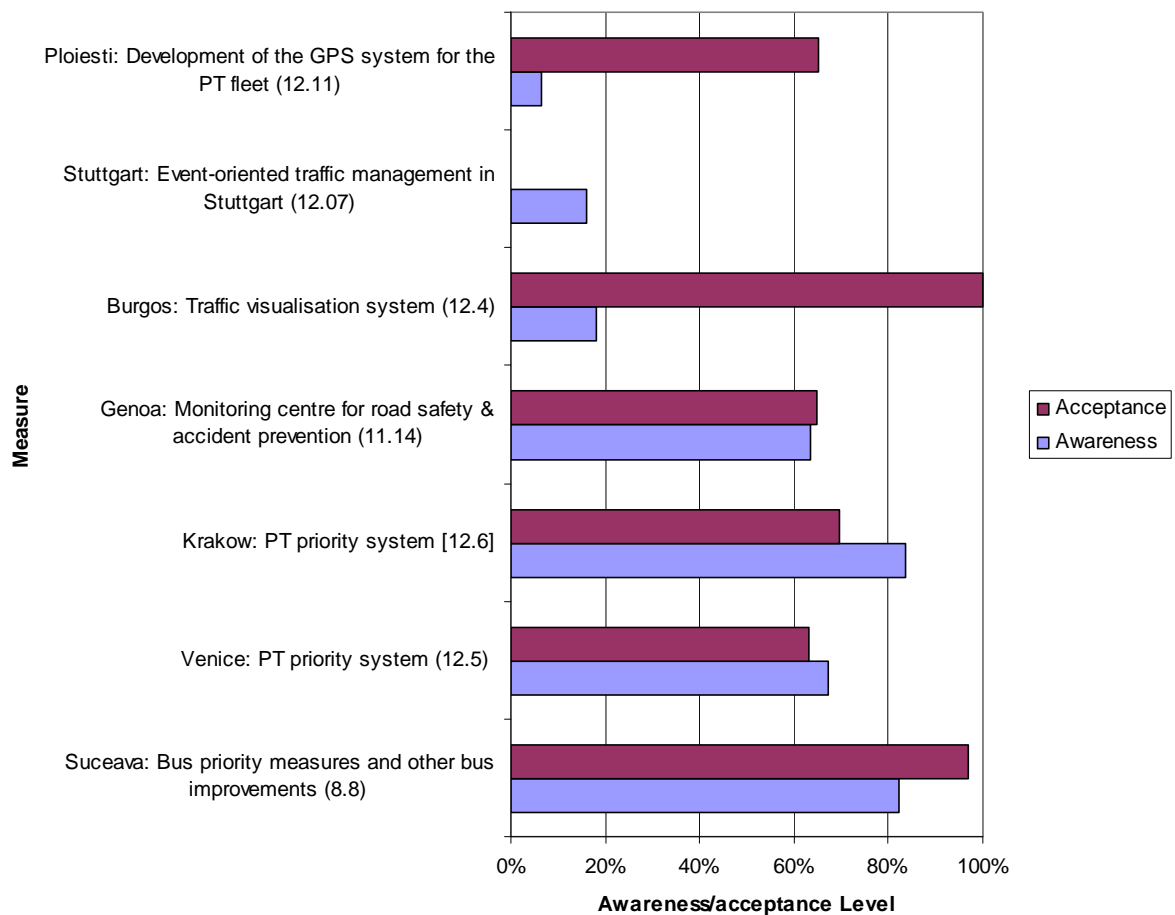


Figure 7: Awareness and Acceptance Level of Traffic Management Measures

4.4 Transport Impacts

The most important objective of traffic management and control measures is to improve traffic operation and transport service. Therefore a key aspect in the evaluation is the extent to which traffic management and control measures have changed transport operation (e.g. travel time and speed) or the transport service (e.g. public transport punctuality). A wide range of indicators has been used across different projects to quantify transport impacts, the most common being travel time and accuracy of PT time keeping.

Significant PT travel time reductions were achieved in nearly all PT priority measures, as shown in Figure 8. This is expected as the key objective for PT priority measures is to improve travel speed. The most significant travel time reduction was achieved in the high-quality bus corridors in Toulouse, more than 25% (measured). Other measures involved either public transport lanes or public transport priority systems, and substantial travel time savings were achieved, ranging from 3.5% in Malmo to 16% in Toulouse (measured). Increases in PT speed were also achieved from most of these measures, but to a lesser extent because PT travel times included travelling times and stop times at signals and stops. Overall, impacts on travel time were very positive for these measures.

