Competitive and Sustainable Growth Programme

PROGRESS Project 2000-CM.10390

PRICING **RO**AD USE FOR **G**REATER **R**ESPONSIBILITY, **E**FFICIENCY AND **S**USTAINABILITY IN CITIE**S**

Bristol • Copenhagen • Edinburgh • Genoa • Gothenburg • Helsinki • Rome • Trondheim

Main Project Report

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Introduction

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PRoGRESS was founded on urban road pricing initiatives in eight European cities:

- Bristol, UK
- Copenhagen, Denmark
- Edinburgh, UK
- Genoa, Italy
- Gothenburg, Sweden
- Helsinki, Finland
- Rome, Italy
- Trondheim, Norway

The PRoGRESS project consortium comprised 29 organisations drawn from six countries. It was co-ordinated by Bristol City Council.

Objectives and approach

The main goal of the PRoGRESS project was:

> *"to demonstrate and evaluate the effectiveness and acceptance of integrated urban transport pricing schemes to achieve transport goals and raise revenue."*

The PRoGRESS project was based on progressing and evaluating urban road pricing initiatives in the eight PRoGRESS cities. Originally, the eight PRoGRESS sites were intended to comprise:

- One existing road pricing scheme already in operation;
- Four new road pricing schemes;
- Two demonstration schemes to simulate charging systems; and
- One modelling study.

However, three of the envisaged new road pricing schemes had to alter their local focus during the course of the project to become demonstration schemes (with the approval of the European Commission). This was necessary due to time delays resulting from the essential political process surrounding the implementation of a real scheme.

Results, recommendations and conclusions

The eight PRoGRESS sites all successfully delivered operational schemes, demonstrations or modelling studies as required. These were thoroughly assessed in accordance with an evaluation plan developed in co-operation with the CUPID thematic network, and the results were pulled together at a European level to reach conclusions and recommendations for future development and use of road pricing schemes.

From the project experiences with real charging schemes, demonstrations, and modelling and research exercises in the eight cities, the project consortium gained a wealth of valuable information on a range of aspects of road pricing. Some 60 'lessons learned' were identified from the results of PRoGRESS, and recommendations were made about how future RP implementations in European cities could take account of those lessons. These experiences also provide useful information to European and national government, to industry and to research organisations. The lessons learned and recommendations cover:

- Consultation and information;
- Legal and institutional issues;
- Transportation policy;
- Technology and transaction;
- Enforcement; and
- User acceptance.

The key lessons learned and recommendations are shown in tabular form as Annex 1.

1 INTRODUCTION

1.1 The PRoGRESS Project

The PRoGRESS project was a major European demonstration project on urban road pricing that took place over a four-year period from June 2000 to May 2004. It was supported and part-financed by the Directorate-General for Transport and Energy (DG TREN) of the European Commission under the Growth programme in the Fifth Framework for Research and Technological Development.

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1.2 An Introduction to Urban Road Pricing

1.2.1 Basic Charging Scheme Options

Urban road pricing essentially involves direct charging of vehicle users for their road use - usually at congested times and places. Urban road pricing schemes generally have three main aims, either singly or more usually in combination:

- Congestion reduction;
- Environmental improvement;
- Revenue raising.

There are a number of basic charging scheme options that can potentially be used for urban road pricing. The main options include:

- Area licensing schemes;
- Entry permit schemes;
- Cordon charging schemes;
- Multi-cordon charging schemes;
- Zone based charging schemes;
- Distance based charging schemes.

The main characteristics of the alternative basic charging scheme options are described below, together with some of their main advantages and disadvantages. Other advantages and disadvantages are associated with the technology base for implementing the schemes – these are covered in later paragraphs.

Area licensing schemes essentially require that road users who wish to use (or keep) their vehicles within a defined area during a defined time period purchase and display a supplementary licence. This may take the form of a paper licence that can be displayed on the windscreen or dashboard of the vehicle, or may involve registration of the vehicle registration number in a computer database, for example the London congestion charging scheme.

With **entry permit schemes**, vehicles need to have a valid supplementary licence to enter a defined area (the restricted zone). These schemes therefore apply regulations only to moving vehicles passing through entry points on a defined boundary. The Singapore 'Area Licensing Scheme' that operated from 1975 until 1998 was actually an entry permit scheme.

The legislation under which area licensing and entry permit schemes are set up and operate can be framed to apply charges in a number of ways – to either moving vehicles or to moving and parked vehicles.

The main attraction of an area licensing or entry permit charging basis is that for a small, simple scheme it can be relatively simple for the public to understand and relatively straightforward to implement. However, a significant disadvantage is that it is more of a "blunt instrument" for influencing travel demand than other options. This is because charges are levied (typically) on a daily basis for access to the defined area, rather than on a per trip basis. Trip making decisions are therefore correspondingly taken on a daily basis, and there is no incentive to restrict the number of daily trips made once the daily licence has been purchased.

Area licensing or entry permit schemes also provide limited flexibility. There are practical limits on the number of combinations of licence variants (e.g. charging zones, time periods, vehicle types) that could be accommodated within a scheme, due primarily to the need to keep the range of licence types comprehensible.

Cordon charging schemes are perhaps the most commonly proposed form of electronic road pricing. These involve setting up a cordon of road pricing points around a defined area of a town or city. Road users are then charged (usually electronically) each time they cross the cordon.

Cordon charging has the advantage over licensing and permit schemes that each individual trip made into the defined area during the time of operation is subject to a road user charge. Each trip is therefore the subject of a choice decision influenced by the road user charge. Charging regimes can also be relatively sophisticated, with variations by time-of-day and a range of vehicle types.

Simple cordon charging schemes are, however, likely to have boundary effects. These may include increased parking just outside the boundary, local difficulties related to trip origins or destinations located just inside or outside the cordon, and redistribution of traffic on to roads outside the cordon.

Multi-cordon and **zone-based charging schemes** are similar in concept to cordon charging, in that they charge road users each time they cross defined boundaries. Multi-cordon charging schemes typically have two or more concentric cordons, while zone-based schemes levy charges for travelling across defined zone boundaries that may intercept orbital movements as well as radial ones.

Use of multiple cordons or zone-based charges can give a finer level of influence over travel patterns since the charging points can more closely reflect the problem traffic movements that the scheme is seeking to address. Boundary problems can also be reduced if lower charges are levied at more points, rather than concentrating the road user charge at a single cordon. However, multi-cordon and zone-based charging schemes are more expensive to implement and more complex for the public to understand than simple cordon charging.

Distance-based charging schemes levy charges directly on the basis of distance travelled. Such schemes can be used on toll roads (where distance travelled between toll plazas is simple to calculate) but have not yet been implemented in urban areas. A distance-based charging scheme is proposed for heavy goods vehicles in the UK from 2007-8.

Distance-based charging has attractions in that it charges directly for actual travel in the problem areas. It is therefore the logical end-point in a process of creating denser and denser networks of charging zones, and correspondingly should theoretically be even better at influencing demand than multi-cordon or zone-based charging schemes. However, the technology required is more complex and costly to implement.

1.2.2 Charging Technologies

There are a number of different technological solutions for implementing the different types of road pricing scheme. These can be categorised as cash tolling, paper licences, automatic number plate recognition (ANPR), dedicated short-range communications (DSRC) and vehicle positioning systems (VPS).

The applicability of technological solutions is related to the type of scheme envisaged, as summarised in Table 1.1.

Table 1.1 Applicability of Charging Technology Solutions to Types of Scheme

Charging technology	Cash	Paper	ANPR	DSRC	VPS

Type of scheme	tolling	licences			
Area licensing		✓	✓	✓	✓
Entry permit		✓	✓	✓	✓
Cordon charging	✓		✓	✓	✓
Multi-cordon charging			?	✓	✓
Zone-based charging				✓	✓
Distance-based charging	✓				✓

Cash tolling, although best known for motorways and major infrastructure (bridges and tunnels), is possible for cordon charging schemes. It requires manned or automatic collection facilities at each entry point. It may be an appropriate approach for small areas or those that are lightly trafficked, but has adverse implications for land use, because of the need for toll plazas, and staffing. It is more likely that a cash option might be provided in association with another parallel charging mechanism such as DSRC or VPS. A drawback of cash tolling is the need for vehicles to stop and pay, with implications for increased pollution and congestion.

Paper licences can be issued to provide authorisation either to be within a charged area (area licensing) or to enter one (entry permit). A scheme based on paper licences can be set up relatively quickly and might be an attractive option for an initial small scheme implementation.

Paper licences have significant disadvantages in terms of enforceability. Enforcement checks by patrols on parked vehicles in an area licensing scheme are labour intensive but relatively straightforward. However, enforcement checks on moving vehicles (although carried out in the past in Singapore) are much more difficult to accomplish, giving greater opportunity for evasion, through forgery, for example. Moving from paper licences to electronic approaches could also create some transitional problems.

Automatic number plate recognition (ANPR) technology provides a viable option for enforcement checks on area licensing or entry permit schemes (as used in London). Users are required to pay for a licence in advance and register their vehicle registration number in a database for use of the road network in the charged area. ANPR equipment at entry points and other locations then checks the registration number of each vehicle entering the charged area and if it is not recorded in the database as having paid the appropriate licence fee an image is retained for subsequent follow-up action.

Dedicated short range communications (DSRC) based electronic fee collection is becoming increasingly common around the world, both for urban and inter-urban charging. DSRC is based on communications (usually microwave) between an on-vehicle tag or transponder and roadside equipment installed at the charge point. This triggers a charge transaction, which is either recorded in the on-vehicle unit or in an off-vehicle central accounting system.

Vehicle positioning systems (VPS) are those based on an autonomous capability for the vehicle to locate its own position and to compare this with stored details of the charge scheme for the purpose of 'self-charging'. This is usually based on use of satellite-based positioning systems such as the Global Positioning System (GPS) or (in the future) Galileo. The on-board equipment periodically communicates logged charges (for example through GSM) to a back-office system either for billing purposes or to communicate logged charges paid on-board (eg.through a stored value or smart card). Such a charging mechanism can be highly flexible, using GPS to mimic a cordon or zonal scheme, for example, but there are still uncertainties over how best to enforce a GPS-based charging scheme.

1.3 PRoGRESS Project Aims and Objectives

The main goal of the PRoGRESS project was:

> *"to demonstrate and evaluate the effectiveness and acceptance of integrated urban transport pricing schemes to achieve transport goals and raise revenue."*

The demonstration and evaluation activities carried out at the eight PRoGRESS sites had two key results orientated objectives:

1. To develop and assess the political, economic and social framework required for the implementation of road pricing considering:

- Social and political acceptance;
- Legal and organisation issues;
- Financing.

2. To evaluate the impact and effectiveness of these schemes with respect to:

- The technical and operational aspects of the schemes;
- Social equity and acceptance;
- Transport efficiency;
- Raising revenue;
- Improving the quality of the urban environment;
- Maintaining and improving local economic and employment prospects;
- Impacts on land use development.

1.4 Project Approach

The PRoGRESS project was based on progressing and evaluating urban road pricing initiatives in the eight PRoGRESS cities. Originally, the eight PRoGRESS sites were intended to comprise:

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However, three of the envisaged new road pricing schemes had to alter their local focus during the course of the project to become demonstration schemes (with the approval of the Commission). This was necessary due to time delays resulting from the essential political process surrounding the implementation of a real scheme.

The eight PRoGRESS sites all successfully delivered operational schemes, demonstrations or modelling studies as required. These were thoroughly assessed in accordance with an evaluation plan developed in co-operation with the CUPID thematic network, and the results were pulled together at a European level to reach conclusions and recommendations for future development and use of road pricing schemes.

The structure of the project involved seven project workpackages:

WP1 Project management – covering both consortium management and local management.

WP2 Scheme design and development – covering all aspects of the design, specification, modelling and development of the charging schemes.

WP3 Scheme implementation and demonstration – covering building and implementing the charging schemes and demonstrations, and operating the schemes and demonstrations to obtain the results.

WP4 Social, economic and political issues – including monitoring of all issues related to social and political acceptance, legal and institutional frameworks, and financing.

WP5 Evaluation – covering the evaluation of all aspects of the PRoGRESS site initiatives including development and implementation of the demonstration schemes, and the social, political and economic aspects of these schemes.

WP6 Recommendations and exploitation – developing recommendations on the basis of the results, providing input to the thematic network (CUPID) on the overall project results, and developing local implementation plans for taking forward the results of the PRoGRESS project.

WP7 Dissemination – supporting the dissemination activities of CUPID, and carrying out local and national dissemination.

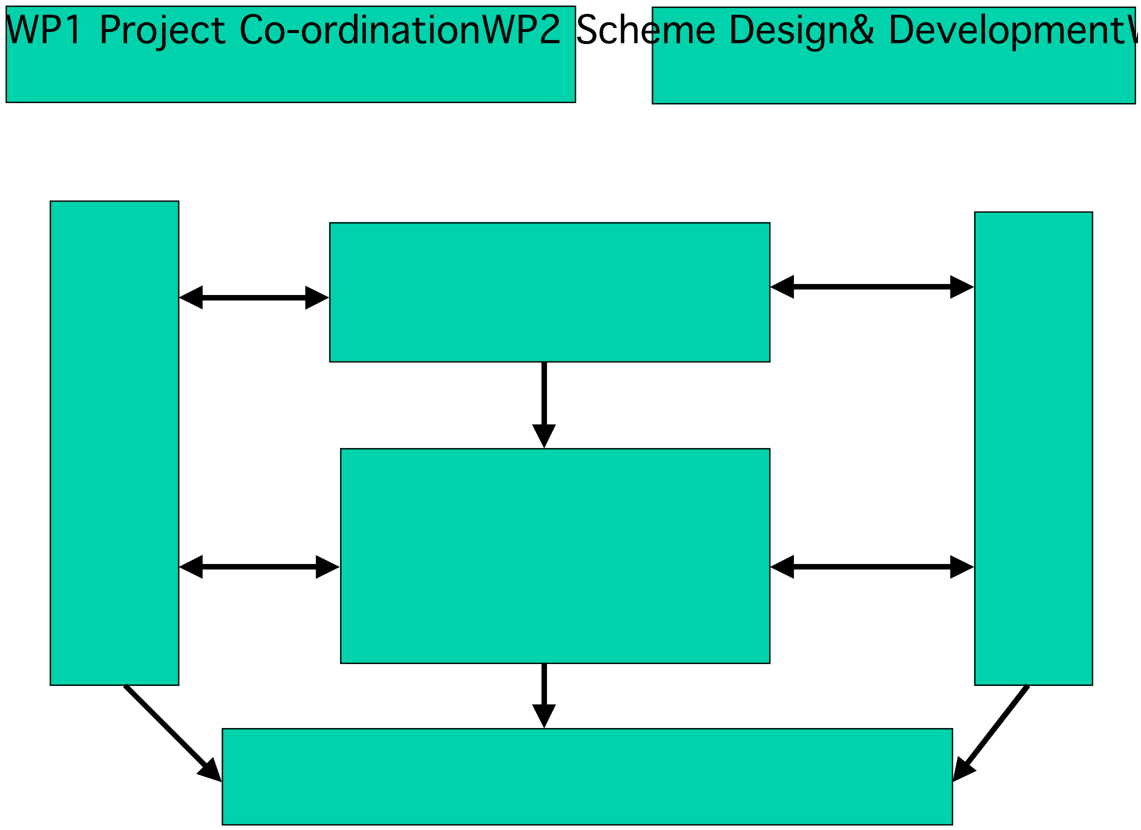


Figure 1.1 PRoGRESS Project Workpackage Structure

1.5 Relationship With the CUPID Project

Throughout the project, the PRoGRESS consortium worked closely with a Thematic Network project called CUPID (Co-ordinating Urban Pricing Integrated Demonstrations). CUPID was also funded by the European Commission to promote state of the art knowledge on urban transport pricing schemes.

Part of CUPID's brief was to provide guidance and assistance to the eight European cities developing and demonstrating urban road pricing as part of the PRoGRESS project. This included undertaking a European cross-site assessment of the demonstration projects of the eight European cities in the PRoGRESS project and producing policy recommendations. Further details can be found at www.transport-pricing.net.

1.6 Contents of this Report

Following this introduction, Section 2 of this report describes the demonstrations and related activities at each of the eight PRoGRESS sites. Section 3 then gives an overview of the evaluation activities undertaken during the project. The main results of the project are presented in Section 4 of the report, while Section 5 sets out the lessons learned, recommendations and conclusions from the project.

Further information on all aspects of the PRoGRESS project can be found at www.progress-project.org (see Section 6). Public deliverables that include further detail on specific aspects of the PRoGRESS project may be downloaded from this site, together with documents that give further detail on the local demonstrations at each site. Section 7 contains a glossary of abbreviations used in the report.

2 THE PROGRESS DEMONSTRATIONS

Seven of the PRoGRESS sites (Bristol, Copenhagen, Edinburgh, Genoa, Gothenburg, Rome, and Trondheim) have implemented or demonstrated a range of pricing schemes as shown in Table 2.1 below. The work in Helsinki has focussed on modelling the effects of different road pricing schemes.

Table 2.1 Pricing Concepts and Technologies Across the PRoGRESS Sites

Scheme concept	Road-pricing technology basis		
	DSRC – electronic tag	ANPR	GPS
Cordon (per trip)	Rome Helsinki	Bristol Genoa Rome	Copenhagen Bristol
Cordon (per day)		Edinburgh	
Zone (per trip)	Trondheim Helsinki		Copenhagen
Distance-based			Copenhagen Gothenburg Bristol

Notes:
1) DSRC – Dedicated Short Range Communication (tags)
2) ANPR – Automatic Number Plate Recognition using digital cameras and OCR (Optical Character Recognition)
3) VPS – Vehicle Positioning System (GPS based)

Rome and Trondheim are the only full-scale implementations but Bristol, Edinburgh, and Genoa are all currently planning for a full-scale implementation. No such decisions have yet been taken in Copenhagen, Gothenburg, and Helsinki.

Figure 2.1 illustrates that the cities are at different stages in the implementation process of road pricing. Both Copenhagen and Gothenburg ran successful demonstration trials of road pricing with volunteer motorists. The cities of Bristol, Edinburgh, and Genoa all worked towards the introduction of full road pricing schemes while running demonstration trials as part of the project.

Trondheim already had a full road tolling scheme at the start of PRoGRESS (since 1991), and made further improvements and alterations to their scheme within the timescale of the project. Rome enhanced an existing access control scheme to become an Access Control Scheme with road pricing, and demonstrated additional evening pricing scenarios. Helsinki did not implement a pricing scheme or trial, but completed a modelling study and raised the profile of road pricing in Greater Helsinki Area by involving local stakeholders.

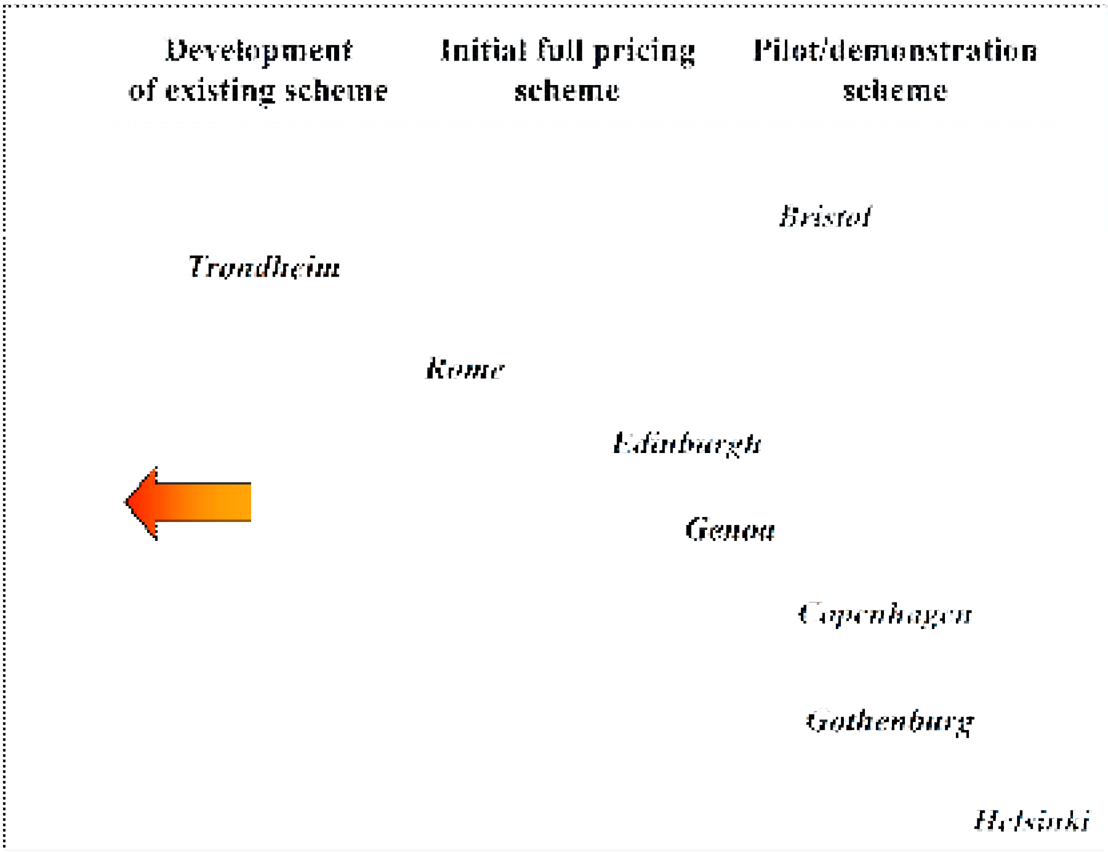


Figure 2.1 Status of Urban Road Pricing in the PRoGRESS Cities

2.1 Bristol

The full road pricing scheme proposed for Bristol could not be made operational within the time-frame of the PRoGRESS project. However, significant research work was undertaken in Bristol on key issues such as the impacts and acceptance of such a scheme. This mainly comprised developing an area wide transport model (BATS), for private and public modes, to investigate future scheme options and appraise their impacts. In addition, attitudinal surveys were undertaken with local populations.

In parallel with this, the UK Government adopted a new policy for a national distance-based charging scheme for heavy goods vehicles, which is likely to use satellite positioning technology. Bristol City Council (BCC) saw the new Government policy as an opportunity for studying the synergy between a national charging system and the local charging scheme. To this end, Bristol worked with the UK Government Department for Transport (DfT) to establish a joint technology demonstration.

The demonstration concentrated on the use of Mobile Positioning System (MPS) based pricing systems in heavy goods vehicles and other commercial vehicles. In addition to the MPS element, the demonstration examined the use of digital cameras and Automatic Number Plate Recognition (ANPR) software as a potential enforcement technology. The trial area followed the cordon used as the basis for developing a full scheme, shown in Figure 2.2 below.

Fifty commercial vehicles participated in the trial, ranging in size from cars through to heavy goods vehicles. Each vehicle was fitted with on-board equipment (OBE) that consists of an on-board unit (mounted to either the dashboard, the glove compartment or underneath the passenger seat), a power lead to the ignition of the vehicle, and a magnetic footprint antenna mounted on the roof.

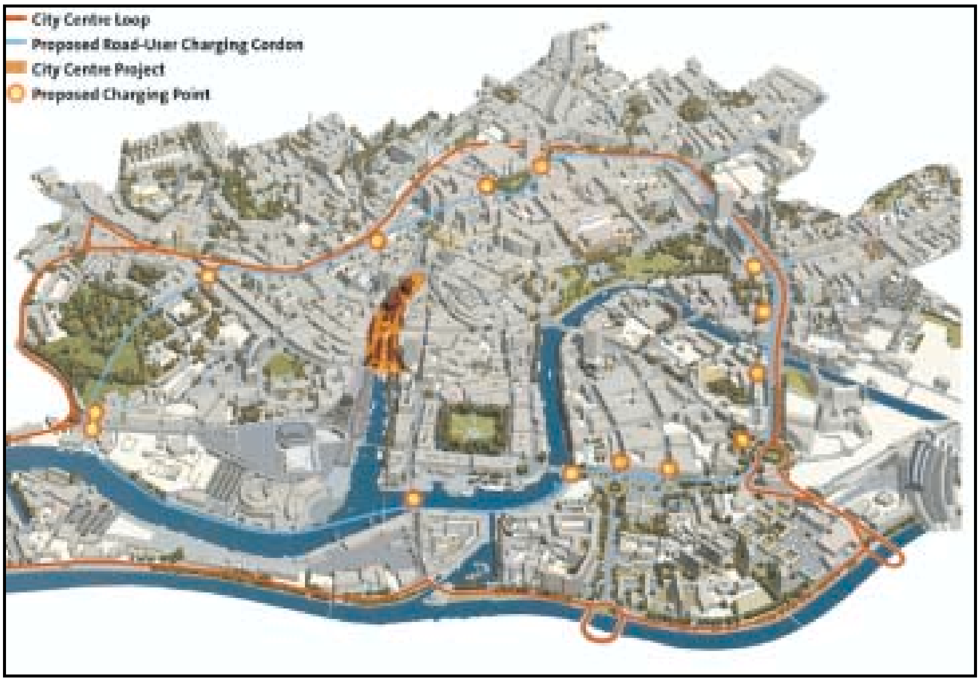


Figure 2.2 The RP Cordon Being Demonstrated

The on-board unit (OBU) contained a smartcard that held a total of 50 charging transactions in the event of communication with the central control system failing. When a vehicle passed a charge point, the OBE communicated with the MPS system and allocated a charge. The functioning of the equipment is illustrated below.

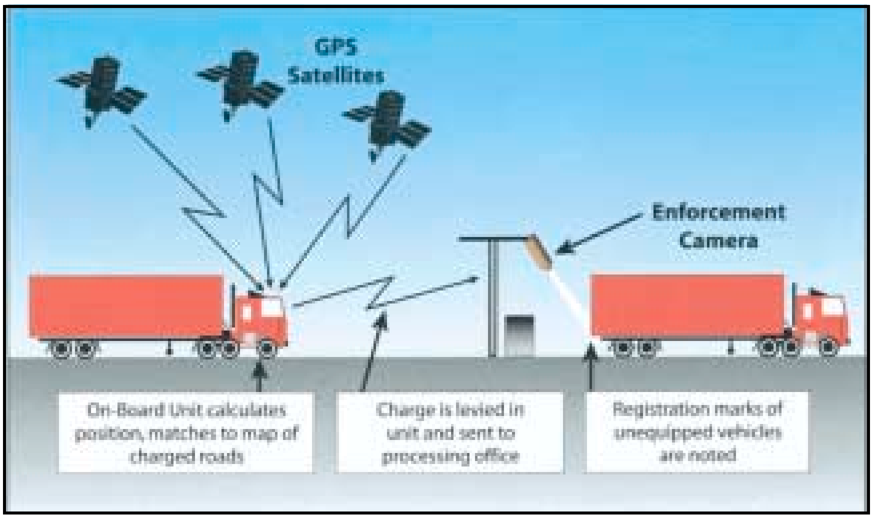


Figure 2.3 Diagram of the MPS Equipment
Source: Department for Transport

For the trial there were 3 different charging methods deployed:

1. **Distance-based corridor charges** on the M4 and M5 motorways and two main access roads into the city. These worked using segments on the roads: the further a vehicle travels on the road, the more segments they pass and the higher the charge allocated (see Figure 2.4).

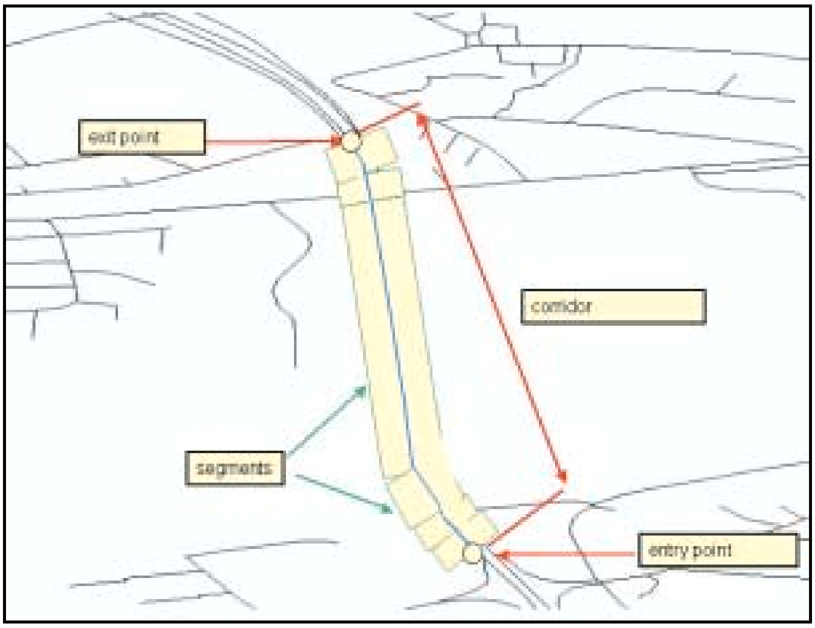


Figure 2.4 Segment- / Corridor-Based Charging

2. **City centre cordon charges** that form the basis of the road pricing scheme detailed in the Local Transport Plan. For this method, 100 points were used to define a zone. There was an outer zone and, 200 metres inside, an inner zone. Charges were only allocated once a vehicle had passed through both zones (see Figure 2.5).

