CUPID
Co-ordinating
Urban Pricing
Integrated
Demonstrations

# CUPID
# DELIVERABLE 3
# STATE OF THE ART – FREQUENTLY ASKED QUESTIONS

**EUROPEAN COMMISSION**
**COMPETITIVE AND SUSTAINABLE GROWTH**
**(GROWTH) PROGRAMME**

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Co-ordinating Urban Pricing
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# 0. EXECUTIVE SUMMARY

The main aim for CUPID is to provide and advance state of the art knowledge on urban transport pricing schemes through a European cross-level site assessment of city demonstration project results to produce robust policy recommendations and to widely disseminate the results. An important part of the assessment will be the liaison with the demonstration cities, gathered in the PRoGRESS-project and guidance for other cities interested and willing to take another step towards the introduction of pricing schemes.

CUPID is a Thematic Network supported by DG TREN of the European Commission, just like PRoGRESS. The network comprises experts from 6 European organisations: Transport & Travel Research Ltd (UK), ISIS (Italy), ITS Leeds (UK), SINTEF (Norway), TIS.PT (Portugal) and the Technical University of Dresden (Germany). The CUPID-website: www.transport-pricing.net.

The main goal therefore for this CUPID Deliverable 3 is to provide cities and other organisations with information which has already been gathered regarding the introduction of urban transport pricing. This information is based on frequently asked questions regarding urban pricing issues. The FAQs cover a wide range of subjects:

- Which kinds of charging can be implemented? Ideally, road pricing charges should be applied universally, because wherever boundaries occur there are likely to be losses of efficiency. In reality due to acceptance, legal and other constraints this is usually not possible. When implemented the possible options are: supplementary licenses, point or cordon pricing and congestion based pricing. The more flexible the pricing solution the more advanced the chosen technology needs to be.

- How to set charges: the critical prerequisite for calculating marginal social costs is the ability to derive reasonable realistic estimates of the external costs on which charges should be based. Currently the best solution is through the use of a model application based on city data. If this is not possible cities have to rely on calculations made elsewhere. An important extra question here is whether drivers who have to pay road charges should no longer pay periodic license fees and fuel taxes. Here two distinctions have to be made. The first is between road travel costs that are dependent on precise timings and location of individual journeys and those which are dependent on more general car ownership and usage. The second is between those elements of road travel costs which fall under local jurisdiction and those which are addressed at the national level.

- How to achieve public opinion in favour of road pricing? The general rules are that 1) The objectives of the pricing strategy have to meet main public concerns, for example environmental benefits and congestion reduction. 2) Pricing strategies have to be perceived as effective solutions. 3) Revenues must be hypothecated within the transport sector and alternative transport modes have to be provided. 4) Fairness issues have to be considered very carefully. The system must be perceived as fair in particular relating to the personal cost-benefit-relationship. 5) Charging only for new facilities can be a relatively easy way to introduce road pricing. 6) Public acceptability can only be expected if people have confidence in the effectiveness of the measure, the use of the revenues, the fairness, transparency and confidentiality of the system. 6) The necessary publicity calls for an intelligent communication strategy. Past experiences resulted in some rules of

thumb for the communication strategy and three stages for implementing road pricing with their own merits for optimising acceptability.

- What is the practical meaning of fair pricing? There are certain definitions of fairness. The definition the EU uses however is based upon a concept of fairness made operational through marginal social cost pricing. This means e.g. linking charges with internal and external costs. Therefore charges will be highly differentiated regarding for example time (whether travelling in the rush hour or not) and place (prices should be higher in bigger cities and lower in rural area) of travelling. People should however have a right to reasonable conditions of access, quality and price of transport, as a guarantee of non-exclusion on an economic basis. Once relevant public transport alternatives are available, significant increases in road user charging could occur. The final implication of the EU-policy is that transport costs should equal transport benefits.

- How to obtain money for financing set-up costs? This is possible via 1) Full Public Private Partnership: the local authority may wish to establish a separate entity jointly with the private sector, which is able to implement the road pricing scheme, and develop complementary measures such as public transport schemes. 2) Partial Public Private Partnership: an approach which involves the local authority administering a scheme, but enabling the private sector to invest in selected elements of the scheme whilst benefiting from revenues raised. 3) Privately financed publicly operated scheme: a more conventional approach would see the local authority develop the scheme on its own initiative, but raising private finance to support identified elements of the overall scheme. 4) Public sector investment: a viable road pricing scheme will incur significant start-up costs before it becomes viable. Only when these costs are met will any operating surplus be released to support infrastructure investment.

- How to overcome legal and institutional framework barriers? The legal barriers to urban road user charging in the majority of EC member states are quite specific. It is difficult for the individual city to achieve a change in this situation alone. Primary legislation is required to enable road use charging to be implemented. Once the primary legislation is in place, authorities will need to give consideration to a number of secondary issues, such as the need for access control systems to be consistent with existing legislation. Enforcement systems must be designed not to infringe concerns over data protection and civil liberties. And a commitment to the hypothecation of revenues to transport investment may be required in order to ensure that the scheme is deemed to be acceptable. Institutional barriers are likely to vary greatly between member states. The key issue to consider is the importance of ensuring a broad base of support for any scheme at the outset. This can only achieved by a process of consensus building whereby the proposals are supported by the key actors and by the public. Success will depend greatly on the existing structures within the area. It is likely that a series of key actors will need to co-operate effectively.

- Why should charging be considered as one of the solutions for urban traffic problems? The problems of increasing traffic levels are well known and understood. Charging is not the sole solution of our traffic problem. It is a part of an integrated strategy, which consist of different strategies. To influence mobility behaviour direct user fees like road pricing which have to be paid in connection with personal road use are particularly effective.

- What are the impacts of charging on traffic flows and net economic benefits? Regarding traffic flows: operational benefits from reduced traffic flows result primarily from the improvement in road operating conditions when users divert to other forms of transport or to other periods. Reduced vehicle kilometres will also result in accident benefits, although these may be offset by increases in vehicle speeds due to a reduction in congestion. The Singapore system saw a 50% reduction in morning peak flows. The economic benefits of road pricing will vary in accordance with the approach taken to scheme design. Most Road User Charging studies and implementations to date have strongly indicated that any Road User Charging scheme should be self-financing and generate substantial revenue which can be used, for example, for other transport measures.

- How to use road capacity and revenues obtained by implementing road pricing? In reality, road pricing schemes are likely only to address the most severe impacts on congestion in city centres. Therefore any reduction in traffic will help to reduce congestion in the short to medium term, but will not necessarily enable the reduction in highway capacity. The key benefit of road pricing to the business sector is that it enables efficient access for goods and people, and measures to reduce such access are likely to result in a loss of support from this sector. The revenues from congestion charging may be used in three ways: a) They can remain within the road transport sector and therefore benefit those who pay them: this will reduce congestion but not control car usage. b) Revenues could be used for financing other parts of a comprehensive strategy to deal with. c) Alternatively, these revenues would allow other taxes which are currently used for the public financing of infrastructure but which are largely unrelated to the costs of infrastructure use to be cut.

The descriptions of the 10 most relevant non-technical EU-projects in the 4$^{th}$ framework regarding to transport pricing for cities, being: CAPRI, EUROTOLL, PETS, QUITS, CONCERT, TRANSPRICE, TRENEN II, AFFORD, PRIMA and PATS provide us with an overview of road pricing research already implemented.

An international overview of road pricing was recently undertaken for the INTERCEPT project, which is supported by DG TREN and DG INFOSOC. This overview provides insights regarding: Approaches to road user charging, technology characteristics of road pricing, electronic fee collection in operation, information about already implemented schemes (and available links to releavnt websites), planned and imminent schemes and a focus on Europe, including: standards, EC-research, summaries of case studies and an international overview of road pricing projects.

# 1. INTRODUCTION

## 1.1 Background

In recent years, considerable research has been undertaken regarding implementing urban pricing projects. In reality however many uncertainties remain concerning the terms and conditions for successful implementation. It now seems clear that large demonstrations are necessary to provide basic empirical evidence on how best to balance important issues, so as to support the identification of urban pricing policies and their effective design and implementation.

The main aim for CUPID is to provide and advance state of the art knowledge on urban transport pricing schemes through a European cross-level site assessment of city demonstration project results to produce robust policy recommendations and to widely disseminate the results. An important part of the assessment will be the liaison with the demonstration cities, gathered in the PRoGRESS-project and guidance for other cities interested and willing to take another step towards the introduction of pricing schemes.

The information of the experts in CUPID is based on national and international projects regarding transport pricing. In the Fourth Framework RTD Programme from the EU, 10 projects were funded on the theme of transport pricing; 9 R & D projects and a concerted action - CAPRI. Three projects dealt with inter-urban pricing - EUROTOLL, PETS and QUITS. Of the seven urban pricing projects - CONCERT (3 sites) and TRANSPRICE (8 sites) undertook pricing demonstration projects, TRENEN II conducted an economic efficiency assessment to evaluate optimal pricing packages, AFFORD developed this to assess practical measures to implement marginal cost pricing allowing for different institutional contexts, equity arguments and acceptability. PRIMA, now completed, and the ongoing PATS project further extend the assessment of pricing acceptance.

At present, the State of the Art for Urban Pricing is based largely upon research and limited trials. At present, there are very few examples of road pricing-based demand management world-wide. The only established area-wide demand management example is in Singapore where a permit based city centre Area Licensing Scheme (ALS) has been operational since 1975, with electronic road pricing introduced in 1998. The main European examples of road pricing are in Norway, where schemes are operational in Oslo, Bergen and Trondheim. A variety of other experiences have been gained elsewhere including schemes in Portugal, California, Toronto, Melbourne and Hong Kong.

## 1.2 The CUPID Thematic Network

CUPID is a Thematic Network supported by DG TREN of the European Commission. The network comprises experts from 6 European organisations:

- Transport & Travel Research Ltd (UK)
- ISIS (Italy)
- ITS Leeds (UK)
- SINTEF (Norway)
- TIS (Portugal)
- Dresden University of Technology (Germany)

The Network will undertake a variety of activities from 2000 until 2004. Key Deliverables will be made available on www.transport-pricing.net.

A key objective of CUPID will be to provide support to the cities in the PRoGR€SS project which is also supported by DG TREN.

## 1.3 Objectives of Deliverable D3

The main goal therefore for this CUPID-deliverable D3 is to provide cities interested in large demonstrations and related organisations with information already known regarding the introduction of urban transport pricing.

Internal brainstorms in the CUPID consortium and liaison with the eight PRoGR€SS cities revealed some questions that are frequently asked by cities regarding urban pricing issues. These frequently asked questions (FAQs) and their answers form the basis of this deliverable. The FAQs cover a wide range of subjects:

- Which kinds of charge can be implemented?
- How to Set Charges?
- How to achieve public opinion in favour of road pricing?
- What is the practical meaning of fair pricing?
- How to finance set-up costs?
- How to overcome legal and institutional barriers?
- Why charging should be considered?
- What is the impact of charging on traffic and the economy? and
- How to use road capacity and revenues obtained by implementing road pricing

The individual chapters and paragraphs covering the above subjects, specifically chapters 3 to 5, can be read individually and are written with this aim in mind. This makes it easy for the reader to find an overview of the information he or she needs without having to read the whole report. The table of contents and Table 1.1 may help in that respect.

Included in this deliverable, serving as interesting sources of information to deepen the subjects mentioned above are:

- the descriptions of the 10 EU-projects in the 4$^{th}$ framework regarding to transport pricing being: CAPRI, EUROTOLL, PETS, QUITS, CONCERT, TRANSPRICE, TRENEN II, AFFORD, PRIMA and PATS; and
- an international overview of transport pricing projects.

## 1.4 Content and set-up of Deliverable D3

The content is grouped around subjects of interest for cities implementing or planning to implement large demonstrations regarding urban pricing. Chapter 2 provides a broader perspective on charging. It covers information on the kinds of charging that can be implemented (§2.2) and the setting of charges (§2.3). Chapter 2 also raises some of the issues which form subjects in chapters 3 to 5, for example acceptability, financial and political constraints. Chapter 3 is about social acceptance: getting the public opinion in favour of road pricing (§3.2) and the practical meaning of fair pricing (§3.3). Chapter 4 contains information about implementing road pricing: obtaining money for financing set-up costs (§4.2) and to overcome legal and institutional framework barriers (§4.3). The subject treated in chapter 5 is

assessment of road pricing. Charging as one of the solutions for urban traffic problems (§5.2), the impact of charging on traffic flows (§5.3) and to use road capacity and revenues obtained by implementing road pricing (§5.4).

Appendix A contains the description of 10 EU 4$^{th}$ framework projects regarding transport pricing. These projects might help the cities interested in specific issues to obtain more information. Each individual project addresses a number of the issues presented in Table 1.1. Appendix B is about examples of transport pricing projects already implemented throughout the world (Singapore, Portugal, California, Toronto, Melbourne and Hong Kong). This chapter focuses in particularly on the more technical aspects.

## Table 1.1: Subjects Covered By Chapters 3 To 5 In This Report

| | Which kinds of charge can be implemented? | How to set charges? | How to get public opinion in favour of road pricing? | What is the practical meaning of fair pricing? | How to finance set-up costs? | How to overcome legal and institutional barriers? | Why charging should be considered? | What is the impact of charging on traffic and the economy | How to use road capacity and revenues obtained from pricing? |
|---|---|---|---|---|---|---|---|---|---|
| | **2.2** | **2.3** | **3.2** | **3.3** | **4.2** | **4.3** | **5.2** | **5.3** | **5.4** |
| (Marginal social cost) pricing | | ■ | | | | | | | |
| Acceptability | | | ■ | | | | | | |
| Charging as solution for traffic problems | | | | | | | ■ | | |
| Communication principles | | | ■ | | | | | | |
| Data deficiencies | | ■ | | | | | | | |
| Differentiate between users | ■ | | | | | | | | |
| Economic benefit | | | | | | | | ■ | |
| Enforcement approaches | ■ | | | ■ | | ■ | | | |
| Exempt from road pricing | ■ | | | ■ | | | | | |
| Fair pricing | | | | ■ | | | | | |
| Financing | | ■ | | | ■ | | | | |
| Impact on traffic flows | | | | | | | | ■ | |
| Legal and institutional barriers | | | | | | ■ | ■ | | |
| Level of technology | ■ | | | | | | | | |
| Political decision process | | ■ | | | | | ■ | | |
| Public opinion | | | ■ | | | | | | |
| Spatial coverage | ■ | | | | | | | | |
| Stages of introduction of pricing | | | ■ | | | | | | |
| Stakeholders | | | | ■ | | | | | |
| Use capacity and benefit | | | | | | | | | ■ |

# 2. PERSPECTIVES ON CHARGING

## 2.1 Introduction

This chapter focuses on the approaches to charging. Subjects covered are: the area to be covered (interurban, urban, city centre) and possible schemes (e.g. paper license, area licence enforced using digital cameras, electronic road pricing and workplace parking levy for example).

It also includes a section on the approaches to setting prices on a sound basis. Subjects covered are: how to calculate adequate proxies of marginal social cost, covering costs, interlinkages between cost calculation and financing and how can political decisions influence the pattern of costs.

Although each paragraph in the State of the Art can be read on its own, this chapter serves also as a general introduction for the chapters 3 to 5.

## 2.2 What kinds of charges can be implemented?

### 2.2.1 Different practical charging methods

There are a number of possible practical approaches for levying road pricing charges which have been reviewed in the literature**.**

*Supplementary Licences*

At the simplest level, *supplementary licenses* can be applied, under which drivers need to purchase a permit to allow them to drive in a particular location and/or at a particular time. This can be introduced using no more than paper licences, but may ultimately operate more efficiently through an electronic tag similar to those used by the Norwegian toll rings. The primary disadvantage of such a system is that it has only a limited potential to encourage efficient travel behaviour. Typically, licenses might be expected to cover a period rather than a single day and, once purchased, may encourage the driver towards maximum car usage in order to perceive value for money. In addition, it may prove extremely difficult to concentrate the operation of licenses in time and space to coincide effectively with the generation of external costs. For example, a license to permit access to the city centre would, in many situations, address only a minority of the externality problem and, if operated throughout the day, would not distinguish between peak commuters and inter-peak shoppers, with potential implications for city centre retailers. Equally, a broader licence for the full urban area would not distinguish between local traffic on uncongested local roads and commuters on congested radial routes.

*Point or Cordon Pricing*

A more advanced approach, which has tended to be the focus of many research and practical feasibility studies regarding road pricing, is *point* or *cordon pricing*, under which vehicles are charged a fixed fee each time they pass a particular point in the network. Such charges are already common to cover operating costs for major bridges and tunnels and can be operated

manually (via toll booths) or electronically (such as through smartcard technology interacting with either roadside microwave beacons or a Global Positioning System). Some existing point charging schemes (eg the Dartford Tunnel in London and the Oslo Toll Ring) use electronic tag technology. However, this is only feasible where frequent users are offered the option of a periodic payment at a discounted rate, which removes the primary efficiency advantage that the approach has over supplementary licensing: that the payment relates directly to the number of times the charged area is accessed.

*Congestion charging*

Within the research community, there has also been a significant amount of work carried out investigating more continuous charging systems, which seek to charge at a level more closely linked to congestion. The most feasible of these mechanisms would be distance-based charging, where vehicles would pay fees at pre-specified rate per kilometre throughout the trip. This approach is only possible with smartcard technology, but can be achieved with a small and relatively simple in-vehicle unit, in communication with roadside beacons or a Global Positioning System. The advantage of such a system is that it allows charges to relate directly to road usage throughout a wide area. It could also be set up to modify the charge rate in time and space, so that higher charges could be levied on congested major routes in peak periods. The main practical disadvantage is that there is no low technology alternative. Therefore, it would not be possible to introduce a distance-based scheme with an initial manual or paper-based payment system pending mass application of smartcard technology. Also, once the system was in place, it would be necessary to deal with unequipped vehicles (e.g. visitors) through a simpler charging approach until such time as smartcard technology becomes universal. However, as a feasible long-term objective, road pricing based on in-vehicle calculations of travel distance may offer the greatest efficiency benefits.

*Workplace Parking Levies*

There are certainly other ways to levy additional charges on motorists. Parking charges are already widely accepted in Europe, and provide an excellent means to deter parking in public spaces. This does not address the volume of private parking found in the city centre (around 50% of total parking capacity in many city centres), and in the UK, the national government is proposing to enable *workplace parking levies* related to the volume and usage of privately owned parking capacity currently provided free of charge to employees. However, such schemes are primarily relevant only to a subset of drivers within the central business district (due to the likely availability of free on-street parking outside the centre) and are most likely to operate as a periodic tax on businesses rather than a daily charge for employees. Even if efforts were made to achieve the latter, it would almost certainly be impossible to relate the charges to features of drivers' journeys in time and space which are an appropriate proxy for external costs. Therefore this approach, although of some relevance to the debate on road user charging, it of less benefit when wider objective of economic efficiency are considered.

### 2.2.2 Selection of Optimum Approach

In very broad terms, there are three (significantly inter-related) dimensions to the decision between the different approaches:

- the ability of the system to differentiate between users in relation to the external costs generated;

- the level of technology employed; and
- approaches to enforcement.

*Differentiation between users*

In general, authorities are likely to need to differentiate between users. The specific needs of residents, employees, deliveries, emergency services, and a variety of other groups such as disabled people will have to be addressed in a publicly acceptable manner in order to build acceptance for a pricing scheme.

Most cities interested in urban pricing projects want to keep exemptions to a minimum. However groups such as service vehicles (maintenance, garbage, utilities) and emergency, residents, disabled people and public transport are the categories that may require full exemptions. The charges may be differentiated for the following groups as well: elderly people, freight operators, commercial activities, shop owners, employees and students in toll areas.

Examples: Rome, Trondheim

Current examples in the EU regarding urban pricing are Rome and Trondheim. In Rome exemptions are an important issue. The whole process is currently being revised because the permit process including the exemptions was governed by different regulations. Now one regulation will handle all permits. In Trondheim emergency services, public transport, disabled drivers, two wheelers and battery powered vehicles are exempted.

For emergency or services entrances procedures need to be established, e.g. how to handle entries and exits from hospitals present in the pricing zone and how to handle unanticipated entrances by police? In Rome these issues are currently expected to be solved in the following way: Police, CRI, Military will be handled by licence plate reading, while other temporary authorised entrances will be handled by reservation (appointments at hospital, staying at hotels etc. Otherwise, emergency entrances will be handled by a post-justification once the sanction has been issued.

Supplementary licence or cordon tolling schemes based around paper permits or passes are restricted in the complexity of differentiation permissible because of the need to enable operators to distinguish visually between user classes. This approach may be made more flexible by the introduction of simple technological innovation such as bar-coded permits, but any scheme must be clearly enforceable.

Electronic pricing schemes, such as smartcard tags or GPS monitoring enable a wider range of differentiation between user type to be monitored.

