TRANSPORT RESEARCH LABORATORY

Summary of the EUROTOLL project

Prepared for Driver Information and Traffic Management Division, Department of the Environment, Transport and the Regions

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TRL REPORT 419

First Published 1999
ISSN 0968-4107

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Executive Summary

The EUROTOLL project (European Project for Toll Effects and Pricing Strategies) was part of the General-Directorate for Transport (DGVII) Fourth Framework Programme for research and development in the field of transport. The primary aim of the project was to obtain a better understanding of road user reactions with regard to transport demand management (TDM) mechanisms, particularly road pricing. In addition, the findings of the project were intended to provide policy makers with practical advice on strategic pricing issues, such as the need to raise finance from road use, the management of demand for road space in response to the implementation of road pricing, and the internalisation of external costs. The project also had the objective of developing assessment methodologies, such that the achievements of the various TDM measures implemented could be quantified.

The project was based on ten urban and interurban case studies in France, Germany, Italy, Austria and Great Britain. The key findings from these case studies relating to the main issues under investigation were:

Strategies for demand management in EUROTOLL case studies

TDM measures need to be targeted at those users who, in theory, are not restricted to one means of travel, in terms of time, mode and route. These road users may modify their travel behaviour in response to TDM measures, so as to obtain a net increase in utility. Other road users may choose to 'stay and pay', gaining from the fact that travel times have been reduced. Not all road users will receive a benefit: some may not value the savings in time made under road pricing above the monetary cost of the toll. But modifying their travel behaviour would decrease their utility.

The EUROTOLL project thus identifies Essential Road Users (ERU) who should be assigned priority for road space. Those who choose to stay and pay a toll implicitly define themselves as ERU. In turn, EUROTOLL recommends the targeting of TDM measures to those who choose not to stay and pay – Targeted Road Users (TRU). In order to increase general acceptance of road pricing schemes, the TRU should be provided with attractive alternatives to travelling when, where and by which mode the ERU travels.

Demand reactions with regard to TDM strategies

From the experiences of the EUROTOLL case studies, it was clear that with TDM measures (primarily road pricing), individuals would take appropriate avoidance strategies, with the aim of maintaining a degree of car mobility while minimising the financial burden of pricing. Consequently, the most favoured reactions of road users to peak-period road pricing were trip re-timing and changes of route. However, there were different reactions in different situations, particularly at urban as opposed to interurban locations. In urban areas, trip purpose often has a schedule constraint, such as the individual's need to arrive at his/her place of work by a certain time. Under these conditions the individual's value of time is at a higher level than for journeys which do not have a schedule constraint. Interurban roads are characterised far more by leisure and holiday traffic. These trips are not so constrained, and therefore the value of time for individuals on these trips is not so high as for those on commuting trips. Consequently, the elasticity of demand with respect to cost is low for urban trips as compared to that for interurban trips. Thus, variable road pricing is more effective at temporal spreading of traffic flow for interurban traffic than urban traffic.

The EUROTOLL project focussed on the short-term effects of TDM measures. Therefore it did not study any long-term changes in trip destination. For pricing at peak periods, modal shift was seen to be limited, since the alternative to the car (public transport) was already seen to be at capacity. The price/performance ratio usually favoured the car. However, where the cost of using the car was substantially increased, and an attractive public transport alternative provided, there was greater potential for modal shift.

Integration of information and pricing

Strategies to integrate pricing measures and transport information were found to be capable of reinforcing the positive effects of both. Integration strategies should not be limited to providing pricing information via modern information technologies (telematics). In networks without traffic problems, information should focus on safety and comfort. In congested networks, information has to support the TDM measure (to aim at a high acceptance of the measure and to provide incentives to react) by explaining the pricing scheme, the reasons behind it and possible alternatives. In urban road networks information about alternative modes becomes highly important. The advantages of the alternative mode concerning price and travel time are an important element of integrated pricing strategies.

