Final Report for Publication

OPIUM

Operational Project for Integrated Urban Management

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OPIUM

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EXECUTIVE SUMMARY

OPIUM (Operational Project for Integrated Urban Management) was established by a consortium of 6 European cities (Gent, Heidelberg, Liverpool, Nantes, Patra and Utrecht) to fulfil the following objectives:-

- To design and implement a range of physical traffic management measures within the OPIUM cities;
- To evaluate the impact of the measures on transport efficiency, safety and modal split in urban areas, with particular reference to the impact on vulnerable road users;
- To make recommendations for the future development of urban transport policies taking account of different urban environments, including legal and institutional barriers, the need to improve the quality of life, and the needs of different users of the urban transport system (including elderly and disabled persons).

The OPIUM cities have implemented measures with a view to shifting the policy balance away from the provision of more road space for the private car towards the management and control of traffic, often in combination with improved public transport and better circumstances for pedestrians and cyclists. The City of Patra was, however, forced to withdraw from the Consortium in the face of institutional barriers to implementation.

The OPIUM project ran from 1996-1999, and was concerned with the design, development and implementation of the following physical traffic management measures:-

- Restriction of private car road space
- Traffic calming
- Parking management and guidance
- Public transport priority
- Bicycle measures
- Pedestrianisation

A detailed evaluation plan was developed which enabled the assessment of the OPIUM impacts in all partner cities on a comparative basis. Data were collected under seven headings:

- User Acceptance
- Behavioural
- Operational
- Legal
- Environment
- Safety
- Socio-economic

The impact of each individual type of measure may be summarised as follows:

Restriction of private car road space: These schemes were very successful in terms of the impact on travel behaviour and thereby environmental and other impacts. The main difficulty was achieving widespread support for innovative measures throughout the community.

Traffic calming: this approach can achieve excellent benefits on a local level, and help to reinforce measures designed to promote modal shift. An understanding of the potential negative impacts related to reducing car speeds must be developed, and a long-term strategy to mitigate these impacts by further reducing car usage developed.

Parking management and guidance: these measures appeared to be very successful. Whilst individually they only achieve benefits on a local level, wider implementation could result in more substantial impacts on modal split. Parking measures are generally self-financing, and may yield further benefits by reducing traffic circulation.

Public Transport priority: these achieved some benefits on a local level, but appear not able to achieve a significant impact on modal split unless implemented on a more extensive scale. Bus priority measures may be more successful when integrated with traffic restrictions, and improvements to bus services.

Bicycle measures/pedestrianisation: cycling measures and pedestrianisation can play an important part within wider traffic circulation plans. Their impact is less effective when viewed in isolation.

The following general conclusions and recommendations are put forward based on the experience of OPIUM.

- The OPIUM applications have managed to provide a significant level of local and European benefits, despite their limited geographic scope. Full benefits will be maximised by widening the scope and scale of future such applications;

- Public consultation will play an increasingly important role in determining the success or failure of traffic management measures; public consultation may be used to gauge public opinion at key stages within project design and implementation, to educate the public as to the intended benefits of the measure, and to allow citizens to feed their views, opinions and wishes into the design process based upon their empirical experience;

- There is a need to promote and market traffic management measures on a pro-active basis (and this could encompass elements of the public consultation process), in order to ensure that the general public understands and accepts the changes which are being proposed. A user needs acceptance survey at project outset can identify existing concerns, and attitudes towards the measures proposed for implementation, and may also feed valuable insights into the overall design process;

- Traffic management measures will yield benefits in their own right, even if only implemented at a comparatively low scale, but their deployment as part of a co-ordinated strategy including public transport improvements, private car restrictions and telematics-based control measures, has the potential to yield highly significant benefits. It is necessary to determine the correct scale and geographic scope before design and deployment of a measure, in order to realise the maximum benefit;

- Authorities contemplating deployment of physical measures can learn directly from the experience of OPIUM and similar demonstration projects. This is important in order to ensure best practice and resolve the barriers to implementation;

- Measures must be properly targeted in order to ensure that the correct target groups reap the benefits of the applications;

- The issue of shopkeeper / trader resistance to physical measures must be addressed; detailed research is required to measure the actual financial impact of such measures on traders, as opposed to the perceived negative impact. In addition, wider consultation processes involving shopkeepers, and a careful targeting and selection of the measures should be utilised to ensure that traders can be persuaded to accept such measures more readily;

- The co-operation of all agencies involved in city and transport planning and operations within the test site and beyond is required in order to ensure the smooth and timely implementation of measures within the available budget.

Figure 1 summarises the factors to take into account at the various stages of designing, implementing and monitoring projects involving physical measures.

Based on the experience of OPIUM, there are a number of areas worthy of further research and development, as indicated below.

1.	Research on the relationship between land-use and urban transport
2.	Research on the effect of pricing measures on modal split
3.	Setting standards for urban transport policy
4.	Development of public consultation and participation techniques
5.	Development of evaluation techniques to reflect new objectives
6.	Development of evaluation techniques to provide monetary evaluation of externalities
7.	Increasing the sophistication of user needs evaluation techniques
8.	Promotion of traffic management measures on a pro-active basis
9.	Ensuring the wider dissemination of outputs for projects such as OPIUM
10.	Research on how to target measures more effectively
11.	Research on the key issue of trader/shopkeeper resistance
12.	Research on how to best integrate all agencies involved in city transport planning and operations

Figure 1: OPIUM Guidelines for Urban Transport Planning & Policy-Making

1. INTRODUCTION

OPIUM (Operational Project for Integrated Urban Management) has brought together researchers and transport authorities in five European cities (Gent, Heidelberg, Liverpool, Nantes and Utrecht) who worked together to implement and evaluate physical traffic management measures. The overall aims of the project were to contribute to a greater level of sustainable mobility within European urban areas. In order to achieve this, a series of physical traffic management measures have been implemented and analysed by each of the partner cities.

The specific objectives of the OPIUM project were as follows:

- To design and implement a range of physical traffic management measures in each of the five cities;
- To evaluate the impact of the measures on transport efficiency, safety and modal split, with particular attention focused on vulnerable road users;
- To make recommendations for the future development of urban transport policies taking into account the different urban environments including legal and institutional barriers, the need to improve the quality of life and the needs of different users of the urban transport system.

The second chapter of the report gives a global overview of the OPIUM project. It describes the cities involved and the measures introduced in each city.

The third chapter describes the design process for the measures implemented within the project, taking explicit account of user needs.

Chapter 4 gives an overview of the key elements for the implementation of physical measures in urban environments.

Chapter 5 assesses the results of the project.

Finally, chapter 6 sets out conclusions and overall recommendations for future urban transport policy, based upon the lessons learnt from the OPIUM project.

2. OVERVIEW

2.1 Introduction

The OPIUM project involved the implementation of six different types of measure:

- Restriction of private car road space;
- Traffic calming;
- Parking management and guidance;
- Public transport priority measures;
- Bicycle measures;
- Pedestrianisation.

Table 1 shows the range of measures implemented in each city.

Table 1: Opium Measures Implemented in the Cities

	Gent	Heidelberg	Liverpool	Nantes	Patra	Utrecht
Restriction of private car road space	✓					✓
Traffic calming		✓		✓	(✓)	
Parking management and guidance	✓	✓		✓	(✓)	✓
Public transport priority			✓	✓	(✓)	✓
Bicycle measures	✓	✓	✓			
Pedestrianisation	✓					✓

(✓) Design only (see section 2.2)

The range of measures implemented offers an opportunity for cross-city evaluation, but the results of the measures in the different cities are variable because of differences in legal frameworks, organisational rules and existing travel behaviour patterns. This reflects the varying situation across European cities.

OPIUM began in January 1996 and ended in February 1999.

2.2 Opium Measures

An overview of the six types of physical measure implemented in OPIUM is presented in Tables 2 to 7.

TABLE 2 RESTRICTION OF PRIVATE CAR ROAD SPACE

The objective of restricting car traffic is to reduce the impact on everyday life of the private car. Car traffic during the last few decades has resulted in environmental impacts and congestion at levels which reduce quality of life, and impede the essential functions of the city. The restriction of the road space available to the private car provides extra space for other users, including the emergency services and public amenity vehicles, as well as public transport, bicycles and pedestrians.

The additional space made available for public transport can be used to create dedicated bus lanes, and as a result, will facilitate an increase in bus transit speed.

The allocation of more space for pedestrians and cyclists will improve safety for these vulnerable road users.

The restriction of private car road space will of course impact adversely on car drivers if the benefit to pedestrians, cyclists and public transport users are to be maximised. The needs of both groups conflict directly, and this issue must be addressed with care.

The restriction of private car road space can be organised in various ways. Decisions must be made regarding the exact locations, the types of car traffic to be restricted and the times of day during which restrictions may apply. The mechanisms for enforcement, and the need for exemptions for essential users must also be considered. The restrictions may encompass both a restriction on the space allocated for parking, and upon road space for movement.

Parking space reduction

Parking control is a key issue in planning the traffic structure of a city. A balance has to be found between accessibility and operational viability. Restricting the parking availability in the city centre can create an operationally viable city but will decrease accessibility and may have an impact on the volume of visitors attracted to the city centre. Clearly, all the important destinations of the city have to be accessible by an efficient means of transport, and unless comprehensive public transport is available, this may mean the use of the car. Traditionally, the number of parking spaces at a destination must be derived from the parking demand of the different user groups including residents, visitors and workers. Increasingly, however, there is a realisation that the provision of parking to accommodate anticipated demand may lead to congestion, and that measures must be taken to restrict parking and promote a modal shift.

In the cities of Gent and Utrecht, where private car road space was restricted in the city centre, the supply of on-street parking spaces was reduced. The additional road space that became available by this means was re-allocated to public transport and to vulnerable road users.

The implementation of parking space reduction occurred differently in each city, according to the existing parking regime, and the decisions that were made regarding the needs of different user groups.

Car road space reduction

The space available for traffic circulation in urban areas is usually strictly limited. Different measures to reduce the use of this space by the private car have been implemented in the OPIUM cities as follows:

- Road closures: restricting the number of roads open to car traffic in the city centre.
- Lane reduction: a reduction of the number of lanes available for car traffic on a road.
- Exclusion of cars: the complete exclusion of cars from the city centre.

TABLE 3 TRAFFIC CALMING

The increasing number of road accidents, and the relationship between accident severity and vehicle speed means that it is desirable to reduce vehicle speeds in urban areas. This is of greatest importance in areas where the movements of vulnerable road users conflict with car traffic. High traffic speed can be controlled by the use of physical measures, with the objective of slowing down the speed of cars. The application of road humps, for example, helps to enforce speed limits, leading to a safer environment for vulnerable road users.

Safety is the principal objective of traffic calming measures. Improved road safety may be achieved by reducing vehicle speeds or traffic volumes. Reduction in vehicle speeds alone will lead to perceived improvements in road safety and the quality of the urban environment, in particular a reduction in traffic noise, although vehicle emissions are increased at low speeds. Reductions in traffic volumes, on the other hand, improve all aspects of the environment.

Measures to calm traffic can vary according to the objectives that have to be achieved. The objective may be the reduction of specific types of accidents or a general improvement in environmental quality. It could also be desired to discourage car traffic from using certain streets as "rat runs".

Traffic calming has a significant impact on car drivers. On some residential access roads, it cannot remove significant volumes of car traffic, but is intended to reduce the speed at which certain drivers drive through those streets where the category of vulnerable road users form an important road user group. In these instances, many of the car drivers can be expected to be local residents, and must be educated in order that they understand that their own community will gain from speed reductions.

Pedestrians and cyclists benefit from traffic calming measures. Physical measures are implemented to slow down car traffic and to increase the comfort of pedestrians at crossings. As a result, the safety of pedestrians will increase. The needs and user requirements of cyclists are similar to those of pedestrians.

Public transport users, on the other hand, may find the quality of the ride worse after implementation of physical traffic calming measures unless specially designed measures which do not affect buses are introduced. Journey time may increase because of the lowering of the speed. It should also be recognised that traffic calming can contribute to localised increases in emission levels as a result of traffic decelerating and accelerating before and after the calming measure.

Within OPIUM traffic-calming measures were introduced in the cities of Heidelberg and Nantes. In Heidelberg, speed was reduced to 7 km/h in a certain area and within Nantes, measures were implemented to restrict the speed of cars to 50km/h along a corridor designated for enhanced bus services.

TABLE 4 PARKING MANAGEMENT AND GUIDANCE

Parking management involves the efficient management of parking space by implementation of time-related or financial measures which may be differentiated according to the needs of different user groups.

Parking guidance is implemented in order to reduce the time taken by car drivers searching for a parking space close to the desired destination. The use of parking spaces available in the urban area can thus be optimised, whilst also decreasing the volume of car traffic.

In general, car drivers wish to reach a parking space close to their destination as quickly as possible. Furthermore, parking should be offered at a price which reflects the needs of different user groups. Within residential areas, users want parking to be available close to home and close to local shopping areas. Within the city centre, it may be desirable to reduce parking, especially for commuters, whilst not restricting economic activity. A parking guidance system can offer better service for the car driver in providing information about the parking space availability.

In order to increase operational viability and decrease congestion in the city centre, parking should be transferred to the edge of the city centre. It is important that parking spaces at the edge of the city centre offer good connections with public transport and information about the fastest way to reach key destinations.

The car driver usually is willing to pay more for a parking space close to the destination than for a parking space at the edge of the city where a modal change is required.

The less space dedicated to car traffic, the greater the benefit for pedestrians and cyclists. Underground parking significantly reduces the open space allocated to parked cars, although car traffic levels cannot be reduced by underground parking. It is, therefore, preferable that cars park at the edge of the city in order to minimise congestion.

Within the OPIUM project, the cities of Gent, Heidelberg, Nantes and Utrecht have been working on parking management. Measures have been implemented in order to reduce the number of on street parking places and to redistribute them, favouring residents and short-stay users. Park and ride sites have been implemented at the edge of the city and additional public transport is offered to the city centre.

TABLE 5 PUBLIC TRANSPORT PRIORITY MEASURES

In order to provide efficient public transport as an alternative to private transport, priority measures can be implemented. The measures can be physically implemented by means of separate bus lanes or by providing priority at traffic lights and major junctions. Priority at traffic lights may allow the free flow of public transport within the general traffic, or the detection of approaching buses to enable a green signal to be provided.

The quality of public transport can be determined by means of a number of different indicators; these include access to the bus service, reliability of the service, the journey time and cost, and passenger comfort. Improvements made in either one of these categories will induce a modal shift away from private to public transport. The relative importance of these categories will vary with the requirements of passengers, and the values which they put on each component of the journey. Workers will generally value time highly, whilst shoppers and other leisure travellers may value cost or comfort.

Within OPIUM, direct measures were implemented in Nantes, Liverpool and Utrecht in order to give priority to public transport. Bus lanes were created, and priority at traffic lights was re-allocated to allow public transport to proceed efficiently. In Gent, priority is given to public transport, but in an indirect way, through a reduction of car traffic in the pedestrian area, resulting in more space for public transport.

TABLE 6 BICYCLE MEASURES

Bicycles offer a suitable alternative to short-distance car traffic. They are predominantly used for distances up to 10 kilometres. Since 70% of the movements in the urban environment may be shorter than 5 kilometres, the potential usage of the bicycle is substantial.

The needs of cyclists are threefold. First of all, the safety of the route is very important. Cyclists belong to the category of vulnerable road users because of their low speed in comparison to car traffic. Conflict with car traffic should be avoided as much as possible in order to maximise the safety of cyclists. Secondly, accessibility to a wide range of destinations, and the provision of secure cycle storage at each is also essential. Finally, a coherent and continuous bicycle network is essential since the safety of the route will be compromised if users even have to contend with a single dangerous crossing point.

Both cyclists and pedestrians need good dedicated routes which are segregated from other vehicle traffic. In many cities, cycles and pedestrians share the same space. This situation is not optimal because of the difference in speed and the potential for conflict between these modes. It does, however, reflect the importance placed on cycling as a mode in cities where demand is low. The provision of fully segregated cycle-ways can be achieved by narrowing streets for car traffic: the needs of the car drivers may not be fulfilled, but such measures represent a reallocation of road space towards environmentally friendly modes of travel which can most easily be justified once a significant level of cycle demand has been established.

TABLE 7 PEDESTRIANISATION
The highest number of journeys within an urban area are made on foot. Pedestrians are the most vulnerable category of road users. To improve road safety, measures have been implemented either to lower the speeds of car traffic, or to ban cars completely from the city centre. 85% of the accidents, involving pedestrians, occur at road crossings. To combat this, coherent car-free areas are necessary to increase pedestrian safety. The design of pedestrian routes must be simple and well signed. Design must pay attention to the needs of pedestrians with impaired mobility. Road crossings need to be replaced by platforms or speed tables at walkway level, which focus the attention of the car drivers to the presence of the pedestrian. A minimum width for footpaths should also be adopted. As part of its global mobility plan, the City of Gent created an extensive pedestrian area, as a coherent zone dedicated to the needs of pedestrians. Other transport modes such as public transport, bicycles, vehicles loading and unloading and specific activities (emergency services, doctors etc.) use the zone but in a well-controlled way. The City of Utrecht introduced car-free zones in certain historical squares in order to create an improved environment for pedestrians.

2.3 OPIUM Cities

OPIUM began with seven partner cities from Belgium, France, Germany, Greece, the Netherlands and the United Kingdom. During the course of the project the Greek city (Patra) was forced to withdraw when it became clear that the planned measures could not be implemented in the project timescale, due to institutional and political barriers. Six cities remained, ranging from a small historical city to major conurbations and regional capitals. The cities, their broad transportation strategies, and their local objectives in OPIUM, are summarised in Table 8.

Table 8: The Opium Cities

City	Characteristics	Transportation Strategy	OPIUM Objectives
Gent	Largest city in Flanders (Belgium). Population 227,000 (city) 380,000 (agglomeration). Employment is mostly in the public sector. There is a high proportion of students.	In 1993, the City Council of Gent established a global mobility plan. This plan comprises the following strategies: • A short-term strategy which deals with traffic control and traffic management (safety solutions, 30km zones, circulation measures, parking management); • A long-term strategy, which deals with more structural measures to solve the traffic problems in the city (urban planning, P&R, etc). The mobility plan supports the following measures: • a transport plan for the inner city; • a bicycle plan; • parking management measures; • the construction of a traffic model (bicycles, cars, public transport); • urban planning measures (e.g. making life in the city centre more attractive); • a public transport plan (in conjunction with De Lijn, the Flemish public transport company); • traffic safety plans for the rest of the city; • the construction of a hierarchy for the road network.	The OPIUM measures were designed to encourage the use of the bicycle and reduce car traffic by establishing (i) a network of bicycle routes with cycle lanes and priority measures at traffic lights, (ii) a parking management scheme restricting the number of on-street parking spaces, (iii) creation of new pedestrian areas.
Heidelberg	University city in Rhein-Neckar area (Germany). Population 132,000, one of 3 centres in a region of 1.2 million. Heidelberg is an important centre for higher education. The universities provide most of the employment in the city.	The city setting restricts the traffic flow in the narrow Neckar valley, a further widening of the streets is not possible. The current Transport Development Plan was initiated in 1988. The plan provides a framework for the future planning for sustainable mobility.	The OPIUM measures aimed at an improvement in the conditions for pedestrians, cyclists and public transport users by: • increasing the proportion of commuters using public transport or bicycle; • reducing the number of cars in search of parking space in residential areas; • increasing available parking space for residents; • increasing road safety for pedestrians and

			cyclists; • reducing the average speed of motorised traffic; • decreasing car use for trips in easy walking or cycling distance; • increasing the number of pedestrians and cyclists in suburban areas.
Liverpool	Major industrial/maritime city within Merseyside conurbation (UK). Population 450,000 (city), 1.4 million (region). Liverpool experiences a high unemployment rate which is significantly above the UK average. 56% of households do not own a private car.	The strategic transport policies for Merseyside have been expressed in four Core Policy Themes: • Policy 1: To target additions or improvements to the transport network which are essential to support economic development and urban regeneration opportunities. • Policy 2: To increase the relative attractiveness of public transport and non-motorised forms of transport as a means of moderating the upward trend in car use and securing a shift of mode away from the private car. • Policy 3: To secure the most efficient use of the existing highway network through the application of measures appropriate to the defined function of each road. • Policy 4: To give a high priority to the safety and environmental schemes and measures, aimed at reducing casualties and improving the quality of life for those working and living in Merseyside.	The OPIUM measures formed part of the transport policy for Merseyside and focused on the extension of bus priority measures within Merseytravel's Bus Priority Programme. The aim was to determine how bus priorities can play a part in enhancing highway safety, especially for vulnerable road users, by making alterations to a section of strategic highway into the city without causing significant congestion or economic disadvantages.
Nantes	Major conurbation in western France. Between 1980 and 1990, investment and expenditure of the public transport system enabled public transport to maintain its market share, whereas the private car increased its market share from 46% to 59%, to the detriment of pedestrian and two-wheeled traffic.	To reduce traffic flows in the city centre of Nantes, a new traffic plan was initiated in 1993. This plan has two main elements; firstly, to improve the attractiveness of public transport; and secondly, to replace radial traffic with peripheral movements. The plan is being implemented as follows: • provision of priority to public transport; • development of three concentric ring roads around the city; • promotion of the importance of road safety; • development of pedestrian streets;	The main objective of the OPIUM measures was to offer an equal level of performance between bus and tram services and to improve bus regularity on roads without tramlines.