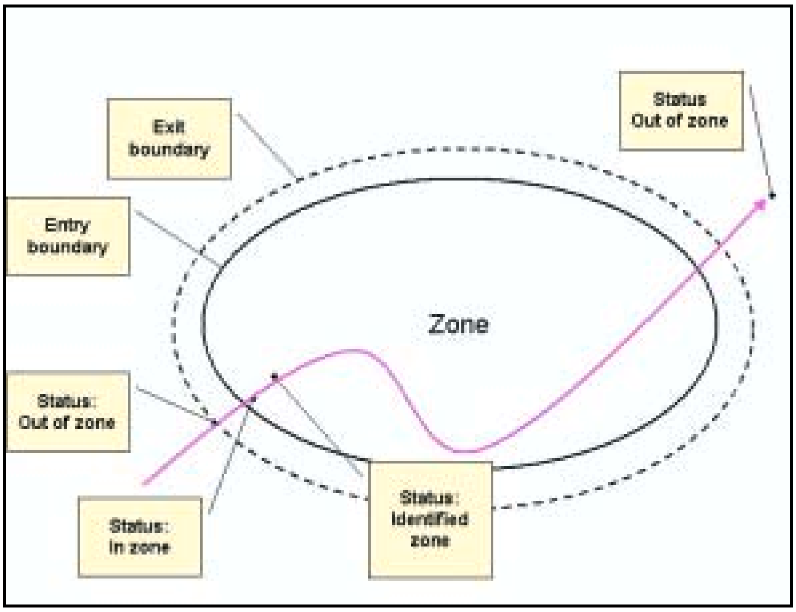


Figure 2.5 Cordon-Based Charging

3. **Individual virtual gantry charges** on each of the main routes in and out of the cordon, based on the cordon entry points. The virtual gantries were 50m by 50m rectangles, activated by a vehicle passing in either direction.

Trials ran for four months in Autumn 2003 and data was collected on vehicle movements when they entered trial areas, and via control vehicle testing. This enabled analysis of VPS performance and fleet pattern analysis. In addition, assessment of ANPR for enforcement purposes was carried out, which would be required to complement any full-size scheme.

2.2 Copenhagen

The main objective of this demonstration project was to understand how road pricing could influence the mobility pattern in the Greater Copenhagen area towards a more sustainable pattern. The question is whether road pricing is an efficient means to change the travel behaviour of the motorists. In other words, is car travel reduced when road pricing is introduced?

To answer this question, 500 volunteer drivers' cars were equipped with a vehicle position system (using GPS technology) with the ability to read virtual cordon rings and zones. A display kept the motorist up to date with the charge in the current zone and with the total cost of the trip (see Figure 2.6).

Figure 2.6 In-car display for volunteer drivers

To be able to test different concepts in the same demonstration project, due to its flexibility vehicle-positioning technology was used. The benefit of using vehicle-positioning technology was its ability to simulate different pricing strategies of interest for Copenhagen.

The demonstration tested the impact on travel patterns of two main types of pricing strategies:

- The multiple zone (or cordon) charging approach.

Dividing the Greater Copenhagen Area into 11 zones (see Figure 2.7). Crossing a zone border costs a small amount of money, but when crossing many borders driving costs become high. The multiple zone system is believed to have less of an effect on central Copenhagen, and is well suited to limit the number of kilometres driven

- The distance charging approach.

Dividing the area into different zones with different levels of charging, but automatically deducting the charge as the car is being driven. The distance charging system gives greater flexibility and allows a detailed management of the mobility pattern. The 11 zones used in the multiple zone system are reduced to 4 zones as the charge increases as the motorist drives closer to the centre.

Using the two basic scenarios above, three different charging schemes and level of charging were tested in the demonstration:

1. Cordon charging – Level of charging: 1.61 Euro/cordon crossing in city centre gradually reduced to 0.26 Euro/cordon crossing in the outskirts; off peak half level;

2. High kilometre/distance charging – Level of charging: 0.67 Euro/km in city centre in gradually reduced to 0.13 Euro/km in the outskirts in peak hours; off peak half level;
3. Low kilometre/distance charging – 0.33 Euro/km in central zone gradually reduced to 0.07 Euro/km in the outskirts; peak hours; charging only in peak hours.

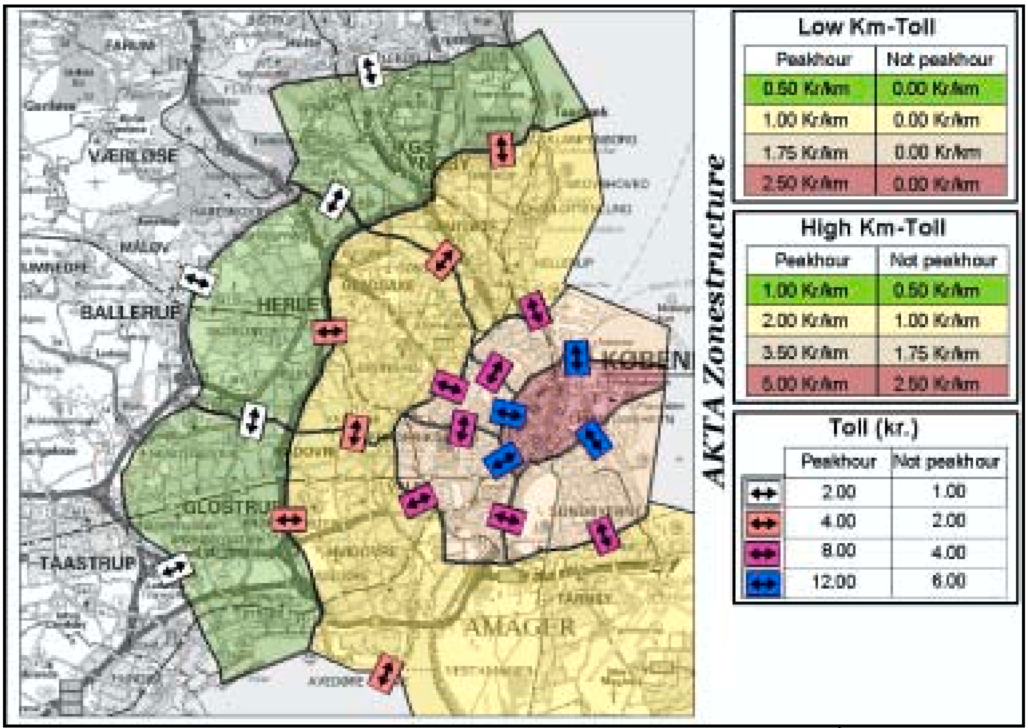


Figure 2.7 The Different Road Pricing and Toll Schemes[1]

With various combinations of user response to these 3 different pricing schemes it was possible to analyse driver sensitivity to the level of charging, the time of charging and the geography of charging.

The trial used real money, with the basic principle that the volunteers were paid the amount of money that correlated to their reduction in travel. This payment is made in two different ways to test if the timing of the payment has any influence on the outcome of the trial. The difference between the two timings of payments can be described as follows:

- The test-drivers lose money from their potential reward, which they may have otherwise received in the future;
- The test-drivers are called upon to pay an amount of money they already had at their disposal, equal to the value of their travel by car.

[1] Illustration from: "THE AKTA ROAD PRICING EXPERIMENT IN COPENHAGEN". Otto Anker Nielsen, Professor, Ph.D. Centre for Traffic and Transport (CTT), Technical University Of Denmark (DTU), oan@ctt.dtu.dk, Mai-Britt Herslund, Associate Professor, M.S5. Psychology., Ctt, Dtu, mh@ctt.dtu.dk.

2.3 Edinburgh

Since the city's road pricing scheme is to be introduced after the lifetime of PRoGRESS, Edinburgh conducted a more limited demonstration within the project. The purposes of the demonstration were:

- To demonstrate the viability of the proposed approach to the technology for a full scheme, in particular focusing on potential problems in the Edinburgh environment and with the likely scheme requirements;
- To investigate aspects of enforcement in the proposed full system;
- To investigate behavioural aspects of the proposed full scheme related specifically to the way in which licences might be purchased.

The demonstration had to be meaningful and useful for the preparation of the full scheme implementation, which implied:

- The viability of the proposed approach for a full scheme should be shown, in particular focusing on potential physical issue of the Edinburgh street environment;
- Behavioural aspects should be investigated with regard to licence purchase using the main anticipated licence purchase methods of telephone, Internet, and retail.

The technology used for the demonstration was therefore determined by the likely technology for the full scheme. Two sites, forming part of the proposed inner cordon for the full scheme, were equipped with cameras and Automatic Number Plate Reading (ANPR) equipment: Dean Bridge and in Home Street (see Figures 2.8 and 2.9).


Figures 2.8 and 2.9 Camera Installations at Home Street and Dean Bridge

Eight retail outlets were recruited to participate in the trial and simulated retailing of congestion charge licences. Four retailers were located on the approaches to the two camera sites, the other four in different parts of the city centre. In addition, volunteers could purchase licenses through a project website (see Figure 2.10).

Figure 2.10 Dedicated NTI Demonstration Licence Purchase Webpage

Around 200 volunteers were recruited at the end of August 2002, all of whom had indicated that they travelled by car regularly into the city centre, and that their routes normally took them through one of the two demonstration sites. The volunteers simulated the purchase of licences whenever travelling to the city centre by car during the day.

In addition to the demonstration activities, extensive survey and public opinion work was carried out in Edinburgh, in the lead up to a full road pricing scheme, the results of which are set out later in this report.

2.4 Genoa

Genoa is working towards a full road pricing scheme for controlling access to the city centre. A multi-modal model (MTCP30), developed in the PRESS project in the EC 4th Framework, was used to investigate and define a feasible RP scheme and preferred options identified.

In the PRoGRESS project the city demonstrated the preferred scheme option. ANPR technology was chosen as the method for operating the scheme, and camera sites set up around the city centre area. The trial focussed on the vehicles and behaviour of volunteer participants, which enabled not only technology trials but also behavioural evaluation. The latter was used to validate model outputs.

The demonstration in PRoGRESS was designed to check the efficiency of the technology and the behaviour of citizens. The demonstration was based on:

- A cordon pricing scheme in a small area of the city centre (1 km^2);
- Automatic Number Plate Recognition systems (cameras at entry points to zone);
- Application of different pricing policies (two fee levels, exemptions, time of day, etc.);
- A six-months period of testing;
- A set of volunteer users with 161 retained as representative sample.

In Table 2.2, the basic scheme parameters are presented. It compares the characteristics of the demonstration scheme (adopted for the PRoGRESS demonstration) and the possible full-size scheme design.

Table 2.2 RP Scheme Parameters in Genoa

Parameter	Unit	Demo Scheme	Possible full-size Scheme
Type of pricing scheme	-	Cordon	Cordon, Time based
Extent of Scheme	-	City centre	City centre
Area involved (DA)	km^2	1	Up to 4,5
Type of tolling technology	-	ANPR	ANPR + DSRC
Number of gates (entrances in DA)		8	11 - 14
Complementary measure(s)	-	Free PT	Free PT Shuttle line P&R
RP exemptions	%	40% (VU screening)	40%
Mean fee level	€	1.00 or 2.00 x passage	0.50 or 1.00 x passage
Volume of RP involved users (in peak hour)	Users/h	150	5,000
Application of RP	Days	150	continuous (300/365)

The demonstration area (DA) is shown in Figure 2.11 below. It covers about 1 km^2 and includes central streets and the entire ancient historical centre. Eight main vehicle entry points controlled access into the zone, and each was equipped with ANPR cameras. Both single lane and twin lane roads were included.

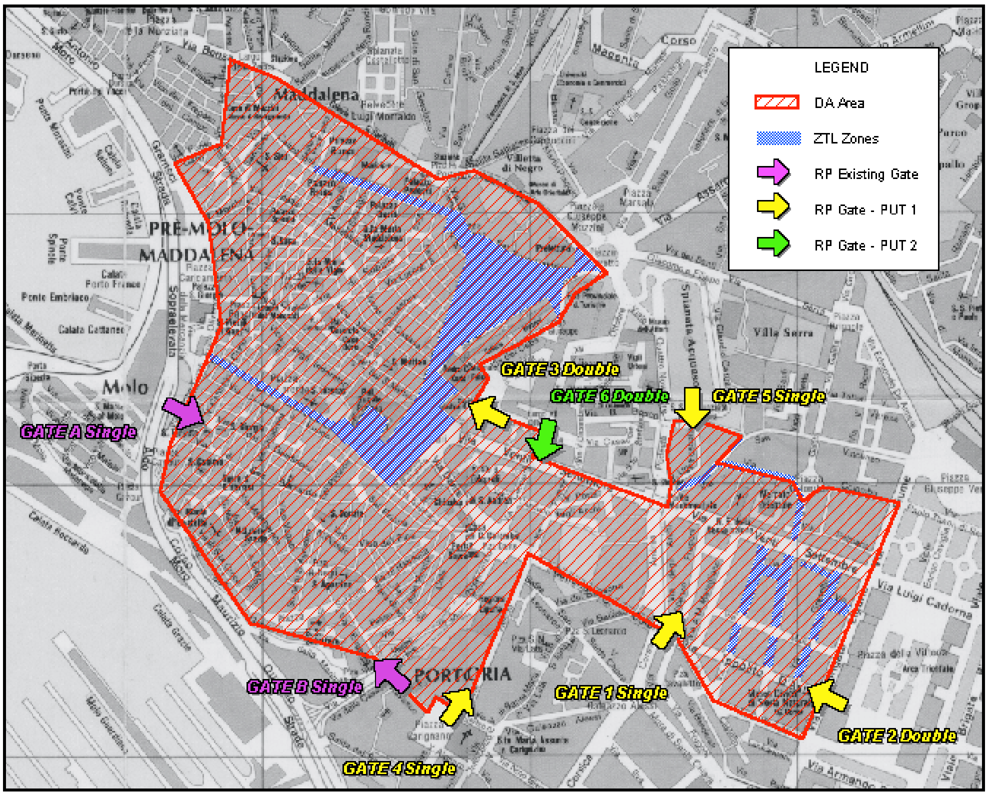


Figure 2.11 Genoa PRoGRESS Demonstration Area (DA)

Results from the trials were used to both test the technology and to validate model outputs relevant to the full-scheme being investigated in Genoa.

2.5 Gothenburg

Gothenburg demonstrated distance-based pricing scheme using VPS technology, supported with modelling work. A number of pricing strategies were analysed and from these two scenarios were selected for demonstration, each with a different focus:

- A congestion-based scenario; and
- A scenario focused on environmental improvement and mobility management.

Both scenarios utilised distance-based charges, made possible by the application of VPS technology. Volunteers agreed to have vehicle fitted with On-Board Equipment, which provided them feedback on the charge levels being levied, as they drove on routes in the trial area.

For congestion based charging the main alternative was to find another departure time before or after the morning peak period. For this reason, the charging period was set as short as possible, from 07:30 to 08:30 in the morning. The main concept was to trial a reduction of marginal trips by car in the peak period and to change average conditions as little as possible. Charges were levied on congestion prone major road links. In order not to redirect traffic onto environmentally sensitive city streets, charges were also needed in other zones in the city.

Two levels of charges were set for the PRoGRESS field trial: 0.78 Euros/km for congestion prone roads and 0.56 Euros/km for all other roads within the defined area, as shown in Figure 2.12 below.

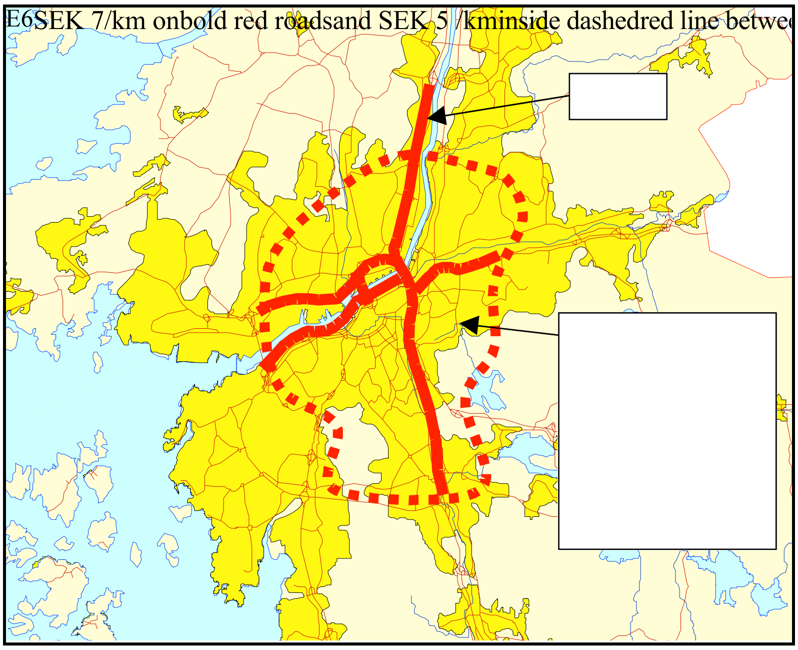


Figure 2.12 Congestion Scenario

The alternative, environmental scenario, aimed at improving the local environment and particularly the city centre. Improvement of the local environment is here defined as reduction of exhaust emissions and noise, but also increased space for pedestrian and cycle movements. As the local environment is influenced by off-peak traffic, charges were applied in all time periods. Zones were defined to limit route choice and avoid the undesirable effects of additional congestion. The zone boundaries were set to be logical for motorists in Gothenburg and areas within the zone boundaries with a similar character and had the same charge level, shown in Figure 2.13 below.

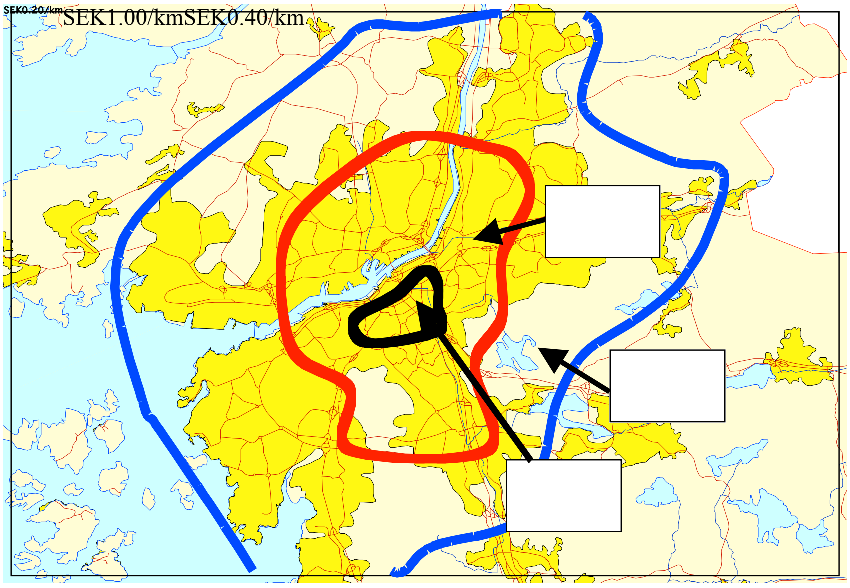


Figure 2.13 Environment / Mobility Scenario

The inner area (black cordon) delimits the central parts of Gothenburg, the middle zone (red cordon) encircles the semi-central parts of the City and the outer zone (blue cordon) delimits the coherent urban areas of Gothenburg.

The Gothenburg PRoGRESS demonstrator could be regarded as a 'state-of-the-art implementation' in a distance-based charging scheme for road transport. The on-board equipment consisted of three parts (see Figure 2.14):

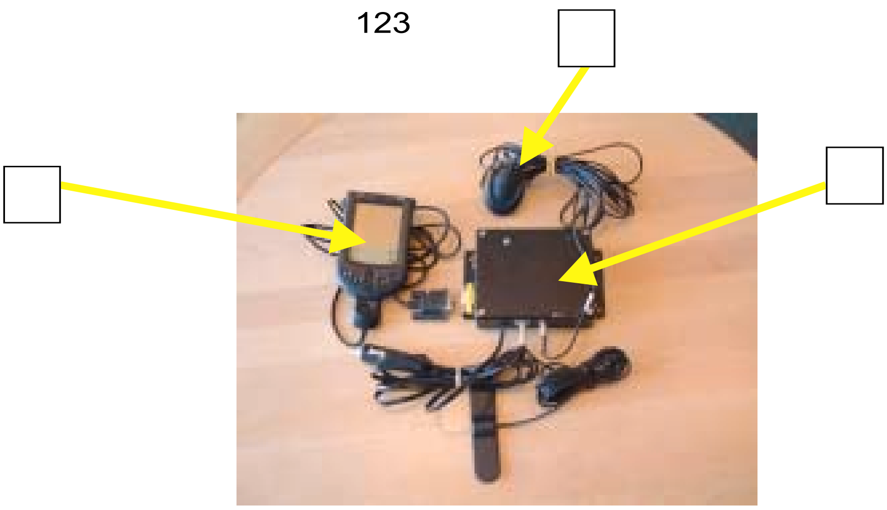


Figure 2.14 On-Board Equipment Components

1) On-board unit containing computer, the application software, a GSM telephone with antennae and software for the GPS positioning. This unit is installed out of sight, typically under one of the front seats;

2) Palm Pilot containing software for the user functions and the user interface. The Palm is installed on the dashboard with the screen visible for the driver;

3) GPS-antennae receiving signals from the GPS satellites.

2.6 Helsinki

Helsinki used the modelling concept from the PRESS project for developing several pricing strategies for the Helsinki metropolitan area. The site did not implement a pricing scheme or trial, but instead completed a modelling study. At the beginning of the project, three main scenarios were defined, based on previous work and experiences. Each of the main scenarios was considered by two alternative pricing methods, trip-based and distance-based charging methods (as well as pricing options, the model included such parameters as public transport supply and prices, and parking fees). The work carried out through PRoGRESS allowed the elimination of one of the three main scenarios originally defined for the project, allowing work to focus on the two remaining.

Although no immediate implementation of road pricing is foreseen in Helsinki, the pricing scenarios that were studied in PRoGRESS were defined taking into account the technical and functional feasibility of an implementation of the scenarios.

Helsinki's participation in PRoGRESS allowed the profile of road pricing in Finland to be raised, and a number of interviews were held with local stakeholders and politicians. A user survey of 500 residents was carried out by telephone interview, finding out views on performance of the traffic system and financing/pricing issues.

The two remaining Helsinki Metropolitan Area road pricing schemes cover the whole region (see Figure 2.15). The work in PRoGRESS has tested how the trip-based and distance-based schemes differ from each other regarding the impacts on road network. This has resulted in a definition of rather dense trip-based zoning system as well including also radial borders aiming to simulate the distance-based scheme.

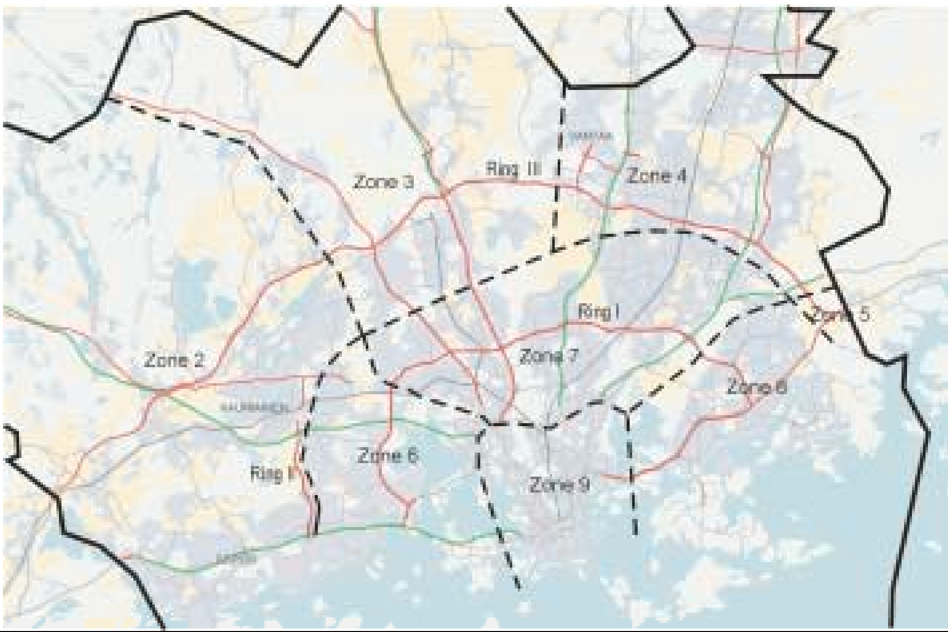
		
Principles	B0: Passage-based payment on zone borders B11: Parking cost – 35% B12: Parking cost –70% B21: Public transport costs +50% B22: Public transport costs –50% B23: Headway decreases by 33%	C0: Distance-based payment at zones C11: Parking cost – 35% C12: Parking cost –70% C21: Public transport costs +50% C22: Public transport costs –50% C23: Headway decreases by 33%
Road pricing tariffs	1.7 / 1.7 euro/passage (inner / outer border) 0.85 euro/passage for diagonal links	0.1 / 0.07 / 0.03 euro/km (inner / middle / outer border)
Charging	All users pay. Morning peak: 6–9am	
Present PT and parking fees in B0 and C0	1.5 euro/trip within city limits and 2.5 euro/trip within HMA. On street parking/3 tariff zones (2, 1, and 0.5 euro/h) between 8am and 5pm on weekdays and between 9am and 3pm on Saturdays. P+R: free parking	

Figure 2.15 Road Pricing Schemes Tested in the Helsinki Metropolitan Area

These two main alternatives (trip- and distance-based) have been studied further in terms of impacts by complementary actions relating to the public transport and parking supply and cost.

Although no immediate implementation of road pricing is foreseen in Helsinki, the pricing scenarios which were studied in PRoGRESS were defined taking into account the technical and functional feasibility of an implementation of the scenarios. It is likely that were pricing to be implemented then it could be achieved using DSRC or GPS based technologies.

2.7 Rome

The PRoGRESS demonstration was undertaken in the Limited Traffic Zone (LTZ) sectors east of the Tiber, the central area in Rome and one of the larger historical centres in the world. The pricing zone has an area of 4.6km^2 and is controlled through 22 entrance gates. The area contains about 42,000 residents and over 116,000 workers.

The system implemented in Rome derives from two independent systems. The first is the access control system, operating by the identification of car plates accessing the Restricted Access Zone, as already adopted in Bologna. The second is a payment system, based on the automatic toll collection system applied to motorway users (TELEPASS). The integration between the two systems generated the system called IRIDE. The process at the gate and the data transfer towards the operating centre is shown in Figure 2.16.

Figure 2.16 The IRIDE System

When a vehicle approaches the gate (the approach is captured by inductive loops), the on-board unit communicates information to a local gate control system. If the smartcard in the on-board unit is not valid, or the vehicle does not have the on-board unit, the video cameras are activated and a photo is taken of the vehicle’s rear number plate. Data and images are then communicated to the central access control system and processed.

LTZ access permits in Rome were adopted in a systematic way in 1994, with access control operated automatically from October 2001 using the IRIDE system. The main objectives were to restrict the number of vehicles accessing the LTZ to those strictly necessary, and to promote public transport and intermodality along rail lines to the historic centre. Enforcement is active during the weekdays from 6.30am to 6.00pm, and on Saturday from 2.00-6.00pm.

A significant demonstration element undertaken in PRoGRESS was the assessment of the impact from the results of introducing different road pricing schemes (based on both per-trip and time-based charging structures) in the LTZ, during the current operational time of the access restriction. The simulation results showed that the replacement of the current scheme, based on the annual fare system, with a per-trip or time-based scheme would not lead to substantial changes in terms of overall modal split, unless mopeds are also charged.

The Rome scheme is an ACS+RP (Access Control System and flat-fare Road Pricing) hybrid scheme where permits are granted by the Municipality and are given free of charge to residents and users who fall into specific categories. From 1998, authorised non-residents were required to pay yearly in order to obtain the permit. The total number of permits allocated, as of May 2004, is 190,000.

Specific assessment was also carried out for the set-up of road pricing application in the evening period (6:00-11:00pm), with extensive consultation and surveys of residents and business owners in the area. Interesting results arise from the analysis of the impacts that the evening road pricing scheme would have on car drivers crossing the LTZ (see Figure 2.17). With just 1 Euro, more than 50% leave the LTZ, only 14.5% of car drivers continue to cross the area with a 3 Euros charge applied in July, and with a 6 Euros charge the majority of vehicles avoided the area. Most car drivers would change their route to avoid the charged area.