Policy issues

At present, the individual road user does not directly bear the full costs of use of the road. TDM measures thus have the objective of removing this market failure, by charging for road use at the marginal cost. In the long run this can lead towards a more sustainable use of car use. In this context, pricing for road use distinguishes between the need to recover costs of infrastructure development, and the management of congestion. To cover the scope of these possibilities, EUROTOLL proposed a 'trinomial road pricing' scheme, simultaneously combining various methods of pricing in order to take into account the various types of costs:

- i a fixed component in the form of a national or area-wide vignette;
- ii a component varying with fuel consumption;
- iii a component varying with the type of network used, and which could take the form of tolls or, initially, of local vignettes.

1 Introduction

1.1 Objectives

The EUROTOLL project (European Project for Toll Effects and Pricing Strategies) was part of the General-Directorate for Transport (DGVII) Fourth Framework Programme for research and development in the field of transport. The primary aim of the project was to obtain a better understanding of Transport Demand Management (TDM) mechanisms, particularly road pricing. In addition, the findings of the project were intended to provide policy makers with practical advice on strategic pricing issues, such as the need to raise finance from road use, the management of demand for road space in response to the implementation of road pricing, and the internalisation of external costs. The project also had the objective of developing assessment methodologies, such that the achievements of various TDM measures implemented could be quantified.

The approach to undertaking the study is outlined in Figure 1 which indicates how conceptual and practical research were combined in three main stages:

1 define the concepts with regard to tolling strategies and users reactions;

2 perform the case studies and operate the concepts;

3 learn from the case studies and consolidate the conceptual research.

1.2 Layout of report

This report first identifies the need for TDM measures, discussing the problems of increasing demand for road space coupled with limited road supply. Specific objectives for each EUROTOLL case study are then defined, in the context of these problems. Strategies involving TDM measures are referred to for each case study, and the observed road user reactions in response to these strategies are alluded to. The more notable of these are route change, trip re-timing and modal change. The report then examines the importance of providing information to road users on the TDM measures in operation. The policy issues with regard to TDM measures, related to transport goals and objectives, are then discussed. A summary of the key features and main observations of each case study is contained in Appendix A.

2 Strategies for demand management in EUROTOLL case studies

2.1 Transport Demand Management (TDM)

Accommodating traffic growth by building more roads is no longer economically, environmentally or socially feasible. Demand for road space will increasingly outstrip supply, resulting in more hours lost due to congestion and more pollution from idling engines. In turn, transport policy is becoming less demand-led; rather, demand is being influenced to match it with supply. Transport Demand Management (TDM) strategies can be applied to facilitate this.

Having clearly defined and limited objectives is essential to the success of a TDM strategy. Table 1 identifies the principal transport policy goals.

Each location needs to identify its own set of transport problems and objectives. For the EUROTOLL case studies, the following specific objectives were identified, along with the measures chosen to achieve them (see Table 2).

By allocating road space priorities amongst road users, the efficiency of TDM measures can be improved. Different groups of road users will have different priorities. With the implementation of a road pricing scheme in peak periods, for example, four different types of road user can be identified:

i Those who place a high value on their time. Assuming that the scheme achieves its aim of reduced congestion in the peak period, thus reducing journey times for those that choose to 'stay and pay', this group will receive a net benefit in welfare. The cost of paying the