		• establishment of cycles lanes; • parking management; • provision of improved information systems. The implementation of this plan began in 1993, with the opening of a second tram line, and will continue until the arrival of the third tram line in 2000.	
Patra	Largest city and major port in Peloponnisos (Greece). Population 200,000. The city experiences severe traffic congestion, especially generated by traffic.	The local transport plan involves the development of infrastructure at inner and outer ring roads, the construction of a new port replacing the existing port, the construction of large car parks in the city centre and the development of a Park and Ride site at the outskirts of the city. The space and sequence of this plan influences the extent of physical measures to be implemented in the city centre.	The objectives of the OPIUM measures in Patra were to significantly improve environmental conditions within central city locations, especially to benefit pedestrians.
Utrecht	Major conurbation in the Netherlands. Population 250,000 (city), 550,000 (region). A high proportion of employment in the region is concentrated in the City of Utrecht. The City experiences high levels of peak commuter traffic, especially along the city feeder roads and ring roads, and affects four motorways.	Local transport policy focuses on implementing an efficient and fully accessible public transport system and establishing effective parking management schemes to reduce traffic flow and on-street parking within the historical city centre. In practice, the city aims to achieve its objectives through: • parking management schemes in the central city, to rearrange and reallocate parking space; • parking management schemes at the borders of the city, to offer parking facilities with a transfer possibility to different kinds of supplementary (public) transport; • development of multi-modal public transport choices; • information and guidance systems.	Implementation aimed to guarantee the successful economic function and accessibility of the city, and to improve quality of life and liveability through a more efficient use of the existing infrastructure.

3. DESIGN

3.1 Methodology

The design of a physical measure is not like designing a well-defined product with limited clear requirements. Neither is it the creative making of a piece of art. The design of a physical measure must have something of both processes. Learning from previous experience, we see that the shape, the function and the use of the measure must fit together. If not, it will not achieve the objectives. Users will not react in the expected way or will not accept the measure if the system does not function as needed or the shape does not express the function of it.

It is also important to remember that the implementation of a physical measure is rarely a stand-alone initiative to solve one isolated problem. On the contrary, it is one element in a comprehensive approach to mobility. We must bear in mind the context in which measures are implemented, whether they are just part of the physical space in the area (e.g. the construction of one bicycle lane on a square), or whether the physical measure deals in fact with the organisation of the whole space (e.g. the design of a pedestrianised area).

In the design process, many choices have to be made. In designing technological systems, a lot of emphasis is placed on a deep analysis of the user needs and a well defined functional architecture of the system to build working and workable systems which are stable for the future, allowing extensions and improvements. Looking to the design of a building, experts stress the need to start from the behaviour of the users and to have a good interaction between the architectural design and the construction of the building. Also, a strong feel for the environment is important.

An efficient design of a physical measure is a complex process in which a set of complementary measures are developed to reach a good functioning system. In this sense the system is the whole set of interacting elements which provide users with the possibility to make trips or to reach a certain place.

Designing a city or an urban environment is subject to a wide range of influences. The decision process has to take into account political and environmental factors, other factors include functional theories emphasising the relationship between form and function. Further, we can indicate what some authors call “normative theories”. Here the generalised connections between human values and settlement forms are highlighted.

Coming back to the concern of OPIUM, the development of efficient physical measures, we realise that good design needs some elements of the different approaches mentioned above.

In the framework of the OPIUM project it was decided to focus on some key elements in the design process. These are:

1. The identification of the users and analysis of their needs.

2. Translation of the user needs into a system requirements specification. Here another important element of the design process arises, namely how to accommodate competing requirements related to the needs of different user group.
3. The conceptual design of the system. In this step, system where the requirements are translated into practical specifications for the organisation of the urban space, and the functions of the transport infrastructure in this urban space. The constraints of the location may make it impossible to satisfy the competing requirements.

3.2 User needs

3.2.1 User Categories

It is important to note that there is not just one type of user but a wide range of users with their own needs that have to be taken into account within the design process.

In general we can indicate 4 user groupings:

- end-users (e.g. pedestrians, cyclists, public transport users, car drivers)
- operators (public transport operators, the road department etc)
- authorities (local, regional, national, European authorities)
- specific destination groupings (hospitals, schools, shopping areas, etc).

The following table gives an overview of the main users that were identified in different OPIUM cities. The analysis of the needs of the different categories within the user-groups influenced the design of the city-specific measures.

Table 9: Overview of Users Identified in the OPIUM Cities

	Gent	Heidelberg	Liverpool	Nantes	Patra	Utrecht
END-USERS						
pedestrians	+	+	+	+	+	+
school children/students	+	+				
workers	+				+	+
shoppers	+	+			+	+
tourists						+
elderly	+					+
disabled people	+					+
small children						
cyclists	+	+	+	+	+	+
school children/students	+		+	+		
workers	+		+			

	Gent	Heidelberg	Liverpool	Nantes	Patra	Utrecht
END-USERS						
shoppers	+		+	+		
tourists						
public transport users	+	+	+	+	+	+
school children/students			+	+		+
workers			+	+	+	+
shoppers			+	+	+	+
leisure/cultural			+			+
car-drivers	+	+	+	+	+	+
workers	+	+	+	+	+	+
shoppers	+	+	+	+	+	+
leisure/cultural	+	+	+		+	+

Table 9a: Overview of Users Identified in the OPIUM Cities

	Gent	Heidelberg	Liverpool	Nantes	Patra	Utrecht
OPERATORS						
technical services municipality/city	+	+	+	+	+	+
private parking operator	+	+			+	
public transport company	+	+	+		+	
private transport company					+	
ministry of public works and transport	+				+	
AUTHORITIES						
community groups			+		+	+
local authority	+	+	+	+	+	+
provincial authority	+	+	+	+ (district)	+	
regional authority	+	+		+		+
national authority		+			+	+
DESTINATION GROUPINGS						
residential area	+	+	+	+	+	+
schools	+	+	+	+	+	+

	Gent	Heidelberg	Liverpool	Nantes	Patra	Utrecht
shopping centre	+	+	+	+	+	+
workplace	+	+	+	+	+	+
leisure/cultural	+		+	+		+
hospitals			+	+		+
elderly homes			+		+	

3.2.2 End-users

The specific needs that should be taken into account when designing physical measures for each individual end-user group are discussed below.

Public transport users

In terms of the physical measures, the needs of public transport users can be summarised in one word: quality. Quality aspects are:

- total time to make a trip
- reliability and regularity
- comfort including transfers and seat availability

The **total time to make the trip** is one of the key factors in modal choice. It is important to assess the total time to go from a specific origin to a specific destination point. If a part of the trip can be done by a high speed train but the trip to the railway station is very difficult, the service does not meet the users' needs. The time taken to transfer between lines and waiting for public transport vehicles is valued by users at twice the in-vehicle time.

The **reliability of the service** is linked to the total trip time. Waiting times and transfer times can be kept to a minimum level if the services are reliable. Furthermore, reliability is essential if public transport wants to provide a good alternative to the private car. Customers do not accept delays to planned services.

The **comfort of the service** is a third criterion to assess the quality of the service. This aspect is also important in the decision process on modal choice.

Pedestrians

The pedestrian's main needs are to have a good accessibility of the area and a safe environment. Measures taken to reduce the number of cars in the city and to slow down their speed are assessed in a positive way by pedestrians. Special attention must be paid to safety on non-signalised crossings, where pedestrians share the road with other transport modes. Whenever possible, pedestrians should be separated in space and/or in time from motorised traffic. When designing routes for pedestrians, the following key-elements must be taken into account:

- **Simplicity:** Pedestrian routes must be designed in such a way that they give a direct and short connection between two identified points.

- **Identification:** Pedestrian routes should be easily identified by the persons using it so that they don't get lost in a maze of identical roads.

- **Coherence:** By chaining pedestrian routes together, a coherent network of routes may be developed.

Cyclists

The needs of cyclists are quite similar to those of pedestrians. The overall need is a safe environment to cycle. The conflict with cars should thus be minimised. Whenever it is necessary to cross a road, measures should be taken in order to protect the cyclist. Moreover the following key-elements must be taken into account when designing routes for cyclists:

- **Coherence:** A good, coherent network is the first need in order to come to a well-functioning cycle system. A network may be defined as coherent if at least 70% of all cycle kilometres are dedicated to the network and all origins and destinations are connected with the network

- **Straight forwardness:** Straight forwardness is also an important need for cyclists. It implies that 3 criteria must be taken into account when designing a cycle route: speed, time and distance. Of these, the distance is the most important factor. Deviations must be minimised in order to meet the cyclist's needs.

Car drivers

The main need of car drivers is to reach the destination as fast as possible and to find a place to park the car near the destination, thus minimising the walking time. In urban areas, the needs of car drivers are mostly conflicting with those of pedestrians. For many years, land use policies have created cities and infrastructures which favour cars and other private traffic, creating an unfavourable climate for pedestrians and cyclists. In order to improve the urban environment, safety and mobility, the overall transport policy has turned towards a situation where more space is allocated to these latter transport modes. In order to meet the needs of car drivers, alternatives must be offered so that destinations can still be reached. The alternatives will vary according to the destination category that is considered (e.g. big supermarkets should still be reached by car, whereas small shopping centres can be pedestrianised when a parking place is offered at the edge of the centre).

3.2.3 Operators

Technical services

Technical service departments of local, regional and national authorities need to work out the global vision on mobility and land-use planning of the authorities involved. The main need of the operator is thus to work out the most optimal scheme according to the guidelines set up by the authorities. 'Most optimal' should be first of all according to the needs of the users and minimising the discomfort, caused by the negative impacts on the other user groupings. Secondly, the cost of the operation should be accorded to the presumed benefits. Although the cost-benefit of a new system is always playing an important role in the choice of measures that should be implemented according to the global needs, this seems to be a difficult matter when considering traffic problems. The benefits of a new infrastructure are first of all not easy to measure (modal shift, number of accidents, level of pollution, use of energy, viability, etc). Secondly, the benefits of the new infrastructure do not directly apply to the 'provider'.

Public transport operator

The main concern of the public transport operator is to attract passengers and to transport them in a cost-efficient way. Both needs imply that the overall journey time (door to door) must be minimised. The average speed of public transport depends on many things, such as the performance of the vehicles, the dwell time, access to the platform, number of doors, access to stations, ticketing, circulation inside the vehicles, and last but not least the circulation conditions in the general traffic. The use of dedicated tracks or lanes and the ability to pre-empt traffic lights are key factors in trying to increase speed.

3.2.4 Authorities

The main concern for authorities on all levels is to offer an efficiently functioning transport system to their citizens, to support the economy and welfare of the country/city. For many years, traffic policies were mainly concerned with accommodating private traffic. The main concern now in urban areas is to keep the city accessible, to improve safety and the quality of life.

3.2.5 Destination groupings

Destinations such as schools, shops, leisure activities, etc. must be accessible for all people using all modes of transport. Depending on the activity, more attention can be paid to one or another end-user (e.g. big supermarkets may need good access by car because of the necessary transport of goods). Although not all destinations need always to be accessible by car when offering alternative transport modes, car accessibility seems to remain the main concern for all destination groupings.

3.3 System requirements

The next step in the design process is the definition of the requirements of the system. Here the designer has to convert the user needs into practical requirements for the system to be implemented.

The need of a user to have a safe street, for example, can be translated into a requirement to separate the pedestrian area from the car area and even the bicycle lane, or into a requirement to take physical measures to reduce the speed of both modes. Often one user need can be translated into a wide range of possible requirements for the system. Here a good knowledge of previous realisations and experiences will help the designer to reach the best solutions. General design rules and standards will be very important in this phase of the process.

The definition of the system requirements can be undertaken from the point of view of each user category. This will result in a list of guidelines for the design of the system bringing together the different needs. On this level the conflicts between the user needs will appear more clearly. Especially in an urban environment, where space is limited, different users have claims on the same space. The requirements of one category of users, for example car drivers, cannot be fulfilled simultaneously with the needs of the pedestrians to have a pedestrian area.

The remainder of this section explains the system requirements for each measure.

3.3.1 Restriction of private car road space

Initially, car space road restriction was a response to traffic congestion, mostly on radial roads to the city centre at peak hours. The first oil crises in the mid 1970s shifted this concern towards energy conservation. Some cities with historic centres were concerned more about the conservation and protection of buildings and spaces. In the 1980s there was an increasing concern about pollution from traffic and air quality. Some cities have also pursued positive concepts for the improvement of urban living conditions and raising the quality of city streets and space.

In all cases, a first and very important requirement when considering car space restriction is to **determine the location of measures** to limit car traffic in achieving the overall vision and **ask more precise questions**. Is the intention, for example, to reduce car traffic throughout the city or only in the city centre? Will car traffic be reduced below the traffic levels of today, or is it the rate of growth which is to be reduced?

The second point is the determination of **which car traffic** will be reduced. Is the aim to reduce only certain types of traffic, such as car commuting (work) journeys, or only peak hour-traffic?

Whenever the choice is made of which traffic should be reduced and at which location, **different schemes** can be worked out, including the narrowing of the road, the suppression of a traffic lane or the restriction of parking places.

The fourth point is to work out a set of **alternative transport possibilities** in order to guarantee the overall mobility and more specifically the accessibility of the city centre. This could be done in two ways: first of all, an alternative set of traffic routes can be determined for destination traffic and for through traffic. In the case of parking place restriction, parking places can be provided at the border of the city centre with additional transport possibilities to the centre, or parking can be provided in underground buildings. In the second place, alternative transport modes can be offered.

3.3.2 Traffic calming

First of all, the safety and environmental problems being addressed need to be **analysed** in detail in order to establish likely causes. The analysis requires robust 'before' data on traffic flows, accidents, speeds and observations per site.

The objective of traffic calming must be well determined. The main need can either be environmental or to reduce accidents. A variety of techniques can be applied to reduce speeds. When there is a special need to reduce the risk of accidents, this should be considered. Traffic calming can also act as a deterrent to traffic choosing a particular route.

The system must **fit into the global traffic and environmental policy**. A co-operative and multi-disciplinary design approach is desirable in most cases, especially in town centres and other environmentally sensitive locations. This may appear to lengthen to design process but should reduce the need for changes at a later stage. Regular liaison with the relevant planning authority should be started early in the process.
Special needs for emergency services and bus operators should be taken into account in order to prevent problems when the traffic calming measures are implemented. For the emergency services, the concerns are twofold. Firstly, the reduction in speed increases the time it takes for a fire appliance or ambulance to reach the incident. Secondly, when ambulances need to take a patient to hospital, road humps or other speed reducing measures can cause difficulties for the ambulance staff and cause discomfort for patients. Similar problems apply to bus services. The introduction of traffic calming can lengthen journey times and bus passengers may find the quality of public transport is worse after the introduction of traffic calming measures.

Benefits for **vulnerable road users** should be optimised when implementing traffic calming schemes. Generally, lower vehicle speeds will benefit all types of vulnerable road users, but it is important to consult local representative groups to ensure that the particular concerns of each user group are taken into account. Often relatively simple cost action may improve accessibility for those who have to use wheelchairs and this will usually also improve conditions for all pedestrians.

Although in general, cyclists may benefit from lower traffic speeds, the design of traffic calming measures must also take into account the needs of cyclists. Poorly designed schemes can inconvenience or even endanger cyclists. Cyclists will not be attracted to routes where they are forced into the possibility of collision with cars, e.g. narrow chicanes.

In general, the needs of the different road users must be taken into account and well balanced in order to come to a well-functioning traffic scheme introducing traffic calming measures. Therefore **a dialogue** should be created between all interested parties, including resident associations, cycling groups, commercial groups, emergency services, bus operators etc.

3.3.3 Parking management and guidance

The minimum **number of parking places** and their **optimal location** must be calculated based on the actual parking demand and the possible substitution of cars and/or parking on that place. The number of parking places is related to the target group. Parking figures are different for residential areas, shopping areas, schools,... and are mostly related to the surface area of the destination or to the number of people involved (e.g. number of working places).

The **interchangeability** of parking places may lead to a lower number of necessary parking places . For example, about 50% of the parking places in a residential area can be used during daytime (when people have left their home for working) by workers in surrounding offices. Alternatively, the parking of a shopping area could be used in the evening for visitors of other activities, such as leisure, cultural, etc.

Parking places must be **easily accessible** by car and from there the destination should be reachable in a **short and clear way**.

Whenever parking places are offered at the border of the city in order to avoid congestion and air pollution, clear **information** must be given on the availability of transport modes into the city centre.

A **parking guidance system** can be set up in order to guide the drivers in a fast and direct way to the free parking places available. The system must fulfil the following requirements:

1. the parking route must be clearly recognisable, this means that:
   - the traffic sign must be recognised easily as a parking sign
   - the lay-out of the parking sign must be related to existing parking signs
   - the parking signs must be visible and readable from distance
   - only the most necessary text should be provided on the sign

2. the guidance system must be consistent, this means that:
   - an unambiguous decision criterion on the location and the kind of information (static or dynamic) that is given, must be handled
   - the parking route must be closed, so that when arriving at a full parking area, the car-driver will immediately be referred to another car-park.
   - the information that is given on the available parking places must be factual and reliable
   - information must be given on the available transport from and to the city centre.

3.3.4 Public transport priority

Fast and reliable public transport will place high demands on the organisation of the network. When the network is completely segregated from other modes e.g. train or metro, this will often be a matter of technical infrastructure measures and the necessary finances. When public transport is not segregated from other traffic, the needs of the public transport user and the operator are more difficult to satisfy. Depending on the environment and the conflict with the needs of the other user groups, different solutions with specific requirements can be considered.

If we look at a single bus or tram route in the urban environment, two practical requirements can be set as an objective for all measures to be implemented. Firstly, the commercial speed which is the average speed taking into account all stops. Depending on the type of service, its function in the public transport network and maybe the competition with the other modes, a desired commercial speed of e.g. 15 km/h up to 40 km/h can be the objective. Secondly, we can define the maximum allowed level of disturbances of this commercial speed. For example, if the commercial speed of a bus on a specific route is expected to be 20 km/h, we could allow variations of 10%, if this doesn't disturb the timetable. In practice, this will be influenced by the general traffic conditions. Therefore the assessment of the feasibility of both requirements, will start from a statistical analysis of the traffic conditions on the public route and the conflicts which can affect the commercial speed of the vehicle.

More generally we can indicate the requirement for public transport priority to provide a solution to conflicts with other traffic, which will mainly be at junctions.

Starting from the delays experienced at the junction and the traffic conditions, appropriate measures must be taken. Here a wide range of measures can be used:

- priority at traffic lights
- bus advance areas
- turning exemptions
- queue relocation
- gap generation facilities
- bus lanes towards the junction
- bus ways towards the junction

At the route level, additional measures can contribute to achieving the general requirements on commercial speed and allowed disturbances:

- bus-only streets sometimes with bus gates
- restricted areas
- bus-stop boarders or lay-byes can also limit the stop time and facilitate the moving of the vehicles.

For all these measures, dimensional and other guidelines are generally available to guarantee their smooth functioning. Consideration of these requirements in relation to the claims of other modes on the urban space will influence the choice of which measures are feasible.

3.3.5 Bicycle measures

The first requirement is to define the **optimal location of the measures** in relation to the needs of the end-users in the specific area. The evaluation of the actual traffic situation together with origin-destination surveys should be the basis for a well-functioning transport system.

A good **coherent network** is the primary condition for a well-functioning bicycle infrastructure. A bicycle network should be designed to connect the relevant origins and destinations paying attention to:

- consistency in quality
- simplicity

- attractiveness of the route
- safety
- the network must be closed
- traffic attracting locations must be connected to the network

Consistency in quality is reached when 70% of all bicycle kilometres are made on the direct connections.

Straightforwardness is defined by three criteria: speed, time and distance. By measuring all deviation distances, the mean deviation factor between all origins and destinations can be calculated. Based on this the optimal bicycle network can be determined.

When planning routes as part of a global bicycle network, the following aspects must be considered:

- the routes must be as short as possible, linked in a logical way and accessible from connecting streets
- it is recommended that routes with a light traffic flow should be used wherever possible

Safety of cyclists can be achieved by separating cyclists from car traffic in space or in time.

For **ground level crossings** the following systems can be required to guarantee safety for the cyclists and reduce the travel time:

- increase of the level of attention of the car driver crossing a bicycle route by the continuation of the bicycle lane over the intersection, or by the installation of a hump about 5 metres in front of the cycle lane and on the cycle lane
- creation of by-passes
- reduction in the general traffic speed
- provision of traffic lights to reassign the traffic space in time :
  - traffic light control (short cycle time)
  - on demand priority request
  - green waves
- cycle advance area: a zone dedicated for cyclists in front of traffic lights. The zone is about 2 metres in length and cars are stopped behind this zone.