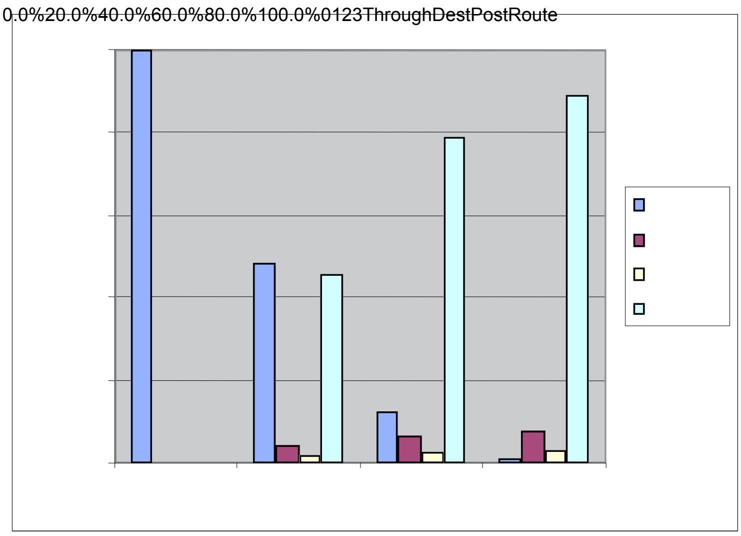


Figure 2.17 Impacts on Car Drivers Crossing the Rome LTZ of the Evening RP Scheme

In order to reduce the usage of tourist coaches, the city has been divided into two LTZ areas:

- LTZ1 all-inclusive inside the Aurelian walls, including the area of the operating ACS+RP scheme;
- LTZ2 all-inclusive between the GRA and the Aurelian walls.

Figure 2.18 Coach System in Rome

To implement the scheme for the bus/coach, the city put in operation system of 'reception, assistance, and control', which is based on the organisation of five checkpoints. Tour coaches entering the LTZ must stop at a checkpoint to register and collect permits for driving and parking their vehicle. These permits have to be purchased, with a variable fare dependent on the number of vehicles in the city and the number of requests to access the LTZ. The coach scheme is currently managed by STA but will eventually be transferred to a consortium of local tourism operators. However, the concerns and operational solutions have been negotiated with a single body representing a crucial set of stakeholders. STA currently verify the coach access to LTZ and the match it with the sold permits.

The increase of two-wheeled vehicles in the city centre, that are not presently detected by the electronic system and not charged, has lead the Municipality to conduct an extensive survey to assess their impact on the city centre.

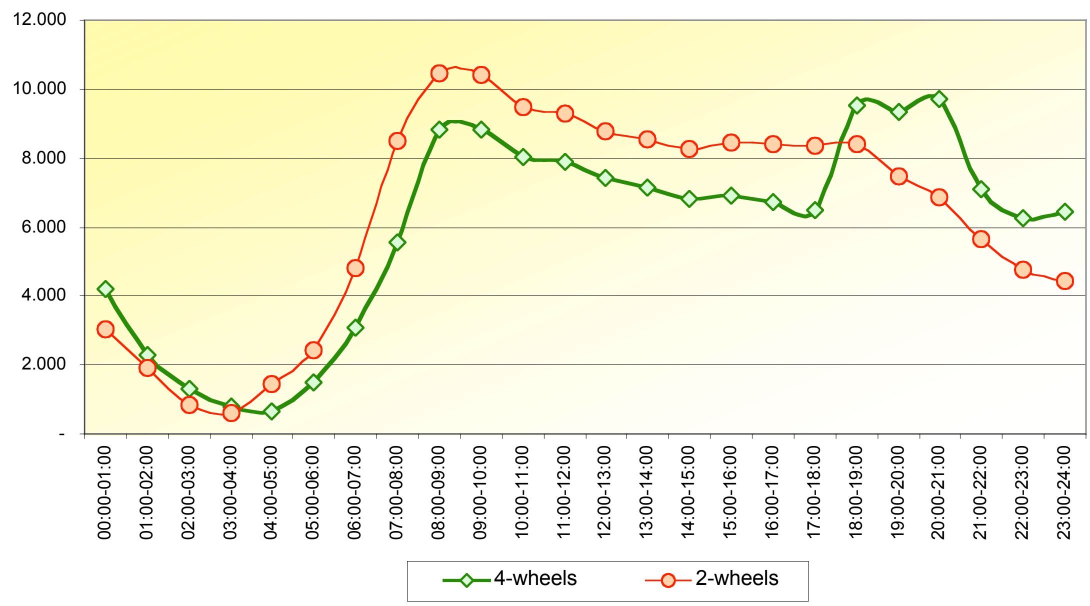


Figure 2.19 Vehicles accessing the Rome LTZ (all gates). Mean Values Per Day in May 2004

The result of the survey shows that there are more two-wheeled vehicles in the restriction period then 4-wheeled vehicles.

The need to consider these emerging problems resulted in the design of new solutions with a project called PICOR (Integrated Pricing in Rome Municipality), discussed with the Municipality and then submitted to the Ministry of Environment for its approval and co-financing. The PICOR project and task 6.1 of CIVITAS-MIRACLES are composed of three parts: the evening RP scheme, consisting of pure road pricing in the period 6-11pm during the week while maintaining the ACS+RP scheme during the day; the set-up of electronic control for two-wheeled vehicles; and revision of the RP policy for tourism coaches, testing VPS technologies.

These activities should cover the emerging ACS+RP issues, aiding the creation of a ‘Clean Zone’ in the city centre. These measures should also combine with the RP policies (coach, on-street payment) presently applied in the city. The evening scheme will be integrated with the on-street parking payment in the central LTZ (were users will pay the evening access but will not pay the parking), this will benefit those who have a destination in the LTZ but will still charge the through traffic.

2.8 Trondheim

Trondheim has had a full electronic road pricing scheme running since 1991. The scheme had a major upgrade in 1998 when a zonal charging system covering the whole urban area replaced the old toll ring. The technology was changed to the new CEN 5.8 GHz DSRC standard during the PRoGRESS project. This upgrade was done in 2001 when a new national standard for EFC was introduced (the AutoPass standard).

A main part of the demonstration in Trondheim was the evaluation of the long-term effects of the existing RP system. According to the current tolling agreement between the state and the city of Trondheim, urban tolling will be brought to an end in 2005, thus this was an important period for political discussions. Any new local road user charging initiatives will need to be agreed before this date, and PRoGRESS has given impetus to this decision process.

The demonstration in Trondheim consisted of the following three parts:

- Evaluation of long-term effects of the existing tolling system;
- Implementation of a new toll ring around the city centre, a CBD ring;
- Stated Preference survey for a through-traffic charging system in the city centre.

The first part of the demonstration addressed the existing RP system. No new technical implementations were needed. The second part of the demonstration involved implementation of new road pricing equipment around the CBD area. This was an extension of the existing tolling system, using the same technology and infrastructure.

The final element was undertaken by a Stated Preference survey of a through-traffic charging scheme instead of a demonstration.

The introduction of a Central Business District (CBD) toll cordon was a major part of the Trondheim PRoGRESS demonstrator. The measure was a continuation of the development of the charging system, from the 1991 single toll cordon and the 1998 zone based system. Hypotheses were formed that the CBD ring would facilitate:

- Improved access to CBD for car drivers with demand and willingness to pay;
- Improved environment in CBD and main arteries, through traffic calming;
- Improved conditions for public transport;
- Increased equity in the charging system.

As this part of the demonstrator consisted of a real, full-scale system, the schedule for the data collection and after survey had to be adjusted according to the project plan for implementation of the CBD ring (see Figure 2.20). The evaluation of the CBD ring was based on transaction data from the operator of the Trondheim RP scheme.

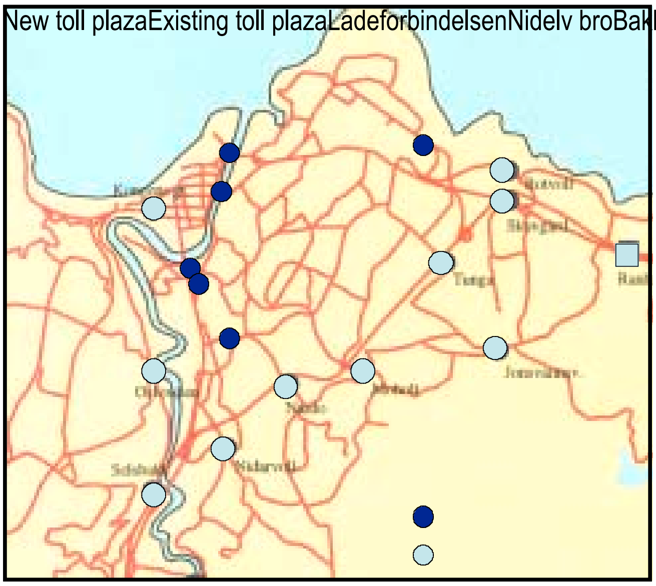


Figure 2.20 Location of Toll Stations for the CBD Ring

The operating hours and pricing scheme for the new CBD cordon were identical to the previous RP system in Trondheim. However, the new CBD ring mainly affects the residents living between the river defining the city centre, and the bypass road to the east of the city. Under the previous charging scheme this part of the Trondheim population can take their car to the city centre free of charge (except for the parking fees). All other car users had to pay road tolls to bring their car to the city centre. When the CBD ring was implemented, all car drivers had to pay tolls to take their car into the town centre.

3 THE EVALUATION PROCESS

3.1 Overview

Deliverable 4 of the CUPID thematic network, Evaluation Framework, provided a common evaluation framework for PRoGRESS. The concept was developed through the MAESTRO project in the 4th Framework, set up to guide cross-site European evaluation. Figure 3.1 indicates that evaluation of a demonstration project is one of four stages within the project lifecycle, the others being:

- Identification of the need to carry out a project;
- Definition of project objectives;
- Use of the project results for dissemination and transfer to other situations.

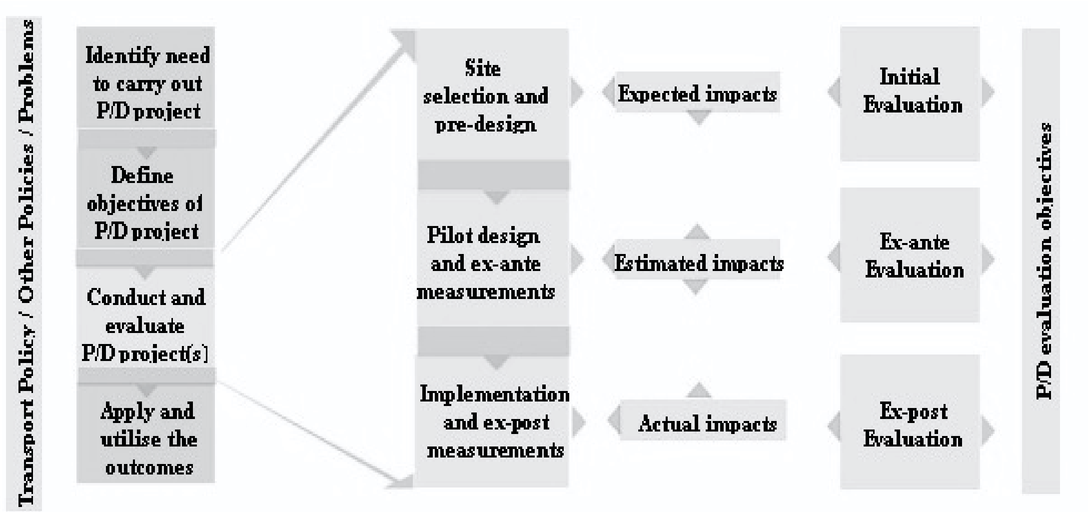


Figure 3.1 Key Stages of the Implementation and Evaluation Process (Source: MAESTRO)

The evaluation of PRoGRESS followed the principles shown in Figure 3.1, and a more detailed flowchart is shown in Figure 3.2. CUPID was responsible for the evaluation framework and the co-operation between the two projects was a valuable aspect of PRoGRESS.

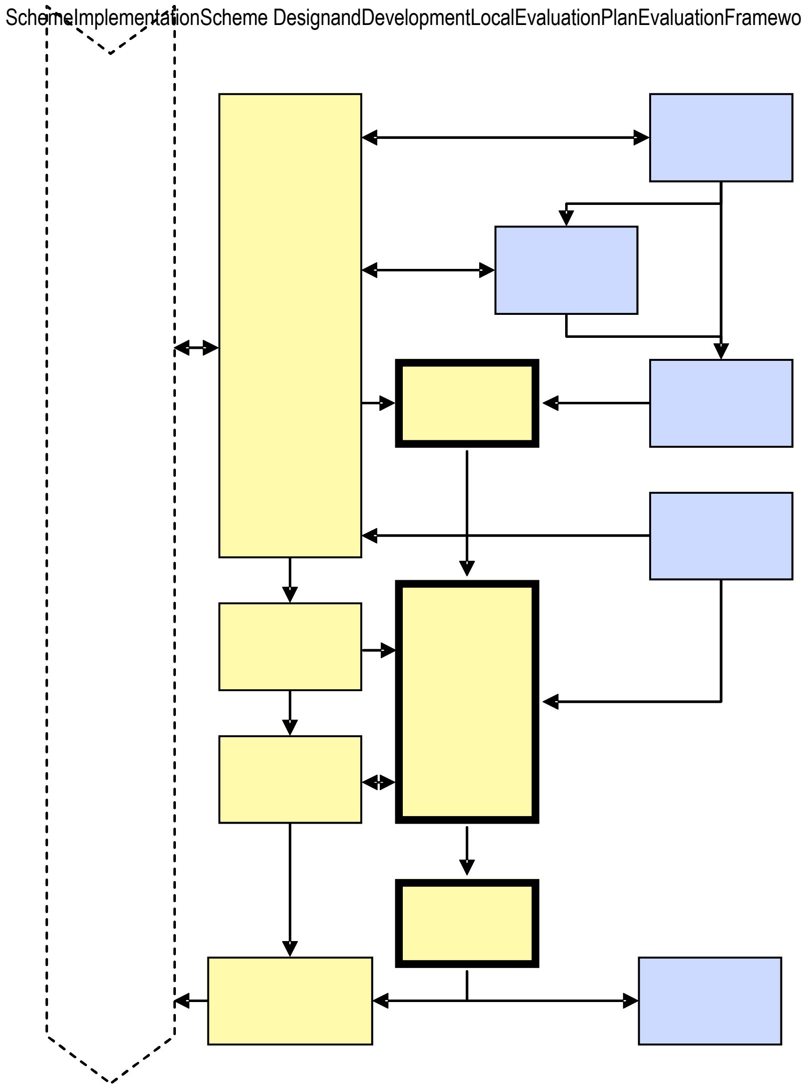


Figure 3.2 The PRoGRESS Evaluation Process

Local Evaluation Plans were developed early in the PRoGRESS project, and served two major purposes:

1. They were used in the communication with local stakeholders and politicians;
2. They were used internally in communication with CUPID.

The first point was very important for those cities planning full-scale road pricing schemes. From a European perspective, the second point is the most important. The experiences of working with RP schemes and concepts were shared among the cities involved. During the project, internal workshops with international experts were set up by the CUPID project to cover relevant issues raised by the cities and to bring in outside views and advice.

3.1.1 Evaluation Objectives

Each city had specific goals for developing a road pricing scheme, which are summarised in Table 3.1.

Table 3.1 Primary Goals for the RP Schemes in the PRoGRESS Cities

Primary Goal	Bristol	Copenhagen	Edinburgh	Genoa	Gothenburg	Helsinki	Rome	Trondheim
Demand Management	x	x	x		x	x		(x)
Area Access Control				x			x	
Environmental Management		x			x			
Raising Revenues			x					x

Demand management was the most common goal, as controlling car use in the urban area is important in all partner cities. However, other topics like environmental impacts and revenue raising are important too. Access control was generally driven by a combination of demand management and environment management.

3.1.2 Evaluation Topics Covered

The demonstrations covered many aspects concerning implementation of a road pricing scheme. A list of key topics monitored in the demonstrators is shown in Table 3.2, which shows a lot of commonality between cities. Hence, an overall evaluation framework was able to be applied to the project sites.

Table 3.2 List of Topics Monitored in the Demonstrations

Main topics in the demonstrations	Bristol	Copenhagen	Edinburgh	Genoa	Gothenburg	Helsinki	Rome	Trondheim
User/stakeholder reactions	x	x	x	x	x	No demonstration	x	x
Traffic demand	x	x	(x)	x	x		x	x
Technology	x	x	x	x	x		x*	x*
Environmental effects							x	(x)

* Real life system

User and stakeholder reaction were clearly very interesting for the cities, as were the impacts on traffic demand. The trials in Edinburgh and Bristol, for example, were not intended to influence travel behaviour, but impact on traffic was of interest as part of the full scheme development. Technology is another topic of common interest, and the project benefited from a number of key RP technologies featuring in the demonstrations. Only sites with full-scale implementations, Rome and Trondheim, could do actual environmental monitoring after implementation, but other sites modelled potential impact that were largely derived from changes in predicted traffic levels.

3.1.3 Transferability

Transferability refers to the applicability of project experience and results to other cities and was achieved at two levels:

Internal to project
The PRoGRESS cities designed or implemented specific measures selected from a whole range of scheme options. By exchanging project results, the PRoGRESS partners were able to gain useful information and support each other in developing pricing schemes.

External to project
Deliverable D7.2 is a Practical Implementation Guide for Cities, summarising the results of PRoGRESS into a focussed number of lessons learnt in the project and how these could be put into action by cities thinking about implementing road pricing. As well as this, the project website has been used for dissemination purposes since 2001: in total, more than 27,000 people had visited the website by May 2004.

CUPID evaluation also gathered results from each local project and produced an overview of impacts and results at a European level. The impact study provided data and information intended to be useable by other cities with similar characteristics where RP measures are being considered.

3.2 Political, Economic and Social Frameworks

This aspect of the PRoGRESS project was covered by work under workpackage 4, with the objective:

> *"To develop and assess the political, economic and social framework required for the implementation of road pricing considering social and political acceptance, legal and organisational issues, and financing, in the real urban situations of the cities of Bristol, Copenhagen, Edinburgh, Genoa, Gothenburg, Helsinki, Rome, Trondheim."*

In practice, the work was split into two main outcomes, which are described in the next two sub-sections, covering:

- Firstly, legal, organisational and financial issues under the deliverable number D4.2, submitted in November 2002.
- Secondly, social and political issues (including consultation) under the deliverable number D4.3, submitted in March 2004.

3.2.1 Assessment of Legal, Organisational and Financing Issues

The legal, organisational and financial frameworks at most sites were well developed by the end of 2002, and not much further development took place over the remaining lifetime of the PRoGRESS project. This means a relatively stable description could be provided.

An assessment of these topics was carried out by describing:

- The national legal framework for the implementation of road pricing in each of the PRoGRESS countries, as far as it existed
- Local legislation and the approval processes with which the schemes must comply
- The organisational frameworks, i.e. the local contractual and delivery frameworks for road pricing, including a list of the agencies involved, their responsibilities and their interactions. Conclusions were made to highlight the key issues that have influenced the organisational frameworks for the project.
- The anticipated scheme costs, the revenue flow, the investment envisaged through the surplus revenue and, again, a summary of the key issues that have influenced the financing structure.

Overall lessons learnt from the experience of the eight PRoGRESS cities completed this assessment.

3.2.2 Assessment of Consultation, Marketing and Press Coverage

Information was gathered and descriptions made about consultation and political awareness, which described the degree and type of consultation carried out and how if differed between the general public, special interest groups or politicians. It has been reported in Deliverable 4.3.

There are many stakeholders that will have a direct or indirect interest in any proposed road pricing scheme. The 'key stakeholders' in the context of this assessment are those that have a particular need to use the road network within the charged area and/or have to be consulted by law. The principal groups of key stakeholders are government, emergency services and public utilities, business, transport operators, special interest groups, and residents.

A description of the principal consultation methods that are available was completed, for consultation with stakeholders and for wider public consultation. The methods described cover:

- Piloting changes;
- Open / public meetings;
- Using representative groups, face-to face interviews and focus groups;
- Questionnaire-based surveys;

- Citizens' panels and citizens' juries;
- Ballots / referenda / deliberative polling;
- Written consultation;
- Open days / roadshows / exhibitions; and
- Information technology.

Not all of these methods are equally applicable for stakeholders and the public and evaluation outputs include discussion about how they can be best used in different cases, and in particular how they have been used in the PRoGRESS cities.

The main part of the assessment consisted of individual reports for each city on results and conclusions for consultation with stakeholders, consultation with the public, and marketing and awareness raising. Finally, common themes and key conclusions that are valid across sites have then been drawn together.

3.3 Assessment of Pricing Scheme Impacts

A range of techniques was used to assess the impact of pricing schemes, guided by the evaluation framework provided by CUPID. The main evaluation indicators were arranged under the following eleven headings:

- Acceptability;
- Equity;
- Privacy;
- Safety;
- Capacity;
- Quality of service;
- Resource consumption;
- Pollution, nuisance;
- Economics;
- Employment;
- Regional development.

Indicators were agreed under each of the evaluation topics above, adopted by all sites, and totalling some 60 indicators overall. Discussions took place on what modifications to the indicators were required in order to provide meaningful results at each site, and still maintain cross-site evaluation objectives.

Each of the sites considered how they would generate data either through historic data, new monitoring plans or surveys. Traffic models were also developed and used to forecast future changes post scheme implementation. The aim for many of the indicators was to collect data from three points in time: Baseline, Before and After scheme implementation. This then would cover the three-stage evaluation process from CUPID, based on MAESTRO guidelines.

A list of collected data and surveys called the Data and Survey Inventory (DSI) was a tool used in the evaluation process. Figure 3.3 shows an example of the DSI form. It consists of two forms: level 1 gives an overview of the survey activities in the site; and more detailed information about the individual surveys is presented in the level 2 forms (not shown here).

PROGR€SS City Survey Inventory
Level 1: Overview of all survey activity

PROGR€SS City

☐ Bristol ☐ Edinburgh ☐ Gothenburg ☐ Rome
☐ Copenhagen ☐ Genoa ☐ Helsinki ☒ Trondheim

City sequence number of survey	Title of survey	General description	Execution period
1	RVU1990	«Before toll ring-data» on background and travel behaviour of the Trondheim population	Autumn 1990
2	RVU1992	«After toll ring / before zone based charging-data» on background and travel behaviour of the Trondheim population	Autumn 1992
3	RVU2001	«After zone based charging-data» on background and travel behaviour of the population in the greater Trondheim area	Spring 2001
4	MINIRVU2003	«After CBD charging zone-data» on background and travel behaviour of the population in the main affected area	Spring 2003
5	IBIS_INFO-USER	Background, attitudes, travel behaviour and assessment of the changes in service level of bus users in the test area and control area	Spring 2002
6	IBIS_INFO-TARGET	In-depth survey of attitudes, travel behaviour and assessment of the changes in information service from specific target groups	Spring 2002
7	IBIS_THROUGH-RECRUIT	Initial recruitment of test participants having the required travel habits, and stating a willingness to participate	Winter 2003
8	IBIS_ THROUGH - BEFORE	«Before-data» on background, attitudes, expectations and travel behaviour of the test participants	Winter 2003
9	IBIS_ THROUGH - DURING	«During-data» on attitudes and perceptions of the test participants	Winter 2003
10	IBIS _ THROUGH - TRANSACTIONS	Before-, during- and after-data on behaviour of the test participants from Central System	Winter 2003
11	IBIS_ THROUGH - COUNTS	Continuos automatic traffic counts on approach roads	Winter 2003

First date for filling in this form	Original date:	21.11.01
Revised filling in	Revision number:	2
	Revision date:	12.04.02

Figure 3.3 Level 1 of the DSI Form

The DSI was updated continuously by the cities during the project. Well over 100 different surveys or data collection exercises were carried out by the cities, generating a huge amount of data to meet the evaluation needs for their RP schemes. The second level form described each survey or data collection exercise in detail.

Examples of the surveys and data collection exercises, from each of the eight PRoGRESS cities, include:

1. Multi-modal model developed for Bristol, enabling a prediction of post-implementation traffic levels in Bristol in combination with various Public Transport packages;
2. Stated preference surveys with 279 residents of Copenhagen, to validate other data sources (including field trials with the same respondents);
3. Postal and telephone interviews, both with general members of the public and the Edinburgh Citizen's Panel, a group of 2,000 representative residents;
4. Updating the private and public transport OD matrices for Genoa for use in models for design activities, based on a survey involving 45,000 citizens of the Province of Genoa;
5. Attitude and travel behaviour surveys with test participants, following recruitment to GPS trials in Gothenburg, followed by in-trial travel diaries;
6. Opinion and acceptance surveys on road pricing in Helsinki;
7. Attitude survey results with different user segments (businesses and residents) to index opinions before and after the addition of road pricing to the Rome LTZ;
8. Mode split, time of travel, OD and user acceptance surveys in Trondheim for 1990, 1992, 2001 tracking the long-term impacts of road pricing.

In addition to the common indicators CUPID provided there were many local assessments carried out. This fed into further development of local road pricing schemes and/or assessment of options for future work.

3.4 Assessment of Technology

Assessment of technology was done in each of the sites where technical trials took place. This covered the first three types of technical systems currently in use road pricing:

1. DSRC (electronic tags) using the CEN 5.8 GHz DSRC microwave;
2. Vehicle Positioning Systems, using satellite technology;
3. Video based systems with automatic number plate recognition (ANPR); and
4. Simple paper based permits.

DSRC technologies have been used in operational charging/tolling systems for some time and are typically used in cordon-based systems as well as motorway tolling. The trials with GPS systems represent a new application of technology and are designed to operate in time- or distance-based charging systems. ANPR is now being used in the day-to-day operation of RP, which is an advance from previous enforcement-only applications. Simple paper based permits were not tested in the PRoGRESS trials having been superseded by electronics based identification formats.

3.4.1 DSRC – Trondheim and Rome

Both Trondheim and Rome have implemented tag-based DSRC systems: Trondheim in 1991, in parallel with manual payment and an ANPR based enforcement system; and Rome in 2001, in parallel with ANPR systems.

Trondheim

The Trondheim toll system was, from the start in 1991, based primarily on automatic charging, using electronic read-only tags mounted in the vehicles using DSRC protocols (over 90 % of the vehicles were equipped with tags), with some manual pay toll-plazas (mainly for visiting traffic). International regulations require that the electronic tags used in tolling systems must use a communication frequency of 5.8 GHz. This change in frequency lead to the development of a new Norwegian standard for toll collection systems, called AutoPASS. All OBUs in the cars was replaced with new read/write tags according to the DSRC standard in 2001.

Figure 3.4 The AutoPASS OBU

The AutoPASS system complies with the provisional European standard for wireless communication between vehicles and toll stations (ENV for DSRC). In addition, full specifications were set up for all other elements needed in a toll system, i.e. accounting, clearing, black lists, exception handling, and enforcement. This will secure full technical interoperability. Technical issues were resolved and the system is working well in Trondheim.

As a part of the AutoPASS system, contractual interoperability was introduced in 2003. This means that all AutoPASS users have only one contract that covers the use in all Norwegian urban and rural toll systems. Clearing between the different tolling companies is done by the accounting system.

Rome
For Rome, test and management procedures for the access control system were made after the completion of the installation of the system in July 2001, when the system entered the pre-exercise phase. Testing was made in particular on the ANPR elements. These testing operations covered the 24-hour period that is considered necessary for normal workday. The tag and communications systems were based on standard tolling technology (in use elsewhere in Italy), and so the main evaluation activities were concentrated on the ANPR system, reported later in this section of the report.

3.4.2 VPS – Bristol, Copenhagen, and Gothenburg

Three of the PRoGRESS sites undertook trials of Vehicle Positioning Systems (VPS), which are charging systems based on GPS. The advantage VPS has is being able to test more advanced concepts of charging, such as:

- Combining a motorway segment-based charge with a city centre cordon (Bristol);
- Comparing distance with trip (cordon) based charges (Copenhagen); and
- Contrasting congestion-based and environmental-based charges (Gothenburg).

Complex charge concepts were therefore tested at the three demonstration sites. A major aim of the evaluation was to assess if the equipment was ready to support these concepts, and the other to evaluate what additional benefits such pricing concepts had over more well tried approaches.

Bristol
The Bristol demonstration was evaluated using a combination of volunteer vehicles and control vehicle test runs. This twin approach enabled assessment of:

- Equipment fitting, ongoing operation and provision of monitoring data from a 50 strong fleet of commercial vehicles on a 3 month trial basis;
- Detailed comparison of control vehicle logs completed during the test runs through every charge point or motorway segment of the test area with corresponding back-office data.

The data provided by the fleet vehicles during the trial enabled an assessment to be made of different pricing schemes, contrasting peak hour cordon charges with area licence charges for the same period, and comparing these against peak-hour only cordon charges. The data from the control vehicle was used in an analysis of performance rates for correct vehicle location with the proportion of the time GPS signal loss was experienced on motorway against city centre trial areas.

Other elements of the technology evaluation included interviews with the fleet managers (regarding driver acceptance and reliability issues) and a post-trial inspection of all VPS on-board units to diagnosis of any faults that may have developed during the trial.

Copenhagen

Once a VPS selected system supplier had begun to produce the equipment, the system was put through initial testing before rolling out to volunteers. These assessments comprised:

- Factory test, based on a fully working prototype fulfilling all specifications;
- Field test, ensuring the prototypes fulfil the requirements under real life conditions, check that the equipment can supply the log data in an effective and useful way for further and use a configuration file to automatic change between different working modes;
- Acceptance test, to verify that the equipment delivered fulfils the specifications.

During the demonstration three different charging systems were tested along with a reference case with no taxation. The three charging systems were all multi-zonal. Two were km-charged, but with different charges in each zone. The third taxation system, zonal charges, charged only when zonal borders (cordons) were crossed with the highest cost of border crossing close to the centre of the city. The high km-charge system and the zonal charging system were twice as expensive in the rush hours (7-9am and 3-6pm) than the rest of the day. The low km-charge system applied only in the rush hours (at a level similar to the out of rush hour charge in the high km-charge system).