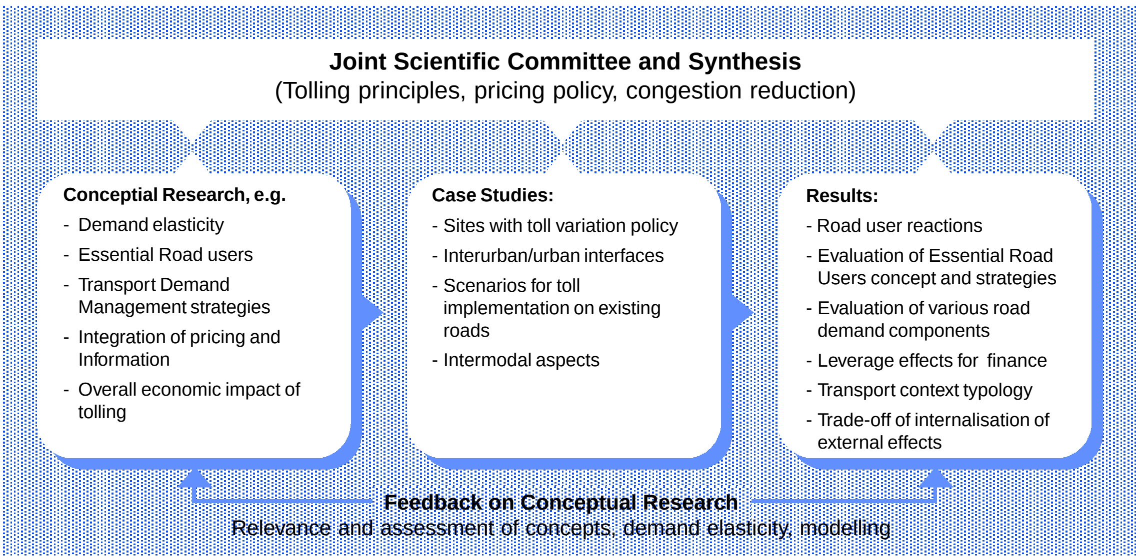

Figure 1 EUROTOLL philosophy

Table 1 Transport policy goals and sub-goals

General transport policy goals	*Transport policy sub-goals*
Sustainable mobility.	Inter-operability.
Increased network efficiency.	Encourage co-operation between transport modes.
Increased network accessibility.	Reduce congestion, Recover infrastructure cost.
Increased network safety.	Internalise external costs.
Fair pricing and harmonisation.	Balance charges among users.
	Essential road users concept (priority to certain user groups or activities).
	Increase public transport share, reduce pollution.

Table 2 EUROTOLL case studies and transport objectives

Case study	*Current status*	*Transport objectives*	*Set of measures*
A1 (France).	In operation since 1992.	Spread demand on A1 motorway.	Peak/off-peak hours tolls on week-end returns to Paris. Information + VMS.
A5/A6 (France).	In operation from 1995 until 1997.	Shift demand from A6 to A5.	Different toll tariffs re routes (variable re season). Information campaign (seasonal).
A7/A75 (France).	In operation.	Attract users on A75 free motorway. Spread demand on A7.	Different toll re routes (permanent). Information campaign on A7 (seasonal).
Normandy Tancarville Bridges (France).	In operation since 1995 for Normandy bridge.	Shift road traffic on a new bridge.	Different toll re routes (permanent).
A11 Florence (Italy).	Trial in 1998 (delay).	Better equilibrium between modes.	Integrated payment system (tolls, PT, parking). Smart card multiservices.
A12/A13 (Austria).	In operation/trial reference 1995.	Increase share of rail. Recover transport infrastructure costs.	Generalisation and differentiation of tolls (between night and day) on corridor (ecopoints).
Stuttgart (Germany).	Trial.	Better use of the urban road network.	Cordon pricing, P+R peak/off-peak tolls integrated payment systems.
Truck vignette (Germany).	In operation since 1995/questionnaire.	Influence road freight transport.	Vignette. Tolling system as a substitute for vignette.
Leicester (UK).	Trial in 1998.	Reduce car journeys in peak periods by 10-20%. Shift to PT. Shift to other time periods and increase car occupancy.	Corridor variable pricing tests, P+R, dedicated bus lane.
A10/A11 (France).	In operation in 1996.	Smooth peak hours.	Peak/off-peak hours tolls on week-end returns to Paris ·information + VMS.

toll is outweighed by the value they place on the savings in time they achieve.

ii Those who place a lower value on their time than group i, and decide to change their travel behaviour to avoid the toll. This group will also receive a net benefit in welfare since the savings they achieve by not paying the toll outweigh the cost to them in changing the timing and length of their travel. However, they would experience less welfare than with no scheme.

iii Those who place a similar value on time as those in group ii, but decide to stay and pay. This group will be worse off since the savings they place on a reduced travel time are outweighed by the cost of paying the toll.

iv Those who refuse to pay the toll, and change their travel behaviour.