Safety on **bicycle routes** is strongly dependent on the road and traffic characteristics. The following general ‘rules’ must be considered:

- On roads with a **general traffic function**, a **physical barrier** must be installed by means of two sided bicycle lanes. The preferred barrier has a width of minimum 0,5 metre. The width of a one-direction bicycle lane can vary between 1,8 and 2,5 metre, where the latter is recommended;
- On streets within **light traffic flow areas**, a **physical barrier** is **desirable**, when there is sufficient space available;

- On streets within **light traffic flow areas**, where **limited space** is available, solutions without the physical barrier can be accepted when car traffic is calmed (e.g. by means of a hump with a by-pass for bicycles).
- A street with one-way direction for cars and two-way for bicycles can be conceived if enough safety measures are foreseen (signs, markings, etc.). Two-way bicycle lanes should be of minimum 3.5 metres wide. It should be mentioned that cycling in the 'wrong' direction can give a feeling of 'insecurity'. Also, at intersections the situation may be unsafe.
- On streets within **light traffic flow areas** where a new layout is impossible (e.g. because of a bus route along the street), bicycle measures can take the form of **bicycle lanes**, that must be free from standing and running cars.

Bicycle sheds should be provided at 'destinations' of bicycle traffic, i.e. at stations, shopping areas, service centres and work locations. The number of sheds required is dependent on the location within the city and the kind of attraction. Cycle sheds in residential districts to encourage ownership and use of bicycles is also to be promoted.

3.3.6 Pedestrianisation

A first requirement when implementing pedestrian schemes is to define the **optimal location**, according to the needs of the end-users in the specific area.

A **network of pedestrian routes** should be designed connecting the relevant origins and destinations and paying attention to:

- straightforwardness
- identification of the route
- comfort of the pedestrian (rest-zones, etc)
- attractiveness of the route
- safety

Safety of pedestrians can be achieved by separating pedestrians from car traffic in space or in time.

For **ground-level crossings** the following requirements must be considered:

- creation of by-passes
- reduction of traffic speed
- shortening of crossing length
- provision of traffic lights

On **footpaths** safety can be guaranteed by adopting a minimum width of 1.5 metres, without any obstacles. Car parking on footpaths must be prevented.

The **transition** from the footpath to the traffic road (at crossings) must be adapted to the special needs of handicapped, elderly, etc. by:

- lowering of the borders of the footpath at crossings
- ensuring the gradient of the road is a maximum of 12%
- ensuring that the water channels do not hinder the passage of wheelchairs

A raised crossing place draws the attention of car drivers and diminishes the difficulties of road crossings.

Pedestrian areas should be created where appropriate in order to improve the quality of life. Pedestrian areas must be attractive and kept clean.

3.4 Conceptual design

The conceptual design is often the most difficult part of the design process. Here the designer has to find the best answer for all the user needs and to draw the best concept for the specific context he is working in. Here he has to make a lot of choices. Good system design requires a structured way of making these choices. It is important to make the conflicts and the choices clear. If not, they will remain hidden and will disturb the good functioning of the system at the end.

Making choices is the subject of many handbooks on system design. We mention here only the strategic choice approach. This method stresses the need to indicate conflicts and possible choices in a clear way e.g. using a matrix in which the cells indicate the level of coexistence of the requirements. For each conflict the designer has to decide on which level the requirements can be fulfilled. Then the designer has to evaluate the impact of this. Eventually he may have to broaden his approach.

Coming back to the example of the construction of a bicycle lane in a narrow street, the conflict between parking places and bicycle lanes cannot be resolved on the level of the street itself. The designer will look then to this conflict on a higher level, namely the whole area where parking possibilities are often available.

4. IMPLEMENTATION

This chapter presents an overview of the key elements for the implementation of physical measures in urban environments, derived from the implementation within OPIUM. The elements are described in a series of tables dealing with the experiences of OPIUM, some remarks on the cost of individual measures, and barriers to implementation.

4.1 Restriction of private car road space

4.1.1 Reduction of parking space

OPIUM experience

From the implementation in the OPIUM cities it is clear that the reduction of on-street parking places is a very popular measure (at least for non-car users) which improves the quality of life and gives extra space for pedestrians or cyclists. When on-street parking spaces are reduced, the option can be taken whether or not to replace them elsewhere. A strict reduction can induce a modal shift from private traffic to public transport or cycling. In the OPIUM cities the option was taken to keep parking availability at the same level, but at different locations, in order to assure the accessibility of the city centre and its commercial life. On-street parking has been replaced by underground or ground-level car parks.

Cost

If parking spaces removed are replaced elsewhere, this measure can be very costly. Underground car parks are extremely costly to build but may be the preferred solution if car parking is to be provided in the city centre. Surface car parks are less expensive and are more common on the fringe of the centre - but in this case additional transport must be provided to the city centre.

Barriers to implementation

Parking restriction in the central area often leads to complaints from shopkeepers and residents. Shopkeepers consider parking restrictions in front of their door as a negative development for their businesses. Even when new parking places are provided close to the shops (e.g. up to 500m), the complaints are still heard. When parking is located at the border of the city centre, it can take time to convince people to come into the centre. Once the initial resistance has been overcome, however, the situation is likely to be reversed.

In many cities, residents are given priority to park their car by means of a ‘resident card’ that can be given for free or for a low price and which allows parking in a dedicated ‘resident parking zone’. Wherever parking spaces are restricted, special attention is paid to the needs of the residents. They might lose their favourite place in front of their house, but they will be able to find a place on a short distance away.

4.1.2 Road narrowing

OPIUM experience

In Heidelberg, a good example is given of road narrowing (see Plate 1) in order to increase safety at crossings, by the introduction of ‘pavement noses’. The pathway is broadened on a length of several metres into the driving lanes on one or both sides of the street. This improves vision for pedestrians (e.g. whenever cars are parked) and reduces the crossing length. Moreover, traffic speed is reduced at these crucial points.

Cost

The cost of the operation can be very low, when only painting on the street is sufficient. In most cases however, it is appropriate to build platforms and introduce new lighting and signs, which will increase the total cost.

Barriers to implementation

Barriers for implementing this type of measure seem to be very low, because the cost is very low, it makes roads safer and has only a small impact on car accessibility.

Plate 1: Road Narrowing (Heidelberg)

4.1.3 Lane reduction

OPIUM experience

In general, reducing the number of lanes for cars is implemented in order to make more space available for other traffic modes, such as pedestrians, cyclists and public transport. On roads with frequent junctions however, the reduction of lanes from 2 to 1, will only have a very limited effect on the overall capacity of the road, as the capacity of the junctions is the real determining factor.

Cost

The cost of lane reduction depends on the design of the newly available space. As a minimum, the reduction of lanes can be done simply by painting the road and installing bollards. Other costs are dependent on the street reconstruction for cyclists or pedestrians, bus or tram lanes or the provision of trees, etc.

4.1.4 Exclusion of cars

The exclusion of cars can be from a certain street, from a square or from a total area, such as the inner city centre. It can be done just with traffic signs or in combination with obstacles (e.g. bollards). The advantage of these is that people are forced to use another way and that the street is kept car-free. New technologies are available on the market to remove obstacles in an automatic way for public transport vehicles, deliveries, emergency services, etc.

OPIUM experience

In Gent, the heart of the city centre was made car-free. The zone is marked with traffic signs that accept loading vehicles in some streets at certain hours, buses, taxis, post vehicles and emergency services. To prevent abuse, the border of the city centre is controlled by automatic bollards. In Utrecht (see Plate 2) two main purposes led to the exclusion of cars from one central street: the cutting of through traffic in the city and the provision of a bus-only lane.

Heidelberg (see Plate 3) introduced a small pedestrian area in which only the cars of a few residents are allowed. The street is closed down with bollards at one side

Cost

The cost for car traffic exclusion varies according to the technology used. When only signs are used, the cost is very low. Whenever automatic bollards are necessary, the cost increases and depends on the system that is used.

Barriers to implementation

The exclusion of car traffic is rarely accepted by local shopkeepers, residents or car users in general. It takes very strong persistence and persuasion to implement car traffic exclusion in order to make space available to pedestrians and cyclists and to reinstate e.g. a historical city centre.

Plate 2: Bus Lane (Utrecht)   Plate 3: Pedestrian and Car Reduced Area (Heidelberg)

4.2 Traffic calming

Traffic calming can be applied in many different situations although the greatest focus is on urban residential areas. These streets are often used by through traffic trying to avoid traffic jams on main roads - this is known as rat-running. Different techniques can be used in order to slow down traffic, e.g. road humps, platforms, chicanes, etc.

OPIUM experience

Within the OPIUM project, Heidelberg implemented some traffic calmed areas. The roads that were chosen have a quite low traffic load and are connecting infrastructures like shops, housing areas and schools. The implementation included signs at the beginning and at the end of the traffic calmed area, signs painted on the road and road narrowing. Traffic was restricted to 7 km/h in some areas, whereas normally the restriction is to 30km./h.

Cost

The cost for traffic calming can be very low, depending on the design of the road, the number of signs needed, etc.

Barriers to implementation

Traffic calming measures are usually accepted by the residents, as they all favour less traffic and increased safety in their street. Some of the techniques used such as rumble strips and jiggle bars are not well accepted because of the negligible impact they have and the noise they cause. One should also be careful with the use of road humps, platforms and tables. Vertical deflectors should not be used on public transport routes or important traffic roads because of the unacceptability for buses and emergency services.

Plate 4: 30 Km/h Road Markings (Heidelberg)

4.3 Parking management and guidance

Within the OPIUM project, three important aspects of effective parking policy were demonstrated:

- Parking management
- Parking guidance
- Park and Ride.

4.3.1 Parking Management

OPIUM experience

The parking management scheme in Gent includes the reduction of on-street parking places but they are replaced by underground parking in the central area. For these car parks, the municipality chose a progressive tariff structure in order to have a frequent turnover, which extends the overall parking capacity. At night, extremely low prices are set in order to use the existing capacity. Residential parking is regulated by means of a parking card that can be obtained at a price of 50 ECU.

Although all parking management schemes differ, it is clear that nowadays, more and more attention is paid to on-street parking and where possible it is avoided. Priority is paid to resident parking in the city centre by the introduction of fees for most of the parking places and the creation of a parking licence for residents at a fair price. The parking management can be in the hands of the Municipality itself or can be done by a private company. Private parking buildings should be included in the parking management scheme in order to come to a global solution for the whole area.

Cost

The cost of the implementation of a parking management scheme can only be calculated case by case. It includes the cost of parking meters, maintenance and control but can also be offset by substantial incomes.

Barriers to implementation

Parking policy and management have a major impact on car mobility in a city. Parking spaces attract a lot of traffic and whenever policy-makers want to reduce traffic in the city, the first tool is the reduction of parking spaces. Such measures have strong barriers to implementation mainly from shop-keepers, residents that fear reduced accessibility, and car-users in general.

4.3.2 Parking Guidance

OPIUM experience

Parking guidance systems were introduced in the cities of Gent, Heidelberg and Utrecht. The systems are not different in concept, but vary in the technical elaboration: supplier, signs, indications, data transmission etc. When implementing a parking guidance system, the main item for consideration is the information that is shown to the users. One can choose either to indicate the exact number of vacant places on the sign or to indicate whether a car park is ‘full’ or ‘free’.

Cost

The cost of parking guidance varies according to the system that is used. The signs that are used and their number, the method of data calculation, data transmission, etc. affect the total cost. What is clear from the different applications is that data transmission is a very important cost factor and a system that indicates the exact number of available places is much more expensive than a system with only ‘free’ and ‘full’ indications, due to the difference in frequency of data transmission.

Barriers to implementation

There are few barriers to the implementation of a parking guidance system except cost, although the design of the system needs the approval of different actors. If private car park owners are involved, they may fear that their car park place will be made less attractive than others. Some resistance can also come from residents due to the physical obstruction caused by the signs, especially when a large number of signs are placed in the city centre.

4.3.3 Park and Ride (P&R)

OPIUM experience

Park and Ride provision is mainly foreseen at the border of the city or the city centre in order to meet the parking demand and to avoid car traffic in the centre. Because of the extra resistance that parking at the border can bring, due to the additional transport that must be taken in order to reach the centre, the price for the parking place and for the additional transport should be low, compared to the prices for parking within the city centre.

Utrecht opted to create major car parks at the border of the city centre from where regular express bus services run into the centre. The P&R facilities are also indicated in the parking guidance system and information on available transport means (including departure times) is given. When the shopping express from the P&R Galgenwaard was introduced, no fares were charged. After some weeks a small charge was introduced, but still the system is very well used.

Nantes built a new Park and Ride building (Le Cardo) at the border of the city centre, along the second tramway line. Surveys had indicated that there existed an important demand for parking facilities along the tramway lines. Parking at Le Cardo is free, providing that the driver shows a local bus/tram ticket. At the entrance to the car park (see Plate 5), a real time information display was installed, giving information on the next departure times of the trams and 4 connecting bus routes.

Cost

The cost for the provision of P&R facilities depends on the service that is offered. In order to make the Park and Ride system attractive, major efforts must be made in order to give people an easy transfer to the city centre at a fair price. A regular transport system and real-time information panels will increase the attractiveness of P&R but also increase the costs. A good balance must be found between a fair price for the system that is offered (parking and public transport) and the cost of operating the system.

Barriers to implementation

Barriers to implementation are mainly the cost of implementing the Park and Ride system.

Plate 5: Entrance to Le Cardo (Nantes)

4.4 Public transport priority

The objective of public transport priority measures is to improve reliability, speed and service capacity. Bus lanes, bus ways, restricted areas or traffic control measures give public transport vehicles an important advantage over private traffic, and at the same time can provide penalties for private vehicles by reducing available capacity on links or at junctions.

OPIUM experience

Public transport priority measures were introduced in the cities of Liverpool and Nantes. In the City of Liverpool 3 with-flow sections of the road were dedicated in peak hours to buses, taxis and cycles.

They are configured to a standard design, which is between 3.25 and 4m width. The lanes are red-coloured and designated by all standard British signage and lining with supporting street infrastructure signs. The lanes are not implemented along the whole corridor but only at strategic places e.g. at the approach of traffic lights where traffic queues are common.

In Nantes, ‘alternating bus lanes’ were implemented (see Plate 7), giving priority to buses when approaching junctions. The length of the bus lane depends on the observed queue length. Successful experiments with this design had previously been implemented on other main roads in the centre, improving regularity of bus lines in both directions. The introduction of these bus lanes also has the effect of narrowing the lane width for general traffic.

Cost

The cost of the creation of bus lanes can be very low as only painting and signage are involved. Where it comes to the reconstruction of roads and/or crossings, the total cost will be much higher.

Barriers to implementation

Barriers for implementation come mainly from car users who do not want to give up space in favour of other transport modes. In the UK, a specific barrier for implementation occurs, as the public transport priority scheme must be accepted by the people involved (residents and shop-keepers along the corridor), so that a number of public hearings and information rounds must be organised. Non-acceptance by some actors can lead to a redesign of the scheme. There is also a requirement, in order to prove the validity of the scheme to Central Government, to undertake an economic assessment, basically calculating the time lost on the private car versus time gained on the bus.

In Nantes, a barrier to implementation of bus priority in OPIUM came from the construction of the 3rd tramline. During the works, road capacity must be taken over by other roads in order to assure the continued accessibility of the city centre. In this case, the total reshaping of the road, including the narrowing of the lane width for general traffic is not acceptable. Therefore, in the first stage, only limited priority could be given to public transport. Moreover, the number of different actors in the global transport planning (District of Nantes, responsible for the general traffic movement plan and each city within the agglomeration of Nantes (20), responsible for its own roads and SEMITAN, the public transport company for the District) make decision taking difficult and may delay the implementation of planned measures in favour of public transport.

Plate 6: Bus, Taxi and Cycle Lane (Liverpool)

Plate 7: Bus Priority and Restriction of Car Road Space (Nantes)

4.5 Bicycle measures

The main objective of bicycle measures is to make the use of bicycles competitive with other transport modes. Key factors are time, safety and comfort. The increase of safety for cyclists and the provision of special facilities make city centres more attractive for cycling. Within the OPIUM project, this is demonstrated by the cities of Gent, Heidelberg and Liverpool.

4.5.1 Bicycle routes

OPIUM experience

In Gent, two bicycle routes were designed and implemented. They are part of a total bicycle network consisting of a chain of bicycle tracks, suggestion lanes, safe crossings and "speed zone 30" measures. In the latter zones, no extra bicycle lanes are provided as cars go at the same speed. Heidelberg has built a number of new bicycle lanes in order to increase safety at specific locations. In Liverpool, the public transport priority measures that were installed at four locations along the corridor serve a dual function, in that way they also act as cycle lanes. Additionally, extensive consultation was undertaken with representatives of the various cycling bodies in the city for an import junction, which resulted in the incorporation of safe cycle features in the revised junction design.

Cost

The cost of implementation consists of design and construction works. Whenever existing infrastructures can be used (e.g. painting of cycle suggestion lanes), the cost of implementation is very low. When it comes to new infrastructures, the cost may be relatively high, depending on the circumstances.
Barriers to implementation

Other than cost, there are no major barriers to the implementation of bicycle routes as far as new infrastructure is concerned. When the implementation of cycling facilities results in the reduction of private car road space, however, major objections can be expected.

4.5.2 Bicycle signage

Signage for cycle routes is very important in order to guide cyclists to the dedicated cycle route. In Liverpool standard signage was used to indicate that cyclists could cycle in the bus- and taxi lane.

OPIUM experience

In Gent, innovative signage was designed in order to indicate the right direction for cyclists. These signs are exclusively used on the newly designed cycle routes implemented within OPIUM.

Cost

The only cost for bicycle signage is that of the signs, which is minimal.

Barriers to implementation

No barriers for implementation were featured.

Figure 2: Design of Bicycle Signage (Gent)

4.5.3 Bike and Ride, bicycle sheds etc.

In order to promote the use of bikes in intermodal transport and in general for short distance trips, it is important to provide adequate cycle accommodation. The choice of the location of bicycle sheds, and also the system that is used are important in order to prohibit theft.

OPIUM experience

Gent developed a new type of bicycle shed which is very secure and which can easily be used for all types of bicycles. They are located near shopping centres, student quarters, schools, stations, tram and bus stops. The new sheds of this type can accommodate about 1500 bicycles. In Heidelberg about 700 bicycle parkings were installed near the main stations. In order to allow the parking of bicycles very close to the entrance of the station, some car parking places were removed.

Cost

A sheltered cycle rack should cost around 300 ECU per place. For non-sheltered racks the price may vary between 50 and 100 ECU per bike place (depending on the design, the material used and the number of places in one rack).

Barriers to implementation

The only barrier for the implementation of bicycle sheds could be the price and the difficulty of locating sheds in some cases (e.g. where car parking has to be removed in favour of cycle racks).

Plate 8: Bicycle Shed (Heidelberg)

4.6 Pedestrianisation

The main objective of pedestrianisation measures is to improve the safety of pedestrians in the urban environment. Pedestrians are the most vulnerable road users. An increase in pedestrian safety is therefore a must in order to encourage the use of non-motorised traffic for short trips. Pedestrianisation can include the total banning of cars from the streets, or the reconstruction of the road in order to slow down the allowed traffic and to increase safety at pedestrian crossings (see Section 3: traffic calming).

OPIUM experience

In Gent it was decided to enlarge the existing pedestrian zone. Since the beginning of the eighties, the municipal authority started creating streets exclusively for pedestrians. The pedestrian zone was at that time still crossed here and there by car traffic. Within the new mobility plan, a coherent pedestrian zone of 12.000 m² was created without disruptions. Following the banning of the car in a number of streets, a global plan for reshaping these streets is set up. In Heidelberg, traffic calming aims at better conditions for pedestrians and cyclists. In the areas where a maximum speed of 7 km./h was implemented, pedestrians are allowed to use the whole street. Cars and bicycles can drive on the street at a low speed and they need to pay attention to pedestrians. These traffic calmed areas form a major part of the pedestrian network in Kirchheim which connects important institutions and places for children like schools, playgrounds, etc. In Utrecht 10 parking places were removed from the square ‘Neude’ and the space was dedicated to pedestrians.

Pedestrianised areas are in general indicated by signage, which prohibits car traffic in the streets or on the squares, except for emergency services, buses and loading activities within certain time periods. From the first results of implementation it can be learnt that in some cases it is necessary to close down the streets by physical obstacles in order to avoid the misuse of the situation. Different techniques can be used, e.g. movable bollards. In all cases, special attention must be paid to easy accessibility of the area for public transport, emergency services, doctors, etc.

Cost

The cost of pedestrianisation schemes can be very low when signage is only implemented. When it comes to the reshaping of the streets with new paving etc., and the installation of physical barriers in order to close down the street for car traffic, much higher costs are predicted.

Barriers to implementation

The main barrier for implementation is the negative vision on pedestrianisation coming from shopkeepers in the area. They fear that clients will not be able to reach the shop because they cannot use the car and park in front of the shop. Also the accessibility for ‘loading and unloading’ is feared. Residents e.g. elderly can be against the new situation as they fear they cannot be reached anymore by ‘nurses or social workers, doctors, etc. In general it must be said that people are afraid of the new situation and that the restriction of car road space always leads to some displeasure of people who are used to go into the centre by car. It requires substantial political will and perseverance to implement pedestrianisation schemes.