*Level of technology for different kinds of road pricing*

In general terms, the greater the ability of a charging system to differentiate, the more complex and continuous it is likely to be and the more advanced technology it will require. Supplementary licensing schemes offer the potential for a degree of differentiation between users, but are comparatively simple in their approach, and do not identify particular trip making behaviour and issues such as distance travelled or duration of stay. Schemes based

around electronic tags give more flexibility since they can enable tags to be issued for difference purposes such as off-peak access only.

Toll and cordon scheme are more complex as they are related to the act of crossing a specific point or cordon. Multiple charge points or cordons can be introduced to enable the fees levied to be varied. Simple technologies, such as toll booths can be applied, but in many dense urban areas, the physical space required will not be available and an electronic system must be implemented.

Congestion charging schemes require continuous monitoring of vehicles in order to calculate distance travelled or even more complex indicators of external costs imposed. These systems may be GPS driven or utilise similar technologies. Whilst more complex and costly, many of these technologies already exist on a trial basis.

*Approaches to enforcement*

The third issue under pricing methods is enforcement, which relates closely to the technology adopted. For manual payment, such as roadside toll booths under point charging, enforcement is implicit as all aspects of the transaction take place in the presence of an operator who can differentiate by location, time of day or vehicle type, as required. Such an assumption still requires monitoring of toll booth operatives in order to detect potential fraud. All other technological approaches will require an enforcement effort additional to the original transaction to ensure drivers do not routinely abuse the system. In general, enforcement should become easier the more complex the technology adopted.

For example, for paper-based licenses, the only approach to ensure that drivers comply with the conditions of the system is to monitor all vehicles using the charged area. For most schemes, this may be best achieved through observation of vehicles displaying licenses entering the area, either manually (as was the tradition in Singapore prior to the introduction of electronic technology) or via cameras. In the latter case, the process may be largely automated by the use of number plate recognition technology to identify vehicles and compare them with a list of vehicles possessing valid permits. Indeed, the paper license itself might rapidly become redundant except as a receipt to prove that a vehicle should appear on the register. This means, of course, that licenses would need to be purchased for vehicles rather than for drivers and would not be transferable.

For electronic pricing technology, it is generally assumed that an electronic communication with roadside or satellite equipment would be the key enforcement mechanism, backed up by roadside vehicle recognition equipment to detect and broadly classify passing vehicles (to cater for unequipped or wrongly equipped vehicles). In the case of smartcard technology, the in-vehicle unit would be capable of providing not only a validation of the transaction, but also any details required to pursue a defaulter (e.g. vehicle registration number). However, this facility has civil liberties implications under some legal environments and, therefore, it has generally been assumed that a roadside camera would only be used to identify vehicles which do not satisfy the transaction criteria (as is the case in Norway).

For all enforcement approaches, careful consideration needs to be given to the proportion of transactions monitored. Much of the academic literature has assumed that this would need to be approaching 100 per cent, to meet credibility and acceptability constraints, prompting concerns that the administrative effort associated with enforcement could easily cripple a

road pricing system in a large city. However, compliance with most other traffic regulations is monitored (with varying degrees of success) through selective enforcement procedures and appropriately higher fines to deter regular disobedience, an approach which may be both more feasible to implement and more acceptable to drivers.

A related question concerns which authorities would be responsible for operating enforcement procedures and pursuing the resulting fines. It is normally accepted that existing general policing authorities would not be involved and that non-compliance would be treated as a civil rather than a criminal matter in legal terms. Therefore, there may be a need to create a new (or expanded) policing and penalty administration system dedicated entirely to traffic.

Examples of Approaches to Enforcement

Europrice identifies three principles that are necessary for an effective enforcement: 1) flexibility, so that enforcement can target problem areas, 2) adequate penalty charges, in order to discourage violation and 3) accuracy, for public acceptability.

Examples of three cities in the Europrice project are stated below.

Bristol: enforcement will take place electronically with the use of cameras and linkage to the driver vehicle licence authorities. It is envisaged that the non-payment violations will be treated as a civil offence as with non-payment of parking charges. Legislation is necessary for video footage to be admissible in court and to allow co-ordination with the driver vehicle license authority (DVLA).

Rome: The procedures are being revised; the envisioned version is that just like in Bristol the unauthorised drivers will be detected by detectors provided with video enforcement, in order to film the plates of the faulty vehicles. The owner of the violating vehicle will be identified by linking the system with the local administration and the Public Car Register (PCR). The sanctions through telematic systems are only valid if the Ministry of Public Works has previously approved the system and the related sanction procedures.

Trondheim: As in Bristol and Rome, in Trondheim pictures are being taken from number plates of unauthorised cars. The pictures are automatically transmitted to the toll road company. License numbers are matched with the National Vehicle Register files and invoices send.

For enforcement next to electronic tags, smart cards etc. often a licence plate recognition will be used according to the implementation plans for e.g. Bristol, Genoa and Rome (Europrice project).

The technology should also be reliable and safe in order to improve acceptability. The acceptability will improve if the person entering or leaving the part of the city for which the person has to pay does not have to stop, this driving situation is comparable with the situation in the past (see § 2.3.1). For acceptability reasons therefore using smart cards and microwave beacons are better then physical measures like ticket booths, toll gates etc. Privacy issues however need to be addressed very well when introducing electronic technology. More crucial even will be the FORTRIN research programme in Copenhagen. In this project a computer is installed in the car which will be able to charge the user according to vehicle type, distance driven, time and location.

For more information about the kinds of charging that can be implemented, contact the author: Dave Milne, Institute for Transport Studies, University Of Leeds, LEEDS, LS2 9JT, United Kingdom, e-mail: dmilne@its.leeds.ac.uk

## 2.3 How to Set charges?

### 2.3.1 Background to setting charges

The concept underlying road pricing is the economic theory of *Marginal Cost Pricing*. This suggests that an efficient transport system which provides maximum benefit to society can only be achieved if users pay the full costs of their travel (Pigou, 1920). Effectively, the highway is priced as any other commodity would be, at its market value, whilst and existing charge is made for the social impact of usage of the highway. Without road pricing, there is currently a discrepancy between the *Marginal Personal Cost* which drivers perceive (made up of their travel time, vehicle operating costs and any direct payments, such as parking charges) and the full *Marginal Social Cost* of their trip (which also includes *External Costs* such as delays to other travellers, negative impacts on the environment, uninsured accident costs etc). Moreover, driver perception of vehicle operating costs may be lower than the true cost and further distorted by the comparatively low marginal cost of car usage. A further market distortion is experienced amongst lower socio-economic groups who, once the investment in a car is committed, may not be able to afford the marginal cost increase of public transport over car usage.

In order to ensure that modal choice is based upon the true costs of an individual trip, economic welfare theory argues that drivers should pay an additional road price for each trip, equal to the sum of associated external costs.

In reality, the identification of road user charges will be a complex task, and, in the short term, will need to reflect a pragmatic compromise between imposing marginal social cost pricing, and the development of a pricing structure which is publicly acceptable and practical to operate. The decision will also reflect the wider objectives of the individual city, which may be more closely related to environmental or financial objectives than to economic theory.

### 2.3.2 The Influence Of Political Decisions

Since the definition of marginal social cost price is still a matter for conjecture, it is not expected that cities implementing pricing will adopt such a strategy in the immediate future. As more complex congestion-based charging schemes emerge, the technology will enable more complex pricing structure to be introduced, and so a more economically rigorous pricing structure will become a realistic goal.

Therefore, political decisions are likely to have a considerable influence on the ability to introduce marginal cost-based road pricing in European Cities. One issue is that the level and distribution of charges suggested by estimating external costs may not be consistent with existing policies towards the taxation of road transport. For example, where vehicle licensing and taxes on fuel are currently set at artificially high levels in order to raise revenues for the national treasury, imposing additional charges on road use equal to full external costs may be considered politically untenable. Also, existing policies towards different interest groups, based on characteristics of the vehicle or user, may not easily be compatible with an approach

to calculating charges which doesn't take account of them. So, politicians may be faced with a series of dilemmas over how to reconcile road pricing charges with other measures designed to promote economic activity and mobility for those with a perceived social need. A potential threat to efficient charging is the prospect that correct charge levels would only apply to a small percentage of travellers, due to widespread privileges and exemptions forced by compromises with other policy objectives.

On the other hand, political prudence may result in charges equal to full marginal external costs being viewed as a longer term objective to be achieved, along with other potential policy changes, over an appropriate period of time, rather than implemented from day one.

A second issue concerns political decisions regarding the complexity and geographical scope of a road pricing scheme. Modelling work in the AFFORD project has shown that a major factor affecting the pattern of charges and efficiency of a road pricing system is the concentration of charges in space. Put simply, the first-best optimum road pricing solution in economics assumes that every link drivers use from their origin to their destination has the capability of being charged. While this is clearly infeasible for any real-world application, it should be possible to define a realistic subset of links or sub-areas of the network which will give a *best-practice* second-best efficiency solution. However, if pre-existing political boundaries and lack of effective co-operation between different institutions means that the spatial parameters of a road pricing system are quite inflexible, then the resulting pattern of charges may be seriously sub-optimal to a degree where the very existence of economic welfare benefits may be threatened.

A third issue where political decisions are critical is the use of charge revenue. As stated above, there are still unresolved arguments between economists and practitioners about how revenue should best be spent. From a political viewpoint, there are very important issues relating to the comparison between the pattern of charges levied and the pattern of benefits resulting from the use of revenue. The decisions associated with this will ultimately determine whether a road pricing scheme is progressive or regressive in equity terms. In some cases, where a particular desired use of revenue results in a distribution of benefits that is significantly different to the distribution of charges, there may be a political desire to attempt to redress this through modification of the pattern of charges, so that, for example, a group which receives little or no benefit from the revenue is not expected to bear the full brunt of the charge. On the other hand, there may be a converse desire to use road pricing as a progressive taxation mechanism to force higher-income car owners to cross-subsidise the modes of transport used by lower-income non-car owners.

Whilst the following paragraphs explain how a theoretical model of Marginal Social Cost might be developed. Whilst, as discussed, full implementation is unlikely to be practical in the immediate future, the development of transparent and substantiated estimates of road user charges can only assist in the process of winning acceptability. It is also relevant to note that the groups on the right wing of the political spectrum, who would traditionally oppose taxation on road space and road users, are far more likely to accept a market-driven assessment of the costs of road transport than a charge which is perceived merely as a tax on motorists. The Adam Smith institute in the UK, for example has broadly supported social cost pricing from a free market perspective. Clearly, however, there may be debate on the value of social costs of many environmental impacts, but, a pricing structure which draws on the theory of the true cost of motoring, may be more acceptable to groups that would oppose a rationale based upon environmental or other criteria.

### 2.3.3 Calculating adequate proxies for Marginal Social Cost

The principle of marginal social cost pricing is much easier to describe than to implement. In particular, a critical prerequisite is the ability to derive reasonably realistic estimates of the external costs on which charges should be based. To date, there have been only a small number of studies which have focussed explicitly on external cost estimation. Given the general absence of evidence from real-world data and widespread modelling studies, the best approach for estimating external costs in any given situation is through the direct use of model applications based on local data. As the focus of the CUPID study is road transport, the most appropriate models would be those which provide detailed representation of road network interactions and congestion. Traffic modelling software packages, such as SATURN, TRIPS and EMME/2, are traditionally used to provide adequate representations of current travel conditions through static user optimum equilibrium assignment approaches. Modifying the modelling approach, to adopt a static system optimal equilibrium assignment, allows the external costs of congestion to be calculated (on a link-by-link and journey-by-journey basis). Proxies for other external cost elements can be added to the model generalised cost functions, as increments to distance, time and/or delay costs (assuming linear relationships). Any cost elements which relate more to the capital and maintenance costs of car ownership than to individual trips are rather more difficult to address in this way and may be better dealt with by simpler approaches outside the model although, as outline above, the discrepancy between real and perceived costs of motoring represent a serious market distortion.

### 2.3.4 Dealing with local data deficiencies

In situations where there is no access to a traffic modelling application based on local data, the only feasible approach for deriving estimates of external cost levels is to rely on calculations made elsewhere. Clearly, this may involve quite serious problems of transferability between locations, which may be expected to relate particularly to issues of scale, level of congestion and local topography.

UNIfication of accounts and marginal costs for Transport Efficiency (UNITE) is a Fifth Framework Project which is attempting to derive estimates for the levels of full social costs in European transport networks. It covers pricing and taxation policies for all significant passenger and freight modes at the urban, inter-urban and international levels. The approach involves developing 'transport accounts' (a comprehensive statement of all the costs, benefits and revenues associated with a given mode in a predefined geographic area & time period), using 'marginal cost' perspectives. The aim is to develop a framework, including real data, that can be used to demonstrate the levels of charge that are required to promote efficiency, while also showing (for example) levels of cost coverage, to allow consideration of other pricing objectives. Much of the work is based around case studies using real-world data & practical model applications. A series of case studies to be carried out in the UNITE project may be particularly useful in providing sources of alternative information about external costs and for shedding light on transferability issues.

### 2.3.5 Covering costs

While real-world examples of road pricing are few, all countries operate a national periodic license on car owners to allow their vehicles to use the road network and levy taxes on buying fuel beyond the level of normal purchase tax. This is generally seen as covering the costs of maintaining the existing road infrastructure and, in some cases, contributing towards transport infrastructure expansion. However, explicit hypothecation along these lines is rare

and, over time, most governments have come to treat both vehicle licensing and fuel taxation as significant general revenue raising measures for the national treasury.

The potential introduction of road pricing raises a number of important issues. In particular, the question is often raised regarding whether drivers who are subject to road pricing charges should no longer pay periodic license fees and fuel taxes, or should receive partial rebates. To provide a sound practical answer to this inquiry, two critical distinctions need to be made.

First, it is important to distinguish between those elements of road travel cost which are critically dependent on the precise timing and location of individual journeys and those which are dependent on more general car ownership and usage. Congestion and some aspects of environmental costs are primarily dependent on the precise definitions of a car journey in time and space and, therefore, the only behaviourally effective way to levy charges is on something approaching a trip-by-trip basis. On the other hand, the costs of maintaining the road network and many of the larger environmental externalities (eg carbon dioxide production) are not so time and location sensitive, depending more on vehicle specification and total kilometres driven.

Second, it is important to distinguish between those elements of road travel cost which, in practice, fall primarily under local jurisdiction and those which are generally addressed at the national level. Congestion and the negative impacts of road traffic on human living environments are primarily issues considered and dealt with by local government agencies at the urban or regional level. In contrast, significant transport infrastructure expansion, maintenance of the most important strategic routes and international responsibility for meeting carbon dioxide reduction targets falls most naturally to national government. Also, where road maintenance is the responsibility of local government agents, there are sometimes traditional institutional relationships between the local and national level. The use of revenues collected nationally to contribute towards local expenditure may be used to provide national government with an element of political control over local policymaking.

Therefore, it is clear that the most appropriate basis for road pricing is to cover journey specific congestion and environmental costs at the local level. These are costs for which there is currently no behaviourally effective cost mechanism and, therefore, they should be seen as additional to and, as far as possible, separate from existing national taxes. While it may be that the sum of road pricing charges and other national road travel related taxes would, in some cases, not equal the total external costs generated within the road transport sector, the reasons for this are essentially political and any resetting of national taxes to take account of it would, therefore, by definition, be a political decision. Certainly, economics supports the idea that the sum of all costs imposed within the transport sector should equal the full costs of use, in order to ensure efficient competition between modes, optimal land use decisions etc. However, in practice, it may be unrealistic to view changes in long-standing attitudes to national taxation as a prerequisite to introducing behaviourally efficient charges for infrastructure use. The implication of this argument is that cost coverage issues are largely peripheral to the road pricing debate. The main area where adjustment of existing charges may be required is in local parking and the primary cost constraint is that any road pricing system is sufficiently cheap to operate to ensure that net revenues cover costs and provide the potential for overall welfare benefits. "Previous research has produced varied estimates regarding the levels of operating costs for road pricing systems. In the United States, Small (1992) suggested that operating an electronic toll collection system for Los Angeles would cost less than 5% of revenue, assuming that charges were based on the external costs of congestion. However, in the U.K., the London Congestion Charging Research Programme

found that operating costs may account for between 13% and 33% of revenue, depending upon the choice of technology, for a range of practically motivated charging scenarios (MVA, 1995)."

### 2.3.6 How To Define The Geographic Structure For Pricing

CUPID specifically addresses the issue of urban pricing, but, ideally, road pricing charges should be applied universally, because wherever boundaries and discontinuities occur there are likely to be losses of efficiency due to drivers at the margins facing opportunities to avoid paying charges. One contributor to the long-standing success of road pricing in Singapore is undoubtedly the fact that the island environment provides the city with a natural closed system. Similarly, in Norway, geography has assisted planners by making it possible to define toll rings which are difficult to evade by alternative routes and which do not create economic tensions between neighbouring settlements.

However, most urban environments do not have these advantages and defining the spatial extent of the system and the precise locations of charging points is likely to be critical to achieving an efficient outcome. The key elements of the problem are as follows:

- there is likely to be a simple trade-off between spatial coverage and the absolute magnitude of the impact: a road pricing system which covers only the very central core of the city will probably affect a relatively small percentage of travellers and, therefore, provide very limited congestion relief at the city-wide level;
- in order to improve the efficiency of road use throughout the city, the geographic spread of trips interacting with the urban area needs to be considered: if a significant proportion of journeys have origins or destinations beyond the main developed urban area (as may be common with smaller cities), then the best-practice second-best solution may involve levying charges across the travelling region rather than solely within the city boundary; and
- the impact of driver route choice has tended to be underestimated within the economic approaches, leading to the (potentially false) assumption than an effective proxy for efficient pricing may easily be achieved through the definition of a simple charging cordon: in practice, the spatial complexity of travel demand and network topology in the real-world may make it difficult for practitioners to define successful cordon structures purely on a judgmental basis.

The implication of these issues is that the modelling approaches used to estimate appropriate levels of charge should also be applied to investigate questions of location.

### 2.3.7 Catering for service providers within the urban area

According to the economic theory, all traffic should be charged for the external costs generated, regardless of journey purpose, vehicle type etc. Clearly, this will not happen in practice and exemptions (or significant discounts) will need to be given for emergency vehicles, essential services, the disabled etc. There is no unanimous and comprehensive view on the precise form such privileges would need to take at present. However, one thing that is clear is that it is difficult to make a valid efficiency argument for providing exemptions to public transport, taxi services or delivery vehicles. In the case of public transport, the higher vehicle occupancy should mean that the cost increase per capita is minimal and may be more than offset by the cost and reliability benefits of reduced congestion. In the case of taxi services, the increased cost of the trip would be justified and would provide incentives to schedule journeys more efficiently and reduce ‘empty running’. Equally, for delivery

services, the increase in travel cost would be valid and should be passed onto the customer to ensure efficient activity and location decisions. Indeed, with the potential e-commerce revolution in the coming years and the uncertainty over whether this will result in more or less efficient goods travel patterns, it is absolutely essential that businesses transporting goods are faced with the full social costs of their activities.

The key issue which unites service providers is that they are likely to be extremely frequent road users. It is easy to imagine a taxi or postal delivery van passing a particular point on the road several times in both directions during a peak period. Therefore, service vehicles will fare differently under the alternative pricing methods available. As stated above, supplementary licensing is likely to encourage frequent use during the charged period and, therefore, would have the smallest impact on service vehicles. On the other hand, point pricing could have either a negligible or extremely large impact, depending on the precise pattern of journeys made. A charging point close to a railway station or major delivery centre could involve service vehicles making multiple crossings during relatively short trips and incurring charges far in excess of external cost. By far the best system for levying a fair charge for this traffic would be distance-based charging. However, whichever system is in force, service providers are likely to lead the lobby for payment systems involving frequent user discounts. If such options are to be offered, they should be costed at a level appropriate to the total externalities generated by circulating business traffic, to ensure that they do not provide an attractive discount option for daily commuters.

Transportation of freight is an important issue for almost all the cities trying to implement urban pricing schemes. The cities want to maintain or enhance the economic vitality of the urban area, after the introduction of the pricing scheme. Obviously an important solution for congestion can be the introduction of urban pricing. On the other hand, if transporting freight to and from the cities becomes too expensive, business might move elsewhere as well.

In order to implement pricing successfully, it is essential to ensure introducing urban pricing has more benefits then disadvantages for the local businesses. Ideas already stated by Europrice cities to influence this situation are:

- stop charging in the evening or introduce free city centre parking in order to maintain a healthy leisure / recreational economy;
- part of full exemption for freight transporters or business as a whole; and
- to allow commercial traffic to only pay for a maximum amount of crossings per month.