With a total of 500 car drivers driving in average of 4 months, the data collected can be compared to one car driving for 2,000 months or approximately 160 years. Position data was stored every second in the GPS unit and later transferred to the research database. The data was collected with a large number of different car types in the greater metropolitan area of Copenhagen (2,654 km^2), of which the pricing system covered the inner part (368 km^2). The total area of map-matching with a reasonable number of observations included the Island of Zealand (total of 9,312 km^2).

Surveys were done with participants before they joined the trial (to assess suitability), during the trial using Stated Preference surveys (for comparison with VPS monitored behaviour) and after the trial to confirm their understanding and travel choices in the different charge scenarios.

The benefit of using vehicle positioning technology was its ability to simulate different pricing strategies of interest for Copenhagen. By precisely equipping the necessary number of vehicles for the demonstration purpose, a demonstration could be carried out without having to build large gantries along main roads and without other costly infrastructure investment.

Gothenburg

The Gothenburg PRoGRESS field trial demonstrated a complete road pricing scheme, excluding a control/enforcement mechanism against fraud (other than the check of vehicle odometers when trial was completed). For the research carried out in PRoGRESS a specifically designed logging functions was added in order to monitor the trial participants, the performance of equipment and gather data for analysis of scenario impacts. The complete logging service included the following functions:

- Allocation of initial account balance
- Application of the pricing mechanism
- Performing payment transactions
- Using the internet site
- Logging driver behaviour

Beside the parts of the system that contains the road pricing system, the use of VPS enabled collection of information on the travel behaviour of each vehicle. Each movement of the vehicle was logged, typically once every 100 meters. This enabled analysis of the travel behaviour. This logging information was communicated by GSM from the vehicle in parallel with the payment transaction information, and communicated to the central system server. Here the information was transferred into a journey-description file where the log data (time-stamped co-ordinates) was sorted into journeys and travel paths for future analysis.

3.4.3 ANPR – Bristol, Genoa, Edinburgh and Rome

Bristol

Two types of ANPR were trialled in Bristol. Fixed camera systems were tested at two locations as well as a mobile system that could be transported to different locations by van and operated at the roadside. One of the fixed sites used a two-camera system to cover a two-lane highway, although both were based in the city centre, where urban speed limits applied, and were only operated in an in-bound direction. The focus was to determine ANPR suitability for enforcement purposes, in support of a DSRC or VPS-based scheme.

The mobile system was tested on 10 weekdays, for a duration of 12 hours per day. Its ability to pick up volunteer vehicles (participating in the VPS trial) was the basis for the test. Records kept by roadside operators meant it was possible to calculate the different proportions of passing vehicle whose:

- Number plate was captured by the camera;
- Read successfully by the OCR software; and then
- Matched with the hot-list of volunteer vehicles.

A number of lessons were also learned about the placement and operating characteristics of mobile systems, for enforcement purposes.

Fixed cameras were in operation in Bristol for 24 hours a day for three months. During and after this period various assessments were made of the technology, based on:

- Comparison of the number of ANPR gathered vehicles in a period with Automatic Traffic Count data;
- Comparison of manual roadside monitoring survey data with ANPR derived data;
- Video gathered images compared to the text based ANPR output files.

From these tests it was possible to assess the likely performance rates of the fixed ANPR for capturing images and then ‘reading’ those images correctly and so providing accurate text file outputs.

Edinburgh

The purposes of the ANPR technology demonstration in Edinburgh were:

- To demonstrate the viability of the proposed approach to the technology for a full scheme, in particular focusing on potential problems in the Edinburgh environment and with the likely scheme requirements;
- To investigate aspects of enforcement in the proposed full system.

Two sites were equipped with cameras and Automatic Number Plate Reading (ANPR) equipment: the sites form part of the proposed inner cordon for the full scheme, at Dean Bridge and in Home Street.

A number of aspects of enforcement were investigated in addition to the standard camera and ANPR configurations at the two sites. These were based on a series of special tests that investigated the following:

- The use of additional cameras mounted on tripods on the pavement;
- Capture of both front and rear number plates;
- Identification of the direction of vehicles passing through the cameras’ fields of view.

Special software was developed in order to analyse the performance of the ANPR equipment. A total of 150 hours of video recordings were analysed from the standard camera/ANPR configuration, and a further 19 hours were analysed form the special tests.

One of the aims of the demonstration was to monitor each site for three months to detect each passage of the volunteer drivers and, for selected periods, to analyse the operation of each site in detail. The analysis aimed to obtain a full understanding of the operation of the equipment under different traffic and environmental conditions and with different dispositions of cameras in relation to traffic.

The detailed analysis of the enforcement was carried out for a number of 1-hour periods for each site, over a period of several months. The analysis was based on the checking of the percentage of number plates identified correctly and identifying wherever possible the reasons for incorrect or missed reads. Periods analysed covered a range of weather and lighting conditions (although there was only one light snowfall during the test period and no lying snow), and periods of both light and heavy traffic.

Two different system suppliers provided equipment for the trial (PIPS and MVI). PIPS camera equipment was installed at both sites, with the standard configuration of two cameras pointing at the front of traffic passing each of the sites. During the period from 16 September 2002 to 13 January 2003, MVI ANPR equipment was installed at Dean Bridge and PIPS ANPR equipment at Home Street. On 13 January the ANPR equipment was swapped, so that for the final period from 14 January to 21 February the MVI ANPR equipment was installed at Home Street and the PIPS ANPR equipment at Dean Bridge.

The video analysis was conducted using postgraduate students who were recruited by TRI to view images from the context cameras at each site and to look at licence plate details, which were matched against ANPR records to determine the accuracy of the proposed enforcement system.

In total, there were nearly 100,000 vehicles recorded over 150 hours. The detection rate was reasonably high from the outset, but the cameras were re-focused and realigned several times during the trial, so results improved further as the trials progressed. A key finding was that the number plate reading rate was entirely sufficient to ensure adequate enforcement even at difficult sites.

Genoa

The technology that Municipality of Genoa installed was ANPR (cameras plus Optical Character Recognition) at eight access points into the city centre.

The installation of the cameras and control center was performed between October and December 2002. This phase included the civil works to set up the poles, the cameras, the infra-red lights and the magnetic induction loops; traffic diversion where necessary; the set up of the connections between the local units and the control center; and the tuning of the hardware system.

The ANPR cameras were operated for a 'running-in' period during which time careful monitoring of vehicle number plates against a set of volunteer vehicles was carried out. The volunteer vehicles were obtained from an Automobile Association and vehicles operated by the Municipality of Genoa. It total, a preliminary two months period was necessary in order to calibrate the number plate database and reduce recognition errors. During the running-in period some changes were made to components to rectify hardware problems.

During the trial assessment was made of the:

- Number of plates correctly read;

- Proportion of plates incorrectly read, with reasons documented (dirty, obscured, broken, invalid format or foreign vehicle number plates).

Overall numbers were calculated for each of these categories enabling an assessment of the likely performance in ongoing operations.

The demonstration phase with volunteer users started in Genoa at the start of March 2003, and was completed at the end of August 2003. The volunteer users (VUs), acted as a sample of all citizens, and their results factored up to full-size scheme outcomes. The volunteers had at their disposal a budget from the Municipality to pay their passages inside the trial area. They could keep unused money at the end of the experimental period. Thus they are obliged to decide, when a trip choice is being made, whether to use their car (and reduce their budget), or to use another mode. Detection of the volunteer users was via the ANPR system

<u>Rome</u>
Technology assessments in Rome were focussed on ANPR applied at the entrance point to the access controlled zone (LTZ).

The test operations covered a 24-hour period on a normal weekday. The assessment was based on sample days in August 2000, when data was collected over a period of time outside the time of normal access control. The analysis was conducted on five of the possible entry gates.

From the test data it was possible to check if the system could match number plates passing the camera sites to a corresponding list of LTZ (access controlled zone) permit holders. This was done by firstly applying two-stages of ANPR algorithms to the data; the first automatically as the vehicle passed the camera and the second on remaining images using a managed process on a separate computer. Finally, the small proportion of images which were unreadable by either computer systems were checked manually to see if the image had been captured in a readable form by the camera, and what was the cause of the error.

4 PROJECT RESULTS

The main results of the PRoGRESS project can be grouped under four headings:

- Legal, organisational, and financing issues (section 4.1);
- Consultation, marketing, and press coverage issues (section 4.2);
- Charging technologies (section 4.3); and
- Charging scheme impacts (section 4.4).

These are each described in the following subsections.

4.1 Legal and Organisational Issues

Legal, organisational and financial issues were examined in PRoGRESS based on the experiences of the eight cities involved. This section describes the situation in the PRoGRESS cities with respect to:

- The national legal framework for the implementation of road pricing in each of the PRoGRESS countries (as far as it exists) and any local legislation and approval processes with which the schemes must comply.
- The organisational frameworks, such as the local contractual and delivery frameworks for road pricing.

All of the eight PRoGRESS demonstrators are currently at different stages of development. These differences were reflected in the contributions that the sites could provide on these issues, with some sites being very advanced in having legal frameworks, organisational structures and full finance plans in place, while other sites still only had preliminary thoughts.

4.1.1 Legal Frameworks

A national legal framework for urban road pricing is in place in Norway, Italy, and the UK. It does not yet exist in Denmark, Finland and Sweden. Details within the existing legislation vary between countries and, similarly, it will be necessary to tailor future legislation in other countries to their current legislative frameworks and general political contexts.

<u>Norway</u>
In Norway, all road projects involving road tolling require approval from local and regional bodies, and sanctioning by the Parliament. The implementation has to be initialised by local political bodies.

At the time of planning and introduction of the existing city toll rings in the last decade, the Norwegian Road Act did not accept demand management to be the main rationale for implementation or design of road pricing projects. Revenues from road tolling could only be used for investments and maintenance in the transport sector.

The new paragraph 7 of the Road Traffic Act was passed by The Norwegian Parliament in June 2001. This paragraph opens up the possibility for introduction of congestion pricing (or road pricing to reduce congestion). The purpose of congestion pricing should be local regulation of traffic. Traffic flow and environment should be improved. The motorists should pay to use specific parts of the road network in peak hours.

It is a condition in the new law that tolling (ie to raise money for transport infrastructure and maintenance) is not mixed with congestion pricing in the same area. This implies that existing tolling schemes must be stopped before a new congestion pricing scheme can be introduced. The reason for this condition is that the nature of tolling is to maximise income, while the congestion pricing schemes aim at limiting traffic.

Tolling systems are agreements limited to a specific number of years. This is not the case with congestion pricing, which is a demand management measure. Therefore, it is important that a congestion pricing scheme is initiated at local level, and formal local approval will be required in each case. This is also stipulated by the new law. The Public Roads Administration will present the case to the Ministry of Transport, and the Government will eventually put a proposition before the Parliament who will make the final decision. This is the same democratic procedure as for toll roads.

<u>Italy</u>

Many parliamentary Acts have been set up in the last few years referring to air and noise pollution, while land use and environmental protection have been enshrined in several acts published after the Second World War.

From the general point of view, the context within which the implementation of urban road pricing is proceeding in Italy is framed by a set of national laws disciplining land-use planning and transport management. The fundamental law on land-use planning in Italy is Law 1150/42 (Legge Urbanistica), which introduced the Master Plan as a planning control instrument based on the zoning principle, e.g. programming interventions dividing a region in areas with homogeneous development characteristics.

Further legal acts delegated competencies on land-use planning and transport management to regional and local authorities. For instance, law 393/59 granted the authority to local administrations to limit parking time and car circulation in their jurisdictional area "in order to safeguard human health, public order and environmental and cultural city heritage".

The ministerial decree 1444/68 related to law 765/67 officially recognised the specific environmental and cultural values of historical city centres, defining the historic centre as Area A, the first of six homogeneous zones subdividing the territory of each municipality.

In the 1970s, an array of specific rules were adopted linked to contingencies, e.g. oil crises, pollution peaks, but no systematic approach was adopted at the national level to manage the fast growing role of the private car in everyday urban life.

Law 122/89 (an integration of law 393/59 mentioned above) foresaw the creation of the 'blue area', characterised by the opportunity to limit access to certain categories of vehicles and to impose parking fees. Application of the 'blue area' in Rome started only in 1992, when the area and the time restriction periods were finally defined. This developed into the Limited Traffic Zone scheme, which in turn now incorporates road pricing as a feature.

Reference to possible road pricing techniques is contained in article 7 of the Italian Traffic Code. It contains the possibility to subordinate the access to a Limited Traffic Zone (LTZ) to the payment of a certain sum. This means that road pricing is permitted only if the target area is characterised as a LTZ. The designation of an urban area to LTZ is adopted by the Municipality through a resolution of the City Council.

In the case of road pricing, the resolution must also indicate all the elements of the scheme to be adopted, such as:

- Amount of the fees
- Hours of payment for access
- Exemptions rights and modalities
- Subjects and vehicles with exemption rights
- Tolling procedures
- Subjects entitled to operate the system

<u>United Kingdom</u>
In England and Wales, the Transport Act 2000, provides enabling powers for road pricing schemes to be introduced by Local Authorities with approval for implementation from the Secretary of State for Transport. The Transport Act 2000 clarifies that the approval of road pricing schemes is closely linked to an integrated strategy for the improvement of transport and not solely for revenue raising:

> "A local charging scheme may only be made if it appears desirable for the purpose of directly or indirectly facilitating the achievement of policies in the charging authorities' local transport plans." (Transport Act 2000, part III, chapter 1, section 164)

The Act specifies that the scheme has to be submitted to the Secretary of State for approval via a scheme order, which should specify: the roads on which charges are to be imposed, how a vehicle is to be charged, specify the classes of vehicle to be charged, the level of charges and the period for which the charging is to be enforced. The Act also includes sections on consultation, enforcement, equipment, and funding/use of revenues.

In addition to the Act, the national Department for Transport, in consultation with interested local authorities, has compiled regulations and guidance for local authorities developing schemes. This guidance provides the outline for scheme development and appraisal criteria for Secretary of State approval. The guidance clearly identifies the criteria for Government approval of an order and provides local authorities with an outline to meet these criteria.

As in England and Wales, the Scottish Assembly has promoted a new approach to transport policy in recent years, resulting in a new Scottish Transport Act. The Transport (Scotland) Act 2001 contains the necessary legislation giving local authorities in Scotland enabling powers relating to the introduction of congestion charging as part of Integrated Transport Initiatives. The Scottish legislation is fundamentally different to that introduced in England in that, although it allows for the introduction of road pricing, it does not allow for the introduction of any workplace parking levy schemes. In Scotland there is also a two-stage approval process, where any scheme will initially require approval in principle followed by detailed approval by Scottish Ministers.

The legislation has four important pre-conditions in relation to the introduction of urban road pricing:

- The revenue must be spent only on transport
- The money raised must be additional to, not in place of, existing funding
- There must be transparent accounting for income and expenditure
- There must be significant investment in public transport from the outset

4.1.2 Organisational Frameworks

Copenhagen, Gothenburg, and Helsinki had no clear plans for possible organisational frameworks at the stage reached during PRoGRESS.

Bristol was in the process of developing their organisational structure during PRoGRESS, which will be dependent on the procurement method adopted. The organisational framework was being developed from in-house experience of major schemes with advice from third parties, in particular the 4Ps (public private partnerships programme), sponsored by the UK Local Government Association.

The implementation of a major scheme such as road pricing requires a number of elements to be brought together. However, the roles and management structure of these elements still require further definition and are dependent on the procurement route decided by the project management board (and ratified politically), management systems to be adopted and the role of central government support (both financial and technical). However, it is currently considered that there are three options for the management of the system – fully managed in-house, joint venture with the private sector, or management through a concession.

In Norway, special toll companies have been established for each tolling project with the sole purpose to collect the money from users and pay down the loans on the project that had been financed through this scheme. These companies are owned by the municipalities or counties concerned.

The toll companies in Norway are normally not responsible for any matters concerning the road construction and operation. The construction and maintenance of the roads is, so far, normally carried out by the local road administration.

Trondheim has a local toll company. According to Norwegian legislation, the toll company is a public company. Because the number of toll projects has increased significantly over the last decade, the toll company of Trondheim now also handles several other tolling projects in the county of Sør-Trøndelag and Nord-Trøndelag. The company is owned by the municipality of Trondheim (40 %), the municipality of Stjoerdal (20%), and the counties of Sør-Trøndelag (20%) and Nord-Trøndelag (20%).

One intention with the AutoPASS project, which has defined the Norwegian standard for EFC systems, has been to make the EFC systems fully interoperable throughout the country. Technical interoperability is secured by the EFC standard, and in late 2003 the contractual agreements about full interoperability were signed. This opens the AutoPASS OBU for transparent use in any toll system in Norway.

Edinburgh, in a similar approach to Norway, established a company, Transport Initiatives Edinburgh Ltd (**tie**), for the procurement, project management and finance management of the charging system. **tie** is wholly owned by the local authority and the local authority will therefore retain strategic direction on matters such as levels of charge and hours of operation, but **tie** will co-operate with the private sector to deliver the investment projects.

In Italy, it is the municipality itself (as in Genoa) or, in the case of Rome, their previously established organisational arm (STA), who organise the pricing scheme. They co-operate closely with the local transport operators to ensure a coherent approach for road pricing and public transport provision.

4.2 Consultation, Marketing, and Press Coverage

4.2.1 Consultation on Road Pricing

Consultation with stakeholder organisations and with members of the public formed a key part of all the PRoGRESS demonstrations. This reflects the importance of consultation in development of road pricing schemes. Public consultation can help create 'ownership' of the RP scheme. This includes support and/or acceptance for the principles of the scheme, as well as providing input to detailed design aspects.

A reasonable level of public acceptance is critical to the success of road pricing for a number of reasons. These include:

- Acceptance and understanding of a scheme will promote desirable changes in travel behaviour and help the scheme meet its demand management objectives.
- A reasonable level of acceptance will minimise the risk of undesirable responses such as extensive violation of a scheme.
- Public acceptance is required in order that the required political support from democratically elected decision-makers can be maintained.

4.2.2 Consultation with Stakeholders

<u>The consultation process</u>

There are many stakeholders who will have a direct or indirect interest in any proposed road pricing scheme. The key stakeholders considered in the context of PRoGRESS were those that have a particular need to use the road network within the charged area and/or who cities are legally obliged to consult. The principal groups of key stakeholders are government, emergency services and public utilities, business, transport operators, and special interest groups.

Table 4.1 summarises the key stakeholder organisations consulted by the eight PRoGRESS cities. This includes organisations already consulted and those where future consultation is planned. Figure 4.1 shows a poster used in Gothenburg to publicise their PRoGRESS project at various stakeholder consultation events.

Table 4.1 Key stakeholders for consultation

	Bristol	Copenhagen	Edinburgh	Genoa	Gothenburg	Helsinki	Rome	Trondheim
Government								
Ministry of Transport	C	C	C		F	C	C	C
Ministry of Finance and Taxation		C				C	C	
Driver and vehicle license authority	F		C	C				
Regional Government			C	F	F	C		C
Surrounding authorities	C	C	C			C	C	
Emergency services and public utilities								
Police	C		C				C	
Fire brigade	C		C				C	

Health and ambulance services	F		C				F	
Public utility providers	C		C				C	
Business								
National business organisations	C		C					
Local business organisations	C		C	F	C	C	C	C
Trade unions	F		C	C			C	C
Financial institutions	C		C					C
Retailers	C		C	C			C	
Consumer interest groups			C	C	C			
Freight transport industry	C		C	C			F	C
Vehicle service industry	C		C					
Manufacturing industry	C		C				F	
Educational establishments	F		C					
Tourist and leisure organisations	C		C				C	C
Transport operators								
Public transport operators	C		C	C		F	C	C
Taxi operators	F		C	C			C	C
Vehicle rental and leasing operators	F		C					
Parking operators	F		C	C			C	
Interest groups								
Motoring organisations	C		C	C		F		C
Cyclist and pedestrian organisations	C		C				F	C
Environmental groups	F		C	C			F	C
Road safety organisations			C				C	

C: have already been consulted (status December 2003); F: will be included in future consultation

Figure 4.1 The Gothenburg PRoGRESS Poster

Stakeholder consultation results

Different stakeholders have different agendas, and therefore a variety of key issues emerged for different groups, with some common themes as well. The overall outputs of the stakeholder consultations (across the PRoGRESS cities) are summarised below.

Politicians

One of the clearest observations from the PRoGRESS sites was the need for a political champion or figurehead, who takes ownership of the road pricing concept. Unlike the officials involved in the preparation of any scheme, politicians depend on re-election, and the fear of losing elections by promoting road pricing holds many politicians back. Even where there is strong enough political support to go ahead with charging plans, politicians can easily be disheartened if they find that public support is eroding in the run-up to the scheme introduction.

One way of divorcing the road pricing issue from elections is to hold a referendum. It should be noted, though, that a referendum just before the last steps of the scheme introduction is very likely to hit the lowest level of support, and therefore runs the greatest risk of failure. An alternative to an early referendum is the Stockholm approach - here the referendum is to be held around one year after a congestion charging scheme will have been implemented on a trial basis. While this approach carries a large financial risk, it provides the best chances for the referendum to be won, since experience has shown that public support for a charging scheme increases again once it is up and running and people start to feel its benefits.

General Business

Business organisations as a whole tend to take a positive view on charging, in particular for the less restrictive schemes that operate only in the peak, or even only in the morning peak hours. Chambers of Commerce are good channels to reach business in any consultation exercise, both for providing them with information about the envisaged scheme and its potential benefit for the business community, and for seeking their views on the scheme design.

Retailers

Retailers that are located within the envisaged charging zone are generally among a scheme's most vociferous opponents. They fear the competition from retailers located outside the zone, and a resulting reduction in their customer numbers. Since it is clearly the purpose of most schemes to deter car traffic from entering the charged area, this fear is understandable, and can only be allayed if retailers can be convinced that the public transport alternatives offered to their current customers are good enough to provide viable alternatives to the car. Another mitigating measure for the potential loss of customers would be to invest some of the charging income on promotional measures for the charged area.

Further to the fears about loss of customers, there are also concerns that those customers that still come have less money in their pockets to spend. Some ways to address this fear would be: a parking policy that would reduce parking charges during the main shopping hours; the creation of additional spaces (although this may turn out to be counterproductive for congestion reduction); or the use of some of the road pricing revenue to allow a reduction of public transport fares.

The final concern for retailers is that they may have to increase the prices of their goods to accommodate additional costs for deliveries, and thereby become less competitive than their out-of-town rivals. However, if there is only a daily charge rather than a charge per trip delivery vehicles making frequent may have more to gain from reduced congestion than to lose from the once-per-day charge. Moreover, the low level of charges foreseen currently by European cities should only add very marginally to the costs of bringing items to sale.

Wider stakeholder issues

Good public transport alternatives to the car will be requested by most, if not all, stakeholder groups and this generally comes through as the most important of all conditions for a road pricing scheme to be acceptable. It is crucial for the general acceptance of any scheme that people believe that these alternatives will be in place as soon as charging starts.

In all cities that are considering road pricing or have done so in the past, revenues are earmarked for transport investment. The majority now focus on local public transport, although there are also other alternatives, such as road infrastructure investment or packages that comprise public transport as well as cycle and pedestrian facilities, traffic calming and improved road surfaces. The most important key issue is that the revenue is used, and is seen to be used, on additional transport investment, and not regarded as 'just another tax on the car driver'.

Many of the stakeholder groups request exemptions from the charge for their members. The one group that is given exemptions in every scheme is (formally identified) disabled drivers. Other than that, exemptions vary between cities, and no general advice can be given, since there are not only cultural but also legislative differences to be considered.

A final consideration brought forward by stakeholders across all cities is the need for routes around the charged area that allow traffic to by-pass it. Stakeholders as well as the general public expect to be able to move between different parts of the city, which lie outside the charged area, without having to enter it or having to make excessive detours around it.

4.2.3 Consultation with the General Public

<u>Consultation methods</u>

Extensive public consultation was undertaken in PRoGRESS using a wide range of methods. These are summarised in Table 4.2. Figure 4.2 shows an example of stimulus material used in public consultation surveys in Rome.

Table 4.2 Consultation Methods Used by the PRoGRESS Cities

Consultation method	Bristol	Copen-hagen	Edin-burgh	Genoa	Gothen-burg	Helsinki	Rome	Trond-Heim
Piloting changes		Π			Π			
Open/public meetings	Π		Π					Π
Focus groups	Π	Π	Π					
Questionnaire -based surveys	Π	Π	Π		Π	Π	Π	
Citizens' panels	Π		Π					
Citizens' juries		Π						
Ballots/ referenda/ deliberative polling			Π					
Written consultation	Π		Π					
Open days/ roadshows/ exhibitions			Π					
Information technology		Π	Π		Π			

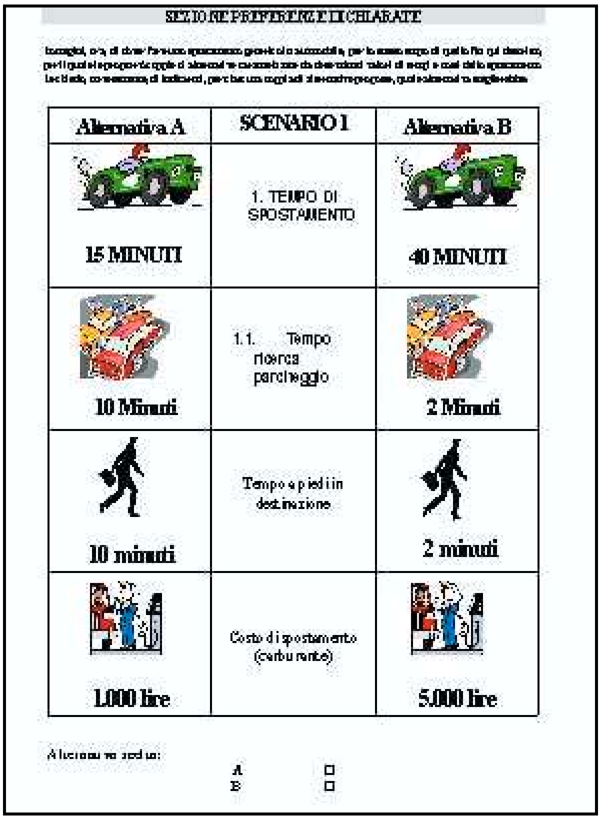


Figure 4.2 Example of Stated Preference Scenario Presented to Interviewees in Rome

<u>Consultation results</u>

Some of the key issues raised in consultations with the general public were similar to those raised by stakeholders. Additional views commonly raised across the sites are highlighted below.

Pressure to tackle the problem

The introduction of road pricing will only go ahead where people feel that there are very strong reasons to do so. Whether there is a new section of road infrastructure or a congestion charge, people will only willingly pay for this if they perceive that the size of the problem is such that something needs to be done.

The most important implication of congestion in terms of the immediacy with which the problem is perceived is generally the time lost in traffic jams, whether by car drivers or passengers, public transport passengers or delivery vehicles. Where these problems are large enough, there are the best chances for the introduction of charging.

Another result of too much car traffic is pollution with its implications on health, the general environment and, in some cities, on the architectural heritage. All of these will provide additional arguments for demand management, and therefore for charging. However, in most cities, these will be supporting arguments that add to the urgency for action, rather than the primary incentive.

Need for a long-term consultation strategy

One key element that came through from charging schemes implemented so far as well as from those nearing the implementation phase was the need for a coherent long-term consultation strategy. The level of public awareness of plans for a charging scheme as such as well as the level of awareness of the details of any envisaged scheme are generally far lower than those who have invested in public relations and information campaigns would like to believe. Strategies need to be drawn up very carefully to create and then carry public support through all the various phases of scheme design and implementation. The shorter the process from the initial scheme conception to its final implementation is, the easier it will be to maintain the initial momentum.

Moreover, the public want to be seen as being consulted on the scheme and "to have had their say" in the final scheme design. Consultation with the public should therefore focus on the scheme design and the ways it could achieve its targets while minimising the pain for those who will have to pay.

Scheme design

One difference between consultation with stakeholders and that with the general public is that the latter are somewhat more directly concerned by the level of charges, since most of them have no opportunity to pass the extra cost for their journeys on to customers or employers. Therefore, the level of charge is crucial to general acceptability, and a very careful balance needs to be struck between making the charges high enough to achieve the objective of congestion reduction, and keeping them low enough to avoid public unhappiness.

Any exemptions have to be, and have to be seen to be, fair. Residents within and outside the charged area will need to feel that they get a fair deal out of the overall charging and revenue re-investment package.

A final issue that tends to loom large in the public debate about charging schemes is the issue of privacy. However, recent research shows people feel there are so many ways in which their movements can be traced, if authorities want to do it that privacy issues seem to be decreasing.

4.2.4 Marketing and Awareness Raising

Marketing and awareness raising are key activities in implementing and operating road pricing schemes. Such activities need to commence at an early stage and continue throughout the operational lifetime of a charging scheme.

Marketing and awareness raising was a feature of most of the PRoGRESS city demonstrations, and a number of valuable overall lessons were learned. The principal communications channels used in this context were press releases and other media contacts, websites, and posters and leaflets of various descriptions. The approaches to using them and the ways they were deployed varied significantly from city to city.