Plate 9: Cycle and Pedestrian Pathway (Heidelberg)

5. EVALUATION AND ASSESSMENT

5.1 Introduction

The format for the overall evaluation was established early in the project. All cities followed the same methodology in order to enforce a level of consistency and to enable a cross-city analysis. This evaluation methodology identified the collection of data under a total of seven headings:

- User Acceptance
- Behavioural
- Operational
- Legal
- Environment
- Safety
- Socio-economic

Details of the methodology are given in Annex A.

5.2 Results

Table 10 gives an overview of the impacts in each city. Subsequent parts of this chapter assess the results for each measure in turn, and the results by type of impact. Detailed results for each city are given in Annex B.

Table 10: Summary of City Impacts

	GENT	HEIDELBERG	LIVERPOOL	NANTES	UTRECHT
Primary Measure	*Bicycle measures* *Pedestrianisation* *Parking management and guidance* *Restriction of private car road space*	*Traffic calming* *Parking management and guidance*	*Public transport priority* *Bicycle measures*	*Parking management and guidance* *Public transport priority*	*Parking management and guidance* *Restriction of private car road space*
User Acceptance	Strong support from many groups, strong opposition from shop-keepers	Well supported schemes. Perceived road safety has increased.	Support from most groups. Mixed views amongst car drivers. Opposition from shop-keepers	Support from bus and cycle users. Opposition from car drivers reducing	Mixed support, with concerns relating to city centre access. Particular opposition from shop-keepers
Behavioural	Increase in public transport usage of around 4-5%, and a substantial increase in cycling. Car traffic dropped, particularly in the central area	Increase in pedestrian and cyclist activity in traffic calmed area	Overall impact limited, but decrease in AM peak hour car traffic of 2.8%, and lower decrease in PM recorded.	New Light Rail Transit Line masks changes resulting from Bus Priority. 20% reduction in car traffic on Rue Bellamy. Park and Ride has attracted significant users.	10% increase in slow-mode travel and some increase in local public transport usage. Decreased car usage. Number of visitors has, in fact, increased.
Operational	Improvement in peak hour traffic conditions	Traffic calming successfully reduced traffic speeds. Parking management reduced traffic circulation by 25%.	Measures contribute to longer-term objectives by increasing bus speeds by around 6%, at the expense of a reduction in car speeds	Bus performance has improved with 6 minute journey time saving: car speeds reduced. Park and ride reduces urban traffic.	Increased efficiency of car parks due to reduction in waiting time to a maximum of 5 minutes at entrance
Legal & Institutional	The dialectic of political policy versus trade resistance has been encountered.	Non-compulsory consultation proved able to overcome many of the problems which occurred	Financial and consultation barriers overcome successfully. Some instances of parking/loading restriction violations, but duration limited to 10 minutes	Closer institutional links would enable complementary planning measures	OPIUM measures have increased local co-operation and raised awareness of the importance of consultation issues

	GENT	HEIDELBERG	LIVERPOOL	NANTES	UTRECHT
Environmental	Significant local benefits in terms of noise, with around 33% reduction in air pollution	Parking management improves environment. Traffic calming: some benefits, but low speeds lead to increased air pollution	Some air quality problems due to lower traffic speeds leading to 6% increase in emissions. No perceptible impacts	Bus priority lead to reduced noise, but lower traffic speeds lead to decrease in air quality. Park and ride reduces urban car travel.	Benefits due to traffic reduction may be further increased by new park and ride sites
Road Safety	Improvement in city centre, with a saving of 44% accidents in the pedestrian areas, and 9% accidents in zone 30 areas	Slight accident reduction. Improved perception of road safety	No problems identified from available data. Before improvements, 17% of accidents related to buses – these should be reduced by avoiding conflict	Increase in accidents identified, but not linked to schemes	No significant trend identified from limited available data
Socio-economic	Positive benefits with a payback of around 1 year	Revenues lead to strong benefits with a payback period of around 1.3 years.	Strong benefits to public transport users repay investment with 1 year. Disbenefits to car drivers reinforce policy, although they represent economic disbenefit.	Strong benefits identified, (partially reflecting impact of new Metro Line), with a payback period of 7 years.	Benefits reflect savings in parking time. Payback period of 6 years Further benefits may be achieved as parking revenue increases

5.3 Restriction of Private Car Road Space

The restriction of private car road space within OPIUM comprised two activities: the restriction of on-street parking places and the reduction of road-space dedicated to car traffic.

The cities of Gent and Utrecht decreased the number of on-street parking places. The remaining parking places were dedicated to residents, disabled people and to short-term parking. The overall reaction to these measures was rather positive amongst residents. Visitors were also content, particularly in Gent, where parking places were provided in underground car parks. In both cities, a parking guidance system leads visitors directly to available places. The main complaint about these measures comes from shopkeepers who fear a loss in custom when parking spaces adjacent to shops are reduced. The experience in Utrecht indicates, however, an increase in evening and weekend visitors, suggesting that these concerns are unfounded.

The new circulation plans, together with the creation of pedestrian areas, also reduces the availability of road space for private cars. The new space that becomes available is dedicated to the use of public transport and vulnerable road users. Both user groups favour the measures undertaken and appreciate the increased safety in pedestrian areas and the smoother operation of public transport, whereas car traffic is reduced.

In Nantes, the project road area was redesigned with a relocation of space. The one way street was reformed to a street for two directions, with a resulting decrease of capacity. As a result of the implementation of the measures, the traffic intensity lowered during the observed period by 20%.

Overall, these schemes were very successful in terms of the impact on travel behaviour and thereby environmental and other impacts. The main difficulty was achieving widespread support for innovative measures throughout the community. Residents and visitors who use the schemes are generally supportive, although shopkeepers are often concerned about the impact on trade. Vulnerable road users benefits from, reallocation of road space away from the private car, towards the pedestrian. These measure can reduce traffic speeds as well as volumes, although a reduction in speed without a corresponding reduction in volume may have a negative impact on air quality.

5.4 Traffic Calming

In Heidelberg, in the area of Kirchheim, traffic speed reductions were implemented by the restricted use of physical measures. The evaluation indicated that whilst the volume of cars entering Kirchheim did not decrease, traffic speeds were reduced as car drivers respect the traffic calming measures which were implemented.

This approach can achieve excellent benefits on a local level, and help to reinforce measures designed to promote modal shift. An understanding of the potential negative impacts related to reducing car speeds must be developed, and a long-term strategy to mitigate these impacts by further reducing car usage developed. Vulnerable users benefit greatly, however, by reductions in speed.

5.5 Parking Management and Guidance

Within the OPIUM cities, parking management and/or parking guidance was introduced in the cities of Gent, Heidelberg, Nantes and Utrecht. The cities of Heidelberg, Gent and Utrecht followed the same approach in their parking strategy. The number of on-street parking places for long stay parking was reduced in the city centre. Additional parking capacity was offered in underground parking places in the city centre and /or at park and ride sites on the edge of the city centre. A parking guidance system, indicating the number of available parking places at different locations leads visitors to available spaces, reducing the circulating traffic seeking parking spaces and parking search times. The on-street parking spaces are reserved for residents, disabled people, deliveries and for short stay parking.

This reallocation of parking places has resulted in decreases in the amount of traffic entering the city centre. A rather small modal shift was obtained towards public transport, with the greatest shift achieved by park and ride schemes.

Most users are in favour of the measures, whilst shopkeepers are strongly opposed to the measures as they still do not believe that access is maintained. Residents are quite satisfied with the new situation although there are still complaints about the availability of parking places.

Regular visitors do not use the parking guidance system as they decide at home where they will park their car. Only when the preferred car park is fully occupied they use the signs to find another parking place.

The City of Nantes has implemented a new Park and Ride facility situated along the tramway line. The facility provides parking for 200 cars and a separate parking space for bicycles. A real time information system was implemented at the entrance of the parking displaying the waiting time for the trams. Sixty percent of the users started using the system since the reshaping of it in September 1997. Most of these users used to drive by car to the city centre. The majority of the users continues the trip by tram. The customers are very satisfied with the parking system.

Overall, these measures appear to be very successful. Whilst individually they only achieve benefits on a local level, wider implementation could result in more substantial impacts on modal split by reducing circulating traffic seeking parking spaces, and by a transfer from car to public transport at park and ride sites. Parking measures are generally self-financing, and may yield further benefits by reducing traffic circulation. Parking management schemes may help to ensure that spaces are reserved for essential users, and are generally supported by users although shopkeepers may be concerned about accessibility from parking areas to retail area.

5.6 Public Transport Priority

In the cities of Nantes and Liverpool, bus lanes have been implemented on radial corridors. Due to the road layout it was not possible to implement continuous bus lanes, but buses are equipped with a vehicle detection system to influence the traffic lights, so that they can obtain an increased probability of a green signal. Cyclists, taxis and emergency vehicles are allowed to use the bus lanes. The evaluation of this measure in both cities proved that public transport journey times decreased on the corridor and that services have been more regular than before the implementation. The journey time for cars increased correspondingly. The implementation of this measure is helping to induce a modal shift from car to bus traffic. In Merseyside only a modest shift was identified, however, whilst in Nantes a more substantial shift was obscured by the greater shift achieved by the new trams.

Some difficulties were identified in the area of parking management. Parked cars and delivery vehicles both disturb the passage of buses. Also, safety problems with cars that are leaving parking places were reported in the City of Nantes.

Cyclists benefits from use of the bus lanes, although the provision of dedicated cycle lanes would be preferable.

Residents and shopkeepers are opposed to the measures in Liverpool because of the loss in parking spaces, but this was not the case in Nantes.

Overall, these measures achieved some benefits on a local level, but appear not able to achieve a significant impact on modal split unless implemented on a more extensive scale. In the OPIUM schemes, continuous bus lanes could not, for various reasons, be implemented. Bus priority measures may be more successful when integrated with traffic restrictions, improved passenger facilities, and improvements to bus services, especially vehicles. These measures do, however, improve bus journey times, and penalise private car users, thereby encouraging modal shift. The reduction in private car speeds may also help to improve the local environment for vulnerable road users. Cyclists, in particular, may benefit from the use of bus lanes, although they may prefer dedicated facilities.

5.7 Bicycle Measures

In the City of Gent, the safety of bicycles has improved since the implementation of the bicycle routes, the zone 30 areas and development of pedestrian areas to which cycles are admitted. The results of the evaluation show that these measures can encourage an increase in the use of bikes for short distances. Also the accompanying measures, such as he introduction of new safe bicycle sheds and the registration of bicycles, were well appreciated by the cyclists.

A few difficulties however for cyclists have occurred at the edge of the project area. The restriction of car traffic within the project area increased the traffic pressure on adjacent roads. Therefore further measures will be needed to develop a full cycle network.

Cycling measures can play an important part within wider traffic circulation plans. Cycle usage is provided by the provision of these facilities. Their impact is less effective when viewed in isolation, and cyclists need a continuous network of safe routes in order to truly benefit from individual measures.

5.8 Pedestrianisation

Pedestrian measures of two types were implemented in OPIUM. An area pedestrianisation scheme was provided in Gent, whilst pedestrian measures were implemented on individual streets in Kircheim, Heidelberg.

Vulnerable road users greatly appreciate the measures that have been undertaken to create the pedestrian area in the City of Gent. The perceived safety of both pedestrians and bicyclists has improved according to the residents inside and outside the project area. The circulation of bicycles improved or remained at an equal level. The number of bicycles increased significantly after the implementation of the measures.

Car drivers, however, believe that the circulation has become less easy within the project area, whilst shopkeepers fear that customers will cease to come to the centre of the city since they cannot park in the vicinity of the shops. Extensive surveys have proven that this fear was not well-grounded. The turnover of shopkeepers did not decrease because of the implementation of the pedestrian area.

In Heidelberg, people were very positive about the improvements to the pedestrian area. Before the implementation people felt very uncomfortable and unsafe. After the implementation, 63% of the respondents stated that the streets were safe enough for their children to walk alone against 46% before implementation.

Pedestrians benefits greatly from pedestrianisation, and vulnerable groups, such as children may particularly require such facilities to be provided. Such measures alone, however, do not contribute directly to modal split, unless they are implemented simultaneously with traffic restrictions as part of a wider traffic circulation plan.

5.9 Results by Impact

The results in the individual cities can be summarised in terms of the impacts of OPIUM against the identified indicators. Overall, the results by type of impact may be summarised as follows:

5.9.1 User Acceptance and Attitudinal

The measures were generally well-received except by groups who were directly penalised.

Shop Keepers

The main area of resistance to the OPIUM measures was amongst shop-keepers particularly concerning the applications in Gent, Liverpool and Utrecht who fear that traffic restrictions discourage visitors and shoppers.

In Liverpool, shopkeepers feared that goods deliveries would not be possible after the implementation of the OPIUM measures (bus priority and traffic management) and their attitudes were most negative compared to other groups. However, the decrease in the number of deliveries was less severe than initially expected. There has been an increase in the use of side streets for this purpose and the enforcement of the parking restrictions remains a problem; 69% of the shops have deliveries outside their shop but 80% of the shops have parking restrictions in front of their doors. Strong opposition was also received from shop-keepers in Gent based on fears that the implementation of the pedestrian area would discourage shoppers who travel to the city by car. Although the shopping environment in the inner city of Utrecht has improved according to most of the inhabitants, 40% of the shopkeepers think it is worse since the traffic circulation measures have been taken. They also believe that customers will go to places outside the centre for shopping purposes due to the implementation of private car restriction measures in the inner city centre.

Car Drivers

In all OPIUM cities the views of car drivers to the OPIUM measures generally differed to other road users and tended to be more negative to measures which restricted car access and parking to the benefit of public transport users, cyclists and pedestrians. Traffic speed and pollution is not considered to be an important problem, compared to the other road users. The level of severity to which car drivers attribute the danger of traffic and the difficulty of crossing the street is much lower than the opinion of other road users, particularly in Utrecht and Liverpool. However, the example of Nantes has demonstrated that initial negative views and opposition by motorists towards the new layout of Bellany Street can at least be neutralised once the effects are demonstrated to them on a practical basis. The most positive views were received on the new Park and Ride system which have influenced many car drivers to change their travel behaviour and use the Park and Ride system to travel into the city centre. This evidence suggests that opposing views of motorists towards public transport priority and car restriction measures can be lessened when a viable and attractive alternative is provided such as Park and Ride.

Public Transport Users

Public transport users reacted most positively towards the OPIUM measures in cities where many of the measures directly or indirectly improve public transport services, whilst reducing the attractiveness of the private car. Bus priority measures, parking management and private car restriction measures in all OPIUM cities were welcomed by public transport users and local residents. In particular, the attitudes of public transport users towards the OPIUM measures in Gent and Nantes were extremely positive as a result of reduced private car traffic in central areas and increased speed and circulation flow of buses and trams. In Nantes the public transport priority measures were well accepted by users whom would like to see the scheme extended to other parts of the city.

The positive acceptance amongst public transport users encompasses most of the six different types of traffic management measures deployed within OPIUM.

Cyclists and Pedestrians

Overall, the surveys conducted across the OPIUM sites show that pedestrians and cyclists are very positive to the idea of traffic calming measures designed to increase the safety of vulnerable road users and improve the circulation of bicycles. The bicycle measures implemented in Gent were especially well received by local residents, pedestrians and cyclists who were in the view that their safety had increased significantly since the implementation of the cycle lanes. The shared bus and cycle lanes in Liverpool were also welcomed by cyclists who appreciate the reduction in vehicle speeds as a result of being able to cycle in the bus lanes. As demonstrated in Nantes, most of the cyclists subscribe the idea that it is better to share the road with buses than with cars, despite the fact that they get stressed when a bus is right behind them.

In contrast to the other cities, pedestrians and cyclists in Utrecht rated the measures for slow traffic including bicycle shelters, walking distances and information facilities for pedestrians lower than the situation before. Their views are less positive than public transport users and car drivers.

5.9.2 Behavioural

The use of the bicycle increased in cities where facilities for cyclists and traffic calming measures were implemented especially in Gent and Heidelberg. Cycling in Gent substantially increased after the implementation of the bicycle sheds and since the traffic calmed area in Heidelberg was created there has been an increase in cyclist and pedestrian activity.

The greatest impact on travel behaviour was experienced by those schemes which used traffic circulation restrictions and parking management to impose a change in behaviour. OPIUM sites have reported decreases in peak hour traffic circulation, higher occupancy levels at car parks and parking places and adherence by motorists to the new speed limits and geographic restrictions. In Utrecht and Gent, car usage and traffic in central areas reduced since the introduction of restricted private car road space and parking management schemes. In Heidleberg company parking fees for employees and subsidised public transport tickets introduced as part of the parking management measures encouraged employees to reduce their car commuting trips. As a result of this scheme, the use of public transport increased to the greatest extent.

The new Park and Ride site in Nantes has attracted a significant number of users and contributed to a reduction in car traffic into the city centre. A further reduction in car traffic was also achieved along Rue Bellamy where public transport was allocated more road space. In Utrecht, the use of local public transport slightly increased and the use of the car decreased after the implementation of OPIUM parking measures and restriction of private car road space. The overall behavioural impact of the public transport priority and bicycle measures in Liverpool was limited with a slight decrease in morning peak hour and afternoon car traffic.

Within the OPIUM cities, public views of public transport and additional transport facilities and services were very positive and people claim to be aware of other transport modes. Evidence suggests that people are willing to change modes and travel behaviour in favour of public transport and other non-car modes however, greater efforts are needed in order to achieve this shift. Park and Ride and parking management schemes proved effective on a local basis, but have limited global impact.

The examples of Nantes, Gent and Liverpool demonstrate how isolated schemes such as bus priority and cycling measures may have a positive impact, but greater benefits on modal split would be achieved if they formed part of a wider package of measures.

5.9.3 Operational and Technical Impacts

The OPIUM measures appeared to meet their operational aims. Some measures had secondary impacts: bus priority and traffic calming schemes led to a reduction in car travel speeds which complemented policy objectives but which might be deemed an operational disbenefit. Different OPIUM sites have reported decreases in peak hour traffic circulation, higher occupancy levels at car parks and parking places, and adherence by motorists to the new speed limits and geographic restrictions. These are encouraging results and highlight the fact that the OPIUM measures do have the potential to control traffic circulation to a significant degree. In Heidelberg traffic calming measures successfully reduced traffic speeds and the parking management scheme reduced traffic circulation by 25%. The parking management and guidance scheme in Utrecht lead to reduced journey times towards the inner city by up to 5 minutes due to increased efficiency in the operation of car parks. The example of Gent demonstrates how the restriction of private car road space can also improve peak hour traffic conditions. The Park and Ride scheme in Nantes has also been successful in bringing about a reduction in traffic circulation.

In Liverpool and Nantes bus priority measures improved overall service reliability through reducing waiting times. These measures have contributed to longer-term objectives by increasing bus speeds and reducing journey times; bus speeds in Liverpool increased by around 6% and in Nantes, bus journey times decreased by 6 minutes.

No technical problems or other issues were identified.

5.9.4 Legal and Institutional Issues

A number of institutional barriers were identified, although these were generally overcome.

In Gent, considerable difficulties were encountered relating to the response of certain sectors of the population to the scheme. These have not, however, resulted in any specific institutional or legal problems, but have raised awareness of the importance of consensus building. In Utrecht the OPIUM measures have increased local co-operation and raised awareness of the importance of consultation issues. In Liverpool some institutional difficulties were encountered due to the need to complete the works within a European timescale which did not reflect the UK funding and planning process. These problems were overcome by a well-planned approach to public consultation and project management. Implementation of the measures was slightly delayed by the need to construct a public consensus for the initiatives. However, once this was achieved, the momentum and support for the OPIUM measures overcame any opposition.

The City of Patra, which was initially a partner in the OPIUM project, did encounter a number of problems, and eventually withdrew. Projects such as OPIUM enable cities to develop their skills in inter-agency co-operation and consultation, and thereby reduce problems in the future.

5.9.5 Environmental Impacts

Environmental improvements within OPIUM have occurred with regard to the issues of noise, severance and air quality. The greatest benefits were gained where road space was closed to private cars or where a significant reduction in circulating traffic was achieved. Within OPIUM the elimination of circulating traffic has played a major role in improving the overall milieu of city centres. Some measures had limited perceptible impact, whilst certain measures which were successful in reducing traffic speeds may have contributed to an increase in local air pollution. This latter effect can be overcome by increasing the scale of restrictions to the point when a modal shift is achieved.

The Park and Ride scheme in Nantes reduced urban car travel contributing to a reduction in vehicle emissions, and other environmental impacts. The OPIUM measures in Utrecht also achieved improvements in environmental conditions due to the elimination of circulating and queuing traffic, and diversion of traffic from car to Park and Ride. Whilst the overall level of environmental benefits in Nantes and Utrecht may be low, wider implementation would lead to significant improvements, especially if the Park and Ride systems were extended.