For more information about setting charges, contact the author: Dave Milne, Institute for Transport Studies, University Of Leeds, LEEDS, LS2 9JT, United Kingdom, e-mail: dmilne@its.leeds.ac.uk

# 3. SOCIAL ACCEPTANCE

## 3.1 Introduction

Social acceptance plays a vital role in the feasibility of the implementation of a road pricing problem. It depends upon the real and perceived benefits of the introduction of road pricing. In general three difficult aspects have to be addressed: social exclusion, economic vitality and the privacy of users. While implementing the pricing issues communication programmes have to run in order to raise awareness and to present to road charging project as the best possible solution for the urban traffic problem. Paragraph 3.2 will present a more in-depth analysis regarding this issue.

The EU does not have a specific policy regarding acceptability for urban pricing projects. But the EU does have a policy on fair and efficient pricing. Fairness is strongly linked with acceptability. If the urban population does not perceive the urban pricing as fair, the local government will meet great difficulties when trying to implement the project. Paragraph 3.3 aims to provide a link between the EU-policy and its consequences for EU-cities implementing pricing projects: the practical meaning of fair pricing.

## 3.2 How to achieve public opinion in favour of road pricing

There are no simple solutions for obtaining acceptability for road pricing measures. However, in terms of public acceptability at least some general rules should be considered in order to make an implementation of a transport pricing measure more likely. (cp. Schlag & Teubel, 1997; Schade, Schlag, et.al., 2000, Schlag & Schade, 2000). These shall be reported in the next section. More specific a communication strategy as one of the main pillars of the introduction procedure has to be designed which “sell“ the measures. In a broader context the whole decision process affects the public opinion. Thus, a tentative process structured into stages which considers acceptability will be reported in section 3.2.4. Finally, one successful introduction of road pricing in the light of "getting the public opinion in favour of road pricing" shall be presented.

### 3.2.1 General Rules

The objectives of the pricing strategy have to meet **main public concerns.** Politicians and the public regard traffic problems in cities as a very important and urgent issue. There is a search for solutions. Thus, marginal cost pricing should give rise to environmental benefits and congestion reduction (and these have to be communicated), safety contributions and other advantages should be perceived and it should meet positive social norms (Goodwin, 1989). A number of guidelines to successful implementation can, therefore, be suggested.

- Pricing strategies have to be perceived as very **effective solutions**, if not as the only effective solution for the perceived traffic problems. People are used to regard public roads as “free“ goods, therefore there will be strong emotional resistance to any attempt to charge for them. If you want people to accept charging for road use or parking there must be very good and convincing reasons. Perhaps the best reason is, that this is the best way of solving perceived urgent problems. The effectiveness of transport pricing may be high but this is not guaranteed and depends on the definition of objectives. The efficiency will be comparatively very high - from the cities’, but not from the

motorists' point of view. Thus, not only the objectives of the intended measures must be valued highly by the public, people must also believe that their behaviour contributes to reach these objectives. The values as well as the expectations (the perceived probability to reach these objectives) should be made transparent and first trials of a new behaviour must be successful so that the new behaviour is perceived as effectively contributing to reach the shared values, thus creating positive contingencies between the behaviour and its consequences.

- **Revenues** must be **hypothecated** and alternatives have to be provided. People want to get something for their money. Thus, there must be a package solution, combining traffic restraints and road charging with a set of transport and environmental improvements (cp. Jones, 1998; Schlag & Schade, 2000).
- **Fairness** issues have to be considered very carefully**.** The system must be perceived as fair in particular relating to the personal cost-benefit-relation. The benefits people see for themselves must balance their costs at least in an immaterial way (e.g. by reaching other valuable objectives). In addition people should not feel to be treated unjust in comparison to others. An important role plays in this context the use of the revenues. With the help of the raised charges it is possible to influence the distributional impacts in the desired direction. Hypothecation of the revenues must result in guaranteeing a desired level of mobility for all, even supporting mobility chances for some groups thus meeting equity issues on a population level (Bannister, 1994; Guiliano, 1994; Langmyhr, 1997; Schade et al., 2000)
- **Charging** only **new facilities** can be a rather easy way to introduce road pricing. Using road pricing only for new infrastructure has a better chance of acceptance, as there is a net benefit form the new investment.
- Public acceptability can only be expected if people have **confidence** among others in the effectiveness of the measure, the use of the revenues, the fairness and anonymity of the system. One precondition to support confidence is *transparency* of the intended measures at an early stage. Connected to transparency, for the acceptability of any change you have to create some commitment of people to the new ideas, perhaps creating some identification with the proposed package of measures. This commitment depends on early and credible communication, on positive experiences (at least by models), on the conviction that this is an effective solution, and on perceived chances of *participation*. People want to see themselves as having at least some degree of control over the things they are affected by. Thus there is a connection between participation, commitment, acceptability and later effectiveness. This points out the importance of early information and participation of people even in concept development. A second precondition for creating confidence is defined responsibility. Who will be responsible for the functioning of the system, for charging and accounting, for revenue allocation, for failures and undesired effects? This has to be defined clearly before implementing the system. Responsibility issues are of particular relevance in connection with the debate of privatisation. And finally, to meet the above requirements it is necessary to design a strategy to communicate the measures.
- The necessary publicity calls for an **intelligent communication strategy.**

### 3.2.2 Some Communication Principles

The communication strategy only works if it covers the whole package. From a psychological point of view a successful communication strategy should - among others - reflect the following principles:

- All the externalities have to be discussed in advance: creating awareness for the problem, then presenting a package of credible solutions.
- Positive objectives must be connected with most effective solutions to reach them. Thus transport pricing has to be communicated as a very effective means to reach commonly shared goals. This can make private costs more acceptable.
- There must be personally positive experiences in first trials changing the transport mode, e.g. time savings, less parking problems, ecological advantages, the possibility to participate in solving traffic problems, attraction of inner-cities etc. Positive experiences on first trials help to get used to the new behaviour. If the first experiences with a newly implemented system have to be positive to hold them, then investments in public transport must go ahead before pricing is introduced to reduce painful first experiences and to have the capacities available.
- The communication has to point out the positive sides of the package, i.e. the uses for which the road charges are used. This connection between push and pull - measures (see hypothecation) was not given in a sufficient way in former road pricing strategies (eg in Stuttgart, Germany) or it was not communicated transparently enough. (FAW, 1995).
- People must feel to have a choice, even if the choice alternatives are restricted and the inputs of their decisions have changed. If they only feel to be forced to compliance, some of them will show reluctance, a strong motive to change the situation for themselves and to restore former perceived possibilities to choose between alternatives. Crucial is the *perceived freedom of choice* (Weiner, 1993).
- If you can not convince people, external control to enforce the desired measures has to be very strong. But this external control will only work if a great majority of people generally agree with the measures and accept that people offending against these measures are enforced and punished. This will certainly work if no more than 20 or 30 per cent of all the people targeted oppose the measure. Thus you have to convince a great majority of road users and even of car drivers. The conviction of a great majority is not only a precondition for the acceptance of the measure, but also a precondition for the acceptance of the control against offenders.
- In addition positive information should be disseminated which corresponds with the desired attitudes and behaviour and negative information for undesired.
- Achieving changes in normative values is another strong element for establishing the new behaviour. Creating new norms on a collective and new intentions on a personal level may motivate to behave in a new manner to meet these new beliefs. But that must be experienced as valuable in a material and in an immaterial sense. Generally, the perception of the situation has to be changed - and this will influence the behaviour of people.
- The pricing scheme, and supporting measures must develop a new transport system, offering real alternatives (bus, tram, shared modes of transport), which are well known (information) and attractive in terms of price, convenience, availability and accessibility etc. Constraints to changes in behaviour must be identified and eliminated. Thereby mobility should not been diminished by transport pricing. Such a favourable situation is a precondition to break old habits and to realise new intentions. Thus positive first experiences with alternatives (in mode, time, route choice) can be understood as a learning exercise which demonstrated what can be gained from changed behaviour. In the first instance, positive expectations, positive values and positive outcomes may be partly communicated by models which explain the scheme, and get vicarious rewards (Bandura, 1977).

- The pricing message has to be communicated by very credible communicators (credible from the point of view of car drivers and other users).

### 3.2.3 Identification Of Stakeholders

It is important for cities to identify the key stakeholders, and to establish whether or not they support the introduction of pricing. Europrice Technical Paper 3 suggests that the most important stakeholders groups are:

- public transport,
- motoring organisation,
- freight transport industry,
- cycling and pedestrian organisation,
- road safety agencies,
- vehicle manufacturing and service industry,
- manufacturing,
- trade unions,
- environmental organisations,
- civic societies,
- interest groups (disabled people, elderly, women),
- chambers of commerce,
- health,
- financial institutions,
- public services,
- retail,
- leisure/tourist organisations,
- employers; and
- education establishment

Added to this list, of course, should be the general public.

The most supportive groups are likely to be public transport, cycling and pedestrian organisations, environmental organisations and employers. Traditionally, the most non-supportive organisations are: motoring organisations, civic societies, interest groups (unless exempt) and the retail sector.

In the UK, however, there is a growing acceptance that increasing congestion is leading to severe delays for drivers, and there is some support for pricing amongst the business community and motoring organisations provide that revenues are clearly ring-fenced to provide improved facilities. Similarly the view was “no, but it is a necessary evil (Trondheim).” The retail sector might be more in favour when toll only has to be paid during rush hour.

The chance for success for the urban pricing project will increase if the traffic problem is evident and the stakeholders are aware of this problem. The stakeholders should be involved in planning alternative transport. Road pricing and alternative transport, including improved public transport, should be part of a road pricing package. This package can also compensate groups whose welfare will decrease by the road pricing scheme. The stakeholders should be involved and consulted from the beginning and all the way through the process.

### 3.2.4 The Process Structured Into Stages

The PRIMA project separates three rather schematic stages of a process aiming at the introduction of a road pricing scheme (Harsman, Pädam, Wijkmark, 2000, 61-62). The first stage is political and strategic, the second consists of iterative assessments, and the third is oriented towards implementation and monitoring activities.

- *Stage I:* This stage starts with the identification and characterisation of a traffic/ transport problem. On this basis a project idea can be formulated by an assigned project management group (project organisation). At the same time the political system has (i) to provide legitimacy to the decision process, (ii) to establish compatibility of views expressed on the local, regional and national levels. At this stage a preliminary feasibility study can be carried out and the major results could be disseminated to the public and discussed in various forms. A final step in the first stage is to identify interest groups and design the decision process accordingly.
- *Stage II:* In the second phase a project organisation is formed to (i) make comprehensive assessment studies that generate alternative solutions, (ii) assess the different alternatives, identify potential winners and losers. At this stage it is meaningful to establish an information channel, by which the project organisation can communicate alternatives with the community (voters, stakeholders and other actors). In this context opposing groups may be invited to select an attached committee that can interact with the project organisation. Ideally, this interaction should result in a consensus about the nature of the transport problems and the set of effective (alternative) solutions. Finally, the end result of the second stage is the formulation of a plan for sequential decision-making.
- *Stage III:* The third stage may be thought of as the "implementation phase". This requires that the project organisation (project team) reorients itself to carry out the implementation and organise a systematic monitoring of consequences over time. In this stage project-management issues may dominate the process. An important task of the monitoring is to follow the ex post acceptance and to suggest further developments of the introduced system.

### 3.2.5 One Practical Example: The Oslo Toll Ring[1]

In the mid-eighties, the city of Oslo was confronted with unsatisfactory traffic flow with significant delays for all. Besides, there were local environmental problems with traffic hold ups and pressure on local streets and residential roads. The public funds for road construction were insufficient. To allow the financing of a road investment program, authorities decided to seek the required additional resources from users. The toll ring was to contribute to the implementation of different projects within 15 years, as opposed to 35 years financed by public grants.

Through the first part of the eighties there was an excited discussion. Different ways of payment were considered like petrol tax, a local toll ring for the Oslo tunnel, increased parking fees and an area based road tax.
Two different motives were proposed:

- To provide money for constructing roads and other transport infrastructure.
- To limit car traffic, completely or in rush hours only.

[1] The successful introduction of road pricing in the Norwegian cities and the reasons behind is described in Langmyhr (1999)

The political process towards implementation was difficult. Four years before the implementation, Oslo City Council and Akershus County Council passed a principle approval about tolls based on motivation 1. Two years later the toll ring passed the formal political approval. Just before that the Norwegian Parliament had changed the law. As a result of this law change, equivalent toll rings were also established in Bergen and Trondheim. After the principal political agreement followed a discussion about localisation. Here one had to combine fairness, maximum of income and practicability (e.g. available land to build toll stations). 210,000 of Oslo's inhabitants live outside the toll ring. In addition, approximately 200,000 of the region's remaining population frequently go to Oslo city centre. A discussion occurred of who would have to pay and who would not have to pay to go to the city centre.

The local majority consisted of the two largest political parties, the social democrats and the conservatives. Certain issues caused strong internal dissension. For example, a considerable group of young people within the labour party demanded that 30% of the revenues were to be allocated to public transport investments. The conservative party considered this breaking the initial agreement. This crisis was solved partly by a warning from the national authorities about a possible termination of national road and railway investments.

Two different factors made the agreement possible at last:

- Opposite regards gave the same substantial solution. The supporters of road construction were satisfied by the official arguments, while those against road construction wanted the toll ring because it would make an opportunity to limit the number of cars into the city when it was established.
- Local disagreement checked by public financial pressure. Fear of losing national grants made municipal politicians willing to make a compromise.

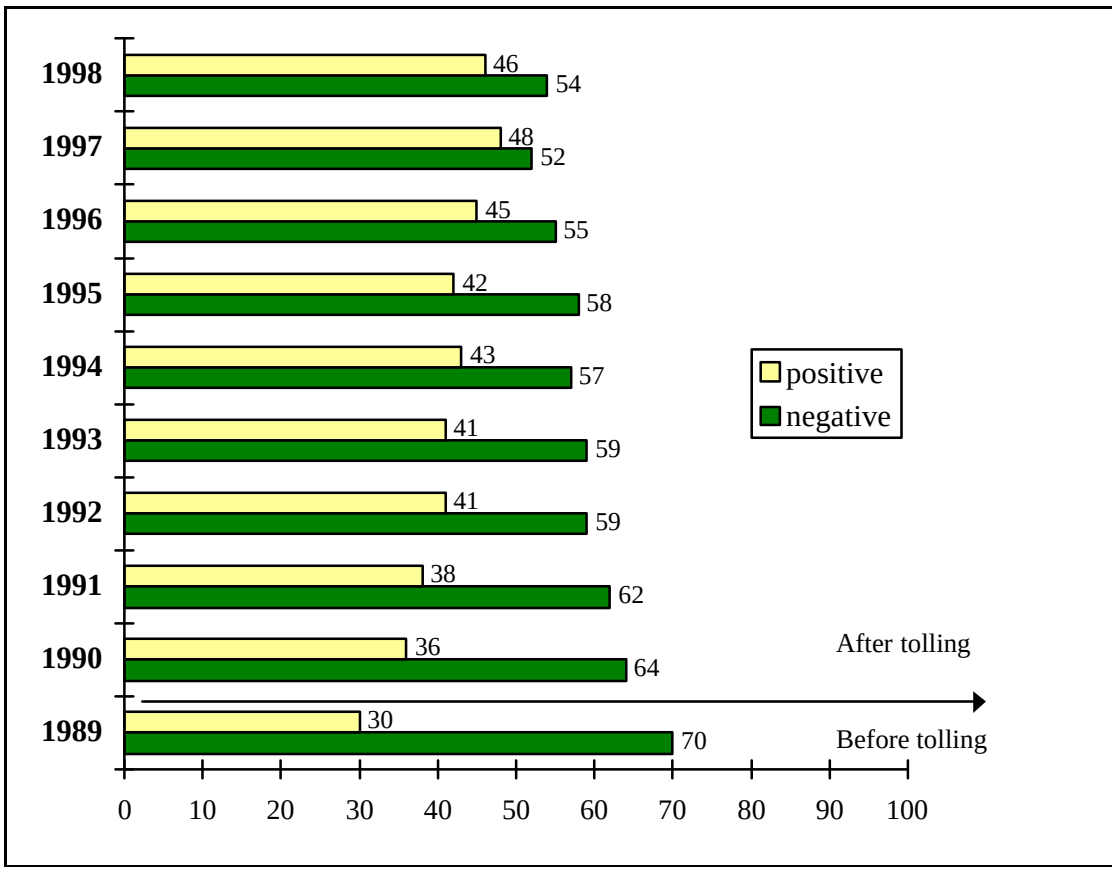
### 3.2.6 Public Acceptability Of Tolls

Norway has a long tradition of using road tolls as a way of financing road investments. It is politically accepted in all parties. Before the extensive toll systems were implemented in the cities, there were tolls on bridges and tunnels connecting the islands to the mainland. There is no general acceptability of road pricing as a demand management measure.

In general it has to be noted that attitudes before the implementation of the toll ring are based more on expectations and estimations rather than on real experiences with the system ('acceptability'). In contrast to the cross-sectioned stated acceptability the revealed behaviour after the introduction of the system ('acceptance') can be seen as a process of dealing with the adaptation to the new mobility situation.

In the year before the implementation of the toll ring, 70% of the city's population were negative towards the toll ring (see Figure 3.1). When the system had been operative for one year this opposition had been reduced to 64%. In 1998 this figure was 54%. The share being very negative has decreased from 40 to 17 percent during the same period. The share being positive to the toll system has steadily increased during the period, from 30 percent before the toll system opened to 46 percent in 1998.

**Figure 3.1: Development Of Attitudes Towards The Oslo Toll Ring (Norwegian Public Roads Administration Et Al. 1999, 9)**




The data show that public acceptance increases with successful implementation, thus showing, that it is possible to raise acceptance by implementing a carefully selected road pricing scheme.

### 3.2.7 Influencing Public Behaviour

Before introducing road pricing measures, alternative mobility-opportunities or modes of transport have to be provided. These alternative modes of transport must already be available, attractive and well-known so that new mobility behaviour is a positive experience, which - in turn - is most important when the road users change the mode of transport for the very first time. Of further importance is that behaviour can be shown in accordance with specific intentions and that the personal benefits of the behaviour outweigh its costs. In such way new habits, together with new normative behaviour expectations, can develop.

When considering the road users' cost-benefit-calculations it is usually assumed that road users always calculate in a rational way, i.e. that before deciding for a specific behaviour they weigh up its advantages and disadvantages, and this also in comparison to other possible behaviours. So for a modification of the road users' cost-benefit-calculations in order to influence behaviour there are four different options (see Table 3.1):

1. to decrease the expected benefits of a undesired behaviour[2] (e.g. restrict parking);

[2] Which has to be defined in advance

2. to decrease the expected costs of the desired behaviour (e.g. reduced prices of public transport, stations which are easy to reach etc.);
3. to increase the expected benefits of the desired behaviour (e.g. bonus for less vehicle km)
4. to increase the expected costs of the undesired behaviour (e.g. road charges)

**Table 3.1: The Variation Of The Road Users' Cost-Benefit-Calculation**

| | Benefits | Costs |
|---|---|---|
| Undesired behaviour | 1 ↑ | 4 ↓ |
| Desired behaviour | 3 ↓ | 2 ↑ |

But, in contrast to the assumptions above, people normally differ in what they perceive as an advantage or disadvantage. Thus, the outcome of the individual weighing-up of advantages and disadvantages is uncertain. Because of that, in practice common behaviour expectations and constraints are often used to control specific behaviour of *all* road users. For instance general threats of punishment for violation of rules increases the costs of undesirable behaviour and therefore suppresses them.

However, people often show reluctance if they are forced to behave in a way that they do not intend. Thus, the emotional value of the restricted behaviour (e.g. to drive free of charge downtown) for the people increases, they seek for loopholes to keep to the behaviour as usual, or they choose additional, unwanted options such as resistance.

In this regard a change in behaviour is not just to reach through heteronomy or external pressure (e.g. prices can be perceived as external pressure) but also - and more considerable - through a change in the individual attitudes of the affected persons. People must feel that they have a choice, even if the alternatives are limited and the inputs for their decisions have changed. If they believe that they are forced to comply they might show reluctance or they might attempt to change the situation for their own advantage and restore former perceived leeways. Crucial is the *perceived freedom of choice* (Weiner, 1993, 206).