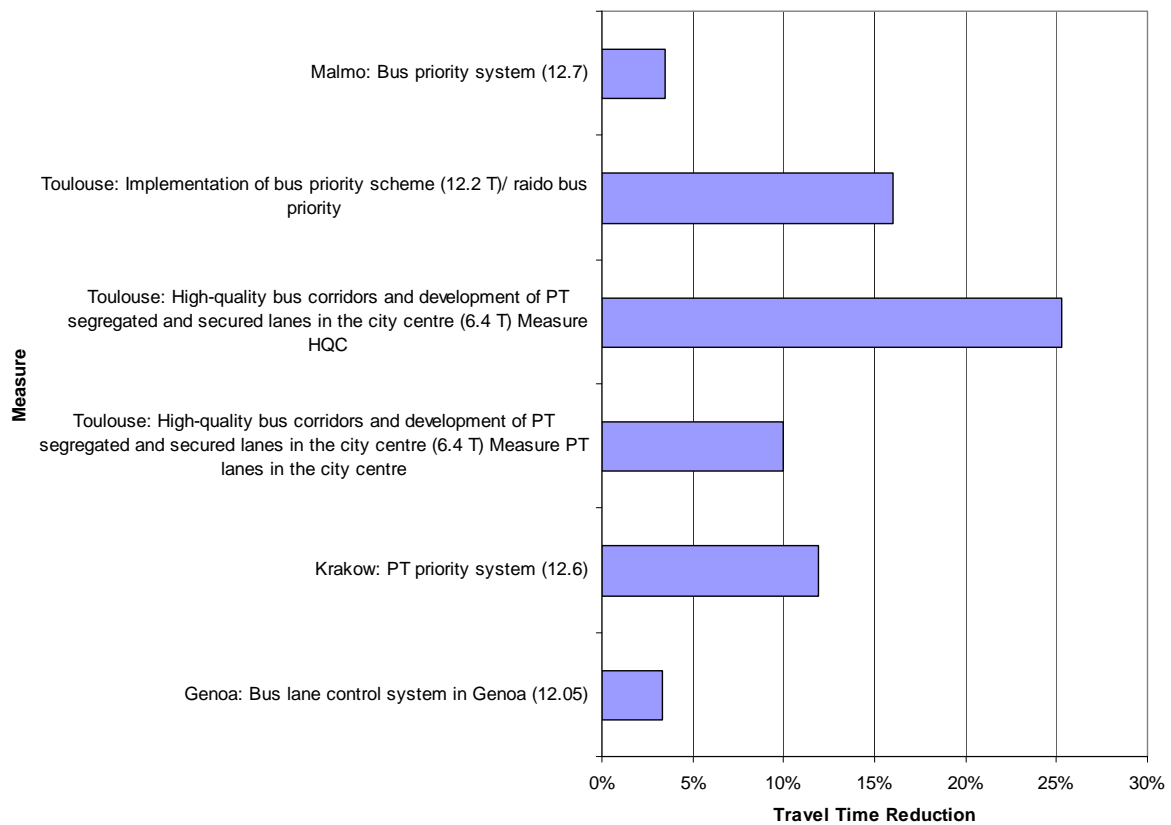


Figure 8: Travel Time Reduction with Traffic Management Measures

Impacts on travel time from other traffic management measures were more varied. Whilst very substantial travel time reductions were achieved by the event-oriented traffic management measure in Stuttgart, the implementation of traffic monitoring and traffic signals at Malmö had actually resulted in increased overall travel and stop times. The possible cause of the latter was that during the ‘after’ evaluation period the traffic signal systems (SPOT) were not fully operational and it could take weeks or even months for the adaptive signal control system to reach optimal state. In Ploiesti, the GPS system for the PT fleet did not generate statistically provable travel time improvements, mainly because the measure was aimed to facilitate information provision so had little impacts on travel time of PT fleet.

Table 4.2: Impacts on Travel Time of Traffic Management Measures

Measure	Impacts on travel time
Event-oriented traffic management in Stuttgart (12.7)	Waiting time reduced by about 8min at approach road 2, at approach road 4, increased by about 30-13 sec; at approach road 3, reduced from 1858 to 25 sec. incident management system reduce travel time by approx. 7000v-hours per year (modelled).
Traffic monitoring and traffic signals (12.2)	Increased; stop times increased;
Development of the GPS system for the PT fleet (12.11)	Not statistically provable, shows a decrease of trips delayed

One of the most important indicators for the quality of public transport services is the accuracy of PT time keeping. Evaluation results on PT punctuality were generally positive for PT lanes and priority measures, as shown in Table 4.3.