Where OPIUM measures have lead to an increase in car journey time, there have been some negative impacts on air quality as demonstrated in Heidelberg, Liverpool and Nantes. Lower car traffic speeds in Liverpool resulted in a 6% increase in emissions and although bus priority in Nantes lead to reduced noise lower traffic speeds caused a decrease in air quality. In Heidelberg the impact of parking management has had overall environmental benefits but low speeds imposed by traffic calming measures has increased air pollution.

Traffic noise is less complex to analyse; noise reductions were achieved in Gent and Nantes where traffic volumes and speeds were reduced.

Clearly the area-wide traffic circulation plans are more effective than isolated corridor-based measures. The results indicate that there is considerable potential for environmental improvements if physical traffic management measures are adopted as a key element of a co-ordinated traffic management, control and development strategy.

5.9.6 Road Safety

There have been no adverse impacts on road safety statistics within the OPIUM test sites. There are some initial indications of reductions in numbers and severity of accidents, but it must be borne in mind that the measures will take some time to assess in terms of their road safety impacts. Nevertheless, the user acceptance surveys demonstrate that there is evidence of a greater perceived sense of safety amongst (vulnerable) road users following implementation of the OPIUM measures in a number of the test sites e.g. Gent, Hiedelberg, and Liverpool.

5.9.7 Socio-economic impacts

All elements of the OPIUM project achieved positive net present values, with payback periods of 10 years or less. In certain cities, the negative impact of measures such as traffic calming and bus priority on car travel time was discounted on the basis that such apparent disbenefits were incurred in order to achieve policy objectives, and should be viewed in a positive, rather than negative light.

6. CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions of the OPIUM project

6.1.1 Summary of impacts

The impact of each individual type of measure may be summarised as follows:

Restriction of private car road space: These schemes were very successful in terms of the impact on travel behaviour and thereby environmental and other impacts. The main difficulty was achieving widespread support for innovative measures throughout the community.

Traffic calming: this approach can achieve excellent benefits on a local level, and help to reinforce measures designed to promote modal shift. An understanding of the potential negative impacts related to reducing car speeds must be developed, and a long-term strategy to mitigate these impacts by further reducing car usage developed.

Parking management and guidance: these measures appeared to be very successful. Whilst individually they only achieve benefits on a local level, wider implementation could result in more substantial impacts on modal split. Parking measures are generally self-financing, and may yield further benefits by reducing traffic circulation.

Public Transport priority: these achieved some benefits on a local level, but appear not able to achieve a significant impact on modal split unless implemented on a more extensive scale. Bus priority measures may be more successful when integrated with traffic restrictions, and improvements to bus services.

Bicycle measures/pedestrianisation: cycling measures and pedestrianisation can play an important part within wider traffic circulation plans. Their impact is less effective when viewed in isolation.

6.1.2 Overall conclusions

The OPIUM measures have provided benefits, on a local level, in 5 cities, and have enabled a range of types of traffic management measure to be tested and evaluated, so that wider implementation programmes can be successfully developed in the future.

Table 11 provides a summary of the ways in which the OPIUM measures might be implemented on a wider basis. Overall, the network-based measures achieve the greatest added value from scheme expansion since the attractiveness of such schemes is related to the range of destinations served.

Traffic calming measures can be viewed in isolation since they are each applicable only to their own area.

The restriction of private road space and pedestrian schemes can achieve great benefits from wider implementation, but may require substantial investment if these benefits are to be realised.

Parking management, once installed on a city-wide basis can only achieve a limited marginal benefit from further extension.

Table 11: Implications of Wider Scheme Implementation

	Marginal benefits of wider implementation may decrease	**Marginal benefits of wider implementation remain constant**	**Marginal benefit of wider implementation increases with scale of scheme**
Restriction of private road space			
Traffic calming			
Parking management and guidance			
Public transport priority measures			
Bicycle measures			
Pedestrianisation			

The OPIUM project as a whole has provided overall social and economic benefits on a local and European level. In particular, vulnerable road users have enjoyed the benefits of reduced car travel speeds, and the conversion of road space into public open space. Public transport users have seen travel speeds increase on bus priority corridors, whilst the delays experienced by car drivers seeking parking spaces have been reduced.

If the maximum benefit is to be achieved from the project, however, it is essential to highlight not only the projects undoubted successes, but the areas in which barriers to modal shift still exist, and where further research may be required.

6.2 Overall recommendations for urban transport policy

6.2.1 Recommendations for the implementation of physical measures in urban traffic management

In this section a set of guidelines for the implementation of physical measures is presented, based on the experiences of the OPIUM project. The different stages within the process are highlighted in Figure 3.

Figure 3: Guidelines for Urban Transport Planning & Policy-Making

6.2.1.1 The planning stage

The implementation of physical measures in an urban environment cannot be seen as a stand-alone action. From the OPIUM project it can be learnt that an **integrated approach** including public transport improvements, private car restrictions and telematics-based control measures has the potential to yield highly significant benefits. It is necessary to determine the geographic scope before the design of the measure, in order to realise the maximum benefit.

An integrated approach also means that **the co-operation of all parties involved** in the process of city and transport planning and implementation is necessary in order to ensure the smooth implementation of measures with minimum of delay and within the available budget. Within the OPIUM project, the main barriers for implementation that were experienced during the project process, were as follows:

- The relationship between different authorities
- The relationship between different transport undertakings
- The relationships between city, regional and national government.

Other barriers that were encountered include:

- The law of the country
- Financial considerations
- Consultation processes
- Political considerations

Taking these elements into account, it should be clear that the implementation of physical measures as part of a process leading towards a sustainable city, where car traffic is not seen as the predominant means of transport for citizens and visitors, must be well considered and fit into a **global transport plan**. The plan must be supported by all actors and have political support and financial backing.

6.2.1.2 Design of physical measures

After the global planning stage in which the actions to undertake are agreed and scheduled, the next step to design the individual measures in detail.

An efficient design of a physical measure is a complex process in which a set of complementary measures are developed to reach a well functioning system. In this sense, a system is a whole set of interacting elements which provide the users the possibility to make trips or to reach a certain place.

So, in the first phase we need to identify the users. It is very important **to analyse the needs of these users** for whom the measure is implemented, because the user will finally decide whether the implementation will be successful or not and change his behaviour according to the individual acceptance and appreciation of the measures involved. The needs of the different users may not coincide totally. Priorities must be identified in order to work towards sustainable mobility.
Secondly, a set of **requirements** to realise the needs of the user must be identified. Here, another important element in the design process arises, namely the decision on competing requirements related to the needs of different user groupings which may conflict (e.g. the needs of car-users may conflict with those of pedestrians and cyclists.

The third phase in the design process is the translation of the requirements into a **conceptual design**, including practical specifications for the organisation of the urban space and the functions of the transport infrastructure in this urban space. Here, for example, the constraints of the place will make the competing requirements sometimes incompatible. The conceptual design is generally the most difficult part of the design process, as the designer needs to find the best answer for all the user needs and to draw the best concept for the specific context he/she is working in.

From the OPIUM project it can be learnt that the user needs must be fully addressed at this point in the process, as they are the basis for the system's functions.

Public consultation seems to be a necessary tool in the design process, in order to come to an acceptable solution for the different user groups involved. A good example of this is the Liverpool project, where an important public consultation has lead to different changes in the lay-out of the road and where at the end the acceptance of the measures introduced is fairly high. In Utrecht, for example, where the public has not been involved in the design of the new circulation plan for the inner city, this has caused a lot of resistance.

6.2.1.3 Implementation issues

Within the OPIUM project much attention has been paid to the **'barriers' to implementation** of physical measures. The main barriers that have been encountered in the OPIUM cities are the following:

- Negative response of certain users to the scheme
- Budgetary constraints
- Building a consensus between the different actors involved (municipality, road administration, public transport organisation and others) is also necessary

Those problems are already addressed above, in the planning and the design phase. If the planning of the measures (including timing and financing) is not done in an appropriate way without adoption of public consultation in the design phase, the implementation of the measures can be delayed or even cancelled.

Already in an early stage of the process, **a consensus is needed** over the goals to be reached (which must be realistic), the way to reach them (the planning stage) and the appropriate design in order to come to the best result. Whenever this consensus is reached, the implementation of the measures can be done smoothly.

Within the implementation phase, particular attention should be paid to the **timing of the implementation**. Works should be done in a phased way and not all together in order to keep the city accessible at all time. If not, measures will be evaluated in a very negative way from the very start of the introduction.

Another important factor in the implementation phase is **the information provided to the public** of the works that are going on, with the exact timing of construction (starting date and end date), so that people have a clear view on the situation.

6.2.1.4 Evaluation and adoption of the plan

Together with the overall planning activity, an **evaluation plan** must be set up in order to get a clear view on the impacts of the measures on the traffic situation and the way in which the introduced measures respond to the objectives that are put forward.

The **timing of the evaluation** is very critical to the results that are achieved. Within the OPIUM project, the timing of the evaluation has had a negative impact on certain results within the project. The evaluation took place very early after the implementation of the measures which had two main effects:

- Users did not have enough time to adapt their behaviour to the new situation
- Some measures were not fully completed so that traffic works still going on influenced the global traffic situation in a negative way.

The physical measures that are implemented are different in the way they have an influence on peoples' behaviour. A part of the measures can be seen as so-called ‘push’ measures, which mean they force people to change their habits. Other measures are the so-called ‘pull’ measures, which are more suggestive and allow users to make their own choice.

It is clear that the first set of measures will have the highest effect in the short term, but may also have a high level of resistance by some of the users. The second set of measures is accepted more easily but may only have a small effect in the short term, while it can obtain greater results in the long term.

The push-measures that are implemented in the OPIUM project include the following:

- Private car road space restriction
- Parking space restriction
- Traffic calming

The other measures that are introduced should be catalogued under the heading of ‘pull-measures’, such as:

- Public transport priority measures

- Bicycle measures
- Pedestrianisation
- Parking guidance

As this latter type of measure is in the majority within the OPIUM project, it should be clear that an evaluation in the short-term is less appropriate, as these types of measures are only likely to have a substantial impact in the longer term.

The evaluation of measures must not just be seen as a formal action but should lead to **modifications of the plan**, in order to come to better results.

6.2.1.5 Guidelines for the implementation of physical measures

Summarising the whole process for the implementation of physical measures, the following critical elements can be identified:

- There is a need to increase the co-operation between local and other agencies.
- Clear and realistic objectives must be put forward.
- A good planning of the actions is necessary: timing and budget.
- Few schemes are supported by all sectors of the community. Public consultation is needed from the start of the project.
- An appropriate design must be presented.
- Measures should be integrated rather than isolated improvements.
- Planning and information is necessary for a smooth implementation.
- Evaluation of measures must be done at the appropriate time and a balanced three stage appraisal is desirable:

  (i) user needs analysis
  (ii) design verification
  (iii) impact analysis

- Based on the evaluation results, the initial plan should be modified where appropriate.

6.2.2 Recommendations for urban transport policy

For many years, the unhindered free-flow of private car traffic has been the main concern for transport planners. The consequences of this policy have been damage to the urban environment and quality of life, coupled with decreasing safety for residents and road users alike. A clear vision and a coherent transport policy were missing.

At the beginning of the seventies, a change in view on traffic management occurred. Step by step, it was concluded that the demand for increasing car traffic could not be fulfilled. Moreover, the increase in cars had led to complete traffic chaos and environmental damage at the urban core. Non motorised modes became unsafe and unattractive partially because of the limited traffic space at their disposal. The dedication of most road infrastructure to the use of cars made pedestrians and cyclists feel vulnerable.

One came to the conclusion that, in order to improve the environment, the viability, the accessibility and the safety of the city, the policy balance had to be shifted away from private car road provision to provision for alternative transport modes.

To achieve a modal shift from private traffic to other transport modes, a global mobility plan is required including actions to discourage the use of private traffic and favouring the public transport users, cyclists and pedestrians. The following set of measures can be implemented to encourage a positive modal shift from car to public transport:

- Traffic management measures
- Regulatory measures
- Financial measures
- Socio-economic measures
- Technical measures

The OPIUM project has focused on the **physical traffic management** measures, which have proved able to provide a significant impact on traffic levels and modal split, whenever a coherent approach is followed.

From the results achieved within the project, it is clear that these physical measures may yield benefits in their own right, even if only implemented at a low scale, but that their deployment as part of a **co-ordinated strategy** including different kinds of measures for all means of transport, has the potential to come to more significant benefits.

In order to shift the balance away from private cars to public transport and non motorised modes, a global transport plan should be set up in close co-operation between all agencies involved in the process of city and transport planning and operations.

Each city should focus on different elements within the transport plan, according to the scale and the shape of the city. Some cities are very compact, others are more spread out, which influences a lot the possibility of the introduction of alternative transport modes such as public transport. Most cities in Europe have a dispersed settlement pattern, largely because of legislation favouring low-density housing and extensive road programmes. This created a need for private cars to satisfy the mobility needs and make it difficult to organise public transport in such a way that it is competitive to private transport.

Besides the different shapes of the city, legal frameworks and organisational rules, different climatic and geographical conditions, life-style and mentality determine the transferability of measures which can be implemented as an answer to specific needs.

Most countries have a variety of standards and rules defining the possible lay-out of roads. Depending on the category of the road, in many countries, the width of the lanes is a fixed design aspect. This can limit the possibilities to calm traffic in city centres.

Therefore the implementation strategy has to take into consideration national and local circumstances, as well as policies pursued in areas other than transport and the environment.

The results achieved within the OPIUM project must be seen as **a first step** towards sustainable mobility. The impact of the measures, although generally positive has been rather limited in scale, reflecting the extent of the measures themselves.

The **second step** should be based on innovations in land-use planning and traffic management. Land-use planning measures could be concerned with the types of settlements which should expand, the places where major developments should be located and the provision of local facilities. The integrated package of traffic management measures could include congestion pricing, park and ride services, investments in transit infrastructure, etc.
It is the responsibility of governments at all levels to bring changes in urban transport policy. Central governments and international organisations have key roles in setting the standards and the framework within with cities can operate. Acceptance by the population of the measures has to be won through providing information on the problems encountered and through consultation on the measures to be applied.

6.2.3 Key areas for further work

There are opportunities for further research and development, as indicated in Table 12.

Table 12: Areas for Further Research and Development

1.	Research on the relationship between land-use and urban transport
2.	Research on the effect of pricing measures on modal split
3.	Setting standards for urban transport policy
4.	Development of public consultation and participation techniques
5.	Development of evaluation techniques to reflect new objectives
6.	Development of evaluation techniques to provide monetary evaluation of externalities
7.	Increasing the sophistication of user needs evaluation techniques
8.	Promotion of traffic management measures on a pro-active basis
9.	Ensuring the wider dissemination of outputs for projects such as OPIUM
10.	Research on how to target measures more effectively
11.	Research on the key issue of trader/shopkeeper resistance
12.	Research on how to best integrate all agencies involved in city transport planning and operations

ANNEX A

EVALUATION METHODOLOGY

A.1 Introduction

The format for the overall evaluation was established early in the project. All cities followed the same methodology in order to enforce a level of consistency and to enable a cross-city analysis. This evaluation methodology identified the collection of data under a total of seven headings:

- User Acceptance
- Behavioural
- Operational
- Legal
- Environment
- Safety
- Socio-economic

Table A.1: Summary of Evaluation

	Traffic Restrictions	**Bus Priority**	**Pedestrian Areas**	**Cycles**	**Traffic Calming**	**Parking Management**
User Acceptance	Results of qualitative surveys					
Behavioural						
Operational	Reports from each city					
Legal						
Environment	Calculation of energy and emissions based upon reduction in vehicle usage	Calculation of energy and emissions based upon changes in vehicle speeds	Calculation of energy and emissions based upon reduction in vehicle usage	Calculation of energy and emissions based upon changes in modal choice	Calculation of energy and emissions based upon changes in vehicle speed	Calculation of energy and emissions based upon changes in distance travelled
Safety	Analysis of accident data for restricted area and surrounding roads	-	Analysis of pedestrian accident data	Analysis of cycle accident data	Analysis of accident data for traffic calming zone	-
Socio-economic	Cost-benefit analysis of environmental, safety, transport and other impacts	Cost-benefit analysis of environmental, safety, transport and other impacts	Cost-benefit analysis of environmental, safety, transport and other impacts	Cost-benefit analysis of environmental, safety, transport and other impacts	Cost-benefit analysis of environmental, safety, transport and other impacts	Cost-benefit analysis of environmental, safety, transport and other impacts

A.2 User Acceptance

It is essential to establish the attitudes of different interest groups towards the measures that have been implemented within OPIUM. The interest groups can be divided into the following categories: public transport users, private car users, pedestrians, cyclists, elderly and disabled people, local authorities, residents and shopkeepers. The aim is to acquire data relating to the acceptance of the measures by means of quantitative and qualitative approaches. Both user and non-user groups have been included in the surveys.

Table A.2: Summary of Attitudinal Surveys

City	User groups	Surveys
Gent	Public transport	Interview with chairman of the public transport organisation (Bond Trein, Tram, Bus))
	Car drivers	Questionnaire based survey at parkings
	Pedestrians	Interview with chairman of the pedestrian organisation (Komaan)
	Cyclists	Interview with chairman of the cyclist organisation (Perpetuüm mobile)
	Operator groupings	Interview with chairman of taxis, interview with the public transport operator: DE LIJN
	Residents	Telephonic survey, letters
	Shopkeepers	Public hearing for shopkeepers, letters
Heidelberg	Residents	Questionnaires, mail delivery with return envelope
		Questionnaires, mail delivery with return envelope
	Employees	Questionnaires, mail delivery with return envelope
		Interviews
	Enterprise representatives	Questionnaires, mail delivery with return envelope
	Parking garage users	
	Parents of children under 10 years	
Liverpool	Public transport	Questionnaire based survey
	Car drivers	Questionnaire based survey
	Pedestrians	Questionnaire based survey
	Cyclists	Questionnaire based survey
	Shopkeepers	Questionnaire based survey
Nantes	Public transport	Interviews with passengers and bus drivers
	Car drivers	Interviews with users of P&R
	Cyclists	Survey with cyclists
Utrecht	Public transport	Inner city survey, shopping express survey (P&R)
	Car drivers	Inner city survey, shopping express survey (P&R), Parking survey, P&R information system survey
		Inner city survey
	Pedestrians	Inner city survey
	Cyclists	Inner city survey
	Elderly and disabled persons	Parking survey, park and ride information system survey, Inner city survey, shopping express survey

Table A.2 presents an overview of the surveys that were undertaken in order to assess the user acceptance and attitudes towards the different measures that were implemented in the cities.

A.3 Behavioural impacts

The impact of transport schemes on travel behaviour is a very important factor which influences modal split and many other related factors such as environmental conditions. This impact is best observed by means of direct surveys of vehicle and personal travel. Therefore vehicle flow and vehicle occupancy data are collected.

The impacts of the measures on bus, car, cycling and walking were determined from the surveys detailed in Table A.3.

Table A.3: Behavioural Impact Surveys

City	Surveys
Gent	Car occupancy Bus occupancy Survey of passers-by Number of cyclists
Heidelberg	Number of cars Number of pedestrians
Liverpool	Car occupancy Bus patronage surveys
Nantes	Car occupancy Bus occupancy Number of cyclists Modal shift
Utrecht	Occupancy of the ShoppingExpress, Theatre Express Car occupancy at P&R Modal shift

A.4 Operational and technical impacts

Observation surveys are the basis for the assessment of the operational and technical impacts. These surveys evaluate the effectiveness and the reliability of the implemented measures. The direct effects of the measures on the traffic conditions are measured, waiting and loading activity, levels of congestion, and the regularity of bus journeys are monitored.

The impact on travel speed is the most important factor in the evaluation of the effectiveness of traffic restriction measures and traffic calming measures. Parking measures may influence overall car journey times. The relative speeds of bus and car travel will determine the impact of bus priority systems.

Technical issues transpired to be of little significance within OPIUM. In general, the required technologies were readily available, and performed satisfactorily. Therefore technical issues were not studied in depth, the main areas of interest being in more complex areas such as user acceptance and institutional issues.

The range of operational and technical data collected is summarised in A.4.

Table A.4: Operational and Technical Impact Surveys

City	Surveys
Gent	Speed of car Speed of bus Traffic count at the entrance roads Car journey time Bus journey time
Heidelberg	Speed of cars Parking search time Average parking time Occupancy of on-street parking
Liverpool	Queue length surveys at five of the signalised junctions along the corridor and on two arms of the Fiveways junction Car journey time Bus journey time Bus service regularity Waiting and loading surveys Automatic traffic counts
Nantes	Traffic counts Speed of bus Speed of car Congestion Car journey time Bus journey time
Utrecht	Traffic count Average parking time Amount of vehicles entering a car park Occupancy rate of P&R-facilities Average searching time for parking space Average travel time Queue length at car parks

A.5 Legal and institutional considerations

Within this category, a qualitative assessment of the legal and institutional issues arising during OPIUM has been undertaken. The implications of implementation of the same measures can differ greatly between the individual cities, according to the institutional frameworks in each.