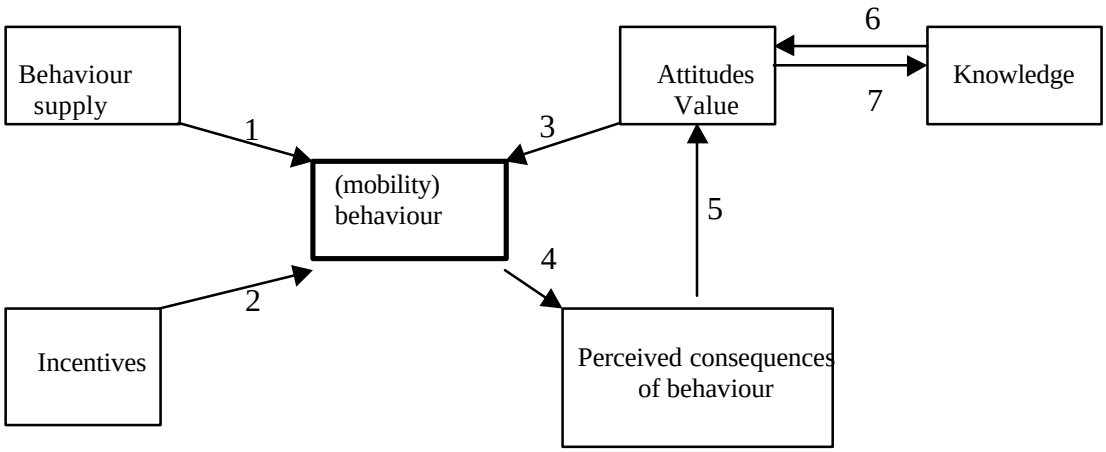
Psychological evaluative research has shown that one single measure on its own cannot lead to a lasting change in people's behaviour. To still be able to influence the behaviour of larger groups of transport users further important preconditions are to be taken into account.

First it is crucial to clearly define the aims of the measure, i.e. to define concrete desirable behaviour patterns (e.g. to use a specific mode of transport, to choose a specific route). Here it is advantageous to negotiate the aims in co-operation with the persons affected.

Second it is better to systematically build up the desired behaviour rather than just to respond to the shown target-behaviour (the so-called 'repair-principle'). For such a purposeful build-up of specific behaviours the following determinants must be considered:
(1) *Behaviour supply* (e.g. the providing of cars to share, of cycleways etc.),
(2) *Incentives* (e.g. the here described prices,
(3) *Attitudes and values* (e.g. environmental awareness) ...

(4/5) Feedback through the person's own *perception of the behaviour and its consequences* (i.e. not only negative feedback about errors, but also positive feedback for showing the desired behaviour);
(6) Change in *attitudes* through increasing the *knowledge*, for which especially positive behaviour patterns should be conveyed, and
(7) *Attitudes* as incentives for the accumulation of *knowledge.*

**Figure 3.2: Model of different behaviour determinants (Fietkau & Kessel, 1981, p. 10)**




Only combining attitudes, behaviour supply, price incentives, and the visibility of consequences of one's own behaviour makes a desirable behaviour possible. Hence, road pricing has to be an integral part of an integrated traffic demand management approach, which - apart from information campaigns - also covers supply modifications and legal measures.

For more information about getting the public opinion in favour of road pricing, contact the author: Jens Schade, Dresden University of Technology, Traffic and Transportation Psychology, D-01062 Dresden, Germany. E-mail: schade@rcs1.urz.tu-dresden.de

## 3.3 What is the Practical Meaning of Fair Pricing?

To arrive at the practical meaning of fair pricing, first a brief theoretical notion of fair pricing is presented, including the EC-policy of fair pricing. The practical aspects in this paragraph lay in the consequences of these European notions for cities and how fair pricing works in cities regarding the aspects linked with fairness: enforcement, exemptions, stakeholders and transportation of freight.

### 3.3.1 Brief Theoretical Notions Of Fairness

Pricing for an individual or institution is considered fairer when:

- Opportunities offered and type of access provided to an economic process are considered more equal (procedural notion of fairness). This means for example that two comparable cities in a country should feel treated the same and are provided with the same means and

constraints by the national governments when it comes to supplying public transport, building roads or extending harbours.

- The equality of the state in which individuals or institutions emerge from an economic process (end-state fairness). This fairness concept is related to the "differentiation principle". It consists in judging the results of the policies by analysing the welfare of the groups lagging behind. Implementation of the differentiation principle means that the aim is to improve the situation of groups with the lowest income (e.g. cheaper tickets for poor people) and of the least best served areas (e.g. improve public transport in rural areas).

Fairness is not pure rational and based on arguments only. An individual values / perception a situation more fair when:

- The situation is more consistent with practises of the past to which the individual has become habituated (Baumol, 1986); an when
- A good or service X distributed to the individual is considered superior by this individual in comparison with good or service Y distributed to another individual.

The above two notions mean that fairness assumes the existence of asymmetry of information and that individuals judge regardless of the valuation of the situation by other parties involved.

### 3.3.2 EC-Policy: Fair And Efficient Pricing

Within the policy of the EC, fair and efficient pricing are inseparable from each other. Fair and efficient pricing in the broadest sense means that prices reflect costs in order for organisations and citizens to base their decisions on the right price signals. This means that the interpretation of the EC on fairness has more to do with a procedural notion of fairness then an end-state fairness. According to EC principles advanced in its policy documents end-state fairness is better achieved through the concept of efficiency, which in turn is made operational through marginal social cost pricing.

Table 3.2 presents the concepts that are part of the EC-policy and ideas on fair and efficient pricing and what these concepts mean for cities implementing projects influencing the fairness of transport pricing, like the PRoGRESS-cities.

## Table 3.2: Concepts That Are Part Of The EC-Policy And Their Consequences For Cities

| Concepts that are part of the EC-policy on fair and efficient pricing | Consequences of the concepts for the cities | Examples of implementation the concepts | Improve feeling of fairness for target groups |
|---|---|---|---|
| Charges are closely and transparently linked with underlying internal costs (e.g. fuel and vehicle costs) and external costs (e.g. pollution costs, noise and congestion cost) | Linking charges with internal and external costs means that charges will be highly differentiated regarding for example time (rush hour or not) and place (bigger cities or rural area) of travelling. | Choose a mechanism for pricing instead of taxation. Make a user pay extra for a new toll road because of the extra service obtained<br>Use tax to fill a transport fund to improve roads and railways | Changing existing taxes to charges. Income deriving from taxes will now directly be used for transport improvement<br>Inform transport users of the improvements being made as a result of pricing |
| Charges should be non-discriminatory across modes and nationals of different member states. | This concept derives from the citizens right to mobility. It does however not imply a right for free transport but a right to reasonable conditions of access, quality and price, that is a guarantee of non-exclusion on economic basis | Co-ordinating road pricing projects in cities in several EU-member states (PRoGR€SS) | When introducing pricing measures, relate to other measures in other areas already existing (museum, disposal of waste etc.)<br>Relate to situations in other countries of the EU with their disadvantages |
| Revenues should flow to authorities in countries where the costs are caused. | With relevant public transport alternatives available, significant increases in road user charging could occur | A tax on trucks driving through Austria, transporting freight that is neither loaded in nor destined for Austria. Without the tax Austria would have the disadvantages of the heavy vehicles without any benefits | Make sure that there are real alternatives to non-minor increases in modal specific transport prices |
| The full infrastructure costs should be recovered from transport users in the long run | transport costs<br>=<br>transport benefits | Infrastructure, environment, and congestion costs covered by electronic road pricing and track charges. An insurance system might cover full social costs and differentiate according to risk. | It is long term, make gradual changes and communicate what you are doing and why |

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# 4. FINANCE, LEGAL AND IMPLEMENTATION ISSUES

## 4.1 Introduction

At present there is still no example of the implementation of road pricing in the EC. This is in part a reflection on the complexity of the subject. Indeed, in many EC member states, urban road pricing is not yet legal, and implementation cannot be achieved. Whilst individual member states are in some cases introducing a legal framework to enable pricing, and the EC supports the principle of Fair and Efficient Pricing, there appears to be no coherent programme to enable widespread take-up of pricing measures across the community.

A further barrier to implementation of road pricing is the need to finance alternative means of transport. Given the high levels of investment needed to provide new transit systems, cities need to identify external sources of funds to introduce schemes in advance of the receipt of revenues which will eventually be hypothecated to transport funds.

This section examines these issues and sets out some of the issues to be considered.

## 4.2 How to Finance Set-up Costs?

The cost of establishing a road user charging scheme is likely to be considerable. Not only are there the physical costs of the necessary infrastructure and personnel, but there will be a variety of lead-in costs whilst the scheme is developed, such as public consultation, media campaigns, and legal/planning costs.

If a road user charging scheme is implemented wholly within the public sector, there is a potential problem of timing. While road user charging should be expected to generate substantial levels of net revenue which can be used eventually to finance additional transport improvements, there will of course be no revenue generated until the road user charging scheme is in place. In some EC member states, public investment in transport is substantial, and the public sector can drive road user charging forward without subsidy. In other states, notably the UK, public subsidy has been driven down in order to reduce personal taxation, and alternative finance sources are likely to be needed.

This is one of the main reasons why it might be attractive to seek the participation of the private sector in establishing a road user charging scheme. Public-private partnership (PPP), could provide for 'up-front' investment to enable other transport improvements to be in place before the imposition of road user charging charges. PPP could be used as the mechanism for procurement of the scheme, as an alternative to more conventional public sector purchasing.

If this approach is preferred, then it is essential therefore that the legal and institutional framework in member states allows for such private sector involvement in the planning of transport schemes. Of course, given the sensitivity of the issue, the relevant local authorities will wish remain in close control of any scheme, and private sector input should be closely regulated.

Moreover, it should be noted that in the UK, where the PPP approach has become commonplace, there are concerns that the private sector is only willing to finance projects

where a significant profit can be achieved. The private sector is often highly risk averse, and demands a rate of return well in excess of that required to justify public investment. Whilst local authorities are restricted in their ability to invest, they should be aware that high levels of private investment will require a high rate of return which may absorb a significant proportion of future revenues. Private sector investment, therefore, represents a valuable source of additional finance, but is less economically advisable where a publicly funded approach can be adopted. A gradual implementation of road pricing which develops a revenue stream from a low charge level in early years may help to reduce dependency on private sector investment.

The various approaches to scheme funding which might be explored are described as follows:

- Full Public Private Partnership: the local authority may wish to establish a separate entity jointly with the private sector, which is able to implement the road pricing scheme, and develop complementary measures such as public transport schemes. This type of scheme, where the private sector takes a substantial level of control over the scheme may represent a longer term solution, but is unlikely to be acceptable socially until the concept of road pricing is better established. A further concern would be that any private sector partner would, presumably, benefit from tolls collected and, therefore, might wish to promote the use of the private car to maximise revenues, or to take control of decisions such as tolling structures.
- Partial Public Private Partnership: a more acceptable approach would involve the local authority administering a scheme, but enabling the private sector to invest in selected elements of the scheme whilst benefiting from revenues raised. For example, the road pricing scheme might be privately developed, but leased to the local authority at a fixed rate, whilst the revenues achieved would be dedicated to lease costs and subsidies for a private public transport system. The disadvantage of this is that the private sector will be less likely to accept risk transfer where it has less control over the revenue stream.
- Privately financed publicly operated scheme: a more conventional approach would see the local authority develop the scheme on its own initiative, but raising private finance to support identified elements of the overall scheme such as the road pricing system and the public transport scheme which might be delivered by different contractors. Once again, care would have to be taken to ensure that private sector partners would not be encouraged to promote car travel, but that toll revenues would go directly to the local authority.
- Public sector investment: a viable road pricing scheme will incur significant start-up costs before it becomes viable. Only when these costs are met will any operating surplus be released to support infrastructure investment. A publicly funded approach, without additional up-front funding, might be applicable in a city like Singapore, but is less appropriate in a major European city where road pricing will need to be underpinned by immediate investment in transport infrastructure, unless significant additional funding sources are available. The only way in which this approach could be viable would be to introduce a low level fee to raise revenues to develop infrastructure and to increase fees to a level capable of demand management once such infrastructure is in place.

In the past, PPP schemes have generally been related to a comparatively simple project such as a single closed system. Whilst it is understandable that local authorities will wish to seek private investment to fund the public transport schemes which are required to enable pricing to be deemed acceptable, further research and demonstration work will be required to determine which models are most suitable.

For more information about obtaining money for financing set-up costs, contact the author: Jo Baker, Transport & Travel Research Ltd, 16 Bore Street, Lichfield, Staffs, WS13 6LL, United Kingdom, e-mail: ttr@compuserve.com

## 4.3 How To Overcome Legal and Institutional Framework Barriers?

The legal barriers to urban road user charging in the majority of EC member states are quite specific. Whilst the collection of tolls on designated highways is legal in most states (although practised to a varying degree), charging within the urban are is generally not legal. It is difficult for the individual city to achieve a change in this situation alone. The Europrice political initiative is one which has assembled a group of cities, sympathetic to the principle of road pricing, to provide a focus for city/regional issues to be debated. It is likely that pan-European initiatives of this kind will help to convince member states that the primary legislation which is required to enable road use charging should be implemented.

Within the UK, the Transport Bill, which was introduced to the House of Commons in 1999, will provide the required legislation. In Rome, the Road code authorises local authorities to introduce road pricing to preserve the environment of historic cities. States such as Denmark, France and the Netherlands are currently appraising the options.

Once the primary legislation is in place, authorities will need to give consideration to a number of secondary issues:

- Access control systems must be implemented in a manner which is consistent with existing legislation.
- Enforcement systems must be designed not to infringe concerns over data protection and civil liberties. For this reason, a paper based system which avoids issues such as vehicle recognition, may provide a short-term solution.
- Once powers to collect charges are in place, a commitment to the hypothecation of revenues to transport investment may be required in order to ensure that the scheme is deemed to be acceptable.

Institutional barriers are likely to vary greatly between member states. The key issue to consider is the importance of ensuring a broad base of support for any scheme at the outset. This can only achieved by a process of consensus building whereby the proposals are supported by the key actors and by the public. Success will depend greatly on the existing structures within the area. It is likely that a series of key actors will need to co-operate effectively. These may include (Table 4.1).

**Table 4.1: Key Operators and their Significance**

| Institution | Significance |
|---|---|
| National Government | Prepare primary legislation to enable pricing |
| Regional Government | Prepare regional policy to permit pricing |
| Local Government | Prepare and plan scheme and raise and administer finance |
| Transport Authority | Planning of services to enable access to areas affected by pricing |
| Planning Authority | Development of land-use planning approach to reinforce pricing |
| Transport Operators | Provision of services to enable access to areas affected by pricing |
| Emergency Services | Development of procedures to ensure that pricing infrastructure does not impede access |

This list is not exhaustive, and will take a different form in every urban area. The important lesson is to ensure that at the outset all actors are identified, and that a forum for effective communication is established. This may require moderation by a neutral expert such as a local academic or consultant, and should be established well in advance of the development of any scheme. The purpose of the forum is to ensure that all potential barriers are identified and resolved in good time. Where significant financial investment of participatory processes must be undertaken in order to overcome such barriers, the partners should be all kept well informed of the processes to be completed in order to distinguish between complex problems which are being addressed, and problems which may be outstanding.

Road pricing is likely to be most easily implemented in a city in which planning and transport powers are vested in a single authority. This is a barrier which may be difficult to overcome where it exists. If powers are held by a variety of authorities, a formal partnership may be needed to implement road pricing in a co-ordinated manner.

Pricing is most commonly seen as a solution for large urban areas. This can pose a severe problem when the area comprises a series of individual local authorities. These authorities may be autonomous, and may have very different policy approaches. In such an instance, it may be preferable for the lead to be taken by a regional or sub-regional authority which has over-arching responsibilities in order to seek to incorporate objectively the views of each smaller area. Scheme promoters must be aware that in such cases the risk of withdrawal of a single partner can leave a gap in a cordon or area-based charging scheme, rendering the scheme impractical. Urban agglomerations are, therefore, particularly vulnerable to political change.

An example is the experience of London. Following the abolition in 1986 of the Greater London Council, transport issues have been addressed by individual Borough Councils. Whilst these co-operate on many practical issues, consensus building in support of transport is very difficult to achieve. The election in 2000 of a single Mayor for London and the creation of the Greater London Authority and Transport for London has helped to overcome these barriers by providing a single decision-making body.

An example of a barrier which still prevails in the UK is the deregulation of public transport provision outside London. Since local authorities have very limited influence over services and fares, it is exceedingly difficult to ensure that adequate services will be in place to provide a suitable alternative to car usage after pricing is introduced. Local authorities can invest in physical infrastructure such as LRT systems, but are less able to develop bus networks, other than by entering into quality partnerships with co-operative operators.

The following guidance on successful implementation was prepared for the Final Report of the CAPTURE project (Table 4.2).

## Table 4.2: Guidance on Successful Overcoming Institutional Barriers

One of the major findings of the CAPTURE project was that what is planned is often not implemented. This seems like a very obvious statement, but in most monitoring and research only that which is implemented is studied and that which is not is ignored. In CAPTURE a decision was taken to accept that some elements (or entire plans) were not being implemented and look for the reasons why, and suggest ways in which mistakes could be lessened in the future. The basic steps in design should include:-

- *Gaining consensus for the need for change* - There is a need for consultation and participation by key actors, and the public. In general this stage may be relatively easy, but it is important that all bodies involved in decision making understand to goals of projects such as to effect a modal shift.

- *Gaining consensus over methods for solving agreed 'problems'* - this stage is more complex. While there is a general consensus that it "would be a good thing" to reduce dependence on the car and to encourage people to use other modes, there may be widely differing views about how to achieve that goal. It is at this stage that consultation with the public is of utmost importance, in order to educate those affected both in terms of what the schemes will actually involve, and how they are designed to improve conditions. It is important that such consultation is done at an early stage so that suggestions from local people can be incorporated (and with very local knowledge they may be better solutions than local authorities or outside consultants can provide), and that the consultation does not just result in hostility to a scheme that has become imprinted as the only solution to those proposing it.

- *Adopting a plan with a 'logically arguable likelihood' of success* - It is often apparent (particularly in hindsight) that many schemes put forward and put into action were never likely to succeed in the goals they set out to achieve. Any scheme which gets as far as being formally proposed should be capable of withstanding critical analysis of its likely success in achieving its goals if it is implemented.

- *Consideration of the likelihood of adoption* - While the actual conditions which determine whether or not a scheme will see its way to completion are complex it is apparent that some sort of local assessment of the likelihood of adoption should be made. Learning from past mistakes, delays, and suchlike is crucial, and in general, assessments of these kinds will be made, but with the belief that "things will be different this time". Of course some measures may be essential to a strategy but will be described as having a very low likelihood of success. Perhaps some of the more controversial elements should be piloted in areas where they are likely to be implemented in order to give them a higher chance of success elsewhere.

- *Ensurance that overall goals are not prejudiced by possible or likely changes to detail* - contingency plan - an example of this problem on a large scale is the Sheffield Supertram system in the UK which was originally designed in a planned public transport system to act as the 'backbone' to the system. But after the design stage the UK government brought in its deregulation of the bus industry which meant that the system was in competition (on price and service levels) with bus services which, from many key locations were able to access the city centre much faster and more cheaply.

- *Cohesive management of plans* - it is important that plans are constantly overseen towards their conclusion. If key personnel change more than is absolutely necessary some key understandings of the project will be lost.

It could be said that it is impossible to decide how to proceed from where we are without agreeing on the goal, and certainly in many senses, this is true. Clear direction and strategy can only be created by actors who are clear and have a common understanding about the end goal. It is this lack of a common vision concerning an end state for transport policy which has been responsible for the lack of progress towards a sensible transport strategy. It is also true that if direction is agreed, then strategies can be defined, and it is here that there is more scope for consensus.

For more information about how to overcome legal and institutional framework barriers, contact the author: Jo Baker, Transport & Travel Research Ltd, 16 Bore Street, Lichfield, Staffs, WS13 6LL, United Kingdom, e-mail: ttr@compuserve.com

# 5. ASSESMENT OF ROADPRICING

## 5.1 Introduction

There is now general acceptance in the European Commission and amongst many transport experts, that attempts to internalise the external costs of transport are desirable in principle. There is, however, limited experience of the ways in which road pricing measures will affect urban areas. The international examples of pricing are not necessarily typical of the potential European case studies.

In order to develop the road pricing concept it is essential to assess the impacts of pilot projects. Such an assessment will be a core element of the work of CUPID. A number of issues must be considered:

- Charging as one of the solutions for urban traffic problems: how effective is pricing at meeting objectives?
- The impacts of charging on traffic flows and net economic benefits: what are the impacts of pricing?
- To use road capacity and revenues obtained by implementing road pricing: how can the revenues from pricing by allocated and what are the implications of these revenues

This chapter provides some initial guidance on these issues. The demonstrations of road pricing to be undertaken within the PRoGRESS project will enhance knowledge of these subjects.

## 5.2 Why Pricing Should be Considered

### 5.2.1 Why Reduce Car Usage?

Car ownership and car usage have increased, and continue to increase significantly across almost all European cities. The need for efficient transport systems and personal mobility is recognised as a vital element of modern day life. Increasingly, however, people are becoming concerned about the impact of these transport systems upon their health, their safety, the local environment, and the global environment. In addition, traffic congestion has a major economic impact, accounting for some 2% of the gross domestic product (GDP) of the European Union (EU) every year.