At Suceava, bus priority measure and other bus improvements significantly reduced the percentages of services delayed. The percentage of delayed services, defined as delays of more than 2 minutes compared to timetables at the moments of arriving/departing, was reduced from 13.09% to 8.9%, representing a 31.8% reduction (measured). In Toulouse, variance was reported to have been reduced by 4.6% between before and after the implementation of the PT lanes (measured). Slight improvements on PT time keeping were also observed as a result of the bus lane control system in Genoa, 0.8% increase in punctuality (measured).

Table 4.3: Accuracy of PT time keeping (Punctuality)

Measure	Accuracy of PT time keeping (Punctuality)
Bus lane control system in Genoa (12.05)	Increased by 0.8%
PT priority system (12.6)	Improved slightly
High-quality bus corridors and development of PT segregated and secured lanes in the city centre (6.4)	Dispersion reduced by 4.6%
Bus priority measures and other bus improvements (8.8) [Joint with 5.6 & 8.9]	Average bus delays improved by 31.8% from 2006 to 2008
Implementation of dedicated bus lanes (8.2)	Improved

In more than one measure, safety impacts were evaluated, and results are summarised in Table 4.4. Overall, observed impacts are positive. For example, perceived PT safety increased by 5% as a result of the clean high mobility corridor at Krakow, and the development of PT segregated and secured lanes in the city centre of Toulouse started to reduce accidents on PT lanes (survey results). However, in Krakow, mixed results of decreased number of total accidents and increased number of fatal accidents were reported following the implementation of the monitoring centre for road safety and accident prevention (recorded). This may be explained by the complex nature of traffic safety. The observed impacts might be only in the small part connected with the measure implementation, and much more time than the evaluation period would usually be required to understand the longer term impacts. This may also explain why safety impacts were only evaluated in a small number of measure implementations and solid conclusions might be hard to reach.

Table 4.4: Safety Impacts

Measure	Impacts on safety
Clean high mobility corridor (8.3)	Passengers' evaluation of PT safety has increased by 5%
Development of PT segregated and secured lanes in the city centre (6.4)	Number of buses involved in road accidents on PT lanes is decreasing
Monitoring centre for road safety & accident prevention (11.16)	Number of accidents slightly decreased, but number of deaths increased

The major part of transport impacts were evaluated using a larger number of rather unique indicators specific to particular measures:

- There was a slowing in the general decline in use of public transport as a result of PT priority system (12.5) at Tallinn (survey data).
- Passenger waiting time at stops was reduced by 10% at Krakow in relation to clean high mobility corridor (8.3) measure (measured).

- Irregularity of PT service was reduced by 3.8% in Krakow in relation to PT priority system (12.6) measure (calculated based on measurement).
- Speed of other traffic (than PT) increased by 14.1% and 3.6% in Toulouse in relation to PT lanes in the city centre and high-quality bus corridors measures respectively (measured).
- Quality of service in Burgos increased by 10% in relation to the traffic visualisation system (12.4) (surveyed).
- Average PT occupancy increased by 3% in Krakow in relation to PT priority system, whilst the same was decreased by 11.4% at Tallinn in relation to the same PT priority measure (surveyed). The latter is related to the increase of PT supply through an expanded fleet.
- Increases of PT passenger volume were observed at Krakow in relation to the clean high mobility corridor and PT priority system measures, and in La Rochelle, a significant increase of 85% was reported in relation to the implementation of the dedicated bus lanes measure (measured).

These results indicate that a wide range of impacts could result from traffic management and control measures. As specific measures may be designed and implemented to address particular problems at local city level, evaluation of unique impacts relevant to particular measures could provide insights into the intended effects of such measure implementations.

A number of special measures, such as “Satellite control for water PT services” in Venice, might not have impacts on road transportation in traditional ways, and it is difficult to quantify impacts based on the above four categories. Under these circumstances, evaluations were more focused on the effects and technical performances of traffic management and control measures.

The reduction of illegal transit based on two measure implementations at Genoa and Venice is shown in Figure 9. Significant reductions of more than 45% in illegal transit were found in both measures (measured). This indicates that the measures are very effective in deterring illegal transit.