Some legal and/or institutional have also lead to a non-acceptance of measures that were initially planned. These aspects to the implementation of measures are considered and described.

A.6 Environmental effects

Environmental impacts are often assessed in a qualitative manner, since some may be extremely subjective, whilst others, despite being more quantifiable, remain difficult to integrate into a more conventional and objective socio-economic assessment framework. Such an approach is liable to ignore the environmental benefits of schemes, which may not offer the economic benefits of travel time savings which a conventional road scheme might achieve.

For this reason, the OPIUM project evaluation was undertaken using a spreadsheet model, developed by Transport and Travel Research (TTR), as a means to identify the widest possible range of environmental impacts. More importantly, the model also attaches economic values to all these impacts, including less tangible effects on the overall quality of life of the local population.

The TTR model provides an assessment of energy consumption and emissions, and utilises current research to predict the impact of changes in travel behaviour on quality of life. In order to do so, it utilises the following data:

- Vehicle kilometres operated by private vehicle fleet by class;
- Vehicle kilometres operated by public transport vehicle fleet by class;
- Vehicle kilometres operated by other vehicles;
- Average air temperatures;
- Average vehicle speeds by class;
- Average trip length by class;
- Average vehicle occupancy by class.

The model provides output, which covers energy consumption, represented by fuel costs, as well as a series of externalities, including the following:

- Greenhouse gas emissions
- Air Quality
- Noise
- Road damage
- Accidents costs
- Congestion

The calculation of externalities is based upon research of the relationship between the values of these impacts and transport schemes.

The TTR model provides its output as quantified economic benefits, which can be included within the overall evaluation framework along with other economic impacts. This ensures that all impacts are treated as being of equal significance. The model also provides detailed outputs of energy consumption and emissions, which are of benefit in the assessment of the environmental impact.

A.7 Road safety

Road Safety data for each scheme has been collected before and after implementation. Such data identifies the number and severity of accidents, and the types of road user involved.

Once data have been gathered for a substantial period, both before and after implementation, a statistical comparison of the two data sets may be undertaken. Delays in the implementation of the OPIUM measures, however, have restricted the effectiveness of this comparison.

A.8 Socio-economic evaluation

The socio-economic evaluation draws together all the elements of this evaluation process. It combines all of the quantifiable benefits of OPIUM into a single Cost-Benefit Analysis.

The main elements of this analysis are set out in table A.5.

Table A5: Evaluation of Scheme Benefits

Evaluation Topic	Economic Impact	Means of Assessment
User Acceptance	Quality of Life (including externalities)	JET model
Behavioural	Revenues	Calculation of patronage and fares
Operational	Travel time	Value of time
Legal	n/a	n/a
Environment	Air quality Noise (Quality of life)	JET model
Safety	Accident costs	JET model, unless local data are available
Socio-economic	n/a	n/a

Scheme costs should be based upon the known capital and operational/maintenance costs of each scheme, and these will be included within the Cost Benefit Analysis. The overall evaluation used a cost-benefit module within the TTR model.

This module discounts at 7% over a 15-year period. It calculates net present values and the scheme payback period.

ANNEX B

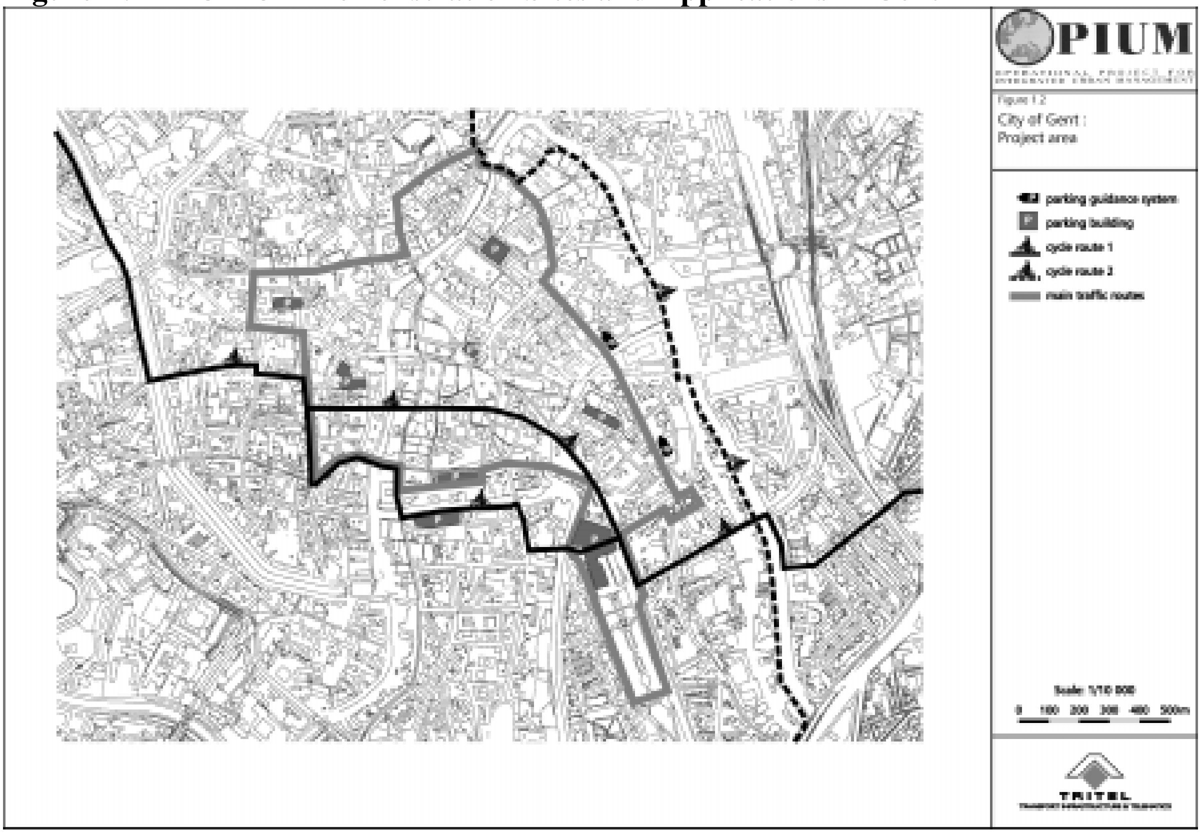
DETAILED INFORMATION FOR EACH CITY

B.1 GENT

B.1.1 Detailed Project Description

The City of **Gent** has introduced a new mobility plan, which aims to ban cars from the heart of the city centre. A parking guidance system leads cars on a direct route to underground parking places in order to keep the city accessible whilst reducing through traffic and traffic seeking parking spaces in the city centre. The streets have been redesigned to meet the needs and desires of pedestrians and public transport users. Within the areas surrounding the pedestrianised centre, traffic has been calmed by the creation of a 30 km/h zone, in order to increase the safety of pedestrians and cyclists. Moreover, in order to attract cycling to the city centre, new bicycle routes have been designed and implemented. The OPIUM demonstration sites and their applications are shown in Figure B1.

Figure B.1 OPIUM Demonstration Sites and Applications in Gent



Bicycle measures

The bicycle plan included measures on different levels to improve conditions for cycling in Gent;

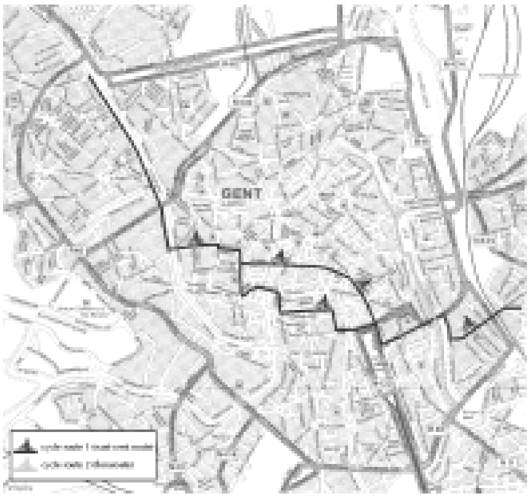
- Infrastructure: the establishment of a network of bicycle routes including cycle lanes, priority measures at traffic lights, and 30 km/h zones.

- Parking measures: the City of Gent has developed its own type of bicycle parking, which is being implemented at a rate of 1,250 units per year. This type combines good safety to park bicycles with a good protection of the unit itself against vandalism.

- Promotion and awareness: an intensive, long-term campaign has been established to support the infrastructure measures.

Within OPIUM, 2 new bicycle routes were designed and implemented, the East-West Route and the Floraroute (see Figure B.2). These two routes are part of an extensive bicycle network which is being implemented. All routes consist of a chain of bicycle tracks, bicycle suggestion lanes, safe crossings and speed zone 30 measures. Cycling is allowed within pedestrian zones.

Figure B.2 OPIUM Bicycle Routes



Pedestrian areas

Within the global mobility plan, the City of Gent has created a large central pedestrian area as a coherent zone dedicated to the needs of pedestrians. Other transport modes such as public transport, bicycles, vehicles loading and unloading and specific activities (emergency services, doctors etc) are allowed into the zone but in a well-controlled way.

Parking guidance system

Within OPIUM, a parking guidance system was implemented, as a first step towards the development of an electronic traffic guidance system. This system links the car parks near the historical city with a central control unit and a number of electronic road signs provided on the main entrance roads, the city ring and an inner ring.

Outside the city ring road, the system shows the total number of free parking places in the car parks. Just before the crossing of the ring road, it allows a first choice. The final (restricted) choice can be made at the level of the inner ring road. The system itself was developed in the second half of 1996, and installed in the spring of 1997. At the same time, the new mobility plan for the city centre was introduced.

B.1.2 Project Impacts

User acceptance

Public transport

The attitude of the public transport users is generally very positive towards the implementation of the measures. Private car traffic diminished inside the project area, enabling buses and trams to travel at a higher speed. Because of the restriction of car traffic in the city centre, traffic lights were removed, improving public transport circulation as a result. Residents consider the circulation of public transport to be as good before and after the implementation of the measures. The speed gained in crossing the inner city is lost in the short-term because of road construction works that still take place at the destination ring. It is expected to improve considerably after completion of the works.

All residents agree about the improvements that have been made by providing priority lanes for public transport. Furthermore, an increase in public transport users of 4%was observed.

Car users

A majority of residents believe that the circulation of car traffic to the city centre has become less fluent (34%) or worse (28%) within the project area. Outside the project area, the circulation was reported as good by 33% of the data sample or less fluent compared to the circulation before the mobility plan. Adjustments to the length of the P-route were asked for as well as adjustments to the exit roads. The local authorities have planned to adjust the P-route in order to avoid through traffic still passing through certain zone 30 areas.

People parking at car parks mostly use the parking guidance system, but this has not been the case for on-street parkers. A majority of 85% of the respondents, found the parking guidance system useful and 77% of the users believe that the system operates efficiently.

The measures that have been carried out in the City of Gent resulted in a decrease in traffic entering and leaving the city. The highest decreases occurred in the traffic entering during the morning peak and leaving during the evening peak. The areas surrounding the city ring suffer from the volume of cars traversing the residential areas in order to avoid the congestion at the city ring. The local authorities of Gent are considering the possibility of extending the traffic calming areas to a larger part of the City of Gent. These measures would discourage car drivers from traversing the residential areas.

The occupancy rates of the car parks increased significantly (e.g. 38% at car parks Vrijdagmarkt and St. Michiels) after the implementation of the mobility plan. The majority of visitors use the car parks one or more times per week.

Most residents park on street inside the P-route. The mobility plan of Gent stipulated that residents should be given priority to park in front of their homes. Half of the residents outside the P-route park in a car park, the other half park on street. The number of available parking places has been evaluated as being insufficient for all residents. The number of visitors parking on residential parking spaces is the cause of these difficulties. These figures explain why no less than 82% of the residents are in favour of reserved parking for residents. Until the present, only 29% of the residents possess a resident card, which allows them access to parking provision within specified zones close to the home of the resident. Finding a parking space with the availability of a resident card seems to be easier for half of the residents that already possess the card.

The number of parking movements on-street decreased by 4.5% according to surveys that were made before and after the implementation of the measures. The decrease was compensated for by an increase in the number of parking movements in car parks.

The parking pressure decreased within, but increased outside the project area. The local authorities are therefore evaluating the possibility of extending the implemented measures to the surrounding areas, for example, the zone 30 measures in the residential areas outside the project area. Parking will become payment parking at these areas to oblige the visitor to park in car parks or on the predefined payment on street parking zones closer to the destination.

Most people though did not change their parking habits, the ones that did usually parked on street and park now in car parks. Improvements for the parking guidance system could still be made at the level of the implementation of the signs.

Pedestrians

The creation of the pedestrian area has been very positive to vulnerable road users. The safety of both pedestrians and cyclists has improved (55% inside and 67% of the residents outside the project area). A majority of residents also believe that the circulation for bicycles and pedestrians has improved (51% inside and 42% outside the project area) or remained at an equal level (41% inside and 49% outside the project area). The number of bicycles counted at the bicycle routes increased significantly after the implementation of the measures.

Remarks were made about the implementation of clear signposting to the most important destinations. The number of bicycle sheds has increased significantly alongside the bicycle network. The residents believe that a sufficient number of measures have been undertaken to improve the bicycle situation within the project area. They ask for a further implementation of the measures in the surrounding areas. Traffic increased outside the project area, thereby decreasing the safety of the cyclists. The local authorities have already planned an extension of the bicycle measures outside the project area. The situation of the bicycle traffic will be enhanced in the future.

Shopkeepers

Many shopkeepers protested against the implementation of the pedestrian area. They fear that visitors will no longer be attracted to the city centre and that this will affect their turnover. About 58% of the shopkeepers find the mobility plan negative for shops in the city centre. The figure is even higher (72%) for shopkeepers that are situated within the pedestrian area. They believe that the implementation could be adjusted by a comprehensive campaign explaining the situation and offering information about the public transport lines. The local authorities have investigated the economic impact of visitors to the inner city of Gent in order to prove that the trade did not change because of the implementation of the measures. In fact the number of shoppers increased in the period between 1997 and 1998. Generally speaking the turnover did not decrease. It could on the other hand be true that turnovers of shopkeepers has decreased within certain streets but not at the level of the City of Gent. Further investigation pointed out that the number of inscriptions to the trade register increased in the pedestrian area after the implementation of the measures compared to a stable number within the whole area of Gent. The number of business failures and cancellations remained at a constant level.

Adjustments to the mobility plan were requested in the area of the general traffic situation and for the design of streets and squares in the city centre.

Residents

All residents have rated the mobility plan very positively, but clearly some improvements are still requested. A negligible proportion of the residents favour abolishing the measures that have been implemented. The majority of residents consider that the parking pressure and the amount of traffic has decreased.

Behavioural impacts

The measures achieved an increase of 4.26% public transport movements. 80% of these extra traveller movements are made by tram. Car occupancy remained at the same level as before the implementation of the OPIUM measures at 1.14 passengers per vehicle.

The number of cyclists using the bicycle routes increased significantly. The number of bicycle sheds increased from 150 in 1994 to 2608 in 1998. An additional 1586 are still planned to be installed during the coming years.

Operational and technical impacts

Traffic entering the City of Gent decreased by an average of 4.5% with the most significant decreases for the traffic entering during the morning peak and for the traffic leaving during the evening peak.

Institutional and legal impacts

As remarked above, considerable difficulties have been encountered in terms of the response of certain sectors of the population to the scheme. These have not, however, resulted in any specific institutional or legal problems, but have raised awareness of the importance of consensus building.

Environmental impacts

Substantial improvements in environmental impacts such as noise and severance have been achieved in the city centre area. Local air quality has also improved. There may, however, be some disbenefits in suburban areas through which traffic has been diverted.

Road safety

Road safety increased within the pedestrian area and within zone 30 areas. With these results the objectives of the OPIUM project have clearly been achieved. Even at the P-route, the number of accidents decreased. It is only at the entrance roads leading towards the inner city that the safety has decreased.

Socio-economic impact

The impact of the scheme is positive, as a result of revenue raised from parking, public transport and other sources.

B.1.3 Transferability

Both OPIUM schemes in Gent are already implemented on a city-wide basis, although scope for further expansion exists. The cycle network can certainly be extended to great effect. The attractiveness of such networks is usually related to the variety of destinations served. A new cycle route not only provides a link to the destinations, which it serves directly, but to destinations on all adjoining cycle routes,

The parking management system could be extended to provide parking information at more locations. It is probably, however, reasonable to say that parking information has already been provided at the best locations within Gent and that further installations might not necessarily add to the value of the whole system

B.2 HEIDELBERG

B.2.1 Detailed project description

A new parking scheme was implemented in the City of **Heidelberg**, incorporating parking guidance and control systems in the area of *Bergheim*. The scheme aims to redistribute the available on-street parking spaces among users, giving priority to residents and short time customers or visitors. Long stay users, such as commuters, are directed to car parks. In the area of *Kirchheim*, the project focused on the implementation of traffic calming and pedestrianisation measures with the overall aim to increase road safety for vulnerable road users. The OPIUM demonstration sites and their applications are shown in Figure B.3.

Figure B.3 OPIUM Demonstration Sites and Applications in Heidelberg

Parking management and guidance

Bergheim, situated within the central area of Heidelberg, has a population of 6,500 and is characterised by a very dense mixture of land use with very little open green space. There are 13,000 employees in Bergheim; 95% are commuters and the majority travel to work by car.

Measures within OPIUM were designed to reduce the number of on-street parking places and to redistribute them, favouring residents and short-stay users. In particular, the measures were designed to restrict the number of parking places to commuters and aimed to encourage them to shift modes from car to public transport, through establishing an effective parking management scheme combined with measures to improve public transport.

The supply and demand of parking space was analysed and determined according to the availability of parking space and the likely demand made by different groups of users, especially taking account of the needs of local residents. A more detailed investigation was undertaken on the actual use of parking space for areas with a very high demand. As a result of the site analysis, two or three scenarios were developed and discussed within the relevant departments of the administration and committees of the municipal council.

The data and information collected provided a framework in which a concept for parking management could be established. As a result, a parking management scheme was implemented aimed at restricting the use of public parking space. This scheme included the following initiatives, which involved designating different parking areas with different conditions:

- parking areas reserved only for residents who purchase a parking permit, which costs about 40 ECUs per year;
- parking areas with time restrictions and different fees (residents with permits are allowed access);
- parking areas which can only be used by commercial/industrial users eg. for deliveries (if not on private space).

The parking management measures were combined with awareness campaigns and initiatives to improve the public transport system. The implementation was designed to encourage more commuters to travel to Bergheim by public transport or bicycle in order to reduce the search for parking spaces within residential areas.

The parking management scheme aimed to cover the costs of maintaining the scheme and parking regulations with the revenue raised by incoming parking fees, permits purchased by residents and penalty fines.

Traffic Calming

The OPIUM measures for traffic calming **Figure B.4:**

in Heidelberg included the implementation of speed reduction of motorised traffic in some streets, the exclusion of motorised traffic within a different area, more crossings for pedestrians and road narrowing. These measures were implemented in Kirchheim (see Figure B.4, right), situated in the south-western district of Heidelberg. It was felt necessary to implement traffic calming measures especially within areas near to kindergartens, homes and schools, in order to increase the safety of children and other vulnerable road users.

Traffic calming had already been implemented in Kirchheim prior to the OPIUM project; 30 km/h zones have been introduced on the main roads throughout the district. Within OPIUM, the impact of this traffic calming measure was initially examined and the following problems were detected:

- high concentration of through car traffic and car parking;
- very narrow roads in the shopping area within the centre of Kirchheim;
- large number of pedestrians.

Several sources of information were used to develop a more detailed picture of the situation in Kirchheim. The information and data, together with the subjective views of the residents, enabled a hierarchy of problems to be identified and resolved.

Possible measures were considered and their likely impacts on traffic calming were assessed and analysed in two or three scenarios. These scenarios were presented and discussed with city authorities and residents, which led to the development of a traffic calming strategy in Kirchheim. This included:

1. the reduction of speed in sensitive areas e.g. a residential area with a maximum speed of 7 km/h and a shopping area with a maximum speed of 20 km/h;

2. the reduction of speed by narrowing the road including:
   - the creation of alternative street parking, so that cars are not parked on the pavement anymore;
   - improvement of crossings for pedestrians and cyclists through the implementation of crossing aids (nose-path) and the creation of additional crossings, with a direct impact on the speed of cars.

Bicycle measures

Figure B.5 Bicycle Lanes

Bicycle measures were also implemented in Heidelberg.
New bicycle lanes have been designed and implemented within OPIUM on the west side of the Mittermaierstrasse (see Figure B.5). The effectiveness of new cycle lanes has been facilitated and complemented by traffic calming measures.

In Bergheim, one of the main axes between the main station and the university was a two-direction bicycle lane on the east side of the street which caused a lot of dangerous situations. To reach the station most cyclists had to cross the main road twice which was very inconvenient. Within OPIUM, the bicycle lane was redesigned and new separate bicycle lanes on both sides of the street will increase road safety safe beneath a main road.