The environmental problem can be summarised as follows:

- The transport sector is responsible for one third of European energy consumption, and its share is increasing
- Increasing energy demand in the transport sector is almost entirely due to the growth in road traffic, particularly the use of the private car.
- The energy consumed in transport is supplied almost exclusively by oil products
- The burning of oil products is responsible for the emission of large quantities of pollutants that are harmful to human health, and contribute significantly to global warming

- During the last 15 years, the energy consumed by urban transport has increased four times more quickly than for inter-urban transport

Research has suggested that it is possible to increase the use of public transport significantly, thereby reducing private vehicle traffic, by implementing integrated packages of measures designed to improve service quality and performance. Even greater reductions in energy and emissions could be achieved if private car traffic is restrained by either physical or fiscal measures.

### 5.2.2 The Role of Pricing as a Means to Reduce Car Usage

Charging is not **the** solution of our traffic problems. It is not even **a** solution, but may form a key part of an integrated strategy, which consists of different instruments. There is neither a ready-made solution, nor the one solution, but there are different options, discussed in section 2.2, which may be implemented depending on given situations and general conditions. Nevertheless; incentives can contribute to an efficient solution of the existing problems, if they are applied meaningful and in combination with further measures. To limit the negative consequences of urban traffic (e.g. heavy congestion, air pollution, environmental damage, noise etc.) first of all technique-based modifications on the supply side were used. For instance:

- reduction of vehicles' energy consumption;
- reduction of emissions produced by vehicles;
- improvements in safety of cars and roads;
- telematic applications which improve the effectiveness of traffic etc.

Whilst these technological options reduce the negative impacts of traffic (growth) to some extent, they can not eliminate it completely. Therefore increasingly behaviour-influencing measures on the demand side, are being discussed (OECD, 1997).

An alternative definition of the ways in the impact of car usage can be reduced, these are commonly called ‘the three E’s’ (Schlag, 1998), is described below:

- *Enforcement:* legal measures, mainly rules and bans, as behaviour-influencing preconditions for a guarantee of a safe traffic and transport;
- *Engineering:* an altered arrangement of supply, affecting the routes for the different means of transport as well as the means of transport themselves;
- *Education:* measures of education, instruction and information of - first and foremost - the vehicle drivers.

As a further possibility for influencing mobility, a fourth ‘E’ is to be considered: fiscal incentives, such as road user fees named ‘*Encouragement’* or ‘*Economy’*. Within other areas, e.g. telecommunications or energy use (Bell et al., 1996), pricing systems have proved to be very effective control means.

Transport policies have in the past focused largely on direct regulation (enforcement). Whilst rules have brought significant improvements in some areas (e.g. safety), they have not been able to unlock the full potential of response options that can be triggered through price signals. Price based policies give citizens and businesses incentives to find solutions for certain problems. The objective of ensuring sustainable transport requires that prices reflect

underlying scarcities which otherwise would not be taken into account sufficiently. Decisions made by individuals with respect to their choice of mode, their location and investments are at least partly based on prices. So prices have to be reasonable to improve transport.

In general the following fiscal elements can be identified within the cost of mobility (cp. Schlag, 1998, 309):

- **Capital and vehicle taxes** - purchase and sale's taxes, value-added tax (VAT), motorcar tax (annual), costs of the acquisition of the driving licence.
- **indirect running taxes**, which enable the access to the use of a road space and which are not to be paid in direct connection with the traffic behaviour. E.g. fuel tax, resident parking fees, monthly ticket for public transport, motorway fees (for goods- and passenger-transport) cordon tolls, road and bridge tolls - as long as not referred to single passages or drives (monthly tickets etc.)
- **direct taxes (referred to use)**, which are limited to the individual range of use (spatial and/or temporal). E.g. taxi costs, parking fees (per time of use), ticket for public transport (per trip), weight-distance-fees for lorries and busses, cordon tolls, road and bridge tolls - referred to single passages and drives, automatically measured road using fees.

### 5.2.3 Effectiveness of Pricing Measures to Reduce Car Usage

In order to influence mobility behaviour, direct user fees like road pricing which have to be paid in connection with the personal road use are particularly effective. In general the influence of price incentives may refer to different levels of the decision hierarchy of road users. Rothengatter (1994) mentions a multiplicity of decision levels, which can reach from impacts on route choice, travel time, journey frequencies, driving widths and impacts on modal split and vehicle selection up to a modification of residence choice.

More specifically, the various behavioural dimensions determining external costs (and thus problems) in urban transport would be optimally affected by theoretical (and so-called) "first-best" pricing measures, if only such measures were possible and applicable. However, on the basis of at present available pricing measures it is difficult to distinguish between types of infrastructure users and categories of external costs the users generate. Thus, the measures up to date can only be called "second-best" measures as they only partially lead to the behavioural responses which would be elicited by "first-best" measures.

Table 5.1 shows to which extent some possible second-best instruments allow for differentiation between important behavioural dimensions. A distinction is made between an unlikely direct impact, a possible direct impact, a likely direct impact (possibly approaching first-best standards), and finally the first-best bench-mark.

**Table 5.1: Dependence of various behavioural dimensions on various pricing instruments (Milne et al., 1999, p. 66).**

| | Car use | | | | | Car ownership | | Spatial behaviour[b] |
|---|---|---|---|---|---|---|---|---|
| | **Vehicle kilometres** | **Number of trips** | **Time of driving (peak or off-peak)** | **Place of driving (area or route)** | **Driving style** | **Fleet Size[a]** | **Vehicle technology** | |
| First-best bench-mark | *** | *** | *** | *** | *** | *** | *** | *** |
| Second-best direct demand management | | | | | | | | |
| *ERP per km* | ** | ** | ** | * | - | ** | - | ** |
| *Parking fees* | * | ** | - | */- | - | * | - | * |
| *Toll booths* | * | ** | * | * | - | ** | - | * |
| *ERP Cordon* | * | ** | ** | * | - | ** | - | * |
| *Peak permits* | * | * | * | * | - | ** | - | */- |
| *Area licences* | * | * | * | * | - | ** | * | ** |
| *Fuel taxes* | ** | ** | - | - | - | ** | ** | ** |
| Indirect demand management | | | | | | | | |
| *Vehicle taxes* | * | * | - | - | - | ** | *see*[#] | - |
| *Subsidising public transport* | * | * | - | */- | - | * | - | * |
| *Subsidising tele-working* | * | ** | * | */- | - | * | - | - |
| *Location subsidies/taxes* | * | - | - | */- | - | - | - | * |
| Supply-side oriented policies | | | | | | | | |
| *Differentiated vehicle taxes* | - | - | - | - | - | - | **[#] | - |
| *Differentiated fuel taxes* | - | - | - | - | - | - | ** | - |

*** optimal (first-best) impact
** likely direct impact, possibly approaching first-best standards
* possible direct impact
– no particularly strong direct impact, or at least unlikely in practice

[a] Also allows for car size.
[b] Location of residence vs. work and leisure activities.

Second-best pricing measures with their imperfect power to differentiate cannot provide perfect incentives for infrastructure users in relation to the external costs they are generating. Also, there is no reason to believe that such measures would be sufficient to secure optimality of long-run developments in mobility behaviour. Therefore, besides second-best pricing, there may be a need for *complementary* policies to affect long-run decisions concerning the factors behind the long-run position and shape of the relevant demand in a socially desirable manner.

For more information about why charging can be seen as one of the solutions for urban traffic problems, contact the author: Jens Schade, Dresden University of Technology, Traffic and Transportation Psychology, D-01062 Dresden, Germany. E-mail: schade@rcs1.urz.tu-dresden.de

## 5.3 What is the impact of charging on traffic and the economy?

### 5.3.1 Traffic Flows

Operational benefits from changes in traffic flows result primarily from the improvement in road operating conditions when users divert to other forms of transport or to other periods. Reduced vehicle kilometres will also result in accident benefits, although these may be offset by increases in vehicle speeds due to a reduction in congestion.

Additional benefits will be achieved due to reduced environmental impacts including air quality and noise, as well as an improvement in the urban environment.

Pricing schemes can achieve significant reductions in traffic flows as identified in the following examples:

Examples of reduction is traffic due to pricing

The Singapore ERP system – the most complete and relevant example of Road User Charging - has expressway gantries which operate during the morning rush hours from 7.30 am to 9.30 am from Mondays to Fridays in the direction of flow to the city. Traffic volumes during the ERP period have dropped by about 15%. There is a slight spreading of the peak hour traffic as some vehicles take advantage of the lower charges between 7.30 am – 8.00 am and 9.00 am – 9.30 am. Weekday charges vary from route to route depending on the time of day. These benefits have been achieved in addition to the impact of the original Singapore Area charging scheme which saw a 50% reduction in AM peak flows with an 83% increase in bus patronage from 1975 to 1992.

Reductions in traffic flow in Trondheim were substantially lower in the order of 5-7%, but these were based upon tolls set to raise revenues rather than to control car usage. Higher tolls were trialled during the CONCERT project, achieving reductions of 10-17%.

The use of varying tolls for different vehicles classes, or for setting lower tolls for a high occupancy vehicle lane may enable the system to further optimise conditions for selected classes of road user.

### 5.3.2 Economic Benefits

The economic benefits of road pricing will vary in accordance with the approach taken to scheme design. A scheme is likely to seek to achieve one or more of the following objectives:

- To raise revenues
- To deter the use of the private car
- To ensure that travellers meet the true cost of their journey in an equitable manner

Each of these objectives will lead to economic benefits either directly, through gaining revenue, or indirectly, through improvements to the economy achieved by reducing congestion.

The CUPID Consortium is in the process if identifying the full range of economic impacts of pricing schemes as part of the development of Deliverable 4, Evaluation Framework. Table 7 provides a breakdown of key economic indicators.

Some of these indicators, such as revenues raised, can be readily expressed as financial values. Others, such as the impact on employment, are less tangible.

Beyond this table lies the full range of socio-economic, environmental and other impacts, many of which are complex to identify in monetary terms, but which make up the wider impact of pricing. The identification and appraisal of these impacts will be a central element in the work of CUPID over the coming years.

**Table 5.2: Provisional List of Economic Indicators**

| | | |
|---|---|---|
| Economic | Direct financial | Investment cost |
| | | Support infrastructure cost |
| | | Level of initial external investment |
| | | Labour cost |
| | | Maintenance cost |
| | | Level of ongoing public subsidy needed |
| | | Operating revenues |
| | | Profitability |
| | Employment | Temporary jobs provided by installation of demonstration |
| | | Long-term jobs provided by operation of demonstration |
| | | Indirect, long-term jobs |
| | Regional development | Long term impact of measure on economy |
| | | Regional access issues |
| | | Change in conditions for shopping |
| | | Change in conditions for tourism |
| | | Vitality |
| | | Overall trade |

The use of road pricing to reduce congestion can offer great benefits both through direct costs and indirect costs both to businesses and residents. The direct reduction in time spent in delays will have a knock-on effect on business efficiency and consumer pricing whilst the improved environment will provide a healthier, more attractive, city, which is likely to help to encourage inward investment. The OECD estimated that 4.1% of GDP was lost to transport externalities in 1994: road pricing may help to reduce this figure.

A longer term social objective, proposed in the White Paper on Fair and Efficient Pricing, is to ensure that all travellers meet the full cost to society of their journeys. For example, in the UK, motorway carry 17% of all vehicle kilometres, but the cost of motorway congestion is only 1% of the total. Conversely, the 1% of vehicle kilometres represented by urban centre peak hour traffic, are responsible for 13% of all congestion costs. Existing fiscal measures such as fuel and vehicles taxation do not reflect these differences. Road User Charging can ensure that travel choices reflect the real cost of travel, rather than perceived cost in order to encourage economically efficient behaviour.

The economic benefits to society can be maximised by developing varying tolls which favour essential road users such as public transport, freight or high occupancy vehicles.

### 5.3.3 Assessment of Potential Benefits

Extensive work has been undertaken to assess the potential benefits of pricing. In the UK, studies and trials of road pricing have been undertaken in Bristol, Leicester and London. The Bristol ELGAR trials, part of the CONCERT project, and the LERTS system in Leicester included real-life trials of modal choice amongst travellers offered the option between the use of the private car and bus-based park and ride. Complementary measures such as variable message sign information on environmental conditions and sliding scales for tolls have been considered. Progress in the UK is now delayed, awaiting the introduction of powers to enable the collection of area tolls, and to permit hypothecation, the direct allocation of funds from tolls to transport infrastructure.

These trials, and an ongoing trial in Bristol for the INTERCEPT project, provide an insight into the public reaction to pricing, but do not enable the longer-term impacts to be assessed. Major decisions, such as whether or not to replace a car, may only be made on a cycle of 3-5 years or even more, and so it is only be means of true demonstration that an accurate long-run assessment of impact can be provided.

Extensive analysis of the impact of pricing has also been undertaken by means of the use of transport models. The advantage of this approach is that the model provides a desk-top assessment on impacts. In some ways this is very helpful as data such as the potential revenues can be identified and used to determine the wider infrastructure measures which might be implemented. Models also provide a first estimate of the charge levels which might be required in order to achieve a specific change in behaviour. A comprehensive review of these issues can be found in the EC supported TASTe Guidelines on the Use of Tools for Assessing Traffic Demand Management Strategies.

For more information about charging on traffic flows and net economic benefits, contact the author: Jo Baker, Transport & Travel Research Ltd, 16 Bore Street, Lichfield, Staffs, WS13 6LL, United Kingdom, e-mail: ttr@compuserve.com

## 5.4 How to Use Road Capacity and Revenues Obtained by Implementing Road Pricing

### 5.4.1 Use of Road Capacity

There are two approaches to the use of road capacity obtained by implementing road pricing. One option is that the road network can be reduced in scale to reflect the reduction in traffic due to road pricing. The road space released may be allocated to public transport as a dedicated corridor, reserved for high occupancy vehicles, or reserved for non-motorised modes or transport. Alternatively the space may be developed either for environmental improvements, or to support local economic activity. This is a highly idealised solution. In reality, road pricing schemes are likely only to address the most severe impacts on congestion in city centres. Therefore any reduction in traffic will help to reduce congestion in the short to medium term, but will not necessarily enable the reduction in highway capacity. The key benefit of road pricing to the business sector is that it enables efficient access for goods and people, and measures to reduce such access are likely to result in a loss of support from this sector.

This approach has been adopted in Singapore where restrictions of vehicle access have been accompanied by the continuing development of high quality public transport alternatives.

The alternative, therefore, is that the spare road capacity is used to improve traffic conditions. The improvements will help to limit the economic impacts of congestion, whilst they will also achieve environmental benefits by reducing the impacts of congestion on air quality. This is the approach which is currently seen in Europe, both in the pricing systems in Norway, as well as the use of road tolls in France and elsewhere.

### 5.4.2 Use of Revenues

The revenues from congestion charging may be used in three ways:

- They can remain within the road transport sector and therefore benefit those who pay them: this will reduce congestion but not control car usage
- revenues could be used for financing other parts of a comprehensive strategy to deal with congestion (e.g. route guidance systems, public transport etc,).
- Alternatively, these revenues would allow other taxes which are currently used for the public financing of infrastructure but which are largely unrelated to the costs of infrastructure use to be allocated to other purposes, or to be cut.

In the long run, congestion charging holds out the prospect of reforming transport taxation in a manner that would greatly increase the efficiency and equity of our transport system.

It could be argued that a congestion charging scheme which subsidises new roads, and thereby attracts more users is actually failing to resolve the problems it is intended to address. On the other hand, in many cities, road pricing is intended to do exactly that. If the Road User Charging scheme too attractive to a motorist, he or she will not consider the public transport alternative unless more road space is re-allocated to rapid transit systems. Segregating public transport routes from other road traffic will increase efficiency by reducing delays caused by congestion. If this increased efficiency is visible to motorists and is a result of road space being taken away from them, they are more likely to think about using public transport.

Visible hypothecation of Road User Charging revenues to public transport alternatives is vital to combat public opposition to congestion charging schemes. Revenues may be used to improve or introduce modal interchange facilities, for example park and ride facilities located on the periphery of the charged area would provide an alternative means of access. The increased volume parking and interchange activity to be expected at such interchange points needs to be estimated and accommodate in a safe and efficient manner.

Responses to the 1997 consultation in the UK on developing an integrated transport policy indicated a very strong feeling that if Road User Charging was to be introduced, the net revenue should be retained by local authorities and spent on local transport. The priority aim should be to improve the attractiveness of alternatives to the private car, especially public transport, for access to and travel in the charged area.

Although it is proposed that transport will have first call on the revenue stream from charging schemes, legislation need not restrict expenditure entirely to transport-related matters. This is because there could be poor value for money if low priority transport projects were undertaken simply because of restrictions on the use of revenues. Public opinion may opt for

the allocation of revenues to other causes such as education and health. On the other hand, the cautious support which the business sectors and motoring groups are beginning to extend to pricing are specifically given on the understanding that revenues will be allocated to transport infrastructure investment, whilst the successful schemes in Norway and Singapore have also been implemented on this basis.

Overall, therefore, there is strong support amongst practitioners for an approach which sees transport revenues ring-fenced and hypothecated within the sector.

On the other hand, economic theory assumes that revenue from road pricing is used to compensate drivers exactly for the fees they have paid. As the overall cost of road travel (i.e. the sum of travel time, vehicle operating costs and money) has risen as a result of charging, this is the only way that an increase in welfare can be achieved. For practical application, economists generally consider that the most effective proxy for this compensation would be the use of road pricing revenues to subsidise general labour or property taxes. The key concern, from an economic efficiency objective, is that revenue should be used in a manner that brings benefit to society, but which does not contribute to economic distortions in the transport sector. Therefore, the one potential use of road pricing revenue which is considered least appropriate is funding increased investment in transport, especially within the road sector.

In contrast, the prospect of raising revenue for desired (but, otherwise, prohibitively expensive) transport projects may be a major factor in motivating the current wave of interest from practitioners in road pricing policies. Indeed, this has always been acknowledged explicitly as the key objective behind the design of the three long-standing Norwegian Toll Rings. Experience suggests that politicians and transport professionals in the field are generally unimpressed by the economic arguments relating to revenue, for two reasons.

- First, a critical practical issue which needs to be resolved to allow the introduction of road pricing is the provision of feasible alternatives for those who do not wish, or cannot afford, to pay. A major limitation of economic theory is that it tends to focus on long-run impacts, assuming flexibility in land use and lifestyle. However, a major constraint for real-world political decision-makers is the much shorter run of the political cycle. Any potential policy which cannot reap tangible benefits on this timescale is likely to modified or abandoned.
- Second, politicians are acutely aware of public distrust regarding the introduction of new taxes (or, for that matter, increases to existing taxes), when the revenue is used to contribute to the general (local or national) treasury pot. Many voters perceive this as encouraging governmental inefficiency and, therefore, it is regularly stated that hypothecation of revenues to uses which are both popular and likely to produce visible results, including some uses which bring direct benefits to car drivers, may be the only way to make road pricing widely acceptable.

While the academic arguments have not yet been fully resolved, the pragmatic view suggests that hypothecation of road pricing revenue for financing transport projects is likely to be essential to achieve support from almost any sector of the public. The balance between investment in road and public transport schemes will likewise need to be driven by the desire to seek a practical solution appropriate to the specific location.

For more information about use road capacity and revenues obtained by implementing road pricing, contact the author: Jo Baker, Transport & Travel Research Ltd, 16 Bore Street, Lichfield, Staffs, WS13 6LL, United Kingdom, e-mail: ttr@compuserve.com

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# APPENDIX A
# SUMMARIES OF 4TH FRAMEWORK PROJECTS

# A.1 INTRODUCTION

In this appendix summaries are provided of the most relevant EU-4th framework projects regarding transport pricing. The content of the previous chapters are for an important part based on the results of the 10 projects presented in this chapter. This chapter is an extra service for the cities interested in investigating certain transport pricing issues more in-depth. Therefore a brief summary is provided of the projects, their aims and contact details from the organisation leading the project. For more information about the results of the 4th framework projects please contact the co-ordinators or contact persons of these projects as stated in the individual project descriptions.

# A.2 CAPRI

*Goal of project*
The objective of the Concerted Action on Transport Pricing Research Integration is to bring together the results of research studies that relate to the role of pricing in transport policy development.

In addition to examining research programmes at the national level, the Concerted Action seeks to facilitate the exchange of results from European level research, including: Strategic Research, Urban Transport and Road Transport tasks in the Fourth Framework, DGVII programme, "The Pricing and Financing of Urban Transport" from the APAS study, the Telematics Applications Programme (DGXIII), the green paper "Towards Fair and Efficient Pricing in Transport", The white paper "Fair Payment for infrastructure Use" , CARD-Me (Concerted Action for Research on Demand Management in Europe) and the Joint Scientific Committee established for pricing projects in the strategic and road sectors.

*Results delivered / short summary*
D1: State of the art,

part A: pricing issues, financing of infrastructure and infrastructure charging, overview of externality issues, inter-urban, overview of urban issues, road issues, rail pricing issues, air issues, shipping issues and practical implementation issues. Part B is a description European and national research projects.