Being pro-active

The one single message that came through from every PRoGRESS city planning the introduction of road pricing was 'be pro-active'. Informing the press and the public with the arguments for road pricing and the details of the envisaged scheme was found to be much preferable to chasing after them with corrections of misconceptions. These are bound to find their way into the media through mis-reporting, biased media "comments" columns or the "letters to the editor" pages. The range of issues that should, and could, be presented to the media depends to a large extent on the stage reached with possible scheme introduction.

Early days

The main problem, when the introduction of some form of road pricing is first considered in a city, is to get people interested. The general public tends to take little note at all at these early stages, and even many stakeholders will think of it as an academic exercise or as something that may be relevant elsewhere, but not for their own city. Engaging the stakeholders will be the first step, if any progress towards scheme implementation is to be made. Since at such a stage, it is unlikely that any concrete scheme design can be discussed, the two main subjects of any presentations to the stakeholders will be the results of any studies that may have been carried out and results from other cities where schemes have already been implemented.

Moving towards scheme introduction

When 'hearts and minds' have to be won, as plans for charging go ahead, it is essential that Councils involve specialists in the planning and conduct of the awareness and marketing campaign. The messages that are being sent out fall into two categories: First of all, there are general messages about the expected benefits of the scheme to society at large. Such messages can be broadcast, printed in Council newsletters, or put on billboards, because they address anybody in the same way. Other messages need to be tailored to different stakeholder groups, who are affected and may benefit in different ways. In all of these cases, specific messages need to be designed, and specific channels have to be found to send these messages to the target audience.

The marketing campaign must also be tied in with the consultation. Winning hearts and minds works best when people feel that they can still influence the scheme design. In the following picture, the marketing sentence chosen in Rome is "IRIDE. Un'occhio di riguardo per la città" which translates as "IRIDE. An eye taking care of the city", this attempts to convince the citizens of the benefits to be gained by implementing the scheme.

Figure 4.3 Typical poster used in the media campaign for scheme activation in Rome

The run-up to the charging scheme going live

When the details of the scheme are finalised, and procurement and installation are under way, it has to be ensured that people are informed where, when and how the scheme will operate. In this last phase of marketing and awareness raising, the key message to anybody who will possibly travel into the charged area in the future, will be "how to minimise the pain", and there are two aspects that need to be addressed by this: information about public transport alternatives and information about payment channels for the charge. Key to this last phase will be the employment of marketing experts who know how to reach different groups in the population with different messages through different channels. This will leave the technical staff to ensure the scheme goes in on time and operates as planned.

4.3 Charging Technologies

The PRoGRESS demonstrations yielded valuable information on technological performance, through testing of a range of technologies under different charging scenarios.

4.3.1 Urban Road Pricing Concepts and Technology Tested

The most basic concept for urban road pricing is a cordon where vehicles are charged per trip or per day for crossing the cordon line. This can be further developed into a zone system where each trip across a zone boundary is charged (see section 1.2). The charges may vary across different times of day and different types of vehicle or user groups. This kind of concept was studied in, Bristol, Edinburgh, Genoa, Rome, and Trondheim.

An alternative to cordon charging is to charge car users by distance travelled in the charging area. Again the charge can be differentiated by time of day, vehicle type, and user group. Both Copenhagen and Gothenburg carried out demonstrations of this type of charging technique through the use of GPS technology. Bristol also conducted a trial with a distance-based charging system, but only for commercial vehicles. Rome analysed a concept where vehicles are charged according to the amount of time they have spent inside the access controlled area.

Four main types of technical systems are used in road pricing:

- Simple paper based permits
- Electronic tags using the CEN 5.8 GHz DSRC microwave standard
- Camera based systems with Automatic Number Plate Recognition (ANPR)
- Vehicle positioning systems (VPS) using the location capabilities of GPS.

The first three technologies had all been used in operational RP systems for some time prior to PRoGRESS. They are typically used in cordon-based systems. The trials with VPS represented a new RP technology and were designed to operate in zonal or distance-based charging systems.

Across the eight PRoGRESS cities, a range of charging concepts and technologies were analysed and demonstrated, as shown in Table 4.3.

Table 4.3 Charging Concepts and Technologies Tested Across the PRoGRESS Sites

Scheme concept	**Road pricing technology basis**		
	DSRC – electronic tag	**ANPR**	**VPS – based on GPS**
Cordon (per trip)	Rome Helsinki	Bristol Genoa Rome	Copenhagen Bristol
Cordon (per day)		Edinburgh	
Zone (per trip)	Trondheim Helsinki	Trondheim (enforcement)	Copenhagen
Distance-based			Copenhagen Gothenburg Bristol

4.3.2 DSRC – Rome and Trondheim

Both Trondheim and Rome have implemented tag-based DSRC systems. The DSRC technology has proven very reliable. The capture rate of the OBU should, according to the AutoPASS specification, be better than 99.5%. The implementation in Trondheim shows even better results.

The Trondheim toll system is based primarily on automatic charging. Over 90% of vehicles are equipped with an electronic OBU. This first generation system used read-only tags based on battery-free SAW technology (Surface Acoustic Wave) communicating at 856 MHz. Manual payment for unequipped vehicles was offered at ticketing machines. Enforcement was carried out with video and OCR in an ANPR system.

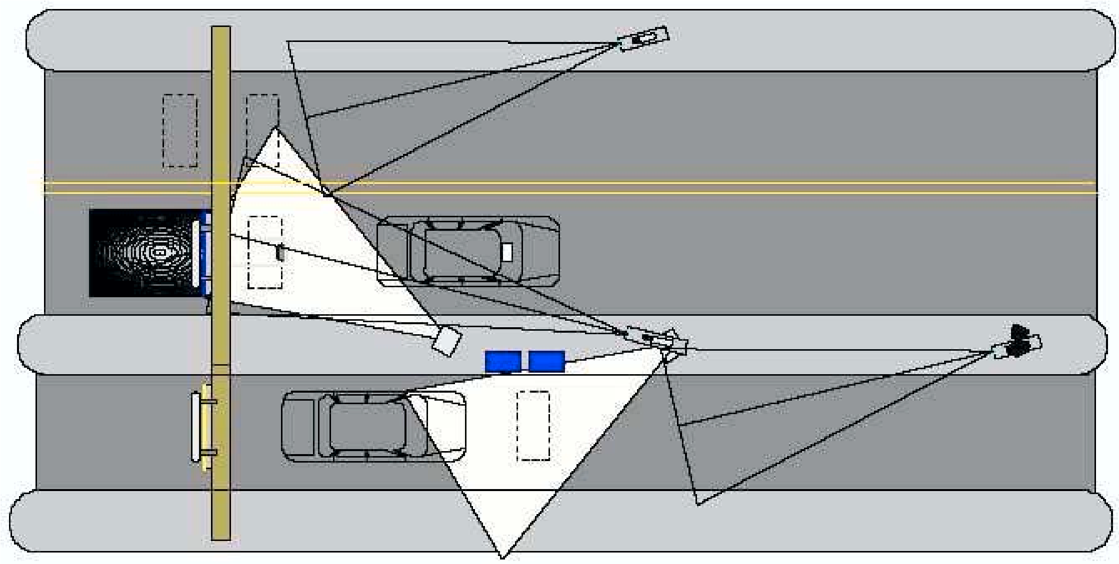


Figure 4.4 Standard Charging Point Design in Trondheim

International standardisation made it necessary to change from the 856 MHz communication to the new the 5.8 GHz DSRC in 2001. This led to the development of the Norwegian AutoPass standard. The OBU of the AutoPass system is a read and write electronic tag. This new technical system was implemented in Trondheim in mid-2001, with all tags and roadside equipment changed without any disruption of the charging system. AutoPASS has technically been a success, and because of the high number of OBU equipped vehicles (100,000 units or about 90% of users), the operational costs are about 10% of the annual turnover.

In Rome, the installation of automatic gates with ANPR systems took place in July 2001, and was followed by verification of the camera technology. During the same period the technical specifications were developed for a high-end onboard unit for access control. This included the Telepark function for on-street parking payment. Technical specifications were also developed for the two types of microchip smartcard (scalable and disposable) for access control and on-street parking payment. This was followed by production of the high-end on-board-units (35,000 units) and microchip smartcards (35,000 units).

These systems were found to be generally robust and reliable, able to handle simple communications at high speeds (particularly as read-only) and unaffected by environmental conditions. There are some issues with metalised windscreens affecting signals and the limit on battery life of the in-vehicle unit means a replacement service is required. Generally, for simple toll-collection using cordon charging, DSRC tags were shown to provide a robust and well-tested technology.

4.3.3 VPS – Bristol, Copenhagen, and Gothenburg

Three of the PRoGRESS sites trialled VPS charging systems based on GPS. The advantage VPS has is being able to test more advanced concepts of charging, such as: combining a motorway segment-based charge with a city centre cordon; contrasting congestion-based and environmental-based charges; and comparing istance with trip based charges. Quite complex charge concepts were tested at the three demonstration sites, working towards more refined marginal cost pricing strategies. A major evaluation aim was to assess if the equipment was ready to support these concepts.

Each GPS-based observation depends on the number of satellites within 'sight', the quality of each signal (depending on atmospheric conditions), and the location of the receiving unit. During the trials this caused the following problems:

- *Signals were lost* (no co-ordinate observation) due to too few satellite signals. This happened often in 'street valleys' where buildings shaded the signal, and of course also in tunnels and parking garages, after which a delay was experienced before the unit could find a signal again;
- The *location accuracy* was reduced due to lack of satellites in direct sight of the antenna or atmospheric conditions. This happened far less frequently than total loss of signal;
- *Specific vehicles* had significantly more loss of signal than others. This could be due to the instalment location of the equipment, the construction of the vehicle or other electronically equipment within the car. In the Bristol trial, the placement of the antenna in a flat (horizontal) position was found to be crucial to getting the best performance from the system. Retro-fitting on-board units was generally found to be quite time-intensive and required skilled fitters.

Further work needs to be carried out concerning methodological, software and technical issues. During the demonstration, problems were experienced regarding loss of battery power, bad quality of GPS reception, and loss of signals, particularly at start-up.

The main findings were that:

- *VPS systems based on GPS were shown to work, although improvements are needed*

The VPS systems worked, but further development was felt necessary to overcome the weaknesses found. The VPS technology did not seem mature enough at the time of testing to support full-scale systems in urban areas without more careful design of schemes and some advances in accuracy or compensatory systems (e.g. dead-reckoning).

- *The equipment is not distracting and privacy may not be as significant an issue as anticipated*

A lesson learned from the Gothenburg trial was that the equipment was not distracting to drivers. In addition, the drivers did not feel under surveillance, and the question of privacy was not an important issue. Some of the participants stated that the general 'surveillance' of the public, through mobile telephones or street cameras, is already high, and that an RP system based on GPS is not particularly peculiar. However, in Bristol, the fact that the system was configured for maximum user privacy and could not be used to track driver movements was felt to help with user acceptance.

4.3.4 ANPR – Bristol, Edinburgh, Genoa, and Rome

Automatic Number Plate Recognition (ANPR) is primarily considered an enforcement tool, targeting those who are trying to avoid a charge, or who have forgotten to register/pay (which was its purpose as tested in Bristol). It can be used as a basis for operating a system by acting as the main monitoring system for incoming vehicles, as in the Rome LTZ or as is being considered for the full Edinburgh scheme.

In Edinburgh the analysis of the technology demonstration indicated that an ANPR-based system would be satisfactory for the proposed full double cordon entry permit scheme. The percentage of vehicles whose number plates were correctly read during the main series of tests was consistent with the performance of London's congestion charging system.

The demonstration highlighted three areas in which the ANPR technology could be adapted to further improve the results that were obtained in the main part of the trial:

- Lane straddling was a bigger problem than had been anticipated. This was caused by the fact that fields of view of adjacent cameras do not overlap, thus a vehicle straddling two lanes was likely not to have its number plate wholly within the field of view of either camera. There are two basic solutions: one is to use more cameras in order to have overlapping fields of view – this was successfully demonstrated in a special test – the other is to use higher resolution (digital) cameras with wider fields of view.
- Special tests using both front- and rear-facing cameras indicated a significantly higher success rate than the front-only camera configuration during the major part of the trials.
- A number of vehicles passing the two trial sites were not read because the ANPR software failed to detect the vehicle presence. A significant improvement in successful reads is likely to be achieved if an external triggering device were used. This is often done for camera-based systems, and could be readily implemented using inductive loops.

In Rome, a record was kept of the proportion of time that the system was not working, and this represented 6% of its total operating time. Overall, during the reference period, the reliability of the system was such that 73.6% of licence numbers were identified successfully. Of the remainder, 6.9% were captured by the camera, but could not be identified by the optical character recognition (OCR) system, and 19.5% of data was not useable (e.g. poor-quality images). In Genoa, error rates of around only 7% were reported.

In Bristol, fixed camera systems were tested (as in the other cities) as well as a mobile system that could be transported to different locations by van and operated at the roadside. The focus was to determine ANPR suitability for enforcement purposes, in support of a DSRC or VPS-based scheme. Figure 4.4 shows a sample image record of a trial volunteer's vehicle during the Bristol trial.

For mobile ANPR camera systems it was found that the system could be used to capture very high volumes of number plate data, with contextual images. This was helped by a dedicated and professional operating team. The data collected could be used to check against large databases of valid/invalid vehicle records and generate enforcement reports that provide the evidence for enforcement action if offences have been committed. Mobile cameras generally cover only one lane at a time, so that on dual-lane roads a 50% check is the maximum that can be achieved. Camera systems required adjustment throughout the day to optimise their performance in different lighting conditions. Skilled operatives are therefore required. During the limited test period, the performance of the mobile cameras was good enough to show that use of such cameras would provide a valuable contribution to enforcement of any road pricing scheme in Bristol.

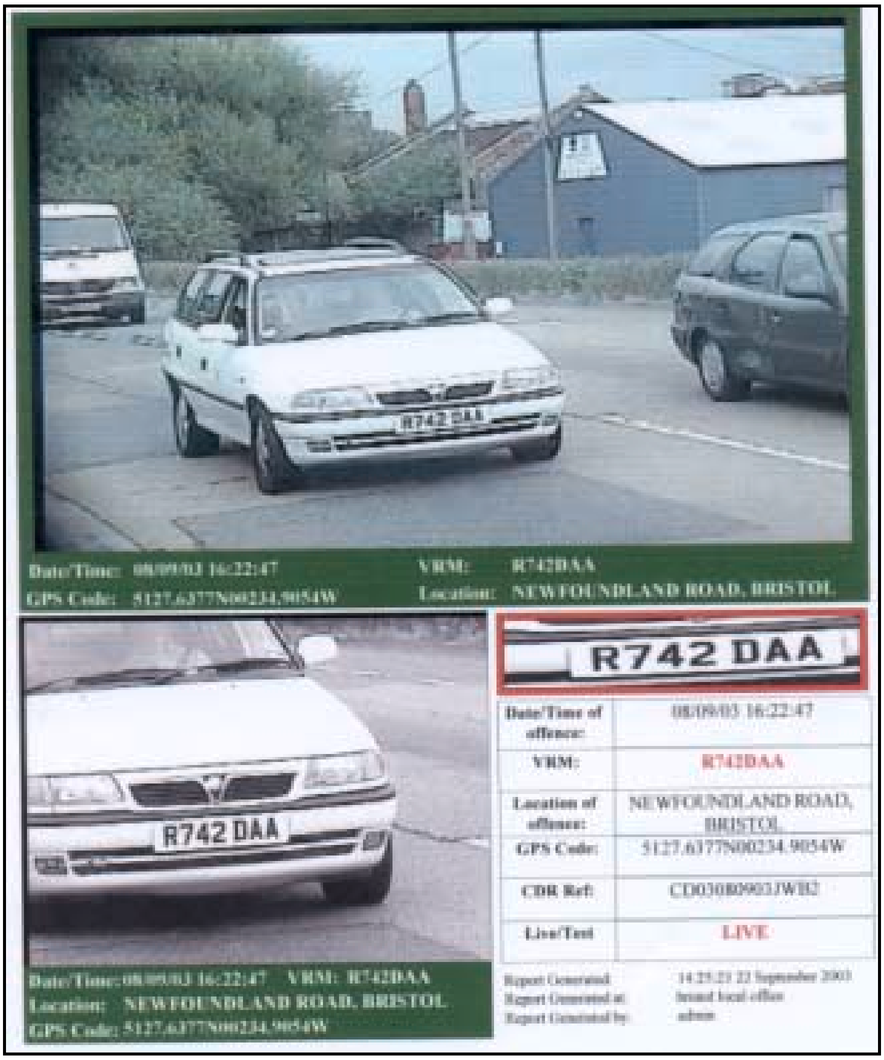


Figure 4.5 An Image Record From the Bristol ANPR trial (BCC vehicle)

The fixed ANPR camera systems worked well for the duration of the trial, with only one small loss of data caused by the ISDN lines failing for a short period. Both text and context image files were produced, and the system passed the site acceptance test (SAT) performance limits and scored well in roadside monitoring tests. Overall, successful image capture and read rates were in the region of 85% to 95%, from a range of tests.

4.4 Charging Scheme Impacts

4.4.1 Introduction

In general, analysis of the preliminary application of the RP schemes tested in PRoGRESS showed reduction of private traffic within the affected area. The application of RP measures already running induced overall benefits in terms of congestion reduction and environmental impacts, while maintaining minimal boundary congestion levels as a side effect.

The integration with the complementary measures in full-scale road pricing schemes demonstrated that road pricing achieves the maximum benefits if combined with complementary measures. This introduction of sustainable mobility measures supports the needs of users affected by the charging measure and promotes the shift from private car to other modes (public transport, walking, cycling).

In cases where a full-scale scheme was not implemented or extended during the lifetime of PRoGRESS, some cities did still work towards its implementation, in many cases by studying the potential impacts to be better informed for public consultation and detailed scheme design. Therefore, modelled results form part of the results of charging scheme impacts that are set out below.

The city sections below tend to focus on traffic impacts. Clearly, there are many other impacts too, and one of the strengths of the PRoGRESS project was that it looked at a wide range of relevant topics necessary for full-scheme introduction. The results from wider impacts or lesson learned are noted in earlier sections of results, and also feature up in the lessons learned, recommendations and conclusions in sections 5 and 6.

Results are presented in the following subsections on a city-by-city basis:

4.4.2 Bristol

Model development

BCC commissioned a study in March 2001 to support the possible introduction of RP as part of its integrated transport strategy for the city. The study undertook a detailed assessment of alternative options for a charging scheme focused on Bristol city centre. It built upon the substantial body of work already undertaken by the Council in recent years to identify the components of an outline RP scheme. The objectives of the study were:

- To define a preferred initial road pricing scheme for Bristol based on an assessment of alternative scheme options;
- To define a preferred package of complementary measures, centred on the RP and LRT (Light Rapid Transit) schemes, that will reinforce the desirable management impacts of the RP scheme and ameliorate undesirable impacts;
- To provide an impact assessment of alternative package options that will constitute a major part of a full NATA (New Approach To Appraisal) assessment and which would be suitable for use within a presentation of alternatives as part of a public consultation exercise.

Scheme assessment

Drawing upon the conclusions of a review of previous studies and the model-based assessment of alternative RP scheme options, the study recommended the charging scheme that should be considered further for implementation should be as follows:

- An electronic cordon charging scheme based on charging vehicles each time they cross the cordon in an inbound (towards the city centre) direction;
- A city centre cordon within the Inner Circuit Road;
- A core charging period that is focused on the morning peak between 7.30am and 10am, with an initial charge level of 1.6 Euros per vehicle per inbound cordon crossing made in the charging period, rising to at least 8 Euros within 10 years of scheme implementation;
- A shoulder charge of 50% of the charge level in the peak period levied in the shoulder-peak time periods 7-7.30am and 10-10.30am, applied when high charges are applied in the core morning peak charge period;
- Exemptions only for public buses, motorcycles, registered disabled vehicles, and emergency service vehicles.

Impact of scheme as tested

The preferred scheme was assessed according to the extent to which it would achieve the scheme objectives described below.

- To reduce congestion and traffic in the city centre.

It was found that the scheme would make a significant impact in reducing congestion levels inside the charging cordon by reducing the amount of traffic entering the city centre – though only in the core morning peak charging period and, when applied, the shoulder-peak charging period. Figure 4.5 shows the amount of traffic projected to be crossing the RP cordon in the inbound direction in the core morning peak period (7.30-10am). The figure compares traffic levels forecast for a with-charging scenario against those forecast for a without-charging scenario (both of which include LRT Line 1 as defined in the Local Transport Plan 2000). Two forecast years are shown: 2007 representing the assumed first year of operation of the scheme with charge levels set at 1.6 Euros per vehicle per cordon crossing; and 2017 representing 10 years of scheme operation with charge levels set at the higher 8 Euros charge. The diagram shows that there is a very significant reduction in traffic crossing the cordon in the core morning peak charging period: 41% compared with the no charge scenario for the 1.6 euros charge in 2007, and a reduction of 64% for the 8 Euros charge by 2017.

The scheme alone would not deliver Bristol City Council's target of reducing traffic in the city centre by 10% by 2005 and 30% by 2015 compared to 1996 levels, since it is concentrated on only the morning peak. Nevertheless, even as a morning peak only scheme, it was estimated that the scheme would contribute significantly to achieving the targets.

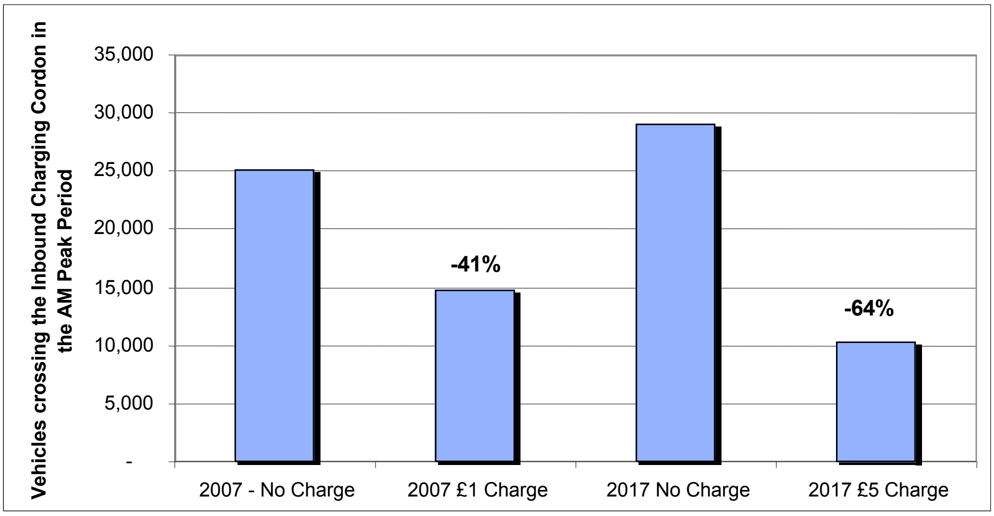


Figure 4.6 Inbound Traffic Crossing the Bristol Cordon – With and Without Charging Scenarios

- To encourage the use of alternative modes to the car and to lessen car dependency, especially at peak periods.

The scheme was forecast to reduce the proportion that car trips form of total trips by motorised modes crossing the cordon in the morning peak period from 55% (existing) to 51% in 2007 with a 1.6 Euros charge and down to 33% in 2017 assuming an 8 Euros charge. It was noted, though, that this masks an increase in park-and-walk trips that still entail the use of car to the edge of the charging cordon.

- To reduce the level of through traffic in the city centre.

In the morning peak charging period, the impact of the charge was predicted to practically eliminate all through traffic (i.e. traffic that has neither origin nor destination inside the charging cordon).

- To seek equity and fairness in the burden of charging.

No evidence was found to indicate that the burden of charging falls unequally on one particular area of Bristol.

- To raise revenue for transport alternatives.

It was found that the scheme would generate a significant revenue stream that could be re-invested in other transport initiatives. It was forecast that the preferred scheme, with a 1.6 Euros charge rising in increments to a 8 Euros charge by 2017 could generate net revenue of around 80m Euros over the 10 year period – the time limit for hypothecation of revenue as allowed under the Transport Act 2000. If the 8 Euros charge was levied immediately upon scheme opening, net revenue of around 176m Euros could be generated.

- National objectives.

An appraisal against the national transport objectives for Economy and Safety, as embodied in the UK New Approach to Appraisal (NATA) was undertaken for the preferred scheme. This comprised an economic evaluation and an accident savings assessment. The economic evaluation indicated that the economic case for the scheme is negative – i.e. the costs of the scheme are greater than the benefits. The scheme does, though, provide a small level of accident savings associated with traffic reduction. The details of the economic evaluation and the impact that it should have on the overall case for the RP scheme as part of a wider strategy will need to be further explored with the national UK Department for Transport.

4.4.3 Copenhagen

Introduction

The overall objective of the project was to gain knowledge concerning how road pricing could be used to change mobility in the Copenhagen area towards a more sustainable pattern. The AKTA trial was not a full-scale implementation, but rather a field test with 500 private cars, which were equipped with on-board road pricing units.

Key results from field experiment

In the trial design, importance was given to making the experience of the test participants as similar as possible to being in a real RP scheme. Therefore a "taximeter" was installed in all test participants cars that continuously showed the calculated cost of driving. The taximeter used GPS to position the car and calculate the current cost of driving (see Figure 4.7).

Figure 4.7 Taximeter in Test Driver's Car

With a total of 500 car drivers driving for an average of 4 months, the data collected can be compared to one car driving for 2,000 months or approximately 160 years.

Different charging schemes

Three different charging schemes were tested, along with a reference case with no charging. The three charging schemes were all multi-zonal. Two were based on a charge per kilometre, but with different charges in each zone. The third charging scheme, zonal charges, charged only when zonal borders (cordons) were crossed with the highest cost of border crossing close to the centre of the city. The expensive km-charge scheme and the zonal charging scheme were twice as expensive in the rush hours (7-9am and 3-6pm) as in the rest of the day. The low km-charge scheme applied only in the rush hours (at a level similar to the off peak charge in the high km-charge scheme).

Validation of the trial

All drivers tested two charging systems or one charging system and a reference system. With the purpose of checking the saving strategies of the drivers, a large number (352) were called by telephone. This revealed that 12% had clearly misunderstood the trial and were following strategies that would increase their costs. 49% were not trying to save money at all, probably because they felt that they could not change their driving pattern. The telephone interview showed that many test participants testing two charge systems, and therefore having no reference system, were confused about how they should save money, while test participants testing a charging system and a reference system in general seemed to have understood the trial. Of those testing a reference system, 59% were not trying to save money, 26% were trying to save money, and 15% were following other strategies.

Results of the trial

The trendlines in Figure 4.8 shows clearly that the high km-charge led the trial participants to reduce their driving. In all three rounds, the average driving is significantly lower when charging is applied compared with the reference system, where no charge is applied. The reasons for the much larger savings in the third round compared with the previous rounds is the fact that the trial participants in the third round were paid cash after the reference period, and they had to pay that money back after the end of the trial. In the first and second round, the trial participants were only paid the difference at the end of the trial. Clearly the timing of the payment has significant influence on the outcome of the trial.

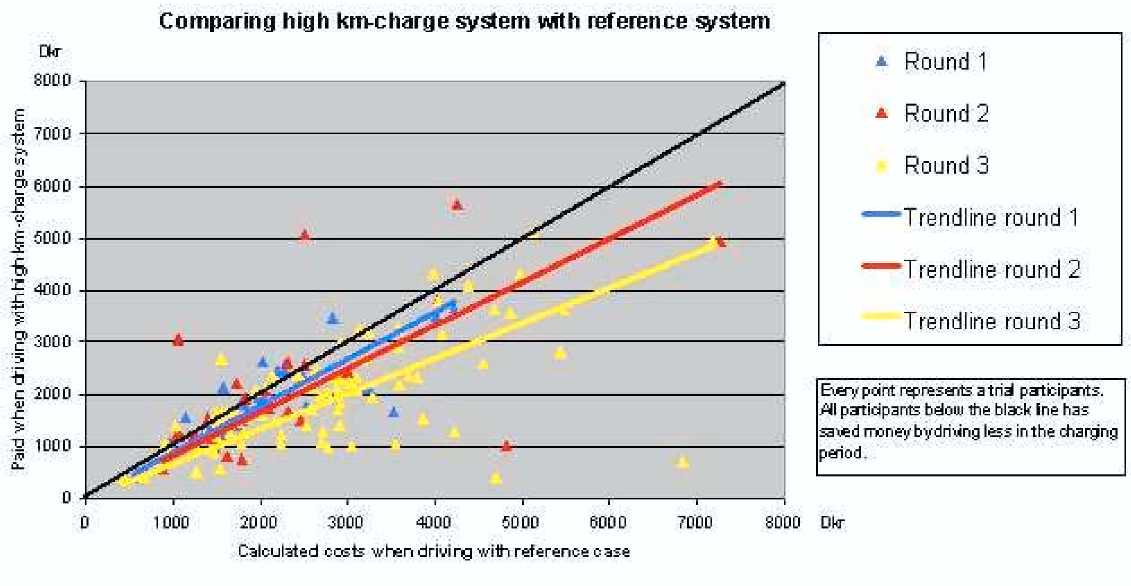


Figure 4.8 Comparison of Pricing Systems

<u>Impact of charging schemes</u>

The Copenhagen trial demonstrated that road user charging *does* affect behaviour; it is not considered as another fixed cost, but as a marginal cost that drivers respond to. But the pricing level needs to be high if road users are to change behaviour, (0.13-0.67 Euros/km in the peak hours and half price in non-peak hours).