B.2.2 Project Impacts

User acceptance and attitudinal

In the area of Bergheim, where the new parking scheme is installed, the measures are well accepted by the users, although the opinion of the different end-users is slightly different, according to the parking opportunity that is offered to each kind of end-user.

Public transport users

Public transport users are not strongly affected by the measures implemented in Bergheim, as they do not have to concern about parking places. The main concern for public transport users is the regularity of public transport, comfortable connections and short travel times. Those aspects of public transport can be affected by private car traffic in such a way that a reduction of private car transport has a positive influence on the flow of public transport vehicles. The accessibility of enterprises with public transport in Bergheim is mostly rated as good or very good. This opinion did not change after the introduction of the parking measures.

Car drivers

In the area of Bergheim, there is a high demand for non-payable parking places. The redistribution of parking places aims to give more parking space for residents and short-term customers, and to reduce on-street parking for long-term parking. As most commuters can use company parking places, only a minority of them are affected by the implemented measures. Because of a reduction in free parking places after the reorganisation, a small percentage shifted towards public transport or bicycle.

Visitors coming regularly to Bergheim usually know where to park and park as planned. Although they make no use of the parking guidance system, only 5% state that it is not necessary. The others think it gives a good orientation and that it is necessary for visitors.

Pedestrians

In Kircheim, traffic calming is proposed in the main shopping street. As works will go hand in hand with the construction of the new tramway line, works are not carried out yet. From the surveys can be learnt that people are very positive to the idea of implementing traffic calming in order to increase safety. For the moment 2/3 of the people interviewed state that they feel very uncomfortable in this street.

Vulnerable road users

The perception of danger was also examined in the area where the pedestrian pathway was improved, especially in order to improve safety for vulnerable road users like children. After the implementation 63% of the interviewed people stated that several streets are safe enough for the children to walk alone, whereas before the implementation this was stated by only 46%. With regard to playing on the street only 40% state this is safe enough on at least one street. It was initially planned to install new a new playground but this had to be cancelled because neighbours refused to agree to have a playground near their houses.

Shopkeepers

Shopkeepers always fear to lose customers and clients if the accessibility for private cars is reduced. The parking guidance system was a concerted action of city authorities and car park owners, and had the intention to make clear to everyone that the City of Heidelberg can be reached by car. The offer of parking places in parking garages can meet the demand but it must be paid for. Within the OPIUM project, a brochure was produced on the availability of customer short term parking on street and long term parking in parking garages. While distributing the leaflet to the shopkeepers to hand out to their customers, they seemed to understand the parking problem, but still needed to be convinced about the availability of other transport modes to bring the customers to their shops.

Residents

The parking management and guidance scheme in Bergheim aims for better parking conditions for residents. In the short-term, residents parking priority policy favours residents against commuters. About 60% of the residents state that this policy has advantages, whereas before the implementation this was only 45%. Outside the resident priority parking area, the parking pressure is rated very high, and 2/3 of the residents without private parking that are not located close to resident priority parking, state that the parking situation is difficult. This opinion does not differ from the opinion before the implementation of resident priority parking.

Public authority

The city council adopted in 1994 the Transport Development Plan. All measures adopted in the OPIUM project are part of this plan. The Transport Development Plan is also part of the municipal programme for CO2 reduction in which is stated to reduce the emissions by 20% by the year 2005 compared to 1988. Within this plan, transport-related actions were also identified as offering great scope for cost-effective CO_2 reductions.

Public transport operator

The principles of the public transport operator and the aims of the Transport Development Plan guarantee a strong interest in transport planning in favour of vulnerable road users. The combination of public transport, walking and cycling makes a strong alternative for car trips. Measures for pedestrians also benefit public transport users as the main before and after transport mode for public transport users is walking. Traffic calming can cause problems for public transport, when physical measures, such as road humps are used. This can disturb in a high level the comfort of the travellers. In Kirchheim however, buses are running through the main roads, where traffic speed is reduced to 30km/h without the use of physical measures.

In Bergheim, the information brochures on parking places also inform on the public transport and Park and Ride facilities outside the city centre, which may attract new public transport users.

Behavioural impacts

The number of pedestrians in Kirchheim increased although the weather conditions during the 1998 counts were not favourable for walking, compared to those of 1997. Also, the number of cyclists seemed to increase in this period, although no special measures were undertaken in favour of these within the OPIUM project.

The number of public transport users increased slightly within this period. This is mainly due to the introduction of the job-ticket and student ticket, which make the use of public transport cheaper than in former times. Also the reduction of on-street parking places has had an influence, although it was not possible to measure its impact specifically.

About 750 interviews were undertaken in order to measure the modal split for commuters to Bergheim. From these was learnt that the use of public transport grew by about 3%, whereas car traffic stayed about the same. Cycling and walking decreased slightly. This leads to an equal share of car traffic and public transport for commuters in 1998.

Two companies introduced parking fees for employees during the parking management scheme along with "job" (subsidised public transport) tickets. In these companies the number of individual car trips decreased and the use of public transport increased to the greatest extent.

In Kirchheim, the daily mobility of children was measured. There was no difference in the mode of travel before and after the implementation of the measures.

Operational and technical impacts

The evaluation of the traffic calming in Kirchheim showed that the number of cars decreased slightly, and that the maximum speed limits are observed.

In Bergheim, the number of cars stayed in global about the same after the parking management scheme, because of the high level of through traffic in the area. In some local streets, however, the number of cars decreased by 25%.

Institutional and legal issues

The OPIUM measures are all part of the Transport Development Plan adopted in Heidelberg in 1994. No major institutional issues were identified. The traffic calming measures on the main shopping street of Kircheim have been delayed, but this is a result of the need to undertake works at the time that the new tramway line is constructed.

Environmental impacts

An improvement in environmental conditions results from the parking management measures. The traffic management measures may have resulted in a slight increase in pollution, since traffic has slowed down: this effect could be eliminated by the introduction of further measures which would achieve greater modal shift.

Road safety

One of the aims of traffic calming in Kirchheim is the reduction of danger for vulnerable road users. Often the perception of danger leads to a restriction of movements of vulnerable road users, leading to a shift to motorised traffic or to the cancellation of the journey.

In Kirchheim, most of the main roads are still considered as dangerous for small children, although the number of accidents with pedestrians is very low. The number went down from 3 accidents in 1996 to 0 accidents in 1998. Parents still would like to have more crossing aids and broader pathways.

In Bergheim the number of accidents in global stayed about the same. Accidents of pedestrians and cyclists slightly decreased.

Socio-economic impacts

The scheme has resulted in strong economic benefits, due to the revenues achieved from the parking management system.

B.2.3 Transferability

Kircheim

Traffic calming measures of the type developed in Kircheim are eminently transferable to other areas of the city. It would be quite appropriate to develop such zones in all residential areas as funds permit.

The main added value benefits which would occur from such a system would be as follows:

<u>Education:</u> drivers would become more familiar with the traffic calming concept and more likely to be aware of speed restrictions. Of course, familiarity can lead to complacency, and the level of compliance with speed restrictions would probably not alter significantly.

<u>Diversion:</u> localised areas of traffic calming may lead drivers to divert to other destinations. Clearly a widespread implementation of such measures would be helpful since it would ensure that traffic is not relocated from one housing area to another. Moreover, widespread implementation would have an additional advantage in that it would help to reduce the concerns of local businesses that they would suffer economic disadvantage compared to businesses in areas where there are no traffic restrictions. The latter effect may be partially discounted because the improved environment which results from traffic calming may actually stimulate local business.

Enforcement: widespread implementation need not require a proportional increase in enforcement. It may be satisfactory to establish one or more specialist enforcement teams, equipped with speed monitoring equipment, who can be deployed amongst the traffic calmed areas. A high public profile will help to ensure awareness of the enforcement programme.

Bergheim

The Bergheim parking information systems is also transferable to other parts of the city. Whilst it is not possible to provide details of every car park at the approaches to the city, it is often helpful to indicate the areas in which ample parking is available, and the number of spaces free in key car parks. As the user approaches the destination, more detailed information systems can provide information on the smaller car parks which are considered in the Bergheim example.

The Bergheim project has also achieved substantial revenues, demonstrating that the transferability of such measures is certainly desirable. There is also a benefit to be achieved in ensuring comparable parking pricing regimes throughout the city, enabling demand for city centre parking to be controlled by increasing central parking costs against the costs of parking in less congested areas.

B.3 LIVERPOOL

B.3.1 Detailed project description

The City of **Liverpool** introduced bus priority and traffic management measures along an important transport corridor running towards the city centre. Within the OPIUM project, the existing bus lane was extended and marked with a red surface dressing to provide priority to buses, taxis and cyclists. Three new extensive sections of bus lane were introduced to complement the enhanced existing bus priority measures. The operational hours of the bus lane were extended. In order to increase safety for pedestrians, the layout of two crossings were changed, and a new design was prepared for a major intersection on the corridor. The OPIUM demonstration sites and their applications are shown in Figure B.6.

Figure B.6 OPIUM Demonstration Sites and Applications in Liverpool

Bus priority measures

The OPIUM measures contributed to a rolling programme of bus priority schemes along several major corridors in the city. Within OPIUM, an existing bus lane along an important transport corridor, (Wavertree Road-Netherley) was extended with a more detailed design marked with a red surface dressing to provide priority to buses, taxis and cyclists.

OPIUM also included the detailed re-design of a major strategic junction, which will eventually increase the effectiveness of bus priority measures.

The following issues were identified as unique to the OPIUM Corridor:

- it cuts through a conservation area;
- it incorporates substantial strategic highway issues e.g.: at the Childwall Five Ways junction;
- it is a potential light rail transit route, so there was a need to design it to complement the light rail transit alignment, and to accommodate the two modes of public transport;
- it joins an area with socio-economic problems (Netherley) to the city centre, but also passes through distinct areas characterised by a greater level of affluence and higher car ownership.

Additional features of the Bus Priority Scheme included the need to take into account suitable restraints to prevent the development of “rat runs” and also to encourage those residents of the intermediate areas to shift modes from private car to public transport for journeys into and out of the city. Furthermore, traffic signals were optimised for people not vehicles flows with time allocated to increase the regularity and efficiency of bus services.

Bicycle measures

The redesign of the 5-ways roundabout junction was undertaken taking full account of the needs of cyclists. Cyclists are also allowed to use bus lanes.

B.3.2 Project Impacts

User acceptance

Pedestrians

A great majority of survey respondents find car traffic fairly or very noisy (86%), but the perception improved following the implementation of the measures. Only 41% actually finds the traffic noise to be a problem. Concerning the perception of speed, the results show that pedestrians perceive traffic to be fairly or very fast (91%). In contrast to traffic noise, traffic speed is considered to be a problem.

Half of the pedestrians find crossing the road very difficult. Quite similar to the results obtained for traffic speed, the level of danger was perceived fairly or very high (90%) as well as the pollution (89%).

Further measures for pedestrians will be needed to improve this overall perception.

Cyclists

In accordance to the opinion of the pedestrians, the cyclists consider the speed of traffic to be fairly fast (64%) and very fast (23%), but they appreciate the reduction in vehicle speeds as a result of being able to cycle in bus lanes.

The level of danger was perceived to be fairly high (59%) or very high (36%). The pollution was evaluated more positively after the implementation of the measures than before. A majority of the cyclists regard parked cars as problematic along the project area. It is suggested that parked cars are the cause of the irregular traffic flows that occur along the corridor.

82% of the interviewees knew that they were permitted to ride in the bus lanes and more than 90% stated that they had already cycled in the bus lanes during the operating times. The fact that the cyclists support the implementation of the bus lanes confirms the better cycling conditions in the bus lanes. The full bicycle measures have yet to be implemented at Five Ways roundabout, however, the interim measures should have improved safety for cyclists at this location. Half of the interviewees had never cycled at Five Ways roundabout. The majority of the ones who had were against the implementation of the measures.

Shopkeepers

The objective of the survey was to assess the attitudes of the shopkeepers towards the implementation of the measures. 90% of the shops have deliveries to or from their shop. Almost half the deliveries take place at least once a day, either parked outside the shop (83%), or using side streets (22%). The remainder uses own parking areas (8%). Shopkeepers feared that goods deliveries would not be possible anymore after the implementation of the measures. It turned out to be that the decrease in the number of deliveries was less severe than was expected. There has been an increase in the use of side streets for this purpose. Though a problem still exists with the enforcement of the parking restrictions. 69% of the shops have deliveries outside their shop but 80% of the shops have parking restrictions in front of their doors.

The amount of parkers at the project has decreased, independent of the implementation of a bus lane. The residents generally believe that a decrease in custom was linked to the implementation of the bus lanes. The attitudes have become worse compared to the reference situation, when measures where introduced. The attitudes of the shopkeepers against the bus lanes are the most negative of all the user groups.

Residents

The attitude of the local residents concerning the general traffic situation is generally more negative than the residents from outside the area. They find the traffic noisy, faster and more dangerous and making more pollution. The opinions on the other hand about the bus lanes were less strong than the outside population. The local population was considerably more in favour of the measures implemented in Five Ways than were the non-locals. The most common use of transport mode of locals at Five Ways is walking opposed to the use of buses by non-locals. This could explain the differences in evaluation.

Bus users

The attitude of bus users who use the bus as a common means of transport differs from the attitude of other transport users. Bus users are generally in favour of the separate bus lanes with approximately 68 % of the users to 57% of the non-users. The traffic speed is perceived to be very fast by bus users and less fast by non-users. Bus users estimate the pollution of traffic higher than non-users. The difficulty of crossing the street and the level of danger is worse for non-users than for users.

Elderly Pedestrians

The attitudes of the elderly corresponded with the overall results of the interviews, although a slightly higher percentage of the elderly was in favour of the measures that had been undertaken.

Mobility-impaired people

Walking is the most important means of transport followed by bus and by car use. The mobility-impaired people were more sensitive to changes in traffic conditions. Traffic speed and noise is evaluated as more negative, pollution as worse and to cross the road as more difficult than the average group. The situation from the point of view of the mobility-impaired people has decreased after the implementation of the measures.

Car drivers

The attitude of the car drivers, which were collected by means of the pedestrian, cyclists and shopkeeper survey contain differing results. The majority of the cyclists and half of the pedestrians evaluated the bus lanes in a positive way. The shopkeepers are generally against it. The traffic speed and pollution is not considered to be an important difficulty, compared to the other road users. The level of severity to which car drivers attribute the danger of traffic and the difficulty of crossing the street is much lower than for the other road users.

Bus operators

The public transport operators are in favour of the bus priority systems. A small improvement in journey times was identified, along with a higher degree of service reliability. The introduction of the measures has shifted the congestion to the end points of the corridor. A major difficulty, however, is the enforcement of the bus lanes, since private cars make use of them at the approaches to the junctions, leading to queuing. Also, parking, and deliveries to shops are still occurring on the bus lanes, where this is no longer permitted, causing congestion.

Behavioural impacts

The traffic entering the project area at the western side has not been altered after the implementation of the measures. The eastern side experienced a slight decrease in the morning peak traffic of approximately 2.8% in volume. The outgoing traffic at the evening peak also experienced a slight decrease in level.

The car occupancy is situated between 1.3 and 1.5 passengers per vehicle. The occupancy rates have increased for more locations than have decreased. The afternoon peak knows a greater increase in occupancy rates than the morning peak.

The number of pedestrians walking on the pavement, crossing the road at recognised crossing points and crossing the road away from a recognised crossing point was recorded. Three different age categories were distinguished for this exercise: under 18 years old, between 18 and 60 and above 60 years.

The pattern of pedestrian movements for the different age groups is similar for the before and the after surveys. Both in the before and after survey, much crossing activity takes place away from designated crossing areas. Even after the implementation of the measures, the number of crossings does not seem to be sufficient, reflecting the difficulty involved in increasing disruption to traffic on this major corridor.

Operational and technical

Assessment of the amount of vehicles

Increase in queue length occurs particularly during the morning peak. The average speed of cars has consequently decreased with a slight increase along a small part of the corridor. The length of the trip along the whole corridor has increased by approximately 2 minutes during the morning peak and 3 minutes during the evening peak.

Assessment of the amount of buses

The average speed of the buses has increased from 21.6 km/h to 23.0 km/h in the morning peak and remained at the same level during the evening peak. This reflects the greater levels of bus priority in the inbound direction during the morning peak. The bus journey times decreased with an average of 40 seconds. Some difficulties exist with loading and unloading activities in the bus lane during the morning peak. These are not major problems since the maximum length of the parking time detected was 10 minutes.

Institutional and legal issues

Some institutional difficulties were encountered due to the need to complete the works within a European timescale which did not reflect the UK funding and planning process. These problems were overcome by a well-planned approach to public consultation and project management. Implementation of the measures was slightly delayed by the need to construct a public consensus for the initiatives. However, once this was achieved, the momentum and support for the OPIUM measures overcame any opposition.

Environmental impacts

Increased delays to cars may lead initially to slightly increased levels of pollution. These increases will be overcome if car usage is gradually reduced through modal shift and a co-ordinated wider implementation of OPIUM measures.

Road safety

The proportion of accidents (17%) which take place on buses, occur when the vehicles are forced to brake sharply. This is a major concern. These incidents can discourage the elderly and disabled from using public transport. Increases in the speed of buses and cars can lead to increased potential for accidents, however faster speeds for buses using bus lanes do not seem to be a problem due to the lower level of potential conflict in segregated traffic lanes.

Socio-economic benefits

The scheme offers major economic benefits to public transport users, achieving an impressive payback. Economic disbenefits are experienced by car users, but these serve to reinforce policy objectives and can be viewed positively.

B.3.3 Transferability

The OPIUM bus priority measures developed in Liverpool could certainly be applied to other corridors in the city. The development of a wider network of bus priority measures has substantial added value, because the wider re-allocation of roadspace to public transport, and away from the private car, will help to maximise the modal shift away from the car. In addition, a wider bus priority network increases the ease by which complex cross-city trips can be made by public transport.

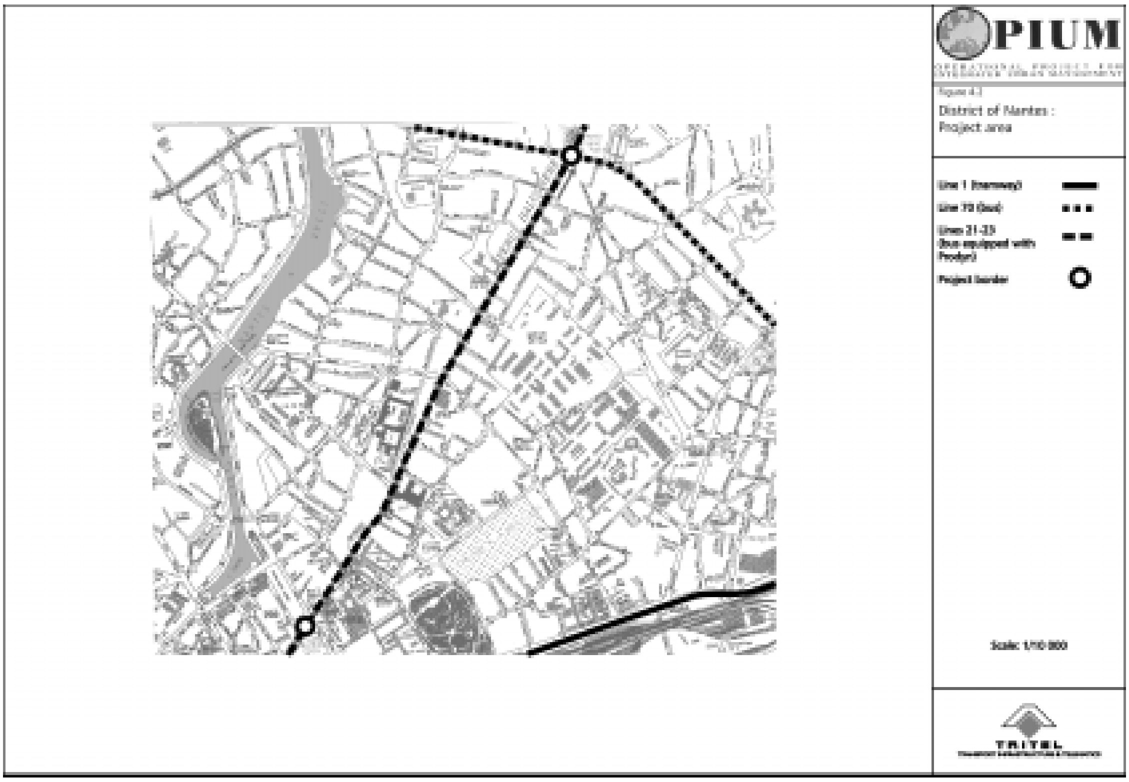
Bus priority measures help to raise the profile of public transport, and a wide appreciation of the importance of bus travel across the city will play a valuable role in promoting longer term modal shift.

B.4 NANTES

B.4.1 Detailed project description

A long-term traffic plan for **Nantes** is intended to improve the attractiveness of public transport and to replace radial traffic with peripheral movements. The plan is being implemented in different stages and concentrates on measures such as bus priority systems, traffic calming and parking management. Specific measures introduced within OPIUM included the development of a park and ride site, Le Cardo, and bus priority measures, including the evaluation of traffic calming along Rue Bellamy. The OPIUM demonstration sites and their applications are shown in Figure B.7.