D2: General economic principles of pricing transport services.

Research on pricing of economic goods in general, ending with the distinguishing between short-run marginal cost, long run marginal cost and average cost pricing. The short-run marginal cost, the relevant concept for efficient pricing is explained further as well as marginal external costs and the role of government. The information about pricing principles is applied to the transport market as well.

D3: Valuation of transport externalities.

This deliverable provides as overview about the state of the art on the valuation of external costs, identify progress in valuation techniques as well as the areas of agreement and disagreement.

D4: Road transport pricing issues with particular reference to urban road pricing.

Main purpose is to examine the implications of recent research into urban road pricing for policy development and identification of future research priorities. The policy conclusions drawn form urban road pricing research are grouped into three main sets of issues: 1) whether to implement, and what to implement, 2) driver response to urban road pricing, and 3) acceptability of urban road pricing.

D6: Rail, other public transport and air transport pricing.

The subjects covered for rail are: overview of objectives for rail infrastructure pricing, efficient use and development of infrastructure, budget constraints, promoting competition, harmonisation across modes and key alternatives. For Air transport pricing: pricing at different levels and environmental costs and environmental pricing.

*For more information:* Tom Sansom, Institute for Transport Studies, University Of Leeds, LEEDS, LS2 9JT, United Kingdom, e-mail: tsansom@its.leeds.ac.uk. project-website: http://www.its.leeds.ac.uk/projects/capri/

## A.3 EUROTOLL

*Goal of project*

EUROTOLL is concerned with tolling strategies and driver reactions. The project draws on the results of ten European case studies which are aligned to a common evaluation framework to enable the effects that are common to different case studies to be identified and rationalised. The following items were subject to research of possible transferable results: price sensitivity / demand reaction, social / individual acceptance, user information, communication aspects, internalisation of external aspects and management of congested networks.

*Results delivered / short summary*

The following items were subject to research of possible transferable results: price sensitivity / demand reaction, social / individual acceptance, user information, communication aspects, internalisation of external aspects and management of congested networks.

Some general conclusions are, given that the aim of road is clearly understood and the use of revenues is clear:

- Pricing *modulation* - that is variation of tolls along time periods or along different routes - *works*: there is an effective decrease of traffic on peak-tolled period or on tolled route. This decrease of traffic can be analysed under three different aspects which are traffic spreading, overall traffic level and mode shift.
- There is an effective spreading of traffic from peak-tolled periods to less tolled periods when time-modulation pricing is in operation, or from higher tolled route to equivalent non or less tolled routes when route-modulation pricing is in operation.
- This spreading of traffic is hardly accompanied by a decrease of *overall* traffic, that is on the whole period - across peak and off peak tolling - or on the whole area, mostly if we consider interurban contexts previously quoted.
- The decrease of traffic in urban/suburban contexts can be observed in experiments such as in the Stuttgart case study: a corridor tolling - when all access roads are tolled - implies more decrease of overall car traffic than cordon tolling. Moreover it looks as if high pricing levels are required in urban/suburban with daily mobility contexts to observe significant decrease in overall car traffic level. These effects of traffic spreading and congestion reduction occur, even with low pricing modulation, only if there is one of these effective possibilities of change: change of timing, change to another acceptable route, change to another acceptable mode or reduction of travelling.
- *In some cases*, given the social and political reluctance to congestion pricing, information can be an efficient way of managing congestion.

The diversity of case studies in the project shows that there is place for tolling strategies with some success *at least* for:

- financing new infrastructure, as shown with ongoing tolled motorways in Europe, including in some urban contexts;
- managing demand on existing infrastructure, in interurban contexts, on congested parts of the network, especially on already tolled facilities where pricing variation is further introduced; and
- managing demand on existing infrastructure, in urban areas when congestion occurs, as would suggest the experiments: however only *added* tolled facilities (new infrastructure) devised to guarantee free flow to their users, are currently *ongoing* examples of congestion pricing schemes.

*Information about co-ordinator:* Lionel Clément, ISIS S.A., 4 Rue des Cuirassiers, 69428 Lyon, Cedex 03, France, e-mail: lionel.clement@isis.tm.fr. Websites with information about the project: http://www.hhh.umn.edu/centers/slp/conpric/eurotoll.htm and http://www.cordis.lu/transport/src/eurotollrep.htm

## A.4 PETS

*Goal of project:*

- to examine the current pricing situation of passenger and freight modes in Member States;
- to assess whether such prices provide appropriate price signals in the light of all relevant internal and external costs; and,
- to forecast the consequences of moving to a more appropriate price level and structure in the light of transport demand and supply developments – as well as financial and other constraints.

*Results delivered / short summary*

A major conclusion is that the methodology to calculate marginal social cost for all modes exists, although many of the valuations remain subject to considerable uncertainty. No support is found for the argument which says that the concept of marginal cost pricing cannot be implemented in practice because it is unmeasurable. The case studies have illustrated that marginal social cost may be estimated for a range of circumstances in a range of countries.

It has been shown that a purely commercial approach to transport pricing is not appropriate and may push prices in the wrong direction. The reason is the prevalence in the transport sector of economies of scale, including the Mohring effect, whereby increases in demand for scheduled public transport services lead to increased service frequency and therefore better services for existing passengers, and because of the importance of externalities. Whilst the former lead to commercial prices being too high, and the latter too low, the relative strength of the two effects differs enormously between the modes and locations.

In measuring externalities for pricing purposes, it is important to estimate the marginal external cost rather than starting with the total cost and then dividing it by the amount of traffic. This is particularly important in the case of congestion and accidents, where much of the total cost is already internalised, and for noise, where the marginal cost is below the average. This means that particularly for noise costs even an ideal pricing system may not be an adequate way of tackling the problem, and regulatory measures are also called for.

The effects of moving to a more efficient pricing system are likely to be diverse, both because of differing circumstances between countries and because of different starting points. For instance, in some countries rail fares are held very low, whereas in others they are close to commercial levels. This makes it difficult to generalise about the effects of efficient pricing from a small number of case studies.

Further extension of deregulation and commercialisation may not benefit rail transport in terms of the relative level of price compared with other modes as - while the process has led to substantial reductions in terms of prices in road freight and air transport - it has tended to raise prices for bus and rail. The explanation is in terms of the very different starting points in terms of pricing policies and subsidies between the modes.

The simple belief that a move to more efficient pricing would uniformly benefit the more environmentally friendly modes at the expense of other modes is also found to be not universally true. For instance, the current price of inter urban motoring is seen to be too high relative to 2010 marginal social cost. This gives little support for the introduction of additional charges on inter-urban roads except for specific cases of serious congestion or especially strong environmental effects. On the other hand, the case for urban road pricing in congested cities is reaffirmed. Similarly whilst there is generally a case for lower prices and increased traffic for public transport, in some cases existing subsidies are already excessive. Only in the urban case study is a substantial diversion of traffic to public transport justified.

In the case of road freight, the picture is mixed but generally there is under-charging of long distance road freight. This is partly a problem of the structure of the existing taxation system. Fuel taxes do not increase sufficiently with the weight (and particularly the axleweight) of the vehicle to reflect the marginal social cost of heavy vehicles. An annual charge over-charges low mileage vehicles and under-charges vehicles used intensively on long distance work. Even the vignette, as currently utilised, is related to time rather than distance run. Thus there is a clear case for reform of road freight vehicle taxation, to introduce a charge based both on vehicle characteristics and distance travelled.

*For more information:* Tom Sansom, Institute for Transport Studies, University Of Leeds, LEEDS, LS2 9JT, United Kingdom, e-mail: tsansom@its.leeds.ac.uk. project-website: does not exist anymore.

## A.5 QUITS

*Goal of project*

The objective of QUITS is to improve decision-making in the transport sector by comparing the quality of modal alternatives available on individual inter-urban routes. The investigation is based on the main assumption that the quality of a transport system depends on both internal (direct costs, travel time) and external (environmental, social and other external costs) variables. QUITS covers all transport modes and deals with both passengers and goods transport.

In the case of transport services, it is the user who, by selecting a given modal option among the alternatives available on a given route, indicates his/her preference, therefore providing an implicit measure of the quality of the service offered on that route.

*Results delivered / short summary:*
The primary goal of the QUITS project was to provide tools for the measurement of quality thus defined. Consistently, the valuation procedure was in principle designed to include only those quality (and cost) factors which are perceived - or can be made such - by the user. For instance, the fare component of the direct costs borne by the transport users should be considered as a whole, as one may safely assume that the user's attention is centred on the amount of total disbursement rather than on the pattern of disaggregation into various sub-components and the corresponding mechanism of price formation. As a consequence, questions such as e.g. the extent to which the infrastructure investment costs are actually recovered through pricing are irrelevant to the measurement of quality levels: the decision of a user to choose a given modal solution will not be affected by the knowledge he may gain of the percentage of investment cost which is left uncovered.

On the other hand, the design and validation of fair and efficient pricing mechanisms in a competitive environment, with a majority of stakeholders aiming at achieving an increased share of investment cost recovery, clearly points at the need for a better understanding of the sensitivity of users behaviour - i.e. quality - to the wide range of pricing instruments available to the policy maker.

The QUITS team has fully understood the broader issues at stake in connection with the price relevance issue, and has undertaken to respond at best to this challenge. As a result, for instance, a specific feature was developed in the QUITS software to allow for the interactive simulation of the impact of changes in fiscal policies on the internal quality indicators (direct costs component).

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## A.6 CONCERT

*Goal of project:*
- To develop policy instruments for shifting private traffic to public transport.
- To specify, demonstrate and evaluate the integration of pricing measures to change modal split in urban areas.

CONCERT-P addressed the hypothesis:"… pricing/restraint measures are needed to achieve a shift from private to public transport.

*Results delivered / short summary:*
CONCERT-P has built, tested and evaluated the three restraint demonstrators: environmental pricing, congestion pricing and access control. Test cases are: Trondheim tollring, Bristol and Barcelona.

The Trondheim results suggest that if the principles of marginal cost congestion pricing (put forward in the original Fair and Efficient Pricing Green Paper of 1995) were applied to urban road networks, then the primary impact would be a temporal spreading of congestion – with less trips during the peak interval and more car trips in the shoulder periods adjacent to the peak.

The Bristol result provides the first indications of the road charging and environmental conditions under which a significant number of car drivers would be induced to switch to

public transport. The demonstrations shows the benefits of linking road pricing with a multimodal integrated payment scheme.

The access control implementation in Barcelona has extended the policy of promoting non-motorised modes of transport in the central area. The main advantage is that this revised system is far more operable for the authorities point of view, with only minimal intervention required by police officers in the control centre.

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## A.7 TRANSPRICE

*Goals of project:*

- Review and investigate technical and financial options for integrated *trans* modal *pricing*.
- Examine integrated *trans* modal *pricing* strategies, tariffs and generalised cost structures by mode of transport and their effects on modal split.
- Assess potential user response and operational, socio-economic, behavioural, financial, land use, environmental and energy impacts of demand management and mode choice-related *trans* modal *pricing* measures, including urban road use pricing.
- Specify and demonstrate *trans* modal *pricing* and integrated payment systems in selected European cities and assess effects on modal split, public and political acceptability.
- Evaluate *trans* modal *pricing* and integrated payment scenarios and actions using a common and comprehensive framework.
- Investigate ways of exploiting traffic data likely to be generated from integrated payment systems and disseminate the overall project results, including cities in Central and Eastern Europe.

*Results delivered / short summary:*

The following recommendations can be made on the basis of the evaluation results and the experiences with urban transport pricing measures examined in the ***TransPrice*** project:

- Transport pricing measures offer several possibilities of changing modal split in urban areas in favour of public transport, Park & Ride, and non-motorised modes; they can also provide significant revenues for financing appropriate transport systems and environmental improvements.
- Road use pricing should be considered when parking pricing measures alone have been found to have exhausted their effectiveness.
- Road use pricing should be considered as a part of a package of demand management measures, in order to increase its effectiveness and acceptability.
- Integrated payment systems should be implemented to support the implementation of transport pricing measures; they can have small but significant impacts on their own.
- Intermodality improvements, such as Park & Ride and integrated ticketing should be implemented together with transport pricing measures in order to enhance the impact of pricing measures.
- Use of the road use pricing revenues affects the acceptability of pricing measures; hypothecation of revenues for investments within the transport and environmental

improvements sectors of a specific urban area substantially increases the potential public acceptability.

In conclusion, an effective trans modal integrated urban transport pricing strategy should combine packages of pricing measures, payment systems, intermodality and public transport improvements, in a comprehensive transport planning and management framework towards sustainable mobility.

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## A.8 TRENEN II

*Goal of project*
The objective of the TRENEN II STRAN project is the development of strategic models for the assessment of pricing reform in transportation and their application to the European Union. The strategic models are designed to analyse two types of policy problems. The first problem is to measure the gap between present and efficient prices across all modes. The second problems is to measure the potential of different types of pricing instruments to improve the pricing of transport.

*Results delivered / short summary*
Conclusions in final report (July 1999)

- Parking policies

Making all roads users pay for the resource cost of their parking place plus an extra charge can be a very effective instrument. It corrects the parking inefficiency and reduces at the same time the congestion externality. This achieves between 30% and 65% of all potential welfare gains in urban areas

- Improved car emission technologies

Using taxes or standards to favour the introduction of cleaner cars is an important instrument for urban areas, in particular for limiting the emissions of diesel cars. The investment in cleaner cars is not necessarily justified in non-urban areas. This instrument can be responsible for between 1% and 4 % of maximal potential welfare gains

- Fuel tax policies

Higher fuel excises could reduce car traffic in urban areas and in non-urban areas in the peak. For this reason, fuel tax instruments can be effective. They also reduce non-urban passenger and freight transport in the off peak period and this is not necessarily justified. Increased fuel taxes are therefore not a good instrument to improve pricing on transport markets.

- Reduced subsidies to public transport

Once one can correct the pricing of car transport it is no longer justified to set tariffs much below the marginal social cost for public transit. Optimal transit prices differ between peak and off peak periods and should cover also the marginal external costs.

- Simple congestion pricing

The simplest congestion pricing is cordon pricing in urban areas and congestion pricing on interregional highways. If this can be combined with an elimination of subsidies for variable costs of public transport, important welfare gains are possible. For urban areas these gains very from 16% to 60% (depending on the location of the cordon) and for interregional transport between 60% and 83% of the potential maximal welfare gains.

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## A.9 AFFORD

*Goal of project:*
The general objective of Project AFFORD is to promote marginal cost pricing practices in the context of urban transport, to show that they are desirable and feasible, and in particular, to show how the barriers to their implementation, institutional and political, can be overcome. The first stage is to operationalise the idea of marginal cost pricing, i.e. the identification, detailed definition and assessment of practical pricing measures.

The more detailed objectives of Project AFFORD are to:

- INCLUDEPICTURE "../../../windows/TEMP/_themes/mytheme/blebul1a.gif" * MERGEFORMATINET \dIdentify and define practical measures to implement marginal cost pricing.
- INCLUDEPICTURE "../../../windows/TEMP/_themes/mytheme/blebul1a.gif" * MERGEFORMATINET \dAssess the effectiveness of such measures in internalising externalities and affecting demand.
- INCLUDEPICTURE "../../../windows/TEMP/_themes/mytheme/blebul1a.gif" * MERGEFORMATINET \dExamine institutional issues affecting their implementation.
- Assess the economic and equity implications of these measures.
- Assess their public and political acceptability, and how this may be improved where appropriate.
- Provide policy guidelines for the practical implementation of pricing measures.

*Results delivered / short summary:*
D1: Deliverable 1: "Operationalisation of Marginal Cost Pricing".
D2A: Economic and equity effects of marginal social cost pricing in transport. Marginal social cost pricing may give rise to substantial welfare benefits for the urban population. These benefits have been estimated by means of transport models for: Edinburgh, Helsinki and Oslo. Distinguished are first best (each traveller is charged the true marginal social costs) and second best solutions (solutions based on real world policy instruments).

- First best solution leads to welfare gains of 200 to 400 Euros per capita per annum. For second best the welfare gains considerable smaller. For first and second best solutions inflict a private loss for the travellers and benefits for operators and the government. The environmental gains are moderate.
- Equity effects are moderate, especially when road pricing is combined with redistribution schemes by means of a public fund. This public fund however generates an efficiency loss throughout the economy amounting to 25% of the amount of Euros raised.
- Optimal second-best marginal cost pricing may imply stiff charges. Less stiff and therefore more acceptable charges do very little to improve the welfare of the urban population.
- Introduction of marginal cost road pricing decreases the number of car trips, sometimes even as much as 30-40%. The effects in terms of car kilometres depends on the form of the instrument. A toll ring may generate even more car kilometres

- Included in the research were also land use effects, accessibility and environment and safety effects.

D2C: The general objectives of this report are to assess acceptability of marginal cost based pricing measures, to analyse the reasons for lacking acceptability and how this may be improved where appropriate. The more detailed objectives of this report are

- to identify key issues, and different interest groups, related to acceptability;
- to develop and use a framework for conceptual, theoretical and empirical analysis of acceptability of marginal cost based pricing measures;
- to assess public, political and business acceptability of the specified pricing measures;
- and to analyse the prerequisites of pricing acceptability.

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## A.10 PRIMA

*Goals of project:*
The objectives and expected results of the project The basic aim of the PRIMA project is to produce policy recommendations and guidance for the implementation of road pricing systems in Europe. The specific objectives of the project are :

- to assess the acceptance of road pricing in urban areas;
- to evaluate optimal designs of road pricing schemes and decision making processes thereby taking account not only of what is technically feasible but also of the acceptability of different schemes;
- to identify barriers towards implementation of electronic urban road pricing systems and to develop a guideline showing how to remove these barriers.

Eight cities, eight case are implemented and analysed to reach the goals as stated above.

*Results delivered / short summary:*
Regarding the acceptance for urban road pricing, the following conclusions van be drawn:

- acceptance relates to perceived benefits. Traffic problems must be evident as well as that road pricing is the only solutions
- acceptance relates to availability of alternative modes of transport. Improved public transport should be part of the policy package.
- Acceptance relates to the level of charges. Fairly low starting levels are needed.
- Acceptance relates to distributional effects. Compensating measures should be considered regarding groups whose welfare will decrease by the pricing scheme because of e.g. location of housing, workplace and service centres.
- Acceptance relates to the design of the decision making process needed for introduction, discussion and implementation of the pricing scheme.
- Acceptance relates to the negotiation abilities of the involved levels of government. A bottom-up strategy initiated from the urban area is essential but supplementing top-down strategy is also needed.
- Acceptance relates to communication efforts initiated in the beginning of the decision making process.
- Acceptance relates to earlier road pricing experiences
- Acceptance relates to the general privatisation trend

- Acceptance from a majority of the citizens cannot be expected.

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## A.11 PATS

*The aim of this project is to:*

- Identify the reasons behind the attitude of acceptance/non-acceptance of transport pricing, and the arguments that support those standpoints;
- Find the means and measures to increase its acceptability;
- Analyse of the distributional effects of pricing;
- Identify the legal and political barriers to the implementation of pricing schemes;

Design acceptable pricing schemes and policy packages, taking account of efficiency and fairness issues.

*Results delivered / short summary*

D1: State of the art synthesis on price acceptability

This deliverable looks at transport pricing in Europe from the perspective of its acceptability. It gives an overview on transport pricing and taxation in Europe and identifies factors that influence the acceptability and thus the success or failure of pricing and taxation measures, instruments and packages.

D2: Socio-economic principles for price acceptability

Transport pricing is currently a highly debated topic in the European Union. What is under discussion in this deliverable is the acceptability of *changes* in transport pricing. They include not only changes in the current pricing levels but also the general adoption of specific pricing strategies already experienced in some countries, such as road user charging and the introduction of completely new instruments. Such *changes* are, for instance, suggested in the Green and White Papers of the Commission and in various national documents reviewed in Deliverable D1.

D3: Emperical studies on price acceptability

Work in progress

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# APPENDIX B
# INTERNATIONAL OVERVIEW OF ROAD PRICING

## B.1 INTRODUCTION

An International Overview of Road Pricing was recently undertaken for the INTERCEPT project, which is supported by DG TREN and DG INFOSOC. CUPID is currently undertaking a more comprehensive review which will be made available on www.transport-pricing.net, and regularly updated. The following review was prepared by Bristol City Council and the INTERCEPT Consortium, and has been made available for reference purposes.

## B.2 ROAD PRICING

Traditionally, the pricing of roads was aimed at raising revenue to pay for their initial construction. In some cases a charge continued to be levied for the service a road provided - normally through Road tolls. The building and operation of transport routes by private enterprise has a long history and continues today on motorways. Private Enterprises – more so than Public ones, require a return on their investments and as such road pricing evolved naturally. Latterly, newer policies have developed with demand management objectives (for environmental or traffic management reasons) that has led to charges being made on roads that were previously free.