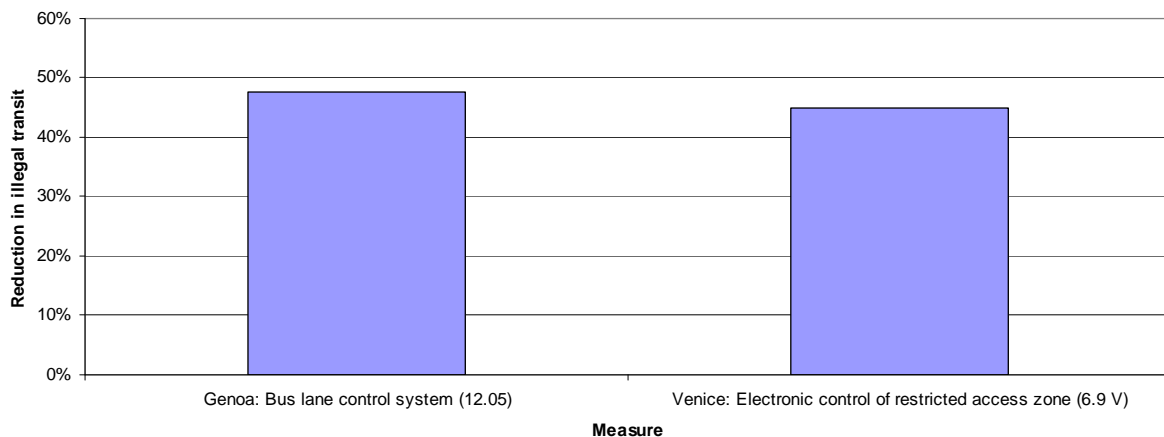


Figure 9: Reductions in Illegal Transit

Other indicators were also used to measure the effectiveness of implementations in terms of whether the systems realised their designed functionality. For example, it was reported that following implementation of the bus priority scheme at Toulouse, 96.4% of the bus priority requests were properly received by controllers and integrated in the traffic light cycle (measured). The green phase increased by 4.5% and 1.2% with priority (measured). In another innovative measure implementation, the satellite based traffic management for SMEs, it was reported that distance per courier task increased from 15.8 to 16.6 km and distance travelled per day increased from 247 to 270 km (measured). These indicate an increase in the efficiency of the courier service.

5 Upscaling and Transferability

5.1 Public Transport Priority measures

Upscaling

Upscaling for public transport measures is possible for both corridor and area wide extensions. However, the existing infrastructure and traffic flow conditions, together with other conflicting interests should be considered.

Transferability

Improvements in the area of public transport may be considered for implementation everywhere. However, as the measures are heavily infrastructure dependent, integration with existing traffic control and road infrastructure systems should be considered.

Table 5.1 Upscaling and transferability possibilities: Public Transport measures

Site	Measure	Upscaling	Transferability
Genoa	Bus lane control system in Genoa (12.5)	N/A	Better integrated with other access control system
Krakow	Clean high mobility corridor (8.3)	Can be extended to other parts of the City	Heavily involved with infrastructure development
Krakow	Public Transport priority system (12.6)	Potential exists for up-scaling to other PT corridors	Tram-bus may not be typical in European cities
Toulouse	High-quality bus corridors and development of PT segregated and secured lanes in the city centre (6.4)	Toulouse intends to implement a new High Quality corridor	Requires substantial infrastructure support
Toulouse	Implementation of bus priority scheme (12.2)	Extension to one whole bus line on a radial road started at the end of 2008	Radio priority system requires infrastructure support
Malmo	Bus priority system (12.7)	Already up-scaled	Dependent on existing traffic flows and conflicting interests
Suceava	Bus priority measures and other bus improvements (8.8)	Already covers city centre	Achievable improvements on PT service is the key
Tallinn	PT priority system (12.5)	It would be practical to upgrade all buses and lines with this measure by 2015	Infrastructure dependent
La Rochelle	Implementation of dedicated bus lanes (8.2)	Up-scaling to longer sections considered	Heavily infrastructure dependent

5.2 Monitoring and Control measures

Upscaling

Upscaling for some measures is not feasible, as full coverage has already been achieved. Extensions in coverage area are possible for the rest of the measures.

Transferability

Implementation of the measures to other cities with compatible traffic monitoring and control infrastructure (including database and GIS data) is recommended.