Hence the *high km-based* pricing level clearly made an impression on the participants. Even if they could not change behaviour, they had examined alternative travel options before rejecting these. The *low km-based* pricing level was in general not sufficiently high to change behaviour, although a few participants made some minor changes when it was easy. The km-based schemes were in general considered to be more fair than the *cordon-based*.

About 50% of the test drivers in some way changed behaviour, and the main changes were concentrated on:

- Choice of different (cheaper) route – mostly for *non-commuting* trips;
- Increased use of kiss-and-ride facilities (more passengers in the test cars);
- Changes in destination and time of day for *non-commuting* trips.

But log data as well as survey data showed very few changes regarding:

- Cancelling of trips;
- Mode choice;
- Commuting;
- Shifting from peak to non-peak hours.

Overall, commuting seemed to be difficult to change, and there was some inertia in changing route as well as time for the trip.

Finally, it was obvious that the participants had little understanding of the real cost – marginal or average – of car driving. The SP interviews stated that the value of road pricing is higher than the value of marginal driving cost (fuel mainly). The road pricing trials on the other hand showed that the participants changed behaviour slightly more (i.e. a lower VoT) than expected assuming that the values of money were equal. It must be concluded that respondents tend to underestimate their behavioural changes due to road user charging in the SP-experiment compared to the field experiment, where real money is involved.

Attitudes towards GPS-based road pricing

The participants' and interviewed persons' attitudes to variable road pricing were less emotional than expected (especially considering the debate in the Danish press). This is an interesting finding that has also been found in previous Danish studies of RP. Most participants did not consider surveillance as a problem (that the cars can be tracked by the logged co-ordinates). The possibility to control speed violations was not considered important. The greatest fear of road users seemed to be that the government will turn road pricing into a hidden tax, and that the revenue will be used for anything else but to improve traffic conditions. It was also felt that revenue should be used for improving public transport (better coverage and lower fares) and to improve traffic safety.

Change in attitudes to road pricing during the trial

Before the trial 69% of the trial participants found road pricing to be a good principle, while 15% found it to be a bad principle. During the trial, 28% changed to a more negative view, while 14% changed to a more positive view. The surprising conclusion is that the trial has had a negative effect on the view on road pricing, which is the opposite of the effect seen when implementing road pricing in Norway and London.

More results to come

The evaluation of the Danish trial data is still on-going. As all positions of the trial participants were measured second-by-second, a large database of locations is being analysed. All locations are map-matched to give precise data about which roads are used. When the map-matched data are ready, the analysis and modelling phase will start giving much more information about the effect of road pricing in Copenhagen.

Key findings

The Danish programme demonstrated that it is possible to develop a road pricing system which charges a kilometre rate based on time, place and distance driven. It also demonstrated that RP to some extent affected the driving pattern of the test drivers. The GPS-based system was widely understood and accepted, and a large proportion of road users in Denmark found variable taxes on car driving more acceptable than the fixed ones. However, payment, security and control functions were not considered at a level of detail that showed that such a scheme is practical. The technical design of these systems was not contained in the programme. As these functions are vital to the feasibility of a road pricing system, there is a need for further technical development.

4.4.4 Edinburgh

Introduction

The work in Edinburgh was divided between development of the full scheme, including modelling and assessment of impacts, and gathering views on various demonstration/ trial elements, which will in turn also inform the development of the main scheme. The section below highlights some of the key results which are pertinent to overall charging scheme impacts in the city.

Modelled impacts of the full scheme

The package of public transport improvements, which form part of the 'preferred option' for implementing an integrated programme of demand management in Edinburgh, would result in an overall increase in public transport (PT) capacity of 52%. One large contributor to this figure is the new tram network that would be built and that would provide 9% of the overall capacity. The bus network would increase by 30% and the train network would nearly double. The number of PT passengers moving into the charged area is predicted to increase by over 50% in 2011 and 67% in 2026. Since the number of cars moving into the area would only go down by 28% in 2011 and 18% in 2026, this would indicate a very large net increase in the number of people accessing the area.

The increase in PT passenger and the decrease in car traffic into the charged area is part of a pattern of modal shift. The figures for this were much lower then those in the previous section, since they reflect changes in the whole Edinburgh 'travel to work' area, but still significant: car trips would fall by 5.5% for 2011 and by 8.2% for 2026, bus trips would rise by 7.5% and 16.4% respectively, cycling and walking would fall slightly in 2011, but changes would be close to zero again in 2026. Trips by 'other PT', however, would rise by a massive 220% for 2011 and 260% for 2026, which is in nearly equal parts due to a significant increase in rail trips and the implementation of the trams.

Concerning trip destinations, there would be an overall small shift in the order of 1.5% and in the long run of 3.7%, but no detailed analysis of which destinations will gain and lose was made. Trip suppression is not expected to take place. Two linked cordons are planned - an inner and an outer cordon. Some re-routing is expected from people who try to avoid the inner charge cordon – orbital movements between the cordons are expected to rise initially by 8% in 2011 and then reduce to 6% in 2026.

Trip distribution over the day is expected to change, but somewhat surprisingly not through traffic spreading outside charging hours. The biggest overall traffic increases are expected between 8.00 and 9.00 and between 17.00 and 18.00, i.e. charging will result in peak concentration. This holds true for both 2011 and even more so for 2026 predictions. When car traffic and public transport were analysed separately, it became evident, however, that these increases arise entirely from public transport.

An analysis of changes by trip purpose showed that commuter trips would be initially very slightly reduced by 0.6%, but pick up again in the long run and increase by 6%. Shopping trips were predicted to increase by 2.3% in 2011 and further by 4.1 % in 2026.

Overall effect on traffic flows

The large shift from car to public transport would lead to significant improvements in traffic flow, as shown in Table 4.4. Average vehicle speeds were predicted to increase significantly, and particularly so in the city centre with improvements approaching the 20% mark. The effect of the charging scheme on congestion was predicted to be even more dramatic with a reduction of 32% both in the medium and long term.

Table 4.4 Changes in Vehicle Speed and Congestion

	2011			2026		
	Reference case	Preferred Option	Difference	Reference case	Preferred Option	Difference
Average vehicle speed (km/h)						
City centre	21.4	25.1	+ 17 %	19.3	23.0	+ 19 %
Around city centre	27.9	27.6	- 1 %	25.0	27.1	+ 8 %
Outskirts and wider area	46.7	49.4	+ 6%	41.3	47.5	+ 15 %
Time lost in congestion (veh*h)						
Overall network	31,284	21,236	-32 %	63,150	42,868	- 32%

The modelling exercise carried out with Edinburgh's LUTI model showed a reduction of pollution through the 'preferred option' for all emission indicators, as shown in Table 4.5.

Table 4.5 Changes in Emissions

	2011	2026
CO_2	- 4.2 %	- 4.7 %
CO	- 6.8 %	- 7.6 %
NO_x	- 0.3 %	- 0.4 %
PM_{10}	- 2.3 %	- 2.7 %
Hydrocarbon	- 5.8 %	- 6.8 %

Behavioural and economic (retail) impacts

Impacts on shopper behaviour and economic impacts were calculated, based on survey results and an economic model of the area.

There are concerns among retailers about the ability of Edinburgh city centre to compete against other towns and cities (particularly Glasgow), and out-of-town shopping centres. These concerns have been exacerbated by the congestion charge proposals.

The views of the general public towards shopping in the city centre were assessed in a consultation exercise. City residents and non-residents were asked for their opinion on the quality of the pedestrian environment, and the range and quality of the shops. The majority of respondents from both samples selected either fairly good or average to describe their opinion of the pedestrian environment quality.

It was felt that the modelling results should help to assuage retailers' fears about the possible negative impact of the charging scheme for their businesses. The model predicted a 0.4% increase in consumer spend within the city for 2011 and a 1.2% increase for 2026 for the 'preferred option' compared with the 'business as usual' case.

Furthermore, the number of people accessing the city centre would, according to the model, increase by 5.1% in 2011 and 11.4% in 2026 through the combined effects of the 'preferred option'.

Both of the above indicators suggest that any loss in retailers' revenue through car drivers staying away from the city would be more than outweighed through additional revenue from those attracted by the improved public transport connections.

The costs of leases inside the inner cordon are initially expected to go down for all sectors: marginally by around 2% for retail and offices and substantially by 19% for industrial sites. In the longer run, lease prices will pick up again, with a long-term forecast of a remaining small decrease of 0.9% for retail, but an increase of 3.7% for offices. Only for industrial sites, the city centre will remain less attractive (-14%) under the preferred option for the foreseeable future, but in the light of the overall objectives of city development, this was not seen as a negative outcome.

4.4.5 Genoa

Introduction

The basic method adopted to evaluate feasibility and design possible road pricing (RP) schemes in Genoa was to design a multi-modal model of the city (M1) and use it to test some basic scenarios. During the demonstration phase, two kinds of information were collected:

- The present traffic volume entering the charging area;
- The level of trip reduction due applying a RP fee, based on a volunteer sample.

Volunteer users

A sample size of at least 150 volunteers, acting for a 6-month trial (6 days a week, total 150 days), was calculated as statistically sufficient to obtain results suitable for the full-size scheme design, with acceptable errors (less than 15%).

Each volunteer was assigned an equal budget of 200 Euros that approximately corresponded to the mean amount they would have spent if charged entering the demonstration charged area (DA) 'as usual' for the 6-month demonstration period (3 months at 2 Euros and 3 months at 1 Euro fee). Since the value of the fee the user perceives is higher when it constitutes a cost (as in the real case) than in the demonstration case (where it represents a missing income), it was estimated that these fees should correspond approximately to a real fee between 0.5 and 1 Euro.

The benefit of the planned complementary measures (public transport facilities) was simulated in the demonstration by providing the volunteer with a card that allowed them free use of particular bus lines connecting external areas and park and ride locations (at the cordon) with charging area inner locations.

Impacts of the demonstration on travel behaviour

In Figure 4.9, the volunteers are grouped according to their behaviour during the demonstration in terms of the reduction in number of trips per week. Most of the sample reduced the number of entries to the charged area by car by more than 50%.

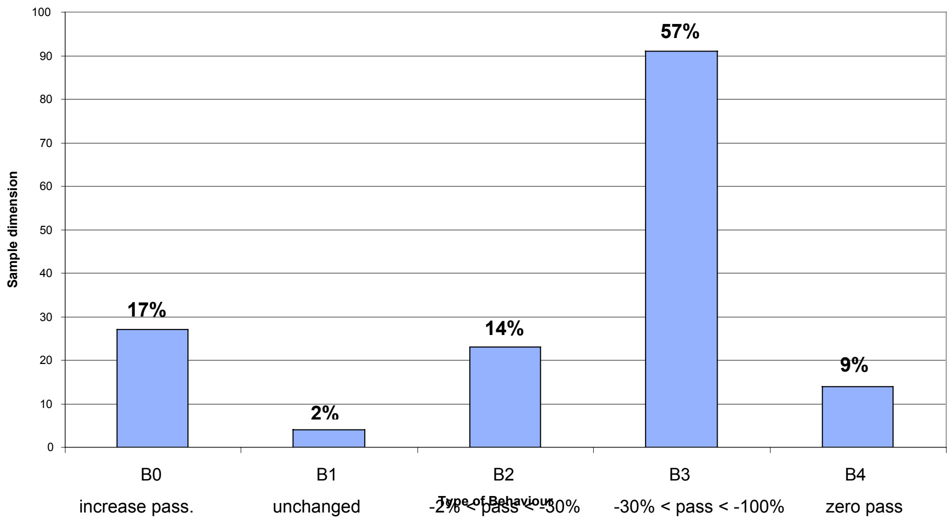


Figure 4.9 Grouping of Volunteer Users According to Their Behaviour With Road Pricing

To provide a breakdown of these results, Tables 4.6 and 4.7 present the computed values from the behaviour of a 159 volunteer sample and a 125 volunteer sample respectively. In the first part of table, the demonstration outcomes are summarised and for the second part of the table the estimated impact of expanding to a full road pricing scheme is shown. Mean data is presented in both cases for:

- REF passages - reference (REF) trips, without road user charging
- RUC passages – number of trips under road user charging
- Mean ERF_vu - Entrance Reduction Factor in the demonstration charged area, under road user charging
- Number of VUs reducing passages – number of volunteer users reducing their trips
- Number of passages per VU reducing passage - number of trips per volunteer user that reduced trips
- DA – demonstration charged area

Table 4.6 Statistical Results of Demonstration: 125 Sample

m¤/yearly		DESIGN PHASE	DEMO March-May	DEMO June-July	DEMO March-July
Demo					
Sample dimension (VUs)	number	*200*	125	125	125
REF passages x VU	pass/month	*21,4*	19,66	18,09	19,1
RP passage reduction due to fee	%	*-50%*	-29%	-36%	-32%
Average RP entrances DA x VU (all VUs)	pass/month	*10,7*	13,97	11,58	13,00
Number of VUs reducing REF passages	number	*200*	101	98	102
Average RP passages x VU reducing pass	pass/month	*10,7*	11,72	8,27	11,16
Full scheme "upgrade"					
Real scheme entrances in DA	7:00 - 20:00	*43500*	46900	45500	46300
Car entrances in DA	%	65%	59%	55%	57%
Motorbike entrances in DA	%	35%	41%	46%	43%
Car exemptions	%	*30%*	30%	30%	30%
Charged passages	7:00 - 20:00	*9900*	13800	11100	12600
Entrances reduction	7:00 - 20:00	*9900*	5600	6200	5900
Vehicle reduction in DA	%	*22,8%*	11,9%	13,6%	12,7%
Private car reduction in DA	%	*35%*	20%	25%	22%
Total expected revenues (280 days charged)		*2,772*	3,864	3,108	3,528

These impacts were calculated with respect to the two time periods (a demonstration from March to May and then from June to July) and for the total five-month period.

The most reliable results can be considered the ones averaged over the five-month demonstration period, shown in the final column of the two tables. From these it was concluded that the mean reduction of entrances (ERF_vu) due to application of a road user charging fee of 0.5-1 Euros (real money equivalent) varies between -32% and -44%, with a mean value of -38%.

In the second parts of Tables 4.6 and 4.7, the results of the demonstration were expanded to cover a full-scale charging scheme scenario, where a proportion of non-exempt private cars are charged. The volumes of cars and motorbikes entering the charged area for this exercise were recorded by the same video technology used for ANPR. In the expansion exercise, motorbikes were assumed to be free of charge and 30% of cars were exempt.

Table 4.7 Statistical Results of Demonstration: 159 Sample

m¤/yearly		DESIGN PHASE	DEMO March-May	DEMO June-July	DEMO March-July
Demo					
Sample dimension (VUs)	number	*200*	159	159	159
REF passages x VU	pass/month	*21,4*	19,9	18,2	19,1
RP passage reduction due to fee charged	%	*-50%*	-42%	-48%	-44%
Average RP entrances DA x VU (all VUs)	pass/month	*10,7*	11,56	9,47	10,71
Number of VUs reducing REF passages	number	*200*	134	132	135
Average RP passages x VU reducing pass	pass/month	*10,7*	9,32	6,57	8,84
Full scheme "upgrade"					
Real scheme entrances in DA	7:00 - 20:00	*43500*	46900	45500	46300
Car entrances in DA	%	65%	59%	55%	57%
Motorbike entrances in DA	%	35%	41%	46%	43%
Car exemptions	%	*30%*	30%	30%	30%
Charged passages	7:00 - 20:00	*9900*	11200	9000	10400
Entrances reduction	7:00 - 20:00	*9900*	8100	8300	8200
Vehicle reduction in DA	%	*-22,8%*	-17,3%	-18,2%	-17,7%
Private car reduction in DA	%	*-35%*	-29%	-33%	-31%
Total expected revenues (280 days at 1 euro)		*2,772*	*3,136*	*2,520*	*2,912*

The result of increasing the size of scheme was that the expected vehicle reduction in the full road pricing area would be between -12% and -19%. Modelling (simulation) of the full-size charging scenario was undertaken across the whole network, which confirmed the values of the ‘upgrade’ of demonstration outcomes shown in Tables 4.6 and 4.7.

The simulation also allowed an examination of what happens to travel levels overall. The main result was that inside the road pricing area there would be less congestion and shorter journeys. With respect to diversionary affects outside the road pricing area, some main streets were predicted to experience an increase of displaced traffic. The maximum level of increase from diverting traffic was predicted to be +53% in via Fiume to Brignole and the increase in the top 15 streets with increased traffic was +17%. However, the impacts averaged across the entire cordon area were not so significant and would not induce serious congestion.

<u>Congestion and environmental impacts</u>
Impact indicators were calculated for two parts of the Genoa network: - RPA (the road pricing area inside the cordon) and COR (area just outside the cordon). Table 4.8 presents the main results.

Table 4.8 Impacts on Road Pricing Area and Cordon – M2 and RP1 Situations

Impact Indicator		No pricing - M2		Road pricing - RP1			
		RPA	Cordon	RPA	var %	Cordon	var %
^{2})	veic/Km^2	267	450	201	-25%	453	1%
CO Emission Density	g/(s*Km^2)	18,85	35,51	16,51	-12%	35,62	0%
NO_x Emission Density	g/(s*Km^2)	0,71	1,41	0,57	-20%	1,42	1%
Energy Emission Density	kJ/(s*Km^2)	3621	6847	2906	-20%	6889	1%
Mean Velocity	Km/h	17,36	19,07	18,49	6%	18,97	-1%

4.4.6 Gothenburg

<u>Introduction</u>
The field trial conducted within the framework of PRoGRESS in Gothenburg was carried out in a real traffic situation and included the development of prototypes and control strategies. The aim of the evaluation was mainly to find out if the tested charging schemes could influence the traffic situation in such a way that they met the objective to reduce congestion levels and to improve the local environment. The evaluation plan focused on three areas of possible impact:

- What does the user think?
- How well can technology be integrated with the driver?
- What are the effects of road pricing on traffic?

Discussions and considerations in the first phase of PRoGRESS led to the conclusion that two scenarios should be tested. These each had a different focus.

The first was a congestion-based scenario (called Congestion Charging). This was aimed at reducing congestion on the main approach roads and in the city centre. It was designed as a distance-based charging scheme with two different zones and charges levied only during the morning peak from 7.30 to 8.30 am.

The second scenario tested (called Environmental Pricing) focused more on improving the local environment in Gothenburg. Three zones were defined where the charging was designed as a distance-based charge for 24 hours a day and seven days a week, in contrast to the limited charging time period in the Congestion Charging scenario.

An overview of the field trial results in Gothenburg is given below.

<u>Impacts on travel behaviour</u>
The reported behavioural changes of the test drivers (in trip diaries) is summarised below.

In the 'environmental' scenario, the journeys by car decreased by almost 10% per day, foremost the long journeys. The total journeys were not affected but those drivers who reduced their number of journeys as a driver mainly chose to travel instead by bicycle or as a passenger. Particularly with regard to journeys made in connection with work, there was a large move from cars to other means of transport.

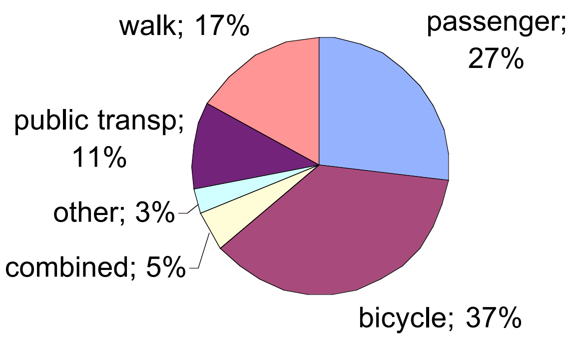


Figure 4.10 Gothenburg Field Trial Results from the Environmental Scenario (reported behavioural changes for motorists switching from driving car to other transport modes)

In the 'congestion' scenario, where charging was imposed during the rush hour instead of during the whole day and night, there was a reduction in car traffic during the rush hour. Charging during the morning rush hour decreased the volume of traffic by about 15%, because many drivers avoided the charges by traveling at a different time.

From attitudinal work done during the demonstration it was found that:

- Opinions stayed approximately the same, but a tendency towards seeing road user charging as negative became slightly less negative and positive attitudes become more positive after trial participation;

- Congestion charging was preferred over environmental pricing;
- Road user charging revenues should be definitely be returned to the traffic system (hypothecation) in order to maximise acceptability and minimise opposition to a scheme.

Traffic impacts

Naturally, the design of the charging scheme is of utmost importance for the efficiency of the traffic system. Figure 4.11 shows the predicted (modelled) impacts of the two road pricing scenarios tested on different areas of the city. In Figure 4.10, CBA is the central business area of Gothenburg and GUA is the Gothenburg urban area.

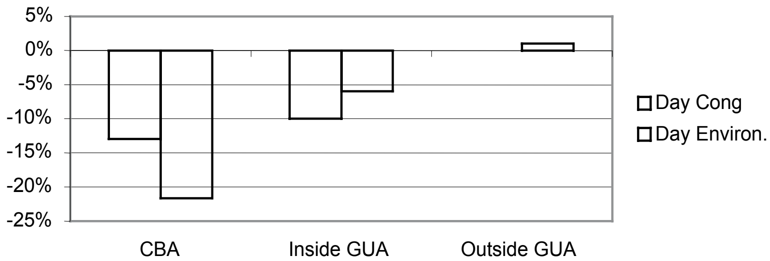


Figure 4.11 Predicted Change in Daily Vehicle Mileage

With the congestion charging scenario (during the AM peak hour) traffic was calculated to decrease within the charged area by 9%, (in veh.km/day) and within the central zone by 13%, compared to a non-charging scenario in the year 2010. In the whole region (GUA), the traffic was reduced by 6%. The corresponding figures for the environmental charging scenario (charges during the whole day) show that car traffic within the GUA would be reduced by 6% and in the central zone by 22%.

Comparing the two types of charging scenario

It was found that the environmental charges reduced traffic levels, but did not reduce congestion to the same extent as the congestion charges. The main reason for this was that the environmental charges did not steer traffic away from the bottlenecks in the road network as efficiently as the congestion charges did.

Transitional charges both on roads close to charged roads and in time periods adjacent to the charged periods were found to be necessary in order to avoid counter impacts. This has been covered in other schemes by looking at 'shoulder charges' to smooth the transition from charged to uncharged periods.

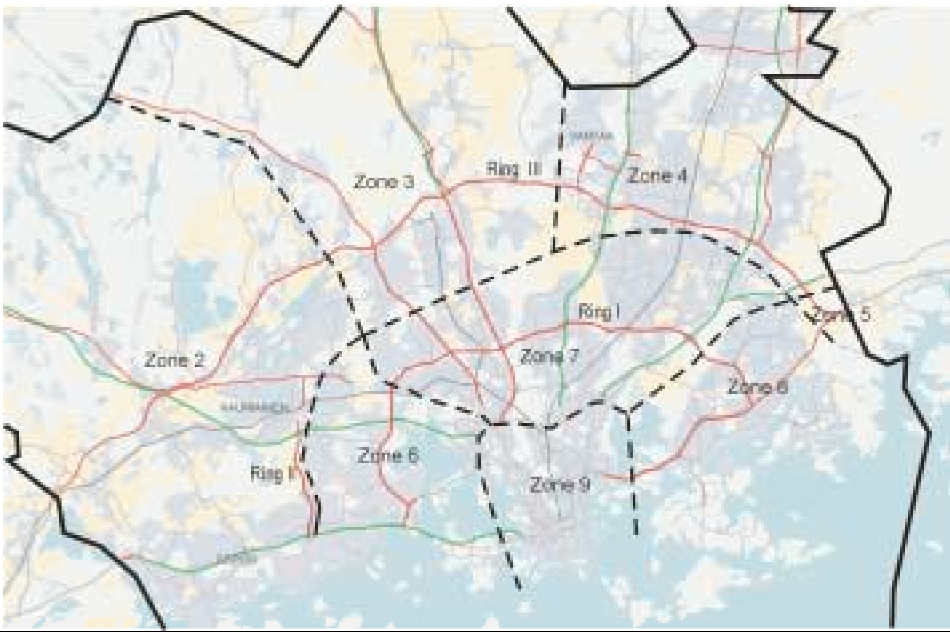
An important observation (and conclusion) from the model simulations, bearing the chosen charging designs in mind, was that congestion in the year 2010 would be considerably greater than today despite the charges. The introduction of road pricing as tested in the demonstration would principally compensate for the traffic increase due to economic growth, but would not bring the traffic to lower levels than today. Additional measures would therefore be needed.

4.4.7 Helsinki

Introduction

The Helsinki Metropolitan Area road pricing scheme as developed and tested in PRoGRESS covered the whole region. One of the project objectives was to test how trip-based and distance-based charging schemes differed from each other regarding the impacts on road network. This resulted in a definition of a rather dense trip-based zoning system (see Figure 4.11) as well as radial borders aiming to simulate the distance-based scheme.

Figure 4.12 Road Pricing Schemes Tested in the Helsinki Metropolitan Area

		
Principles	B0: Passage-based payment on zone borders B11: Parking cost – 35% B12: Parking cost –70% B21: Public transport costs +50% B22: Public transport costs –50% B23: Headway decreases by 33%	C0: Distance-based payment at zones C11: Parking cost – 35% C12: Parking cost –70% C21: Public transport costs +50% C22: Public transport costs –50% C23: Headway decreases by 33%
Road pricing tariffs	1.7 / 1.7 euro/passage (inner / outer border) 0.85 euro/passage for diagonal links	0.1 / 0.07 / 0.03 euro/km (inner / middle / outer border)
Charging	All users pay. Morning peak: 6–9am	
Present PT and parking fees in B0 and C0	1.5 euro/trip within city limits and 2.5 euro/trip within HMA. On street parking/3 tariff zones (2, 1, and 0.5 euro/h) between 8am and 5pm on weekdays and between 9am and 3pm on Saturdays. P+R: free parking	

The two main alternatives (distance-based and trip-based charging) were studied further in terms of impacts by complementary measures relating to public transport and parking fees and supply.

Behavioural and traffic impacts

The main results of the Helsinki study are shown Tables 4.9 and 4.10.

Table 4.9 Predicted Impacts of the Trip-Based Charging Scheme in Helsinki (over the whole area affected)

		Trip-based charging					
Parameter	**Unit**	**B0**	**B11**	**B12**	**B21**	**B22**	**B31**
Modal split: Private transport users	%	-7%	-4%	0%	2%	-18%	-11%
Modal split: Public transport users	%	11%	5%	0%	-3%	24%	14%
Modal split: P&R users	%	0%	0%	0%	0%	13%	13%
Generalised mean travel cost - Private transport	Euro/km	8%	6%	6%	10%	4%	6%
Generalised mean travel cost - Public transport	Euro/km	-2%	-2%	-3%	8%	-12%	-5%
Generalised mean travel cost - P&R transport	Euro/km	-2%	-2%	-2%	6%	-9%	-4%
Monetary mean travel cost - Private transport	Euro/km	12%	12%	8%	15%	8%	12%
Monetary mean travel cost - Public transport	Euro/km	0%	0%	0%	50%	-50%	0%
Monetary mean travel cost - P&R transport	Euro/km	0%	-6%	-6%	19%	-31%	0%

Table 4.10 Predicted Impacts of the Distance-Based Charging Scheme in Helsinki (over the whole area affected)

		Distance-based charging					
Parameter	**Unit**	**C0**	**C11**	**C12**	**C21**	**C22**	**C31**
Modal split: Private transport users	%	-7%	-4%	0%	2%	-18%	-11%
Modal split: Public transport users	%	11%	5%	0%	-3%	24%	14%
Modal split: P&R users	%	0%	0%	0%	0%	13%	13%
Generalised mean travel cost - Private transport	Euro/km	10%	8%	6%	12%	6%	8%
Generalised mean travel cost - Public transport	Euro/km	-2%	-2%	-2%	10%	-12%	-5%
Generalised mean travel cost - P&R transport	Euro/km	0%	0%	0%	6%	-9%	-4%
Monetary mean travel cost - Private transport	Euro/km	15%	12%	8%	19%	15%	15%
Monetary mean travel cost - Public transport	Euro/km	0%	0%	0%	50%	-50%	0%
Monetary mean travel cost - P&R transport	Euro/km	0%	0%	0%	25%	-25%	0%

Energy and environmental impacts

In the Helsinki model, fuel usage was calculated as a measure of energy consumption density. The results are presented at zonal level in Table 4.11.