This state of art review, as part of the INTERCEPT project, examines urban road pricing primarily introduced for demand management reasons. In particular it seeks to review electronic road pricing (ERP) in urban areas. The objectives of urban road pricing are commonly to:

- change the travel behaviour of drivers as they react to reduce the charge they must pay. This might include not making a trip (suppression), changing their route (diversion) or making the journey at another time. Different destinations may be chosen, or the same trips may be made by another mode, e.g. public transport
- raise revenue for improving alternative transport modes or the urban environment. This is a very useful way of balancing the 'sticks' with 'carrots' and return investment to the area from where it was raised. This can have an important positive influence on public acceptance of schemes.
- improve accessibility in the urban area by removing congestion and to prioritise the newly created road space for certain modes e.g. commercial traffic or public transport vehicles.

## B.3 APPROACHES TO ROAD USER CHARGING

Road charging schemes can be administered in different ways. Some of the main options include:

- **real-time congestion charging** – this varies with congestion levels found in that area at the time of charging;
- **time based charging** – the charge levied is proportional to the amount of time spent inside the area covered by the charging scheme;
- **distance based charging** – the charge is directly related to the distance travelled within or along the specified route or area;

- **cordon pricing –** a charge is applied upon the vehicle passing a cordon surrounding an area (or areas if there are multiple cordons). The charge may be levied on traffic in one or both directions
- **area licensing –** a charge made for the permit needed to enter a scheme area during specified times of day which generally can be used as many times as desired during the duration

With regards to the application of tolls, common approaches for toll drivers in order to raise funds for the road infrastructure itself are through the utilisation of:

- road section tolls, along motorways / expressways
- point tolls (tunnel or bridge), to cross or use a particular section of infrastructure along an otherwise free (or lower cost) section of road

## B.4 FOCUS OF REVIEW

Perhaps at its simplest, road user charging can be undertaken using a paper based approach that operates with permits used for area licensing. This was operated successfully in Singapore as the Area Licensing Scheme (ALS). However, for more advanced systems with greater flexibility, reliability and convenience, automatic payment methods are required. Automatic Fee Collection (AFC) can be defined as:

"A system that enables automatic debiting, i.e. paying for a transport service without any action from the user at the moment of the use of the service". *ISO/TC 204 N145, 2 October, 1995 (draft).*

Automatic (or Electronic) Fee Collection (AFC or EFC) is pertinent to both road tolling and electronic road pricing (ERP) in urban areas, hence the reason that this review includes examples from both types of scheme from around the world. At the technology level there is a high degree of overlap between automatic tolling and electronic road pricing, as some of the basic functions are the same.

Urban road pricing generally requires higher levels of functionality to apply a charge equal to marginal social cost in order to manage demand (CAPRI, 1999). The elements of the marginal social cost of driving (e.g. congestion, accidents, local air pollution) can be considered context specific and might vary over time. If behavioural change is desired (e.g. peak spreading or shifting) the charge may need to be set higher to influence users whom are less responsive to price. Ideally, a system should be able to vary charges with the:

- time of day
- day of week
- by class of vehicle / size of engine
- and provide feedback / other services to the end users

## B.5 TECHNOLOGY CHARACTERISTICS

AFC is an essential part of electronic road pricing in urban areas and is in this area that tolling schemes and ERP schemes have the most commonality. Urban road pricing increases the requirement from AFC collection system and broadens the system functions.

These functions should enable (CODE, 1999):

- Collection at motorway speeds
- Automatic detection and classification of all vehicle types
- Charges deducted automatically without driver action
- Options for anonymous payment
- Full multi-lane operation (no channelling needed)
- Non-payers should be identified and recorded for enforcement purposes
- Reliability should be high to ensure few errors.

Such systems usually consist of a group of components which in combination fulfil the functions necessary for automatic fee collection (VASCO, 1997). These components necessary in most cases are:

- on-board unit or in-vehicle equipment (OBE or IVU) within a vehicle, which provides information on the vehicle's unique identity;
- ground equipment for communication, located at the road-side, and used for automatic vehicle classification (AVC) and charging;
- road-side equipment for enforcement, such as video enforcement systems;
- a debiting device, such as a Smart Card may also be part of the in-vehicle unit (IVU) from where the charge is debited. Alternatively, in less complex systems, this may take place from a central account once a vehicle is identified and classified;
- central equipment for the administration and the operation of the system.

There are a number of different ways in which the identification and communication in such systems can be undertaken. Surface Acoustic Wave (SAW) technology has been used to reflect back the in-vehicle tag identity and lasers can read 'bar-code' type identities on tags.

Radio frequency (RF) communications use microwaves to establish contact with tags. Tags vary according to their functions and complexity and can be configured to communicate in one direction (read ID only), two directions (read / write) and include their own processors to perform on-board functions. Infrared is also used as an alternative to microwave in some systems to facilitate communication between the IVU and road-side equipment.

The radio frequency of microwave communications varies between systems. For example, dedicated short range communications (DSRC) which is the preferred standard for Road Transport and Traffic Telematics (RTTT) in Europe has been fixed at 5.8GHz. DSRC systems are the most common type of AFC system but within this description there are a number of combinations which means many systems are basically bespoke, in the absence of full standards.

GPS based systems can remove the need for road side detection infrastructure and have been tested in Germany and Hong Kong. They use GSM cellular networks for communications and track vehicle positions in relation to virtual toll zones.

A number of the technologies available for AFC have reached the stage where they can provide the functionality required for electronic road pricing in urban areas. A number of

implemented schemes are now reviewed in terms of the operation, objectives, functions and technologies used.

## B.6 ELECTRONIC FEE COLLECTION IN OPERATION

This section will seek to review a number of implemented schemes together with a smaller number of schemes that are about to commence operation or being actively studied. A number of major schemes are reviewed in terms of objectives, functions and technology together with impacts (where found).

### B.6.1 Implemented schemes

*Singapore*

The original Singapore Area Licence scheme (ALS) operated from 1975 until recently was a paper based entry permit scheme. Drivers had to buy licences to gain entry to the charged zone, and at the time of introduction a day pass cost 15% of the average daily wage. The APAS study, reported by the CAPRI project (1999), found that morning peak flows into the central area in 1992 were only 50% of that recorded prior to the implementation of the scheme in 1975. As a consequence of this, bus patronage increased by 83%.

The ALS system of charging Road Users worked relatively well in keeping Singapore's traffic problems within manageable levels but the system came to be viewed as labour-intensive and inflexible (LTA, 1999). The Singapore Government therefore started looking into Electronic Road Pricing (ERP) in 1989 in a bid to automate the system and replace it with one that was:

- **Fair** - ERP facilitates a pricing structure that is time and congestion sensitive. It is fair and charges on a per-pass basis;
- **Convenient** – ERP would remove the need to purchase daily/monthly licences;
- **Reliable** – ERP would not require any major involvement of enforcement personnel at the zone entries (or in the processing), the potential for human error is removed.

In Singapore the initial two gantries (ERP control points) for the system started operating along the East Coast Parkway (ECP) expressway in April 1998. Three further gantries were opened in August 1998 along Central Expressway (CTE). Since September 1998, another 28 gantries have started operation. This has made Singapore's ERP system the largest road pricing system in the world.

The ERP system works with pairs of gantries communicating with the IVUs and supporting gantry cameras to detect offenders or incorrectly working in-car equipment. The in car equipment comprises an IVU and a smart card that can be loaded with funds for payment of tolls.

The IVUs have to be permanently attached to the vehicle battery, which requires a special fitting and initialisation appointment. There are a number of IVU installation centres where motorists can replace the faulty smart card or repair the IVU. Installation takes around 20 minutes and is free of charge.

The IVU incorporates a LCD screen to provide feedback on charges to the user when a smart card is first inserted and when the vehicle passes the gantry. A number of icons and sounds

are also used to provided feedback about charges being made, card/IVU error or low levels of funds. The transponder requires a clear 'sight' of the gantry in order to communicate via radio and is attached to the inside of the windscreen. Battery powered IVUs can be hired by visitors for infrequent visits to the tolled area.

The IVUs are colour coded for different types of vehicle classes as the ERP charges vary for different vehicles. The vehicle categories are cars, taxis, motorcycles, light goods vehicles, small buses, heavy goods vehicles, large buses and emergency vehicles.

The stored value smart card is a contact smart card called the CashCard. It is available at banks, post offices and petrol stations and can be topped up at many automatic cash machines. In addition, the card can also be used for other transactions in supermarkets, petrol stations etc.

In operation, the first gantry recognises the presence of an IVU and its classification and instructs it to debit the CashCard with an appropriate amount that is determined from a table of prevailing charges for various categories of vehicles. Between the first and second gantries, the IVU debits this amount from the CashCard and the driver hears a short beep and the new CashCard balance on the IVU display for 10 seconds.

If errors occur for any reason (faults with the card, IVU, communication or other errors) a photograph is taken together from the second gantry printed with the reason for this action. For technical errors drivers are notified at which point they should make an appointment at a service station. For avoidance offences, a fine is sent out that may be settled or disputed.

The first two ERP gantries installed at the ECP expressway operate during the morning rush hours from 7.30am to 9.30am from Mondays to Fridays in the direction of flow to the city. Traffic volumes during the ERP period has dropped by about 15% from 16,000 to 13,000. There is a slight spreading of the peak hour traffic as some vehicles take advantage of the lower charges between 7.30am - 8.00am and 9.00am – 9.30am. Weekday charges vary from route to route depending on the time of day. Drivers with be charged between 1.50 SD and 3.00 SD for driving into the central business district.

Violations are low at around 100 out of a total of 13,000 passes under the initial two gantries. Errors normally occur as a result of Drivers not inserting the CashCards into the IVU correctly, with some card/transponder interface problems accounting for a few errors. A second phase of the scheme is planned to extend its operation onto the Ayer Rajah Expressway.

*Norway*

In Norway three toll rings operate charging motorists for entering Trondheim, Oslo and Bergen. The first scheme opened in Bergen in 1986, Oslo in 1990 and finally Trondheim, which has been in operation since 1991. The Trondheim Toll system is in operation between 0600 and 1800 Monday to Friday with no charge in the evenings and at weekends. Charges are generally one way, into the city, and higher charges are in place during the morning peak until 10:00 am. Bergen motorists pay until 10pm on weekdays and in Oslo there are charges at all times. In Trondheim nearly all but two of the entry points have automatic toll plazas which allow non-stop tolling to take place for those vehicles fitted with Q-Free tags.

The IVUs used in the Norwegian schemes are passive read only MD 856 R/O (SAW-technology) operating at 856- 918 MHz supplied be Q-Free ASA. Communications between IVUs and toll beacons are via microwave. This allows non-stop fee collection from the central accounts of toll ring subscribers, but the relatively low traffic flows at the smaller cities required lower cost technology for the project to be cost effective.

The system charges vehicles at various rates at different pre-determined times of the day and one rate is charged at all entry points. In Trondheim a ceiling of 60 passes a day is set over which the vehicle will not be charged.

The toll rings were installed to raise revenue for planned road infrastructure schemes (matched by government funding) with a limited life of 15 years. 20% of income from the Oslo toll goes towards public transport infrastructure from a fairly low charge of NOK 7.20. Those who wish to drive into the city benefit from better roads with fewer queues at toll plazas and those that do not wish to drive know a heavier burden is falling on motorists and also benefit from better transport alternatives (i.e., Public Transport).

The APAS study of 1990 was reported by CAPRI (1999) to have found that when charges of approximately 1.3 ecu were introduced in Olso in 1990, traffic levels in the central area reduced by around 5%. In Bergan, the lower toll of around 0.7 ecu reduced traffic in the central area by 6-7% during the daytime charging periods.

Studies have been carried out to test the use of the Trondheim Toll Ring for demand management purpose and the results of this are looked at later in this review. There is an ongoing debate about whether the Toll Rings will be maintained for such purposes, and it is likely that this will be the case when the current mandate runs out.

*Portugal*

Auto-Estradas de Portugal, SA (BRISA) is Portugal's leading highway concessionaire and operates the Via Verde (Green Way) motorway tolling scheme (Q-Free, 1999). It uses a MD-5803 READ/WRITE Transponder operating at 5.8 GHz with LDR (31.25 kbit/s data transmission rate) and microwave beacons. Via Verde is primarily a so-called closed tolling scheme, which means that the fare paid depends on the distance travelled. A small number of toll stations are still using an open tolling scheme, meaning that the price is fixed, regardless the distance travelled.

When the car enters the toll road, the IVU receives a message from the roadside system. The message comprises a time stamp and information about the entry location. This message is called a TAP (Time-And-Place) stamp. When leaving the motorway the roadside equipment reads the IVU identity, the vehicle class and the TAP from the transponder. The vehicle class is compared with the vehicle class found by the Automatic Vehicle Classification (AVC) system. Based on the entry location and the vehicle class, the exit lane equipment calculates the correct fare for the journey. This transaction is logged at the toll plaza and later transferred to the central system for clearing.

As the driver drives through the toll plaza, he is informed about the amount withdrawn from his account on a VMS sign at the road side. A signal light on the IVU also gives status feedback to the driver.

The central system is connected to the common electronic banking system of Portugal, SIBS. A high level of integration enables the central system to send payment claims to the SIBS system and receive a confirmation from SIBS when the customer's bank account has been debited. Customer first order their subscription to the automatic tolling service by completing an application with the vehicle details. An IVU is sent back together with instruction for use from BRISA. To activate the IVU and their central account a subscriber uses an Automatic Teller Machine (ATM) and uses a normal bank-card for identification. An option is available for registering the IVU to the bank account which provides SIBS with sufficient information to debit his account based on claims for payments from BRISA.

The use of the Via Verde system is steadily increasing and in the spring of 1998, more than 500000 active subscriptions were registered. As part of a motorway tolling operation the system is designed to raise revenue for the road service provided and encourage use of the road. As such it has the objective of encouraging users to subscribe to the automatic tolling system, rather than the more costly manual payment method. The system is interesting however for two reasons. One is the read/write ability of the 'closed' system which can charge the vehicle based on its exact entry and exits points into the system together with the vehicle class, which adds extra functionality to the tolling approach. The second aspect, is the payment and subscription method which demonstrates the convenience of integration with the banking system for the end user in terms of setting up an account.

*California State Route 91 (HOT lane)*

The State Route 91 high occupancy tolling lane (HOT) was opened December 1995 and is America's first toll road to employ variable congestion pricing (Caltrans, 1999). It is a privately financed, fully automated 10-mile (15 km) group of four toll lanes, located on the median of an existing eight-lane highway in Orange County, California.

Tolls vary during the day according to traffic volumes, direction and other factors so as to maintain free-flow conditions at all times. Currently, tolls follow a published schedule although the technology could permit tolls to vary dynamically. Cars with one or two people pay a toll while vehicles with three or more persons travel free. The project was developed in a partnership between Caltrans (California Department of Transportation) and the California Private Transportation Company.

All tolls are collected electronically by AFC. The system utilises Dedicated Short-Range Communication (DSRC) as a means of RF communication between vehicles and roadside subsystems. There is not, as yet, nation wide standardisation in the US (Traffic Technology Today, June/July 1999). However, the California Department of Transport developed a compatibility specification for automated vehicle Identification equipment that the California Legislature made into law in July 1992 as Title 21. The SR91 electronic toll road meets the Title 21 standard.

The Route 91 Electronic Toll Collection system uses a passive RF tag which utilises back-scatter technology to respond to information from a reader by reflecting and modulating the reader's RF signal. These passive RF tags are generally small and light and relatively inexpensive and have a longer battery life as they operate mostly on power generated by the reader (Traffic Technology Today, June/July 1999).

Initial indications are that the SR91 Toll lanes have successfully created a market of commuters willing to pay premium tolls in order to bypass recurrent congestion on an urban freeway. By the end of the first year, between 70,000 and 80,000 users had obtained transponders and the peak period traffic increased so dramatically that a toll increase was required to protect the toll lanes from congestion (Caltrans, 1999).

Toll lane traffic is currently at 26,000 vehicles per day. Surveys show that 65-70% of the travellers approved the idea of adding new tolled capacity to bypass congestion. However, approval levels for the idea of operating the Highway as a private enterprise have remained in the 35-45% range both before the construction of the lanes and 5 months after opening.

The results of final report by Cal Poly evaluating the SR91 scheme on behalf of CALTRANS (Cal Poly, 1998) were that there was a strong correlation between use of the express lanes and travel time savings, thus showing the objective to offer a congestion free service was achieved. Of more relevance to road pricing are the results of HOV use, which were given free use of the HOV lane, and therefore priority over non-paying single occupancy vehicle (SOV) using the more congested alternative lanes.

Results of monitoring showed a 40% growth in number of peak period HOVs carrying 3 or more passengers (HOV3+) during the first 3 months of operation when HOV3+ paid no tolls. Van-pooling data from local employers with many employees using SR91 showed a 10-15% rise in the formation of van pools and participation levels. This rise is against a small base level of around 3.7% HOV3+ before SR91 tolling opened and the growth in SOV traffic (due to extra capacity) actually meant average occupancy declined. Surveys found in fact that a larger number of commuters switched from HOV to SOV than vice versa in the year after the express lanes opened. The net effect was a 7% decrease in the proportion of HOV users as ride sharers were attracted to using SOV even if they had to pay for a congestion free expressway.

Dynamic pricing on the Interstate 15 (I-15) pilot project in began in March 1998 with charges varying by the time of day and level of congestion. The system utilises vehicle transponders and overhead readers (Federal Highway Administration, 1998). Drivers are informed (via VMS) about the highest toll they can expect during the hours of operation (5:30am-9:30am and 2:30pm-7:30pm), with tolls ranging from 50 cents to $4.00, under regular conditions. The San Diego Association of Governments (SANDAG) has the authority to allow tolls to increase to $8.00 per one-way trip under certain conditions. The charges can change every 6 minutes in 50 cent increments. In response to drivers who may wish to shift modes, a new express bus service has been introduced as part of the pricing program.

*407 ETR Toronto*

A major road construction of roads and bridges has been undertaken in Ontario, Canada by a private-public partnership that has implemented the 407 ETR (Electronic Toll Road) scheme. The technology and billing aspects of this scheme are particularly interesting in that in addition to the usual IVU to Roadside equipment communication, the system can also use video recognition systems. Moreover, billing takes place automatically after a vehicle has used the highway.

The 407 ETR runs east-west across the north of Toronto - Canada's largest city - from Highway 403 in the west to Highway 48 in the east for a total of 69 kilometres. The system

monitors the entry and exit point of all vehicles from the 29 interchanges on the highway. Fully automatic tolling is possible using windscreen transponders that provide audio and visual feedback to drivers that their account is being debited.

Additionally, vehicles without transponders are also able to use the ETR. In this case, the tolls are tallied using a state-of-the-art licence plate recognition system that sends a video image to a central processing computer when the vehicle enters and exits the highway. When the transaction has been processed, an invoice is then sent to the owner of the vehicle by mail.

Failure to settle their payments within 91 days will result in the details of the offending vehicle (and driver) being sent to the Canadian Ministry of Transportation for plate denial. This may result in the vehicle licence plate not being renewed until all outstanding charges are paid in full and a person's account may also be sent to a debt collection agency.

### B.6.2 Planned and imminent schemes

A number of major schemes are being planned or about to be started which are of relevance to this review. The Melbourne CityLink is a toll road, rather than a road pricing scheme, but uses DSRC technology and demonstrates the spread of AFC worldwide. Hong Kong trials to determine their preferred urban road pricing scheme is currently comparing 'standard' DSRC technology with a GPS based system.

*Melbourne City Link*

The City Link scheme has created a 22-km expressway linking the major routes between Melbourne Airport, the port and industrial centres in the south-east (Transurban, 1999). It uses a fully automatic cashless toll payment system of 16 gantries in total to pay for a network of new roads and improvements in Melbourne to speed flow of general traffic. A DSRC system is used with windscreen placed tags and users are required to set up pre-paid accounts or buy a day pass. AFC deducts the appropriate toll (for the class of vehicle) from central account and the tag gives and audio signal when this occurs and when account levels are running low. (ITH, 1999)

*Hong Kong*

In Hong Kong, a large scale 2 year study is helping to decide between two forms of electronic road pricing system that will be introduced to raise revenues and control demand on the strategic road network. (Traffic Technology Today, Tolltrans Supplement, Oct/Nov 1998).

The Hong Kong Transport Department has decided to trial a Vehicle Positioning System (VPS) alongside a 'standard' 5.8GHz DSRC gantry based systems. VPS is based upon the concept of a virtual toll zone using a combination of GPS and cellular networks. The attraction of VPS is the minimal road side infrastructure costs. It was first tested as a concept in Germany where there are few overhead gantries available on the motorway system. On board equipment has a high cost however and enforcement systems may still require additional infrastructure. In the Hong Kong trial on-board VPS equipment consists of a GPS receiver, computer, an odometer for dead reckoning and a modem for communicating via the radio packet data system in Hong Kong.