Table 5.2: Upscaling and transferability possibilities: Monitoring and Control measures

Site	Measure	Upscaling	Transferability
Burgos	Traffic visualisation system (12.4)	Already covered the whole city	Transferable dependent on infrastructure
Genoa	Monitoring centre for road safety & accident prevention (11.14)	Already covered all territory of Genoa	Acceptance of uniform methodology for measuring a coherent set of safety performance indicators is required
Genoa	Decision support tool for environmental impact assessment of traffic planning measures (11.17)	N/A	Calibration for the underlying simulation is the key
Krakow	Monitoring centre for road safety & accident prevention (11.16)	Extension to regional and national level considered	Compatibility with EU on incident collection is the key
Stuttgart	Event-oriented traffic management in Stuttgart (12.7)	Extensions to Neckar Park started; a number of other extensions such as tunnel management under preparation	It is best if event management systems are integrated in traffic management and control systems
Toulouse	Demonstration of EGNOS/ Galileo services use for the PT control and information system (12.1)	N/A	The approach is transferable
Venice	Electronic control of restricted access zone (6.9)	Extension was scheduled with the introduction of 10 further telecameras in the city centre	Collaboration with local authority and police is important
Venice	Satellite control (GPS-GPRS) for water PT services (12.5)	Already covered the whole city	It is best if these systems are integrated in water PT management systems
Venice	Management decision support system for waterborne traffic (12.6)	No up-scaling scheduled as the measure is at the Venice Lagoon scale	Requires bespoke GIS database
Malmö	Satellite based traffic management for SMEs (10.2)	There are substantial economies of scale. Suitable for companies with large number of cars and "short term orders"	Can be implemented as a self-containing system
Malmö	Traffic monitoring (12.2)	No up-scaling considered before a proper after-study	Calibration to local traffic conditions is important
La Rochelle	Implementation of a common transport information data base (12.2)	Already covers the whole Urban Community of La Rochelle	Requires local GIS database
Ploiesti	Development of the GPS system for the PT fleet (12.11)	The public transport network is to be wholly monitored via GPS	Best exploited in integration with other systems based on a common database and common communication protocol
Preston	Management and control (12.6)	N/A	N/A
Preston	Data collection (12.7)	N/A	N/A
Preston	Development of common database (12.8)	Not up-scaled because this is a city-wide measure	Rely on common database

6 Conclusions and Recommendations

6.1 Conclusions

1. A number of public transport priority systems can effectively improve the performance of public transportation. However, because of the diversity of European cities, public transport measures have to be flexible and adapted to the existing infrastructure.
2. Public transport priority is one type of traffic management measure. The implementation of a public transport priority system can be incorporated within a wider transport strategy.
3. Each traffic monitoring and control measure was focused on a specific traffic information and control service such as traffic monitoring, visualisation, common database and decision support systems etc. When combined, a comprehensive traffic monitoring and control system can be developed. It is therefore important to integrate measure implementation with existing systems.
4. Costs for the implementation of Traffic Management and Control measures varied considerably from a few thousands to millions of Euros depending on the nature of the measure and the scale of the implementation. As these costs cannot usually be directly paid back through revenues, funding for the implementations of such measures usually requires additional agreements between operators and the local authority.
5. The majority of traffic management and control measures are focused on improving Public Transport operation and Traffic Information services. There are also a number of special measures which are targeted at water Public Transport in Venice.
6. The impacts of the measures on all categories of indicators such as environment, transport, safety and society, measured by observations and/or questionnaires, were in general positive.
7. Transport impacts have been evaluated using a wide range of indicators reflecting the wide range of impacts that can result from traffic management and control measures. Positive results have been generally achieved. Whilst a few common indicators such as travel time have been used for the majority of measures, some unique indicators relevant to particular measures provided insights into the intended effects of such measures, on which general positive results have also been achieved.
8. Public Transport performance could be best improved when using segregated and secured lanes, followed by PT priority measures.

6.2 Recommendations

The results from the traffic management and control measures show considerable variations in both the scope of impacts and effectiveness of the measures. This may be partially explained by the fact that the scale of implementation and nature of measures are different, and is also a reflection of complex interactions between measure implementation and background transport situations. For successful implementation of traffic management and control measures, not only should the technical perspectives of the measure be properly considered, but also the integration with existing infrastructures and policy. Based on the implementation results of the 25 measures in this cluster, it is recommended that:

1. Of many different types of traffic management and control measures, public transportation priority measures are effective, reliable and generally well accepted by the public, with a flexible scale of implementation at relatively small investment, which should be considered as one of priority traffic management and control measures for European cities.

2. Some traffic management measures used sophisticated systems such as adaptive traffic signal control systems which required substantial infrastructure support and fine tuning. There is risk to implementing such systems in a limited scale and expected benefits may not be achieved (e.g. measure 12.2 in this cluster). It is therefore recommended that technical development should be well monitored and mature technologies should be considered in the first place.
3. Some measures are implemented at functional levels, such as traffic monitoring, decision support and common database systems etc. They are usually implemented as part of integrated measures and their wider impacts are difficult to quantify. It is recommended that detailed evaluation at the functional level should be carried out for such measures so that the effectiveness can be better assessed against what these measures are supposed to achieve.