Table 4.11 Change in Energy Consumption

Parameter	Area	B0	B11	B12	B21	B22	B31	C0	C11	C12	C21	C22	C31
Energy consumption density (kJ/[s*km^2])	Global	-7 %	-5 %	-3 %	0	-17 %	-10 %	-7 %	-5 %	-2 %	1 %	-17 %	-10 %
	Outer zones 2-5	-8 %	-7 %	-7 %	-3 %	-13 %	-10 %	1 %	1 %	2 %	6 %	-5 %	-1 %
	Middle zones 6-8	-7 %	-5 %	-3 %	2 %	-18 %	-11 %	-10 %	-8 %	-6 %	-1 %	-21 %	-14 %
	Innermost zone 9	-16 %	-9 %	0	-4 %	-31 %	-21 %	-13 %	-6 %	4 %	-1 %	-28 %	-18 %

It can be seen that the impacts would be highest in the most heavily congested areas in the city centre and in the vicinity of the congested diagonal routes Ring I, Ring II and Hakamäentie. The Lahdenväylä are, approached from northeast is also very congested at times. The results show that the trip-based charging scenario would reduce energy consumption especially in the central areas (densely populated areas). Distance-based charging would be more effective than trip-based charging in cutting down the energy consumption in the middle zones, but would cause increases at the outer zones.

Overall observations

For traffic impacts, the modelling results indicated that the trip-based and distance-based charge scenarios would not differ very much from each other at the global level. However, the distribution of impacts at the local level would differ – sometimes significantly. All trip-based charging scenarios would increase the traffic flows on Ring Road I. All distance-based scenarios would reduce the flows on Ring Road I and Highway 3.

Combining RP with measures such as parking charges seemed to function in a linear way (at least in the models). A reduction of parking cost compensated for the reduction of traffic by road pricing.

The effect of the public transport fare level was also tested. A reduction of public transport fares by 50% would cause a significant change of the modal split. The reduction in private car usage would be of some 10% magnitude. Raising the fare by 50% would have only a minor effect on the modal split. The elasticity seems to be higher for a reduction of the price than for raising the price. It should however be noted that the public transport supply description used in the model is not a very detailed one, which may have an effect on this.

The effect of public transport headway improvement was also tested. An assumption of headway improvement of some 33% was used, and this would cause a transfer of some 6% of trips, to the benefit of public transport. This accounts for about 60% of the change found if the public transport fares were halved.

For energy use impacts it was concluded that the distance- and trip-based scenarios do not differ significantly from each other at the global level. Locally the results show that the passage-based charging scenarios reduce the energy consumption particularly in the central (densely populated) areas. Traffic starts to avoid higher priced zones and energy consumption is distributed more evenly throughout the whole area. The distance-based scenarios are more effective in the middle zones but cause some adverse effects on the outer zones.

4.4.8 Rome

In this section results are provided which highlight the key findings of the full-scale road pricing demonstration case in Rome where road pricing was introduced as an enhanced access possibility within an existing Access Control System (ACS). Results are clustered in two main categories: users' perception and acceptance of the real system, and impacts of the system on people's transport habits.

User perception and acceptance

The majority of residents and shop owners perceive the ACS as a good idea. In the 2000 and 2003 surveys the acceptance of the system was around 87% for residents and 75% for shop owners (with a 5% increase over the 2000 survey results).

The implementation of a full-scale road pricing policy (a development of the ACS) had a higher acceptance among retailers compared with residents. Different trends emerged from comparison of before and after scenarios. There was a reduction in the percentage of residents favourable to road pricing, from 56% to 49%, while there was an increase in support by shop owners, from 56% to 62%. This trend can be related to the fact that retailers feel that the original ACS had a negative impact on their economics because it limited the number of people moving into the city centre for shopping. Thus, the main differences in the perception of the system are probably related to the different expectations of the two considered target groups: residents prefer a more non-congested city centre, while shop owners are more interested in a more accessible area.

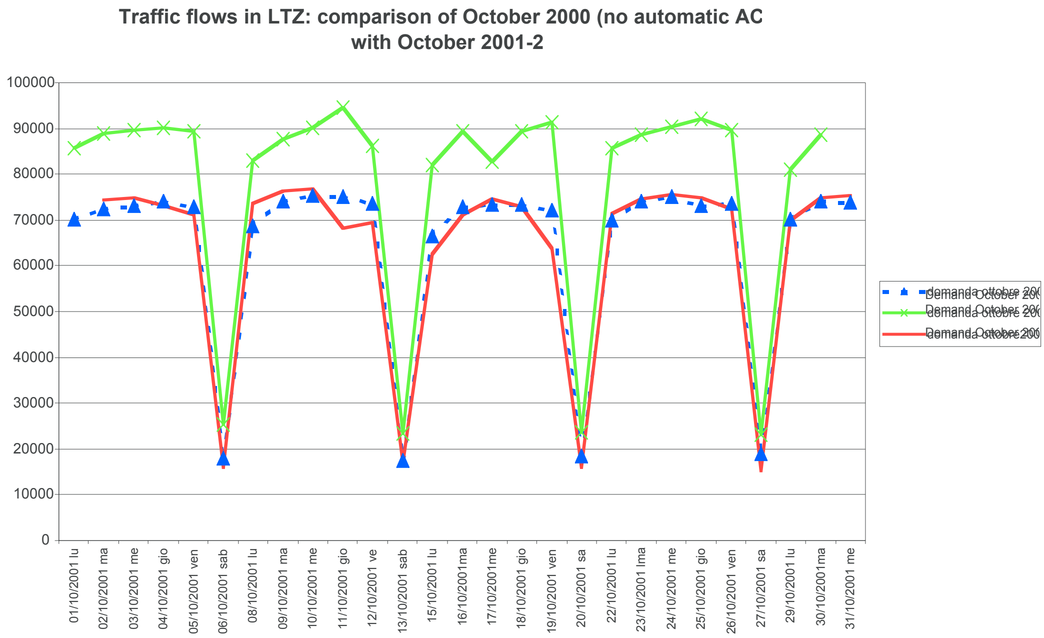
Almost all respondents perceive the system as reliable, and stated that they faced no difficulties in collecting information on the system. Another important finding of the project is that around 80% of residents and 70% of shop owners feel that the system does not intrude into their lives. This is an interesting result because the implementation of the system was delayed by national authorities concerned that such systems would violate citizens' privacy. From a technical point of view, this problem has been overcome by setting up the system so that the only image taken of an unauthorised vehicle accessing the gate is of the rear number plate while the rest of the picture is darkened.

Impacts on travel behaviour

The analysis of respondents' travel habits highlights that the system generates a change in transport behaviour of both residents and shop owners. The former make fewer, and more rational, use of private vehicles, preferring to use public transport for a range of trip purposes (study, business, and shopping). As a consequence of the electronic gates, shop owners also usually prefer to access the zone by public transport, although private transport remains the preferred mode for many businesses.

In conclusion, despite differences among residents and retailers due to their different expectations, the system is accepted and has been able to generate a partial modal split from private transport modes to public transport. Main observations of the implementation of the system are a 10% decrease in traffic during the day that becomes a 20% decrease in the restriction period, 15% decrease in the morning peak hour (8.30-9.30), 10% increase of 2-wheelers (access) and a 6% increase in public transport.

Figure 4.13 Access in the LTZ ex-ante and ex-post ACS+RP activation

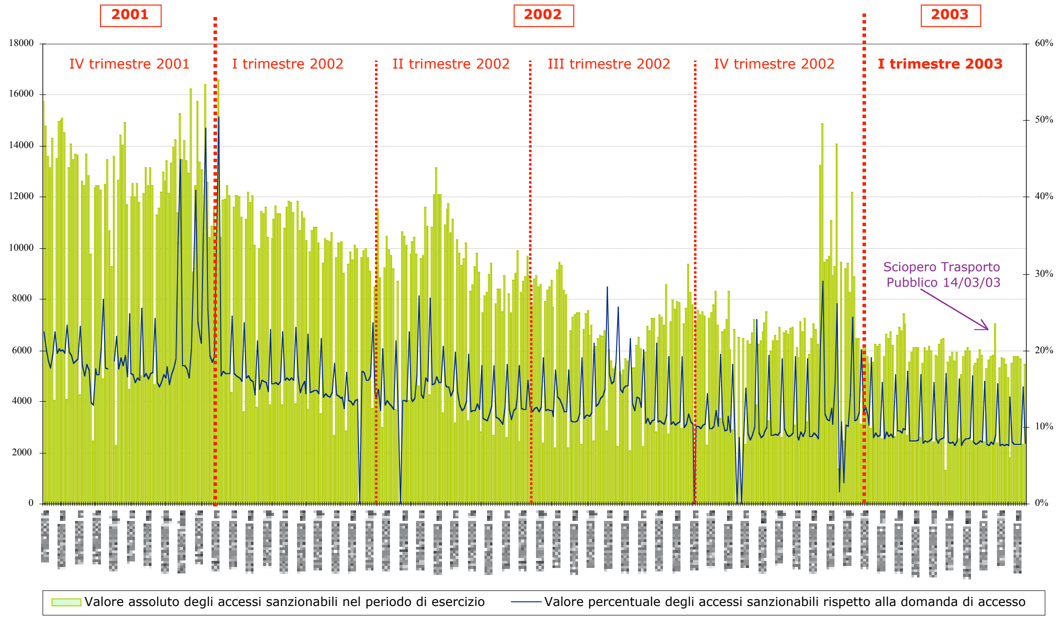


The morning peak phenomenon is lower than in the past, while the evening one is the highest of the day and slightly higher than before the activation of the gates. The decrease can be completely attributed to the activation of the electronic gates, since the traffic outside the restriction window has remained substantially unchanged.

An analysis of LTZ entrance per category shows that the taxable entries are about 24% of the total flows. This analysis enabled the discharge of pure road pricing in the morning, due to the practical impossibility of taxing just a few specific categories.

The lower traffic flows registered during the first three years of working the ACS+RP hybrid scheme derive mainly from a strong reduction in illegal traffic entering LTZ, which has diminished from 36% before the activation of the gates to below 10% after 1.5 years from the activation of the gates as shown in the following figure.

Figure 4.14 The illegal access in the LTZ in percentage and in absolute number

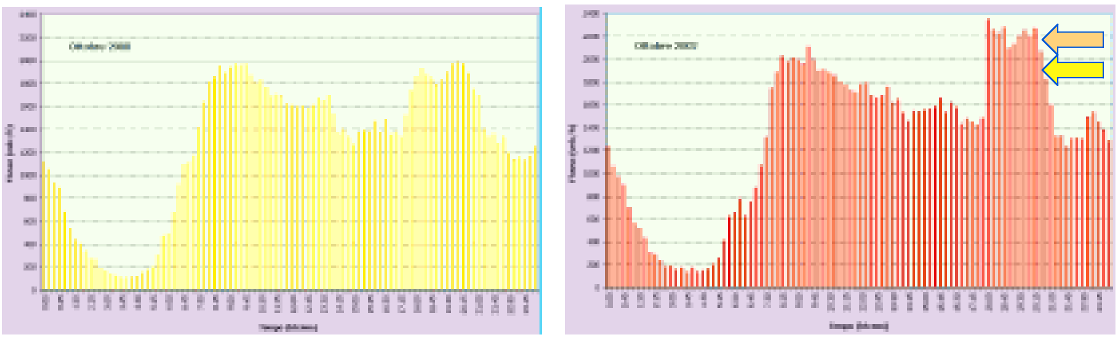


In the first tri-monthly period of 2003, the illegal access rate under 10% and showing a constant decrease rate.

Road user charging evening scheme

The observed data showed a peak of transits towards the LTZ after the ACS+RP scheme is switched off at 6pm. The figure shows the total mean flow in October 2000 and 2002 inside the LTZ in each hour: a new peak appeared around 6 pm.

Figure 4.15 The new peak in LTZ evening flows



In the final part of the PRoGRESS project, the city of Rome implemented a demonstration case study of road pricing in the evening period (6-11pm).

The aim of the evening road pricing scheme was to reduce the high number of through traffic using the LTZ at the end of the ACS+RP operational time (6.30am-6pm). The implementation of a charging system with a fixed charge for each access inside the area will discourage through traffic trips and reduce congestion and pollution in the demonstration area.

Various simulation scenarios were undertaken to define the charge at which higher benefits, in terms of traffic reductions, are obtained. Moreover, in addition to the introduction of the road charges, the improvement of the public transport (PT) service (expressed in terms of travel time reduction) was also considered.

Five scenarios were analysed for summer time operation and four for winter operation (summer and winter travel patterns are very different in Rome). For summer-time operation, the current scenario (called scenario 0) and four simulation scenarios with different charges (3 Euros and 6 Euros) and either with or without PT improvements. For winter, there is one different condition, a 1 Euro charge without PT improvement.

The summer simulation results can be summarised as follows:

- The current modal split of the work and shopping classes is similar; in the third case (leisure) the use of private means (car and, particularly, moped) is much higher;
- In all three cases the private car share drops significantly (about 50% of the initial value), even with a 3 Euros charge;
- Most of the users leaving their car will evenly redistribute between moped and public transport mode;
- The percentage of car drivers changing their destination is usually low; it is a bit higher (about 5.5%) for the leisure-purpose class;
- The percentage of car drivers postponing their trip is appreciable (some 1%) only for the leisure-purpose class;
- The additional effect due to increase of the PT supply on the PT share ranges from about 0.5% (when a 10% reduction of the PT average trip time is assumed) to about 1.5% (when a 20% reduction of the PT average trip time is assumed).

Interesting results emerge from the analysis of the impacts that the road-pricing scheme would have on car drivers crossing the LTZ. Only about 14.5% of the car drivers continue to cross the area with a 3 Euros charge, while this percentage nearly disappears with a 6 Euros charge. Most of the car drivers would change their route, avoiding the charged area.

The winter simulation results showed:

- In all three cases there is a reduction of the number of cars accessing the LTZ. For a 1 Euro charge there is an 8% reduction of cars, which rose to 18% with a 3 Euros charge and 28% with the highest charge.
- An increase in the number of PT users and mopeds is noted as a consequence of the reduction of cars accessing the LTZ. In scenario 3, with a 6 Euros charge the percentage of PT users is more than 50%.
- The alternatives 'change of destination' and 'trip postponement' are chosen by a very small number of users.

4.4.9 Trondheim

Introduction

This section of the report presents key impact results from the Trondheim evaluation activities in the PRoGRESS project:

- Long-term effects of the Trondheim Tolling system since the start in 1991;
- Short-term effects of the 2003 revision of the Trondheim Tolling system;
- Future RP alternatives, including road pricing and the IBIS City Centre through-traffic demonstrator and a feasibility study done on EFC technology used for paring charging.

Long-term effects of the Trondheim Tolling Scheme

The main purpose of the introduction of the Trondheim RP scheme was to raise money for new road infrastructure. This was also the motivation for the expansion of the scheme in 1998, and the expansion in November 2003. In a town with a current population of 150,000 people, the scheme has raised more than 125m Euros spent on road infrastructure for cars, public transport, bicyclists and pedestrians, and measures to reduce environmental problems generated by road traffic. The funding raised through road tolling is being matched with a similar amount of money from public grants.

The findings from the travel surveys show that a RP scheme such as the Trondheim tolling system can have substantial traffic management effects, similar to what one would expect from a congestion charging scheme in terms of reduction in traffic levels during peak hours.

Traffic management was not the main purpose of the scheme, and there are no indications that the RP scheme has affected the overall traffic levels. However, the introduction of the 1991-scheme led to a temporal shift, away from the charged hours, towards evenings and weekends, and the data available suggest similar effects of the 1998-revision for the trips directly affected by the changes in the scheme.

Some of the main findings from the long-term evaluation are:

- The 1991 tolling scheme led to a decrease in car use for the hours and places where the tolling was operating. There are also indications that the 1998 revision of the scheme had a similar effect. However, the tolling scheme has not led to a decrease in total number of car trips or car drivers in the municipality;
- The tolling scheme affects the spatial and temporal travel pattern for car drivers in Trondheim, mainly due to shifts in time of travel for trips affected by the charging.
- The tolling scheme has not led to an increase in ride sharing;
- The 1998 revision of the tolling scheme led to an increase in 'fairness' in terms of including a larger proportion of the car drivers;

- Opinion polls on the attitudes to the Trondheim toll ring indicated decreased opposition during the first years after implementation, but the long-term trends show increasing negative attitudes towards the tolling system;
- There are indications of an increasing concern about the fairness – or lack thereof – of the Trondheim tolling scheme;
- The results indicate an increasing concern about the level of traffic and congestion.
- The tolling scheme has not had any clear effects on house prices in different parts of Trondheim;
- There was no distortion of trade competition due to the toll ring;
- The toll ring has had no evident effect on the air quality.

Short-term effects of the 2003 revision of the Trondheim Tolling system (city centre ring)

Following the introduction of a new city centre ring during the PRoGRESS project, the main evaluation findings were that:

- Generally, the attitudes were more positive toward the new charging points than towards the existing system operating while the interviews were conducted during October 2003;
- The 2003 revision of the tolling scheme led to a reduction in traffic levels across the new charging points, not only during the charged hours but also during the uncharged evening period. The normal charge is 1.5 Euros, which led to a 10-15% decline in traffic levels to/from the city centre.

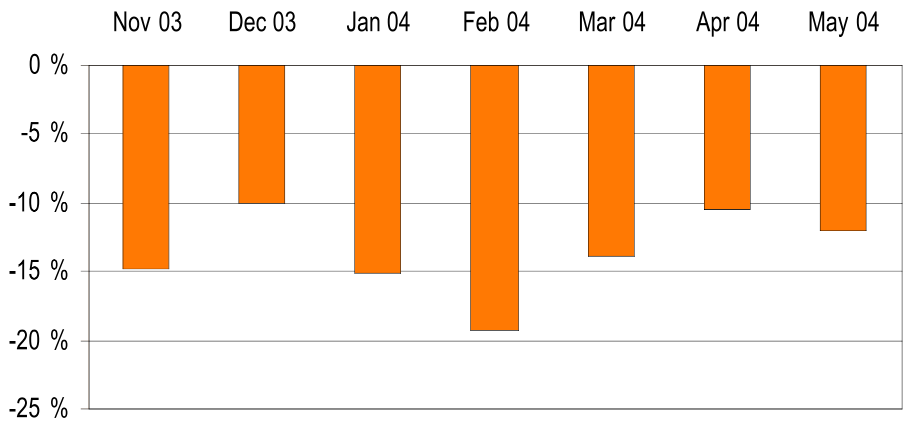


Figure 4.16 Relative Change in Traffic Over the CBD Cordon During Charged Hours (compared to the traffic levels of October 2003)

Future road pricing alternatives

The local discussions about the fate of the EFC equipment after the end of the charging period in 2005 made it necessary for two feasibility studies to be carried out on future use of the RP infrastructure. One looked at a through-traffic scheme for the city centre, while the other looked at use of the EFC technology as an alternative for the existing parking charging system. Results from these studies are covered in the existing documentation from PRoGRESS only to a small extent. More information is, however, available from the Trondheim PRoGRESS partners.

The main attitudinal findings from the evaluation of future road pricing alternatives were that:

- The majority considered a charging principle with the fee depending on the use of the car to be most fair;
- The overall trend from Trondheim surveys is a belief in the efficiency and acceptance of restrictive measures to improve traffic conditions in the city centre. The through-traffic charging is an example of a new charging principle that is supported by a majority;
- The attitudes towards road pricing did not differ much from those towards the current tolling scheme;
- The attitudes towards a combination of road pricing and corresponding reduction in taxes and annual fees were significantly more positive.

The main results from the feasibility studies were:

- The studies of the through-traffic charging showed that it could be a very efficient instrument for controlling the through-traffic. The reduction in the through-traffic was found to be about 20% when the charge is 1.5 Euros and 50% when the charge is 2.5 Euros. Similar results were found independently by a Stated Preference study and by the local transport model.
- The existing EFC technology can be converted to a cost effective system for collecting parking charges. The net income for the city will increase substantially (50-70%). Like the RP system, an EFC-based parking system will be fully automatic and more user-friendly than the existing system. Among the user benefits is also that the fines for 'over parking' will disappear.

5 LESSONS LEARNED, RECOMMENDATIONS AND CONCLUSIONS

5.1 Introduction

The key output of the PRoGRESS project was the lessons learned on how best to take forward urban road pricing in Europe. The following section presents a summary of the key lessons learned, and consequent recommendations and conclusions from PRoGRESS. These are grouped under relevant headings and should be very valuable to any European city authority considering implementing an urban road pricing scheme in the future.

5.2 Consultation and Information

5.2.1 Consultation

An experience from most of the sites is that road pricing is still very controversial. The experiences regarding consultation with the public and others can be summarised through the following lessons learned and recommendations. Most of these confirm previous experiences.

Lesson 1: "Weak support for road pricing as an isolated measure"
A lesson learned in many sites (e.g. Gothenburg), as well as in previous research, is that a majority among the public tend to be against road pricing if presented as an isolated measure. There is generally widespread support for introducing measures that will reduce congestion and substantially improve public transport; however, there is normally opposition to the principle of road pricing.

A *recommendation* is *to present road pricing as part of a strategy*, including other measures, to solve congestion. It is then also crucial in the consultations to communicate clearly. This recommendation is in line with findings from other schemes adopted by the EC, e.g. the CIVITAS initiative.

Lesson 2: "It is hard to find support for full-scale schemes"
It is obvious from several of the sites that it has been difficult, from a political point of view, to implement full-scale road pricing schemes. Instead of full-scale schemes, demonstration projects have therefore been carried out in some cities. A lesson learned is that this approach also provides experiences enabling cities to proceed with consultations leading to the development of a more appropriate full-scale road pricing scheme.

A *recommendation* is therefore *to consider running demonstration projects* as a first step on the way towards implementing a full-scale road pricing scheme.

Lesson 3: "Support tends to erode as more detailed plans are presented"
The more detailed a design becomes, the less able it is to accommodate the preferences of all the different factions, resulting in a steady reduction in support.

A *recommendation* is to be aware of this risk and to *discuss it with politicians and other stakeholders at an early stage*, so that they are not taken by surprise if and when support erodes. Demonstrations make it possible to better communicate the purpose and effects.

Lesson 4: "Difficult to communicate scheme objectives"
Opposition to the road pricing schemes seems to be reduced after implementation, but road pricing is still very controversial. A lesson learned from the consultations carried out (in Gothenburg and Trondheim) is that it is difficult to communicate scheme objectives. The discussion tends to focus on the political process rather than whether the scheme will be able to meet its objectives.

A *recommendation* is to put a lot of *emphasis on providing information on the scheme objectives and traffic effects of the scheme* (and, again, it is also useful to present schemes as part of a strategy).

Lesson 5: "Businesses in city centres are often against road pricing"
Commercial interests often seem to be against road pricing schemes, more so than residents (see Edinburgh and Rome), certainly before the scheme has been implemented. However it seems that the fear of city centre decline can be reduced.

A *recommendation* is to *communicate closely with businesses and stakeholders* so that their fears and concerns can be allayed before the implementation of any measures. Another recommendation is to *announce close monitoring of effects and the possibility for redesigning the charging system* after a certain period of operation.

5.2.2 Information Delivery

An experience from several of the sites is that they have faced an unexpected difficulty to inform the general public, and even participants in demonstrations, on the contents of schemes. Most of these confirm previous experiences; but some new lessons learned are presented here as numbers 6 and 7.

Lesson 6: "Extensive communication is needed"
A lesson learned is that the need for information is immense when a road pricing scheme is to be implemented. However, it is also important to continue to give information to users after implementation to inform them about the benefits of the scheme. In Trondheim, the lack of a continuous information strategy has led to poor knowledge about the scheme.

A *recommendation* is therefore to *make a complete information and consultation plan early* in the implementation process and to budget large resources for the work.

Lesson 7: "Difficult to communicate changes in the schemes"
It has been found difficult (in Rome) to inform those affected in time when changes to the road pricing systems have been carried out. Such changes may refer to the charging period or the charge levels. Large numbers of violations when modifications were applied confirms the difficulties.

A *recommendation* is therefore to *provide abundant information before changes are made and to use several channels* for the information. One important channel is variable message signs placed at the roadside.

Lesson 8: "Good availability of information is needed even in field trials"
A lesson learned from the demonstration sites (e.g. Gothenburg) is that it is important to be available and supply information even though only field trials are conducted. Participants especially, but also media and the public, require a lot of information in order to understand fully how the scheme works and how they are supposed to act.

This underlines the *recommendations* that *thorough information is needed*, both before and during project implementation as well as when the schemes are running. Information can, e.g., be provided through letters, folders, telephone service, a website with FAQ (Frequently Asked Questions), and contacts.

Lesson 9: "It is hard for participants to understand different scenarios"
An experience (from Gothenburg) is that behavioural differences for two different scenarios were not clear among test drivers who tried both scenarios. A probable explanation is that the test drivers did not understand the differences between the scenarios (congestion charging and an environmental scenario) and therefore did not react "logically" to the measures.

A *recommendation* is therefore to *avoid letting the same person try different scenarios in field trials* and instead let different participants try different scenarios. The disadvantage is, of course, that more participants may be needed in order to get reliable behavioural results.

Lesson 10: "The press acts as both opinion makers and opinion reporters"
Analysis of press coverage in Edinburgh and Trondheim has shown that the press tend to act both as opinion makers and opinion reporters. The finding that they act as opinion makers, through comments and a bias towards reporting on foreseen negative impacts, is not surprising. However, it is important to realise this, especially as the traffic planners are often not invited to comment on articles published.

A *recommendation* is to apply a pro-active approach and *formulate an information strategy for the contacts with media*. This can also minimize the risk of growing suspicion towards the project from the media and they feel they have regular access to scheme promoters.

Lesson 11: "Simple schemes are easier to communicate"
A lesson learned from the difficulties found in supplying sufficient information is that it is better to apply simple schemes, at least from a consultation and information point of view. The backdrop is, of course, that what is theoretically best in order to meet scheme objectives, may have to be sacrificed.

A *recommendation* is therefore to *apply simple schemes*, as long as they can still satisfactorily meet the objectives, and then *gradually improve* them.

5.3 Legal and Institutional Issues

The PRoGRESS projects have not primarily dealt with legal and institutional issues. However, experiences from such issues have been gained, and may be interesting for other cities. It needs to be stressed that it is difficult to give clear recommendations, since legal and institutional situations are more or less unique in every city in Europe. Many of the experiences also confirm previous experiences, although one new lesson learned with respect to legal and institutional issues is number 6.

There are many legal and other obstacles, different in different countries, facing cities wanting to implement road pricing schemes. It is obvious – from the PRoGRESS sites and elsewhere – that it is often a time-consuming and difficult task for a single city to overcome these obstacles. A *recommendation to the European Commission* is therefore *to continue to facilitate for cities* wanting to implement effective demand management measures such as road pricing, through Directives and other tools.

Lesson 1: "An unclear framework can complicate the debate and the decision process"
The legal situation regarding road pricing is very different in different countries, for example there is a legal framework allowing road pricing on existing roads in the UK but not in Denmark or Sweden. In Italy there is a legal solution that makes it easy to implement road pricing for cities willing to do so, but at the time of the PRoGRESS demonstrations complicated intermediate steps were needed. A lesson learned is that if no clear legal framework for road pricing is in place, this will complicate the debate and the decision-making process for the schemes.

Therefore, in cities where the legal framework for road pricing is not clear, it is *recommended* to *address legal issues at an early stage* of the process.

Lesson 2: "The legal situation may limit the possible scheme designs"
A lesson learned is that changes in legislation may be required in order to implement a preferred scheme design in a city, the situation in Trondheim being a good example of this. National legislation previously did not accept demand management to be the main rationale for road pricing schemes.

An obvious *recommendation* to cities facing a limitation of scheme designs due to the legal framework is to *either adjust the legal framework* or to *adjust the scheme design*. Adjusting legislation can be very time consuming.

<u>Lesson 3: "Introducing new legislation can give delays"</u>
One experience (from Edinburgh) is when the introduction of the scheme has depended on the passing of legislation this has meant an initial delay to the project. The approval process as defined by the legislation is also an area where delays have been encountered.

The *recommendation* is that *delays* due to changes in the legal framework and/or the approval process *should be expected when making the time schedule* for the implementation of a road pricing scheme.

<u>Lesson 4: "Regulation of revenue use can be important for successful implementation"</u>
One lesson learned (for example, in Gothenburg) is that road pricing can be more accepted if the legislation allows for revenues to be used directly for improving public transport or roads. It has also been found important that the revenues stay in the city or region affected.

A *recommendation* is to *ensure that guarantees are given on how revenues will be used* and who will control them. This can be done either through legal regulation or through agreements with the government.

<u>Lesson 5: "The traffic situation may change during the operation of the system"</u>
An experience (from Rome) is that the traffic situation may change during the operation of the system. Modifications of the scheme design may therefore be needed.

A *recommendation* is to *observe traffic flows and travel behaviour* at certain intervals over time and to run continuous panel surveys.

<u>Lesson 6: "Using an arm's length company can work well"</u>
In some sites (Rome and Edinburgh) a problem encountered in local government was in the delivery of major transport infrastructure projects. The decision was therefore taken to establish an arm's length company, owned by the council, but with the freedom to operate in a private sector environment.

The *recommendation* to a city wanting to implement road pricing is to *consider if this solution is suitable* in that particular city.

5.4 Transportation Policy

Most of the experiences regarding transportation policy are either country-specific or confirm previous experiences. Some new lessons learned with respect to transportation policy are, however, numbers 4 and 7.

Lesson 1: "Distance-based systems give higher flexibility for transportation policy"

Distance-based systems are flexible and can easily be used to solve local congestion problems. GPS technology is well suited for such systems. In a transportation policy where GPS technology is used, the road pricing can thus be used as a more fine-tuned instrument. On the other hand this technology is not as mature as the others for road pricing, and may therefore be difficult to use as a tool in transportation policy (see the section below on technology and transactions).