Trials in Hong Kong involved high speed testing on a dedicated track and a complementary on-street trial of both systems. Seventy five vehicles will be involved with two sets of 25 vehicles fitted with one of the two systems and 25 police vehicles equipped with both. A decision between the two systems is expected by the end of 1999 (Traffic Technology Today,1998).

B.6.3 Summary

Each of the examples highlighted above has different aspects relevant to electronic urban road pricing. The Singapore ERP scheme is the most complete and relevant example primarily because the objectives of the scheme are to reduce congestion and manage demand for road space. In terms of functionality the scheme uses smart card payment systems which provide very flexible charging structures to the operator on one hand whist providing feedback to drivers and allowing additional functions, such as the payment for other goods and services.

In Europe, the Norwegian toll rings are worthy of review given the urban context in which they operate and the successful and long operation lifetime they have had. They are also the only European cities with charges that have some mode switch effects. Although the implementation objectives were firmly biased to raising revenue for transport infrastructure rather than demand management, traffic flows have been effected by the introduction and the schemes have provided a stable test bed with which to test other charging scenarios. The extension of the schemes for demand management purposes – once the initial contract life has expired – is now a real possibility. Low levels of functionality are a feature of the technology however, with users required to be subscribers with central accounts. This reflects the technology of the time and also the need for a low cost system due to the relatively low toll level.

The BRISA system in Portugal operates with read/write tags that enable distance based charges to be made by the use of a time and place ‘stamp’. Demand management objectives do not feature in this system as it has been implemented to raise tolls in a way convenient to the user and operator. There is however good use made of integrating with the banking system that allows the end user to set up their own account to enable direct debits to be made by the motorway operator.

Systems in the US tend to be characterised by tolling schemes. For this reason the SR91 HOT scheme uses tolls to produce congestion free roads, which the motorist can choose to pay for as a service. Demand management objectives are incorporated by allowing HOVs carrying 3 or more passengers to have free access to the toll road. DSRC technology is used to charge variable tolls at different times of the day, in order to preserve the congestion free service. The availability of this option has meant that more HOV users have switched to single occupancy than vice versa, despite there being a large percentage growth in HOV3+ users.

The 407 ETR in Toronto distinguishes itself by being the largest scale operation of video recognition systems for tolling. This element of the system does not utilise automatic fee collection, but sends out bills in conjunction with Ministry of Transportation vehicle records. This means the system combines vehicle detection with payment collection to such a degree that charge avoidance should be very difficult. Drivers who subscribe to a tag service are

charged a lower rate (using AFC) and those without a tag, who are sent a bill based on the vehicle records.

The appropriate use of different technology depends on functionality required from the system and whether it will meet the requirements for road pricing in urban areas. Examining the requirements for urban road pricing schemes the conclusions on each of the main in-vehicle (end user) technologies can be made (CAPRI, 1999).

Supplementary (paper) licenses are adequate for entry level and simple systems requiring little variation over time of day. The approach requires high levels of manpower for checking and enforcement, both reasons given by LTA (Singapore) for the change-over from their long-used paper permit based ALS.

Electronic tags come in two basic varieties (read only or read/ write) and are good for high speed routes and where little user data transfer is required. Relatively low cost, they can be issued for different vehicle types. Work in the US has shown that variation in charges for tolling can be made when combined with VMS signs to notify drivers. They require subscribers to hold central accounts which makes them suitable for tolling schemes, but not urban road pricing where the user should be provided with debit and account information.

Read / Write tags can provide more feedback to users in audio or visual (LED) signals together with LCD displays showing the last few transactions. Accounts can be held centrally for pre-payment, or post-payment can be made. Anonymity is possible which is important to users who may not have a choice about whether to use a road, unlike subscribers to toll roads. Read/write tags cannot integrate with other payment systems, although the payment for road charges can be made in innovative ways. Read/write tag systems can otherwise meet many of the requirements for urban road user charging.

Vehicle Positioning Systems using GPS and cellular communications may be suitable in certain situations, for example when infrastructure for attaching road site equipment is not available. High IVU costs is a feature, but this equipment could be expected to provide a platform for additional driver services.

In-vehicle meters require fitting to the vehicle odometer and may encourage dangerous driving behaviour if they were used for a time based charging system and no examples were found by this review.

Video recognition systems are generally used to supplement the use of tags, by checking vehicle type (i.e. size) against tag identity. The latest systems (407 ETR in Ontario) are also able to distinguish vehicle identity (i.e. registration) at highway conditions and given access to vehicle records can send out retrospective bills for highway tolls. No other functions are provided for drivers however as an IVU is not required by the system

Transponders with smart cards provide processing capacity together with user identity features on the card itself. User feedback is provided via the transponder (with LCD screens and / or audio signal) and two-way communication with road-side equipment. Such a system enables many variations in tariff levels and incentives together with communication with the end-user. The combination with integrated payment systems could include public transport, telephones, parking or other small charge uses (e.g. Singapore) and the convenience of the electronic purse could be a significant factor in public acceptance. Smart cards enable full

anonymity for the user because all transaction details are securely held on the built-in chip where data is read and written. The amount of data that can be transmitted does depend on the vehicle speed and so high speed points can pose a challenge. Other than this, and the higher cost of the technology, transponders with smart cards appear to offer the best system for urban road pricing.

## B.7 FOCUSING ON EUROPE

Automatic fee collection (and urban road pricing) is therefore technologically possible, but its success may depend on how long ago and successful the process of introducing it have been. Road user charging in Europe is limited to road tolls in France, Italy and Portugal for example, and as discussed above, only in Norway do the tolls have some effect on mode shift and is used in an urban setting.

### B.7.1 Road User Charging

The Netherlands are currently pursuing trials of road user charging technologies, but without national legislation as yet. Authorities in Bergen (Norway) are looking for an one year extension of the toll ring in order to take them up to a time when the tolls may be used for demand management. In Italy the authorities have the ability to implement urban road pricing to control the entry of traffic in city areas, but no city has implemented a scheme using this legislation yet.

In Great Britain, the Governments recent White Paper commits to legislation that would allow authorities to introduce urban road user charging and keep revenue for local investment in transport improvements. Legislation will be necessary for pilots schemes with the next opportunity to announce this in November 1999. A number of cities, including Bristol, have put themselves forward for a fast-track scheme to become the first of the cities to pilot real schemes once legislation is available.

The legislative framework for road pricing does not therefore exist as yet in Europe, but a number of countries are in the process of moving towards creating the legal foundations for its introduction.

The EU spirit of ‘subsidiarity’ means that decisions on road pricing will be made by member states rather than on a European wide basis. The EU views the development of pricing technologies as important however and as a result there have been increasing calls for standards in automatic fee collection.

### B.7.2 Standards

A major focus of the DRIVE programme (with nearly half of the projects) was the creation of technical specifications leading towards formal technical standards (Waters Information Services, 1994). DRIVE I and DRIVE II have delivered common specifications to the appropriate European standards bodies.

CEN (European Committee for Standardisation) has a CEN Technical Committee 278 (TC278) to standardise pan-European road and transport telematics systems. Working Group 1 covers EFC requirements for the DSRC link between roadside and vehicles.

A framework has been set in place Europe-wide and compliance would be mandatory within the EC. Standards and their adoption would bring benefits in terms of guidance for future generations of equipment, order to the marketplace and minimise the chance of incompatibility. This will not necessarily lead as far as compatibility or interoperability however. Compatibility would mean that components will work together in a system and interoperability means different systems with the ability to provide and accept services from other systems so operating effectively together (Waters Information Systems, 1994).

The activities in DRIVE I, DRIVE II (from 1992) and the formation of the mixed public private venture that is ERITICO have moved standardisation at the European level to a level that it is much more advanced than at the international level (ISO).

Work on standards has continued with CARD-ME (Concerted Action for Research on Demand Management in Europe) established by DGXIII and DGVII in response to the Council of Transport Ministers calls for ETC standards and interoperability. It provides a platform at Government level for development of policies for toll collection with an emphasis on moving towards standardisation and convergence in the medium to long term with an ultimate aim of paving the way for pan-European interoperability. CARD-ME Support was an accompanying measure following on from CARD-ME in the second call as a result of a Council of Ministers resolution calling upon an acceleration of the identification of obstacles to interoperability and identify and strategy of convergence. Accordingly the CARD-ME Support action aims to:

- specify a common payment system
- assess the impact of systems using satellite navigation and cellular technology
- develop migration routes for convergence of new and existing EFC systems

CARD-ME work is concerned with the procedural and contractual aspects of interoperability rather than the technical problems (the remit of ADVICE, VERA, INITIATIVE and A1) and is actively collaborating with Technical Committee 278 of CEN Road Transport Telematics (TAPs Project Summaries, 1998).

CEN TC 278 has progressed accepting three of the 7-layer OSI reference model layers due to the constraints imposed on DSRC. For each of these layers a separate standard has been proposed by CEN. For the physical layer two standards were proposed, namely one for microwave communication and one for infrared communication (VASCO, 1999).

In the UK, technology trials are planned to take place in Leeds and Edinburgh to examine the equipment needed for electronic urban road pricing. These trials are designed to test equipment in real traffic conditions and money will not be used. It is expected that following selection of the supply companies the construction and testing will take place from February 2000 to the end of that year. The trials will inform the Government of the equipment required for pilot schemes in the UK and define a UK standard. The specification for the equipment has not been released at time of writing.

In summary, DSRC is the preferred method for road pricing as part of European RTT, but full standards are not yet in place. There is also the possibility that Germany may choose VPS instead of DSRC as the preferred system as both are being evaluated in that country. Tolling organisations meanwhile continue to specify systems based on the best current technology

that suits their needs. A similar choice faces those authorities wishing to evaluate urban road pricing trial ahead of legislation.

Whilst it has been noted that road pricing legislation must be initiated at the local (national) level, the EC has been active in promoting the understanding of technical issues, and ultimately standards, together with the non-technical aspects of demonstration trials. A review is made in the next section of this report on the research activities underway relevant to AFC and urban road pricing.

### B.7.3 EC research

Work has continued from DRIVE I and II into the 4th Framework TAPs projects concerned with AFC technology, interoperability and standards. The transport RTD programme has also included a number of projects examining road user charging from the end user impact and as a tool to meet sustainable transport policy objectives.

A summary of Transport Applications Programme research from the first and second calls of the 4th framework programme can be found in Table B.1 below.

**Table B.1: Summary of TAP project coverage**

| Project Objectives | Technology areas |
|---|---|
| ADEPT II<br>To develop and test interoperable payment systems for various transport services. | Microwave transponders, contact and contactless smart cards, open systems architecture and clearing house systems. |
| CARD-ME<br>Inter-operability on EC motorways. Procedural and contractual aspects essential for interoperability. | Not concerned with technical aspects of inter-operability. |
| CARD-ME SUPPORT<br>Identify further obstacles to inter-operability of ERC systems and develop a strategy of convergence. | Not concerned with technical aspects of inter-operability. |
| VASCO<br>Validation of the Dedicated Short Range Communication (DSRC) proposed for standardisation in Europe for road transport and traffic telematics. Includes Electronic Fee Collection (EFC) and validation of inter-operability from different manufacturers. | 5.8GHz and Infrared DSRC communications for on-board and roadside equipment. |
| MOVE-IT<br>Examining contractual inter-operability of Electronic Fee Collection. Legislative, institutional and commercial obstacles will also be examined. | Interfaces for national systems |
| A1<br>Validating the inter-operability across different manufacturers' EFC equipment based on a DSRC link. | DSRC equipment: on-board units, vehicle detection / classification and video enforcement sub-systems. |
| INITIATIVE<br>Validating inter-operability between systems based on DSRC and Global Navigation Satellite Systems with Cellular Networks (GNSS/CN). | In-vehicle units able to operate with both DSRC and GNSS/CN based on existing and emerging standards defined by CEN TC 278. |
| ADVICE<br>Develop and test automatic vehicle classification and enforcement EFC systems. Produce European guidelines for specification of such systems. | 5.8GHz microwave communications, automatic number-plate recognition, digital image technology, IR-sensors and loops. |
| VERA<br>Harmonised approaches to traffic laws using video enforcement technology. | Video recognition and camera systems. |

Many of the projects undertaken during the programme in the fields of AFC involve validations of systems, proposal of standards with the ultimate aim of interoperability. Achieving these objectives should reduce system costs, increase authorities' confidence in the current state of the art and ensure the development of additional services for the end user based on a secure RTT platform.

Within the Transport Research programmes, the Fourth Framework DGVII has given support to several projects which integrate road pricing approaches into demand management strategies and evaluate the impact on modal shift.

*Bristol*

The CONCERT project, supported by DGXIII and DGVII, assessed the potential of demand management tools, such as pricing and restraint approaches, on urban travel patterns. In Bristol the CONCERT project was known as ELGAR in Bristol (Environmental Led Guidance and Restraint) where it also received funding from the UK DETR (TTR, 1998).

The first part of the two-phase project provided air quality information to city bound drivers together with the promotion of a high quality Park and Ride (P&R) alternative to city centre. The P&R site had frequent bus services together with priority measures and real-time passenger information. The second phase involved users of electronic tag equipment to simulate road pricing, together with smart cards for payment at the P&R site. Roadside beacons on the corridors used microwave communication to detect trial volunteers IVUs and deduct credit from their accounts. The trial was run on a reward basis with users given refunds for using public transport and able to 'earn' back the extra value they could have spent on road user charges.

Variable message signs at five locations on a corridor relayed air quality information to drivers and encouraged them to use P&R instead of continuing their journey. During the second phase a charge for driving into the city was introduced for the 116 participants and this was tested at two levels, together with a variation based on the level of pollution. This aimed to test reactions to different pricing levels and also the response to higher charges on high pollution days. The basic charge levels were in force all day from 0630 and were 2.50 UKL (3.74 ECU) and 4.5 UKL (6.75 ECU) with an additional poor air quality charge of 2.5 UKL. Because of the additional public transport costs a user might incur the average effective charge was between 4.85 UKL and 6.85 UKL.

The combination of the financial inducement combined with provision of alternatives resulted in a 15.1% shift from car to other modes. The change between different base charge levels led to a increased shift, but the additional poor air quality charge was not as effective as the planned change. Most of the percentage change came from some of the participants changing mode for all their trips, with a majority continuing to used their car as before. The 15.5% of trips changed from car to other mode were comprised as follows:

- Park and Ride 46%
- Bus 21%
- Train 21%
- Ride Share 7%
- Cycle or Walk 5%

Public acceptance indicators were positive towards the use of road pricing with over half of respondents taking the view that revenue raised from road pricing should be spent on improved public transport.

*Leicester*

The Leicester Environmental Road Tolling Scheme (LERTS) examined the potential for reducing congestion and air pollution from road traffic as part of the EUROTOLL project. This was a project, like CONCERT, aimed at assessing the impact of road pricing as a strand of transport demand management.

In Leicester P&R services with bus priority and smart card payments offered the incentives for drivers to switch from their cars (CAPRI, 1999). This was combined with electronic road pricing and reduced road capacity that provided the restraint aspect of the experiment. In the absence of legislation allowing actual charging the trial was conducted on a reward basis, whereby real value was provided for spending on road charges, but refunded to users as real money if they changed behaviour.

Road user charges were set to reflect changes in air quality and applied to 100 volunteer drivers through electronic tag equipment. This was based on x tags as the IVU and smartcards for the P&R payment. Modal shift by volunteer commuters was found between car and P&R in the order of 16% to 32%. This was in response to charges of 1.5 UKL (2.2 ECU) and 5 UKL (7.5 ECU) respectively for the AM peak period. Other mode shift was found to occur between car to bus (1-4%) and car to ride sharing (1-4%). Overall the user behaviour of drivers to the charging strategies in Leicester were:

- No Change 31.9%
- Use P&R 14.9%
- Used other bus 2.1%
- Route change (local) 10.6%
- Route change (strategic) 14.6%
- Time change 12.8%
- Other (change destination etc) 12.8%

*Athens*

The Athens road pricing trial was part of the TRANSPRICE project which demonstrated a road user charging scheme based on an area licence (CAPRI, 1999). TRANSPRICE investigated the technical and financial options for integrated payment and pricing systems across different modes of transport.

In Athens travel behaviour and mode choice were investigated together with elasticities regarding fee levels and structures. The 50 participants in each of two waves were commuters from the north of the city given a choice of paying to pass a cordon line or using a P&R metro service. Funds were made available for road user charges in a form that meant the participants were given real money at the end of the trial if they did not use all available funds paying for these charges. The scheme therefore worked on a reward basis as have other schemes, such as those in the UK, where road pricing legislation does not yet exist.

It was found that from the selected drivers the reactions were as follows:

- Used their car 25%
- Used P&R (Metro) 21%

- Used other public transport 4%
- Used a combination of the above 50%

A comparison between the first and second wave trials found that the share of car trips (as a percentage of the sum of car and P&R trips) would fall by 6.8% if the average cost difference between car and P&R were increased by 34.8%.

*Trondheim*

As a further extension of the usage of the Trondheim toll ring, the TRON 2 field trial has been carried out as part of the CONCERT project to demonstrate a shift in trip times to reduce peak congestion and therefore use tolling as a demand management measure.

Participants were given a budget according to their regular trip into or across the city so that if they continued their regular journeys all money would be used up by the devised charges. If participants changed their behaviour (by either time of trip or mode) they incurred lower charges and were entitled to keep any money not spent on toll charges. Charge levels were set at much higher levels than the prevalent toll ring charges in order to provide a reasonable reward if behaviour changed. A panel of 176 households was recruited for the project.

Charge levels in the first period were set a 20 NOK and increased to 30 NOK in the second. This produced an overall traffic impact of a 10% reduction and 17% respectively. As in the ELGAR trial a minority of participants were responsible for the majority of the change with 25% changing behaviour. The main behavioural change was a change in trip timing to avoid both the traffic and charging peak, due to travel habits strongly based on the car. If a corresponding change was achieved in the vehicle fleet as a whole this would have a significant effect on reducing peak time congestion delays.

The project also examined attitudes and the changes in opinion following the trial. The following results were obtained (Table B.2).

**Table B.2: Some results of Trondheim project**

| ***Attitude*** | ***For*** | ***Against*** |
|---|---|---|
| Attitude towards road pricing (before) | 23% | 56% |
| Attitude towards road pricing (after) | 30% | 52% |
| Road pricing + reduction in car / fuel tax | 62% | 17% |
| Vary charges according to congestion | 63% | 30% |

A number of the demonstration trials reviewed were put in with a package of measures in order to evaluate an integrated approach to demand management and sustainable transport alternatives. This should be (and generally is) acknowledged not to be representative of many cities urban-wide provision of high quality alternatives to the car. The projects have demonstrated that the pricing mechanism can be used as one element in encouraging behavioural change to effect mode shift.

### B.7.4 Summary of case studies

The examples of road pricing schemes reviewed have all been pilot demonstrations in the absence of legislation for full schemes. They have been used to attempt to understand the feasibility and potential impact of full implementation. In most cases, road pricing was

evaluated as part of a package of measures in an integrated approach to demand management and sustainable transport alternatives. This should be (and generally is) acknowledged not to be representative of many cities urban-wide provision of high quality alternatives to the car. However, the projects have demonstrated that the pricing mechanism can be used as one element in encouraging behavioural change to effect mode shift. This has laid the foundations for further work in the cities concerned and to this list of European cities can be added Copenhagen and Rotterdam who have detailed ideas of road pricing schemes. Waiting for national legislation and concerns over public acceptance are the main problems still to overcome.

## B.8 Conclusions

World-wide automatic fee collection in general is reaching a level of maturity that allows it to be used for large scale schemes with a range of objectives requiring a variety of functions. Growing number of large scale schemes for AFC (e.g., Toronto, Melbourne) in different countries are proving that these types of charging systems are feasible and operable in different countries. Urban road pricing schemes are less numerous than tolling schemes with the largest and most advanced being in Singapore. Demand management is a primary objective in this scheme and the technology is amongst the latest in available DRSC and smart card applications.

The use of road user charging to actively reduce demand and encourage alternatives is a step change from tolling privately funded roads, but one that is being considered and worked towards at a number of locations in Europe. DSRC is the favoured standard which is being worked towards and can provide the basis for a robust system over the next few years. A number of tag / debit combinations exist and can be used depending on the level of functionality required. Some potential might be shown by VPS systems in the near future as the results of Germany's truck tolling trials and similar trials in Hong Kong come forward at the end of 1999.

Any policy geared at charging for roads, which were previously free, will require some level of public acceptance and this will undoubtedly influence how an implemented scheme operates. The feasibility of schemes and public acceptance issues were the subject of research in a number of EC RTD projects. The results of these trials are important to the many countries where legislation does not exist yet for urban road pricing to be implemented, but which could soon be introduced. This applies to countries such as Norway, The Netherlands and the UK. Large scale pilot schemes are planned for the 5th Framework programme and a number of cities are awaiting the legislation to implement and evaluate these as full scale pilot schemes.

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