Figure B.7 OPIUM Demonstration Sites and Applications in Nantes



Parking management

A new Park and Ride site at Le Cardo was developed in order to reduce the number of on-street parking places and to reduce the number of cars entering the city.

The City of *Nantes* also completed the concept of the park and ride scheme at Haluchere, where 236 parking places are provided at the interchange station. Dynamic information is given on the next departure of bus or tram.

Plate B.1: Le Cardo Park and Ride Site

Bus priority measures

During 1996 and 1997, specific elements of the transport plan were implemented along an important transport corridor, the 'Route de Paris'. These measures formed the basis of the OPIUM demonstration project in Nantes. Bus priority measures, including traffic calming were implemented along Rue Bellamy (along a 4,4 km long route, from the Haluchère bus-tram interchange to the city centre of Nantes); these involved the creation of alternating bus lanes and road narrowing, and priority at traffic lights was reallocated to increase the efficiency and regularity of bus services.

A traffic signal bus priority system was applied. The implementation has enabled the effective management bus priority at junctions taking into account the level and control of car traffic, especially the length of car queues on every other arm of the junction. The system is very flexible and can adjust to the real time traffic conditions throughout the day and throughout the week. Moreover, the system is perfectly adapted to the traffic light system of the City of Nantes.

Overall, the OPIUM bus priority measures contribute positively to the development and impact of the City's transport plan, especially with regard to the implementation of new tramlines. It is now realised that public transport priority measures at junctions should be considered as a critical element for future transport planning and policy-making.

Traffic calming

The introduction of traffic calming included measures to reduce the speed of motorised traffic to 50Km/h along the public transport corridor. Within this scheme, principal roads in Nantes remained available and designated for car drivers whilst other roads in the City were affected by the measures designed to reduce speed.

Bus priority measures and traffic calming were implemented together to enhance and ensure the success of the new Park and Ride site, Le Cardo.

B.4.2 Project Impacts

User acceptance

Public transport users

In order to assess the opinions of public transport users on the measures that are taken in order to give priority to public transport, 330 customers using buses on Bellamy street were interviewed. Three quarters of the interviewed people were daily or very regular users, ¼ were occasional users. More than half of the users had been using the bus routes before the new layouts. From these, 70% state that the new layout helps to reduce their journey times and claim that this system should be implemented in other parts of the city. Public transport users are thus quite satisfied with the new situation.

Regarding the new passengers on the line, the previous transport mode was asked for. Half of them were using a private car as a driver, ¼ were using a private car as a passenger and ¼ were cyclists.

Coach and bus drivers

Coaches from outside the District area as well as drivers of public transport vehicles operated by Semitan, are making use of the new road lay-out in favour of public transport. The only difference for coaches is that they do not get the possibility of provoking the "green phase" on junctions, whereas urban buses are equipped with a system that enables them to start ahead of the car lane. Drivers of buses as well as coaches were interviewed.

Because the drivers appreciated very much the benefits of the public transport corridor they were using on their way up to the outskirts of the city, the new situation where car traffic was allowed again in both ways, is not very appreciated, although measures were taken to give buses and coaches free space at the entrance of each crossing. The principle tonality of the interviews was that ‘it is better than nothing’. But there are advantages to the system such as:

- Time savings
- Better fluidity of traffic
- Balance of the journey times in both ways
- Feeling of a better security linked to the speed reduction

Generally speaking, the system seems to be satisfactory as half of the drivers estimate that this layout enables them to recover 3 to 4 minutes delay in off-peak hours. But currently, due to the fact that the city is building the third tram line and having works everywhere, the delays can be so important that the length of the street does not allow to recover all of the lost time.
Their opinion about the admittance of cyclists on the bus lanes, is rather neutral as there are not so many cyclists on this corridor. Some of them state that ‘once you are behind one bicycle, you can not overtake it without causing a danger for cars on the street’. This means that the speed is lower on that part of the road.

Car drivers

Concerning the new layout of Bellamy street, car drivers were at the beginning of the operation not very happy with the operation as it forces them to ‘slalom’ on the street. After a certain period, when they got used to the situation, they claim that it is still not very practical to slalom, but that they get the impression that they are ‘sharing the road with public transport and coaches’; sometimes they stay behind it, sometimes they can over-take. They do accept this situation. A major comment of all users of the street is that they have to watch out very carefully, especially when somebody new is using the corridor as the situation is not always very clear.

Concerning the Park & Ride le Cardo, many car users changed their habits and instead of using the car to go to the city centre, they park in le Cardo and go to the centre by bus or tram (78%). The new layout of the Park and Ride site provoked a high increase in the use of it. Especially the fact that the Parking is secure influenced car drivers in a positive way.

Cyclists

As already mentioned, cyclists share the road with buses and coaches in the new lay-out of Bellamy Street. Although a general view of the opinion of cyclists is difficult to give as they all have a different reason for cycling and different opinions about it, most of the cyclists subscribe the idea that it is better to share the road with buses than with cars, despite the fact that they get stressed when a bus is right behind them. They criticise the lack of visibility for car users when they are coming out of their parking place, as it endangers their position on the road.

Pedestrians

The number of protected crossings on the corridor has increased from 11 to 18 in the new lay-out of the street. All junctions have now been equipped with protected pedestrian crossings. The average distance between two pedestrian crossings has reduced from 300 m to 150 meters. No general counts or surveys have been done for pedestrians.

Behavioural impacts

After the implementation of the measures (including the diminution of car lanes from 2 to 1), the number of cars in Bellamy street going towards the city centre decreased by 20 %.

The use of public transport on this corridor decreased from 39,000 before the implementation of the second tramway line to 36,500 after the implementation of the tramway line and the new layout of the road. This diminution of travellers is mainly due to the shift from bus to tram and to the decrease of operation of buses on the corridor. There is direct relation with the measures implemented on the corridor.

The number of two-wheelers on the corridor towards the city centre also decreased. The following table shows that this decrease relates to motor cycles, while a slight growth in the number of bicycles is showed. Towards the outskirts, an increase of two-wheelers can be appreciated. This data is summarised in table B.1.

Table B.1: The number of two wheelers 'before and after' implementation of the OPIUM measures

		Towards the city centre			**Towards the outskirts**		
		Cyclists	*Motored two-wheelers*	**Total**	*Cyclists*	*Motored two-wheelers*	**Total**
North	*Before*	17	81	**98**	13	6	**19**
	After	20	61	**81**	14	22	**36**
South	*Before*	26	98	**124**	2	2	**4**
	After	28	57	**85**	18	27	**45**

Regarding the use of the Park and Ride in le Cardo a high increase in use was realised since September 1997, when the new layout was installed. From the survey was learnt that the new users of the park & ride previously used the car to travel into the city centre and that they mostly used a public parking in the city centre that was free of charge.

Operational and technical

Journey times

The overall car journey time in the corridor has increased because of the diminution of traffic speed that went up to 70 km./h before the new lay-out and went down after the implementation to the indicated speed limit of 50km/h.

The bus journey times have decreased towards the city centre by 6 minutes (from 19 to 13 minutes) in the peak hours and 2 minutes in off-peak hours (from 15 to 13 minutes). On the way to the outskirts, the journey times have not increased (despite the fact that in the previous situation there was a bus corridor all along the street). Thus the new system has offered more regularity for both directions and a reduction of time to the city centre, without reducing the benefits of the previous situation.

Legal and institutional

Ideally the bus priority measures would be complemented by urban planning actions, which would be enabled by closer co-operation. The need for co-operation between the city and district was a potential barrier to successful implementation, overcome during the OPIUM project.

Environment

The bus priority scheme has lead to reductions in traffic noise, but lower traffic speeds, although deliberately induced, lead to small increases in air pollution.

The park and ride scheme reduces urban car travel, thus contributing to a reduction in vehicle emissions, and other environmental impacts. Whilst the overall level of benefits may be low, wider implementation would lead to significant improvements.

Road safety

The evolution of the number of accidents on Bellamy street is known from 1989 to 1997. For 1998, the figures are not yet available. Over the past ten years, the number of accidents has grown, mainly due to the increase of traffic. Although the gravity of accidents is mostly low (light wounded and no people were killed), the number of seriously wounded people increase from 0 to 6. This increase has no relation to the measures introduced on the street.

Socio-economic

The overall scheme shows a positive socio-economic performance. This reflects, however, an increase in public transport revenues which may have accrued, in part, as a result of the new Light Rail system, but which cannot be distinguished from the OPIUM benefits.

B.4.3 Transferability

As in Liverpool, there is considerable added value in the development of additional bus priority corridors to augment the OPIUM corridor.

The development of additional park and ride sites within Nantes does, in the first instance, offer added value to the existing site. There is a clear advantage in establishing the principle of park and ride within Nantes, and to be able to gain economies of scale in the promotion and organisation of such sites. Bus services may be designed to link multiple park and ride sites via the city centre, achieving a modest improvement in operation by increasing route length and the choice of destinations served. The public become familiar with the Park and Ride concept and, as demand increases, can be confident that overflow facilities exist once one site becomes full. Of course, as the park and ride system is expanded, it will reach a point where supply exceeds demand to an unnecessary degree, and an inefficiency enters the system. Nevertheless, a number of additional sites could certainly be developed without a risk of this eventuality.

B.5 PATRA

B.5.1 Detailed project description

In Patra, traffic calming, parking management and supporting measures have been designed within OPIUM. Implementation of these measures was planned to take place in the OPIUM project, but later rejected owing to the insurmountable barriers to implementation which occurred, and which led to the withdrawal of the Patra partners from the OPIUM consortium.

It is anticipated that the OPIUM measures will be implemented in the future. The proposed demonstration sites and their applications are shown in Figure B.8.

Figure B.8 OPIUM Demonstration Sites and Applications in Patra

Traffic calming

Traffic calming measures were designed for the area surrounding the Old City hospital adjusted to the centre, in a heritage area. The following measures were designed with the overall aim to reduce car traffic:

- pedestrianisation of some major streets in the city centre as well as groups of minor streets;
- traffic calming schemes in some central areas;
- additional space on major streets giving priority to buses (bus lanes).

Bus priority measures

Within OPIUM, bus priority measures have been designed including bus lanes (with flow and contra low), which in combination with recently-introduced mini-bus lines could give a clear priority to buses and restrict car traffic within the city centre.

Parking Management

The requirements for car parks in the city centre and its surrounding area were specified by the municipality. The car parks designed within OPIUM are underground, and only in exceptional cases should be surface level.

This measure was designed in order to reduce and minimise on-street parking within the city centre, and to reallocate and restrict the use of on-street parking so that only local residents have access.

B.6 UTRECHT

B.6.1 Detailed project description

The OPIUM measures in Utrecht primarily focused on the restriction of private road space and parking management; these included the implementation of bus lanes and measures to restrict car traffic and prohibit on-street parking within historical centres, Park and Ride facilities and a parking guidance information system. The OPIUM demonstration sites and their applications are shown in Figure B.9.

Figure B.9 OPIUM Demonstration Sites and Applications in Utrecht

Private car road space restriction

Measures were implemented within OPIUM to reduce the space available to the private car as a means of improving quality of life. Where private car road space was restricted in the city centre, the supply of on-street parking spaces was reduced. The additional road space that became available by this measure was reallocated to public transport and to vulnerable road users.

Two of the main streets in the inner city of Utrecht, which are important streets for through-traffic, were closed to private cars. A bus lane was implemented as an additional measure to support the restriction of private cars, in order to increase road safety, improve the efficiency and accessibility of public transport in the inner city and encourage a positive modal shift.

Pedestrianisation

Pedestrian and car free areas were introduced within OPIUM in three of Utrecht's main historical centres to create an improved environment for pedestrians and to attract visitors. To support this, measures were implemented to prohibit on-street parking within these particular areas.

Parking management and guidance

Within OPIUM, measures were designed and implemented in conjunction with the 'three-ring-concept' adopted by the Municipality of Utrecht and the highway authorities. These included the development of parking information and guidance systems at the following three levels:

- The regional ring: the car driver receives information on the highway and is guided to Park & Ride sites at the edge of town. Supplementary public transport services is now provided by trains and buses;
- The municipal ring: the car driver receives information and guidance to Park & Ride sites. Supplementary public transport is now provided by high quality bus systems and specific shuttle services such as the shopping express;
- The city ring: the car driver receives information about the available parking places, and is guided to the car parks. City bus, city taxi or rent-a-bike facilities will be provided at certain car parks.

The parking management and guidance measures were designed to reduce the level of car traffic and the demand for parking space in the inner city. Three types of information are provided:

- information according to the parking situation and P&R facilities;
- information according to the destination of the car driver, the routes or special events;
- information according to additional transport.

This concept encourages people to leave the car before entering the centre and to use the accompanying travel mode that is offered (bike, taxi, bus, etc). This global concept aims to induce an important modal shift from private car traffic to other 'collective' and/or to more energy and environment friendly transport modes. New P&R sites were designed together with new bus services connecting the parking place with the inner city.

B.6.2 Project Impacts

User acceptance

Public transport users

From the surveys that have been undertaken with people in the city centre, the opinion of public transport users on the general traffic situation was derived. It appeared that the mark public transport users give on traffic safety is lower than the mark given by car drivers and slow traffic. Also safety in car parks is marked lower by them. All have the idea that safety in car parks has grown after the introduction of the Parking Route Information System. This should be due to the higher occupancy rate of the parkings.

Concerning new transport modes such as the Shopping Express, Theatre Express and Traintaxi, it turned out that the familiarity with these transport means has increased (40% of the interviewed people know for example the Shopping Express, where it was 30% at the start of the project). The Shopping express, for example, was rated very highly by users, with all aspects considered to be good, or very good. Reliability and service frequency were considered particularly good.

The Park and Ride site was also considered to perform very well, particularly in terms of accessibility and personal security.

Car drivers and Park&Ride users

For car drivers and Park and Ride users, the measures undertaken within OPIUM have been of particular importance: car free city and squares, Parking route information system and the new Park & Ride facility Galgenwaard with the Shopping Express.

From the evaluation can be learnt that the decision on where to park is made by most users of the Galgenwaard park and ride, or inner city car parks, when they are still at home. The park and ride information system has a maximum impact at times when the availability of parking spaces is limited. When there is indicated that less than 10 places are available, they will use the parking route guidance system to find another parking place. For people that want to park in the inner city, the dynamic information on the available parking places at each site is the most important part of a park and ride information system sign.

From the first evaluation was learnt that park and ride information system gains its importance when coming closer to the city centre. The information that is provided on the regional ring was used by 22% of car drivers, information on the urban ring by 23% and information on the inner city ring by 53%.

From the park and ride information system survey, it was learnt that the information was understood correctly, although some minor remarks were made on the signs used. Two specific points were indicated where the system should be improved: first of all the reliability is questioned by 25% of the users, secondly the information facilities guiding people out of the city are regarded as insufficient.

Pedestrians and cyclists

No specific measures were taken within the OPIUM project for these types of users. However, pedestrians and cyclists rate the aspects that are specific related to slow traffic (such as bicycle shelters, walking distances and information facilities for pedestrians) lower than before OPIUM or less positive than public transport users and car drivers. Naturally many of the OPIUM measures are a direct or indirect benefit to these users.

Residents

The opinion of residents towards the traffic situation in Utrecht is derived from a survey that was held after the modification of the traffic situation in the inner city. Within the questioned group of inhabitants, a slight increase of cycling and walking and a very small decrease of car and bus use was the result. Half of the residents had a positive attitude towards the traffic circulation. The general complaint of those who were not happy with the new situation was that they had to follow a longer route for reaching their houses. People living just outside the inner city complained about the growth of car traffic in their surroundings.

Visitors

Visitors have a more negative opinion about the traffic situation. They think traffic circulation has become very difficult and there is no clear signing to reach the destination.

Shopkeepers

Although the shopping environment in the inner city has improved according to most of the inhabitants, 40% of the shopkeepers think it is worse since the traffic circulation measures have been taken. They also fear that customers will go to places outside the centre to do their shopping, because car traffic is reduced in the inner city centre.

Public authorities

For the Municipality of Utrecht, the most important surplus value of OPIUM for the City of Utrecht is the promotion of the city and the co-operation with Rijkwaterstaat, who is the owner of the national road for the introduction of park and ride information system.

The Municipality has also gained experience in consultation issues, and is now better able to liaise with shopkeepers and other interested parties. The Municipality is now more aware of the benefits which can be achieved by measures such as the Shopping Express.

Finally, OPIUM has highlighted the need for a structured routine monitoring programme for Utrecht, which will enable to collection of reliable travel data to inform future decision-making.

Public Transport Operators

The success of the ShoppingExpress concept, which is now also used for the TheatreExpress, provides an indication of the demand for such a service, and indicates the potential users who decided not to use the service. This makes it possible to optimise the concept further. OPIUM provides starting points for this further development. Besides this, OPIUM gives the public transport companies an incentive to target several other market sectors.

Behavioural impacts

Regarding the Shopping Express, the use of it has grown from 200 passengers on the shopping evening in the first evaluation to 300 users in the second evaluation. On Saturdays the Shopping Express is used by about 1300 passengers. The Theatre Express, that is based on the same concept also yields a profit. On average 150 passengers per week use this transportation mode. Compared to the number of parking places nearby the Theatre (about 100), this transport mode proves to be very welcome.

The modal split for the city centre is derived from the inner city survey and the results are summarised in table B.2.

Table B2: Modal Split in Utrecht

Transport mode[1]	Evaluation of reference situation	First evaluation	Final evaluation
Car and motor	18.4%	15.0%	12.4%
Local public transport	14.3%	16.9%	15.2%
Regional public transport	32.9%	35.3%	26.8%
Pedestrians and cyclists	34.4%	32.8%	45.6%
Total	100.0%	100.0%	100.0%

In comparison to the reference situation, the amount of pedestrians and cyclists has increased by more than 10% (this can be due to weather conditions and variations in travel patterns). The use of local public transport has slightly increased, whereas the use of car and regional public transport has decreased.

In general, one can say that visitors are satisfied with the accessibility of the inner city as well by public transport as by car. The appreciation of public transport and additional transport facilities and services is very positive and people claim to be aware of other transport modes. Therefore it may be concluded that the willingness for a modal shift towards transport modes other than car exists, but that efforts are needed in order actually to achieve this shift.

Operational and technical impacts

[1] Car and motor = car driver, car passenger, motorcyclist; local public transport = local bus, ShoppingExpress, Traintaxi, light rail; regional public transport = regional bus, train; slow traffic = bicycle, moped, pedestrian

In order to measure the impacts of the measures undertaken, the amount of parked cars in car parks and on street and the amount of additional transport users was analysed.

Both the occupancy rate of the car parks as well as the parking time have in general increased. The increase of the occupancy rate however is limited and still 40% of the parking capacity is not used. In peak periods, the occupancy rate can increase up to 100%. The absolute demand for parking space in the inner city has increased in general but particularly on Saturdays. Also, the surveys indicate a higher frequency of parking in the inner city, which underlines the park and ride information system results.

The amount of visitors that come to the city centre has stayed about the same, only on shopping evenings and on Saturdays a growth in visitors is established.

In the final evaluation, the estimation by visitors of travel time towards the inner city is substantially smaller than in both earlier evaluations. After travelling to the city centre, the users need to search for a parking place. After the implementation of park and ride information system the maximum search time was 5 minutes. The waiting time from the parking place to the destination was in 80% of the cases not more than 5 minutes. Also the queuing at car parks has decreased, although on shopping evenings a slight increase occurred (because of the growing amount of visitors).

Legal and institutional issues

The OPIUM measures advanced local experience of public consultation issues, whilst the inter-authority co-operation which was needed to enable the development of the parking information systems has been successful, and is likely to assist further initiatives in the future.

Environmental impacts

The OPIUM measures achieved improvements in environmental conditions due to the elimination of circulating and queuing traffic, and diversion of traffic from car to park and ride. Further benefits may be achieved as the park and ride system is expanded.

Road safety

No particular trend has been identified, either in terms of accident rates or perceptions of safety. Certainly, no problems have been identified. It should be noted, however, that this reflects the nature of the Utrecht schemes, and the limited post-implementation data available.

Socio-economic impacts

The Utrecht measures show a good economic return, with a payback period of around 6 years, reflecting in particular the savings in parking time which are realised. Further benefits may accrue as additional park and ride sites are developed, although overall parking revenues cannot be predicted.

B.6.3 Transferability

Car traffic restriction

Pedestrianisation of squares

These measures can be introduced more widely in Utrecht to a certain degree. At some point, however, a major decision regarding the city centre must be made. If wide-scale pedestrianisation is to be adopted then there will be a need to provide a considerable increase in public transport facilities, and to give greater consideration to traffic circulation around the outside of the pedestrian zone. Specifically, there will be a need to accommodate all passing traffic which previously travelled through the city centre.

Park and Ride

There is scope to beneficially increase the supply of park and ride spaces until the point when the market is saturated.

Parking information

Parking information systems can be installed more widely, but the greatest benefit is likely to be achieved at the locations where the initial system is already installed.

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