A *recommendation* is to *follow the development of GPS-based systems* in order to decide when, it can be a practical tool for road pricing in urban areas.

Lesson 2: "Uncertainty has to be handled"

One experience (from e.g. Gothenburg) is that people want answers to many questions regarding road pricing. The uncertainty of what a potential scheme really will imply is extensive. Often, there are also a lot of political questions unanswered, such as funding, revenue use, and complementary measures.

A *recommendation* is to *form a strategy for how a fact-based dialogue* on advantages as well as disadvantages of road pricing can be achieved. One solution is: as a first step to present facts; as a second step to conduct an extensive dialogue; and as a third step to fine-tune the design of the system. After implementation it is suitable to constantly adjust the scheme to revealed behaviour and needs.

Lesson 3: "Use of revenues must be settled before implementation"

Issues such as acceptance, distributional effects, and the possibility to invest in complementary measures are important in transportation policies. The use of revenues is central for the outcome of these issues.

A *recommendation* is to first *present* to politicians *facts on the distributional effects* of different schemes, *on acceptance and on transport demand* as well as supply. Thereafter, at an early stage in the process, a decision is needed on how revenues should be used.

Lesson 4: "Funds are needed before implementation"

A conclusion from the experience that improved provision of public transport is necessary in order for acceptance is that funding must be available at an early stage. It is thus not only funds for the actual implementation of the road pricing scheme that are needed before implementation.

A *recommendation* is therefore to try *to get a clear commitment* at an early stage from the decision makers that funding will be supplied and that necessary improvements in the transport system will *be in place already from day one* of the scheme.

Lesson 5: "Transportation policy must deal with social equity"
It is clear, from all sites, that different schemes will have different effects on social equity. This will not only be a matter for acceptance, it is also an important task on the political agenda.

A *recommendation* is to *analyse effects of road pricing together with other pricing instruments* such as costs for parking, public transport fares, and Park and Ride. Together, they can be used as a sophisticated set of tools for mobility management.

Lesson 6: "Transportation policy must deal with impacts for business sector"
Several sites in PRoGRESS (e.g. Edinburgh) have found the business sector an important segment to analyse separately. This sector has its specific needs, and impacts from schemes on businesses may have an important influence on the regional economy.

A *recommendation* is therefore to undertake *separate analyses* and *separate consultation exercises with the business sector*.

Lesson 7: "A winning idea is to confirm earlier strategies"
An experience (from e.g. Rome) is that implementing road pricing schemes can be facilitated if transport strategies emphasise earlier objectives of a city's transportation policy. It is an advantage if the design of the road pricing scheme is in line with earlier work undertaken in the city, having used other tools.

A *recommendation* is therefore to *use road pricing schemes to strengthen previously defined transportation strategies* and objectives. Over time, road pricing may then be considered as a part of the city infrastructure.

Lesson 8: "Implementation in London supports other cities"
The implementation in London supports other cities that wish to develop transportation policies that include road pricing. The general support towards measures solving traffic congestion problems as well as the subsequent pollution has shown an increase (in Rome) since the implementation in London.

A *recommendation* is to *learn from other cities that have gone along with full-scale implementations*. In communication, this can be used as reference material since real-life experience is easier to accept than theoretical results.

5.5 Technology and Transaction

In this section, recommendations regarding technology and transaction are given. The lessons learned mainly focus on the experiences from the GPS-based systems since the other technologies are more mature and already tested in full-scale. All the lessons regarding GPS are thus more or less new, whereas the other lessons mainly confirm previous experience.

5.5.1 Experiences from GPS-Based Systems

Lesson 1: "GPS systems have been shown to work"

A lesson learned from the sites using GPS-based systems (Bristol, Copenhagen, and Gothenburg) is that it does work for demonstrations and that a lot can be done to overcome for weaknesses found. There are still improvements needed before it can be implemented on a full-scale in urban areas.

A *recommendation* is to *develop the technology further* and in doing so pay consideration to *learning from the demonstrations* that have taken place in PRoGRESS. It is, after all, difficult to find any other measure with the same potential for efficient and flexible management of traffic in major cities.

Lesson 2: "GPS may not be mature enough for full-scale systems in urban areas"

Another lesson learned (in Bristol, Copenhagen, and Gothenburg) is that the successful application of technology requires further work, before a GPS system can be implemented in full-scale in urban areas. Signal loss in urban-canyons is an issue for schemes requiring precise definition of cordons. A major issue with current GPS-based systems is that they will require a unit installed in all cars and such an installation activity is considerable and very costly. Also, much further work needs to be carried out concerning methodological, software, and technical issues – see some of the following lessons.

A *recommendation* is to *use more mature techniques* (DSRC and/or ANPR) if the road pricing scheme is to be implemented *in urban areas in the very near future*.

Lesson 3: "The equipment does not always work properly"

During the demonstrations problems were experienced (in Copenhagen and Gothenburg) regarding loss of battery power, poor quality of GPS reception, and loss of signals, especially at start-up.

Some *recommendations* are to undertake *massive testing of prototypes* before implementing the final product and to *check the quality of the GPS signal* received when installing the equipment. To compensate for the loss of signals, methods such as *dead reckoning and real-time map matching* can be used.

Lesson 4: "Many pitfalls in field trials using advanced technology"

An experience (from Copenhagen and Gothenburg) is that there are several things regarding technology that may go wrong in a field trial. This is not surprising since testing the technology is one of the purposes of a field trial.

A *recommendation* is to make *controls that log data are collected properly several times during field trials*, and to test if it looks reasonable. To detect errors, it is necessary to carry out more thorough analyses at an early stage than in ordinary surveys of attitudes. It may also be necessary to go through such analyses several times during the trial.

Running a small-scale pilot, that includes analyses of the log data, before the field trial is also recommended.

Lesson 5: "Avoid allocation of functionality to the on-board unit"
Another experience (from Gothenburg) is that the allocation of the price calculation to the on-board unit puts very high requirements on the system in all respects. Such requirements include large needs of memory to store price lists, high processor capacity to calculate the fee in real time, and power capacity for the display. Thus, also the complexity of the system increases, and consequently the sources of errors in all steps of the system development and operations process. Another disadvantage is that updating of the software of the on-board unit becomes complicated. However, trials in Bristol with similar systems meant privacy levels could be very high, and next generation OBU can address the updating requirements.

A *recommendation* is therefore to *allocate all functions except the journey recording to roadside or central systems*. This can be done with retained integrity level. The loss is the continuous display of the cost incurred. The gain is that it is possible to create an interoperable solution without excess requirements on memory and processor capacity.

Lesson 6: "New equipment is often blamed for car malfunctioning"
In one of the demonstrations (Copenhagen) a significant number of participants claimed that their battery was flat because of the GPS unit. It seems that every time a battery goes flat the car driver expect the taximeter to be the culprit even though there might be other causes. The lesson learned is that clarification of the responsibility for car malfunction can be very difficult and new equipment will always be expected to be the main culprit.

A *recommendation* is to *try to identify and solve such problems during the testing* of the prototypes, but also to be aware that there is a risk for this reaction anyhow.

Lesson 7: "The equipment is not distracting and integrity may not be a big issue"
A lesson learned from the demonstrations (in Gothenburg) is that that the equipment was not distracting, the drivers did not feel under surveillance, and that the question of integrity was not an important issue. Further, from a technical point of view, it is no more difficult to guarantee privacy in a GPS-based system than in other systems. However, in Bristol, the privacy built-into the system was perceived to be helpful in explaining the system to (a small sample) of drivers.

A *recommendation* is to *refer to these experiences* if and when the issue of surveillance is brought up in the debate preceding the decision on the technology to use.

Lesson 8: "GPS-based systems are too advanced to be needed for zone charging"
An experience (from Copenhagen) is that while GPS or similar technology is necessary to be able to implement kilometre charging, the situation is different for zone charging.

Such a system does not require the continuous monitoring that is a main benefit of a GPS system.

A *recommendation* is to *consider number plate recognition (ANPR) or DSRC technologies*, which are proven to function well, and should be compared on a cost and ease of implementation basis with GPS to arrive at a final decision.

5.5.2 Experiences from DSRC and ANPR Systems

Lesson 9: "DSRC works successfully"
Experience, both in the PRoGRESS sites (Trondheim) and other cities, is that the technologies using short-range communication (DSRC) work well. It is also a technology that is comparatively cheap to operate, has been used for quite some time and now is becoming standardised. However, it is rather costly to implement, not least since equipment is needed in all cars.

A *recommendation* is to *use this technology* (or pure ANPR systems), as long as it is not crucial for the fulfilment of the scheme objectives to use distance-based systems. The impacts of a distance-based system might also be emulated through the use of several DSRC portals.

Lesson 10: "ANPR works well but does not recognize all vehicles"
A lesson learned from the demonstrations is that the technology using automatic number plate recognition (ANPR) is quite good and affordable. It does, however, have an intrinsic rate of non-recognition in the real operational environment (7% and 15% in Genoa and Rome, respectively).

A *recommendation* is that this technology can be *used as an alternative to DSRC* solutions. A benefit is that it is cheaper and easier to implement since it does not require in-vehicle equipment, though it is probably more expensive to operate. ANPR will be a more or less necessary complement for enforcement purposes.

Lesson 11: "Non-detection and incorrect reads in ANPR systems can be reduced"
The major cause of both non-detection and incorrect reads in one of the ANPR systems (Edinburgh) was the non-overlapping fields of view of the cameras at each site, resulting in lane-straddling vehicles frequently being incorrectly read.

A *recommendation* is to include *overlapping fields of view* for the cameras and consider *twin front- and rear-facing cameras*.

Lesson 12: "Operational costs differ between payment channels"
Transactions requiring manual labour, such as call centres or retail outlets, are more costly than more automated payment channels (Edinburgh).

A *recommendation* is, therefore, to *promote the use of low-cost payment channels* such as the Internet or SMS-based systems.

Lesson 13: "License purchasing systems can perform well"
A licence purchasing system can perform well. In one of the sites (Edinburgh) there were no reported occasions when the telephone service did not function or provided an engaged or unobtainable signal to volunteers, and all recorded telephone licence requests were successfully transcribed into the licence file.

A *recommendation* is that the operation of license purchasing systems *does not have to be a major concern*, apart from the obvious fact that it may be rather costly.

5.5.3 Experiences Regarding Standardisation

Lesson 14: "It is difficult to standardise the on-board equipment"
An experience (from Gothenburg) is that the on-board equipment functionality should be minimised. This conclusion should be valid also for the electronic fee collection (EFC) standardisation in DSRC systems. One reason why on-board functionality should be minimised is that it will be difficult for all European countries and operators to agree on one single service, and even to agree on a generic vehicle classification. Secondly, it will be extremely difficult to organise a pan-European solution where payment information, with the need for security protection, is communicated and understood.

A *recommendation* is that harmonisation of distance-based EFC should be based on *harmonisation of the message containing the time-stamped travel path*. This will minimise the payment information flow, and reduce the need for security measures. Integrity may be protected by e.g. the selection of the trusted body used for performing the payments.

Lesson 15: "For DSRC, standardisation has come a long way"
For the DSRC systems, some issues regarding standardisation have been solved, like the 5.8 GHz communication link that has been used at all the sites using DSRC. However, some issues remain and are under consideration in CEN.

An obvious *recommendation* is to *adapt to the new standard* wherever it has been completed.

Lesson 16: "A benefit if the EFC service can be included in the GPS systems"
Experiences from the PRoGRESS trials show that GPS-based systems are still far from mature to be implemented. Standardisation of GPS solutions is, however, going on. There is a need to guarantee European interoperability at some basic level.

A *recommendation* is therefore to *include* the European DSRC-based common *EFC service* in every *GPS system* as an interface to the numerous existing and emerging systems all over Europe. Another recommendation would be to promote the development of a European *framework for enabling cross-border enforcement* of users that do not pay.

5.6 Enforcement

Many of the lessons learned regarding enforcement confirm previous experiences. Some new lessons are, however, numbers 1, 4, and 6.

5.6.1 Experiences from GPS-Based Systems

Lesson 1: "It is difficult to enforce large GPS systems"
At present there is no fully operational control and enforcement system in relation to distance-based charging. The general problem with a GPS-based system is that it has to be working all the time the car is in a charged area. Here a cordon-based system is much less demanding, because the technology only needs to work when a cordon is crossed, which reduces enforcement to primarily checking the cars crossing cordons.

A *recommendation* is to use one of two less complete alternatives. One way is to install a monitoring system in the car that *continuously checks if the GPS system is working* when the car's engine is operating. Another way is *enforcement by mobile and stationary checkpoints*.

Lesson 2: "The chosen subject of control has big consequences for the system design"
The subject of control in distance-based charging systems determines how the enforcement system should be designed. One possibility is a control aimed at the functionality of the system, in order to detect fraudulent behaviour or equipment manipulation. Another possibility – recommended in Gothenburg – is a control system aimed at the verification of duly performed payments.

A *recommendation* is to *base the control system on verification of performed payments* and not the functionality of the on-board equipment. Another recommendation would be that *all control functions should reside outside the vehicle*. This means that the vehicle equipment does not perform any payment activity, but only communicates transport data to a trusted partner that calculates the fee and performs the payment.

5.6.2 Experiences from ANPR Systems

Lesson 3: "ANPR systems work sufficiently well"
A lesson learned at many sites (e.g. Bristol, Edinburgh, Genoa, Rome, and Trondheim) is that ANPR systems work fairly well. There will probably always be a share of the cars that cannot be identified, but this share is not so high that it should discourage anyone from using ANPR. There are also some improvements that can be made, such as the inclusion of overlapping fields of view for the cameras as well as both front- and rear-facing cameras (see technology and transaction).

The *recommendation* is to *use ANPR-systems* for enforcement and to use the *improvements* described above.

Lesson 4: "ANPR is more efficient than manual control"
At one of the sites (Rome) enforcement was previously carried out manually through police surveillance. After the ANPR system was implemented, the illegal access rate went down drastically. This shows that automatic systems such as ANPR are more efficient than systems using only manual control.

The *recommendation* is, once again, to *use automatic systems, such as ANPR*, for enforcement.

Lesson 5: "Registration of license plates can be done manually"
Even though a lesson learned is that the enforcement system should be automatic, it is not necessary that the actual registration of the video picture be done automatically. This is shown by experience from one system (Trondheim) that is based on taking video pictures of those vehicles violating the regulations and where the operator then registers the licence plates from the pictures as manual work.

A *recommendation* is therefore that *enforcement does not have to be fully automatic in small-scale schemes* with a short planned lifetime.

Lesson 6: "Illegal access can be due to insufficient information"
At one site (Rome), peaks in illegal access were detected at special events, where the operating time window of the system was enlarged. The reason was that not all citizens were reached by information on this, showing that a high rate of illegal access may be due to insufficient information.

The *recommendation* is once again to *put a lot of effort on information, especially when changes to the scheme are applied*. One way of doing this is to use small variable message signs or special lights in order to inform the people directly before passing the gates.

Lesson 7: "Penalty management can probably be co-ordinated"
In many cities it is probably possible to expand the existing management of penalty charges for parking violations to also handling penalty charges from road pricing. Likewise, payment of congestion charges could sometimes be co-ordinated with payments for parking.

A *recommendation* is therefore to *examine the possibility to co-ordinate the handling of penalty charges* from road pricing with the handling of penalty charges for parking violations.

5.7 User Acceptance

Many of the lessons learned regarding user acceptance confirm previous experiences, however some new lessons learned are set out below and concern numbers 1, 4, 6, 7, and 10.

Lesson 1: "Surveillance is not a big issue"
A lesson learned in two of the PRoGRESS sites (e.g. Copenhagen and Gothenburg) was that surveillance was not a big issue among the participants. The reason seems to be that people have become accustomed to using systems where, in principle, it is possible to track them (e.g. credit cards and the Internet).

A *recommendation* is to *communicate,* to the public and the press as well as to politicians, *the fact that surveillance has not been a big issue* at the sites.

Lesson 2: "Verify that traffic problems are actually solved by road pricing"
A lesson learned during the demonstrations is the importance of verifying that traffic problems experienced are actually solved by road pricing. A majority at most of the sites agree that traffic congestion will get worse and needs to be reduced. At one of the sites (Edinburgh) up to two-thirds thought that charging would have no effect, because people are too used to using their cars.

Another lesson learned (from Gothenburg) is that road pricing is more accepted if revenues are used to improve public transport as well as environment. That a road pricing scheme can give satisfactory environmental impacts seems to be a result that is possible to communicate.

A *recommendation* is to *focus on traffic behaviour*, rather than political issues before implementation. It is therefore necessary to communicate clear and distinct facts on effects on traffic behaviour.

Lesson 3: "Support tends to increase after implementation"
An experience from the demonstrations (in Trondheim) is that support tends to increase after implementation. One possible interpretation of the resistance before implementation is that this might be in order to try to influence the decision and thus prevent implementation. Polls have showed that for one scheme, 75% were negative before the scheme started operating. Two months after implementation, the negative share had dropped to below 50%. After two years, approximately 30% were negative. If benefits become clear – which usually does not occur until after implementation – support thus seems to increase.

A *recommendation* is to undertake measures to *increase options for people influenced* by the system when it is implemented. Another recommendation is to *develop such measures and to communicate benefits at an early stage.*

Lesson 4: "Misconceptions easily arise"
Even though a field trial is working well, people seem to exaggerate problems that could potentially occur.

A *recommendation* is to *map the possible misconceptions* and to give extensive and clear *information on how these topics are going to be solved.*

Lesson 5: "Aesthetic issues are important"
Different technologies have different requirements on roadside equipment, and thus affect aesthetic issues differently. Public acceptance may be influenced by the design of the roadside equipment (see Bristol and Rome). Large gantries may, for example, become an aesthetic issue if they are not adjusted to the environment where they are installed.

A *recommendation* is to *involve an architect* when planning for the roadside equipment. It is especially important to consider aesthetic values in culturally valuable areas, such as old city centres. *Another solution is to use a GPS system*, which greatly reduces demand for extensive roadside infrastructure.

Lesson 6: "Easy payment channels are requested"
A lesson learned (in Edinburgh) is that paying by telephone or Internet, when applicable, implies only little hassle. A key finding at one site was that among those participating in the trials some were still unsure of elements in the trial. It was, for instance, found that people do not always read the information provided with regard to payment.

A *recommendation* is to facilitate payments by *supplying several purchase channels*, with high accessibility. These options should also be clearly communicated.

Lesson 7: "Time to become accustomed to scheme should not be underestimated"
People need time to get used to and accept changes in transport policy, even when it comes to modifications of an existing system. An experience (from Rome) is that it was a lengthy and complicated political process to obtain user acceptance of the new scheme, despite the fact that access control already had existed in the city for several years.

A *recommendation* is to *approve a fair time schedule.* A short time schedule may undermine the possibility to use road pricing to solve traffic problems in the foreseeable future.

6 FURTHER INFORMATION

PRoGRESS was a large demonstration project. While this report summarises the main results and outputs of the project, further detail is available from the deliverable reports produced by the consortium on specific aspects of the project.

Further information on all aspects of the PRoGRESS project can be found at www.progress-project.org. Public deliverables that include further detail on specific aspects of the PRoGRESS project may be downloaded from this site, together with documents that give further detail on local information.

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7 GLOSSARY

7.1 Short Names of Contractors

Short Name	Full Name of Contractor
AMT	Azienda Mobilità e Trasporti di Genova
ATAC	ATAC
BCC	Bristol City Council
CEC	City of Edinburgh Council
CityGot	City of Gothenburg
CPH	Municipality of Copenhagen
DAPP	D'Appolonia
DITS	Dipartimento di Idraulica, Trasporti e Strade, University of Rome
DTU	Centre for Traffic and Transport, Technical University of Denmark
FINNRA	Finnish National Road Administration, Uusimaa District
GOA-CdG	Comune di Genova, Mobilità e Traffico
HEL/HKSV	City of Helsinki, Traffic Planning Department
HMAC	Helsinki Metropolitan Area Council
ICC	Ian Catling Consultancy
ISIS	Istituto di Studi per l'Informatica e i Sistemi
PLS	PLS Rambøll Management
PRA	Public Roads Administration, County of Sør-Trøndelag
RGU	Centre for Transport Policy, Robert Gordon University
SET	Sistemi e Telematica
SINTEF	SINTEF
STA	Società Trasporti Automobilistici
TCON	Traficon
TRANSEK	Transek
TRI	Transport Research Institute, Napier University
TTR	Transport and Travel Research
UOW	Transport Studies Group, University of Westminster
VBB	VBB VIAK
VD	Danish Ministry of Transport
VTT	VTT Building and Transport

7.2 Other Abbreviations Used

Abbreviation	Description
ACS+RP	Access Control System and Road Pricing
AKTA	The trial name in Copenhagen
ANPR	Automatic Number Plate Recognition
CBD	Central Business District
CUPID	Co-ordinating Urban Pricing Integrated Demonstrations, the thematic network over-arching PRoGRESS
DA	Demonstration Area (Genoa)
DfT	Department for Transport (UK)
DIRECTS	Demonstration of Interoperable Road-user End-to-end Charging Telematics Systems
DSRC	Dedicated Short Range Communications
DVLA	Driver Vehicle Licensing Agency (UK)
GUA	Gothenburg Urban Area
GPS	Geographic Positioning System (proprietary, US military)
HMA	Helsinki Metropolitan Area
ITS	Intelligent Transport Systems
JSC	Joint Steering Committee
LTZ	Limited Traffic Zone (Rome)
MPS	Mobile Positioning Satellite
PMB	PRoGRESS Management Board
PT	Public Transport
OBE	On-Board Equipment
OBU	On-Board Unit
OCR	Optical Character Recognition
RP	Road Pricing
RPA	Road Pricing Area (potential full scheme for Genoa)
RUC	Road User Charging
SAT	Site Acceptance Test
SP	Stated Preference
tie	Transport Initiatives Edinburgh
VoT	Value of Time
VPS	Vehicle Positioning System
WP	Workpackage

ANNEX 1: KEY LESSONS LEARNT AND RECOMMENDATIONS

Lessons learned	Recommendations to city authorities and other stakeholders
Consultation and Information	
There is weak support for road pricing as an isolated measure	Present road pricing as part of a strategy
It is hard to find support for full-scale schemes	Consider running demonstration projects as a first step
Support tends to erode as more detailed plans are presented	Be aware of this risk and discuss it with politicians and other stakeholders at an early stage
It can be difficult to communicate scheme objectives	Emphasise providing information on the scheme objectives and traffic effects of the scheme
Businesses in city centres are often against road pricing	Communicate closely with businesses so that their fears and concerns can be addressed. Assure them of close monitoring and the possibility for later redesign
Extensive communication is needed	Make a complete information and consultation plan early in the implementation process and allow a large budget for this work
It can be difficult to communicate changes in an existing scheme	Provide abundant information before changes are made and use several channels for the information, including roadside variable message signs
Good availability of information is needed even in field trials	Thorough information is needed both before and during project implementation as well as when the schemes are running
It is hard for trial participants to understand different scenarios	Avoid letting the same person try different scenarios in field trials and instead let different participants try different scenarios
The press acts as both opinion makers and opinion reporters	Apply a pro-active approach and formulate a positive information strategy for the contacts with media
Simple schemes are easier to communicate	Apply simple schemes initially, as long as they can still satisfactorily meet the objectives, and then gradually improve them

Legal and Institutional Issues	
An unclear legal framework can complicate the debate and the decision process	In cities where the legal framework for road pricing is not clear, it is recommended to address legal issues at an early stage of the process
The legal situation may limit the possible scheme designs	Cities facing limitation of scheme designs due to the legal framework need to either adjust the legal framework (which can be very time-consuming) or adjust the scheme design
Introducing new legislation can lead to delays	Delays due to changes in the legal framework and/or the approval process should be anticipated when developing a time schedule for implementation of a charging scheme
Regulation of revenue use can be important for successful implementation	Ensure that guarantees are given on how revenues will be used and who will control them, either through legal regulation or through agreements with government
The traffic situation may change during the operation of the system	Observe traffic flows and travel behaviour at certain intervals over time and run continuous panel surveys
Using an "arm's length" company can work well	Consider if this solution is suitable in that particular city
Transportation Policy	
Distance-based systems give greater flexibility for transportation policy	Follow the development of GPS-based systems in order to decide when it can be a practical tool for road pricing in urban areas
Uncertainty has to be handled	Form a strategy for how a fact-based dialogue on advantages and disadvantages of road user charging can be achieved
Use of revenues must be settled before implementation	Present to politicians facts on the impacts and likely acceptance of schemes, so that an early decision can be made on how revenues should be used
Funds are needed before implementation	Get a clear commitment at an early stage that funding will be provided for necessary improvements in the transport system to be in place from day one of the scheme
Transportation policy must deal with social equity	Analyse effects of road pricing together with other pricing instruments such as costs for parking, public transport fares, and park and ride
Transportation policy must deal with impacts	Undertake separate analyses and separate consultation exercises with the business sector

for the business sector	
A winning idea is to confirm earlier strategies	Use road pricing schemes to strengthen previously defined transportation strategies and objectives, so that over time they may then be considered as a part of the city infrastructure
Implementation in London supports other cities	Learn from other cities that have gone along with full-scale implementations, and cite their real life experience in information and communication materials
Technology and Transaction	
GPS based systems have been shown to work	Develop the technology further and in doing so pay consideration to learning from the demonstrations that took place in PRoGRESS
GPS based systems may not be mature enough for full-scale systems in urban areas	Use more mature techniques (DSRC and/or ANPR) if the road pricing scheme is to be implemented in urban areas in the very near future
GPS based equipment does not always work properly	Undertake extensive testing of prototypes before implementing the final product and consider augmentation by dead reckoning and map matching techniques
There are many pitfalls in field trials using advanced technology	Check that log data are collected properly several times during field trials and carry out thorough analyses at an early stage as the trials progress
Avoid allocation of functionality to the on-board unit with GPS based systems	Allocate all functions except the journey recording to roadside or central systems
New equipment is often blamed for car malfunctioning	Try to identify and solve such problems during testing of the prototypes, but also be aware that there is a risk for this reaction anyhow
GPS based equipment is not distracting and integrity may not be a big issue	Refer to the PRoGRESS experiences if and when the issue of surveillance is brought up in the debate preceding the decision on which technology to use
GPS-based systems are too advanced to be needed for zone charging	Consider ANPR or DSRC technologies, which are proven to function well, and should be compared on a cost and ease of implementation basis with GPS to arrive at a final decision
DSRC works successfully	Use DSRC technology (or pure ANPR systems), as long as it is not crucial for the fulfilment of the scheme objectives to use distance-based systems
ANPR works well but does not recognize all vehicles	ANPR can be used as an alternative to DSRC solutions - it may be cheaper and easier to implement since it requires no in-vehicle equipment, but is probably more expensive to operate

Non-detection and incorrect reads in ANPR systems can be reduced	Include overlapping fields of view for the cameras and consider twin front- and rear-facing cameras
Operational costs differ between payment channels	Promote the use of low-cost payment channels such as the Internet or SMS-based systems
License purchasing systems can perform well	The operation of license purchasing systems does not have to be a major concern, apart from the fact that it may be rather costly
It is difficult to standardise on-board VPS equipment	Harmonisation of distance-based EFC should be based on harmonisation of the message containing the time-stamped travel path
For DSRC, standardisation has come a long way	Adapt to the new standard wherever it has been completed
There would be benefit if the DSRC EFC service can be included in the GPS systems	Include the European DSRC-based common EFC service in every GPS system as an interface to the numerous existing and emerging systems all over Europe.
Enforcement	
It is difficult to enforce large GPS based systems at present	Use one of two imperfect alternatives - either onboard monitoring of the GPS based system enforcement by mobile and stationary checkpoints
The chosen subject of control has big consequences for the system design	Base the control system on verification of performed payments and not the functionality of the on-board equipment
ANPR works well for enforcement checks and is more efficient than manual checks	Use ANPR-systems for enforcement with the enhancements described above
Registration of licence plates can be done manually	Enforcement does not have to be fully automatic in small-scale schemes with a short planned lifetime
Illegal access to charged areas can be due to insufficient information	Put a lot of effort into information, especially when changes to the scheme are applied
Penalty management can often be co-ordinated	Examine the possibility to co-ordinate the handling of penalty charges from road pricing with the handling of penalty charges for parking violations
User Acceptance	

Surveillance is not a big issue	Communicate, to the public and the press as well as to politicians, the fact that surveillance has not been a big issue at the sites
Verify that traffic problems are actually solved by road pricing	Focus on traffic behaviour rather than political issues before implementation and communicate clear and distinct facts on effects on traffic behaviour
Support tends to increase after implementation	Undertake measures to increase options for people influenced by the system when it is implemented
Misconceptions easily arise	Map the possible misconceptions give extensive and clear information on how these topics are going to be solved
Aesthetic issues are important	Involve an architect or urban designer when planning for roadside equipment
Easy payment channels are requested	Facilitate payments by supplying several purchase channels with high accessibility
Time to become accustomed to scheme should not be underestimated	Approve a fair time schedule - a short time schedule may undermine the possibility to use road pricing to solve traffic problems in the foreseeable future