Being a winner or loser under a peak-period road pricing strategy depends on the individual's priority over time and cost. The EUROTOLL project took the approach that those who valued time highly should be given priority over road space. These were identified as Essential Road Users (ERU). Any TDM measures would be unlikely to induce a behavioural change amongst this group. Those who did not value time so highly, and would therefore be more responsive to road pricing, were identified as Targeted Road

Users. TDM measures to provide viable travel alternatives to the car were to be directed at this group, so as to make a road pricing scheme more acceptable.

When specifying the way transport objectives are reached by a given strategy, the quantitative criteria that need to be measured can be listed, as shown in Table 3. This indicates that a wide range of assessment criteria is possible.

2.2 Demand reactions with regard to TDM strategies

Overall, within the EUROTOLL project, it was clear that individuals would take avoidance strategies in response to a set of TDM measures, with the aim of maintaining a degree of car mobility to which they had become accustomed. The four main observed responses to implementing pricing strategies in the EUROTOLL

Table 3 TDM objectives and assessment criteria

TDM objectives	*Assessment criteria*	
Reduce congestion length and time.	Average speed.	PPHTV LV. PPHTV HV.
Reduce travel time.	Average speed.	
Reduce traffic volume in peak periods.	PPHTV LV.	PPHTV HV.
Reduce average trip length.	Average trip length, passenger transport.	Average trip length, freight transport.
Reduce transport costs - user.	Average speed. Fuel consumption. Veh. km LV.	Veh.km. HV. Occupancy level. Truck load factor.
Reduce transport costs (infrastructure).	Veh.km. LV.	Veh.km. HV.
Reduce air pollution.	Volume of emissions. Veh.km. LV. Veh.km. HV.	Average speed. Fuel consumption diesel. Fuel consumption gas.
Reduce noise.	Veh.km. LV. Veh.km. HV.	Average speed.
Reduce accidents.	Number of accidents (by severity and property damages). Veh.km. LV.	Veh.km. HV. Average speed.
Reduce energy consumption.	Fuel consumption diesel. Fuel consumption gas. Veh.km.	Average speed. Share of low fuel vehicles.
Shift to other modes.	Modal split passenger transport.	Modal split freight transport.
Shift to other routes.	Veh.km. base route. Veh.km. alternative route.	ADT base route. ADT alternative route. Average speed base route.
Shift to other time periods.	PPHTV light vehicles.	PPHTV heavy vehicles.
Increase public transport share.	Modal split passenger transport.	(Possibly by trip purpose).
Increase car occupancy.	Occupancy level.	Veh.km. pass. transport.
Increase truck loading efficiency.	Truck load factor per volume unit. Truck load factor per weight unit.	Veh.km. freight transport.
Raise finance.	TDM measures revenues. Transport specific taxes revenues.	Other taxes revenues. Costs of TDM measure. Maintenance costs.
Increase share of intermodal transport chains.	Modal split freight transport. Veh.km. HV.	Truck load factor per volume unit. Truck load factor per weight unit.
Reduce trips by cars.	Modal split passenger transport. Veh.km. light vehicles.	

PPHTV = Peak Period Hourly Traffic Vehicle.
LV = Light Vehicles.
HV = Heavy Vehicles.
ADT = Average Daily Traffic.

case studies were:

i a continuation of travel (both in time and space) along the charged route;

ii an avoidance (in time and/or space) of the charged route;

iii a shift in the mode of travel;

iv a substitution of travel needs for some other activity.

User reactions to TDM measures depend to a large extent on the value individuals place on time savings. Those who value their time highly will choose a transport option that minimises the duration of their journey. The generalised cost of public transport use for an individual is not only a function of the fare per journey and duration of travel, but also of some measure of service level, such as frequency of buses per hour. This determines the non-monetary user cost per passenger journey, and includes the waiting time. This term can be quite a substantial proportion of the overall generalised cost of travelling by public transport. This term does not apply to travelling by car, where waiting time is irrelevant. Thus, even with a transport system that gives priority to public transport over the car, the journey between any i and j set is often quicker by car. Hence, those who value their time highly will choose to travel by car. Furthermore, those who choose to incur a higher monetary cost through road tolls will do so since the value they place on the time savings they make outweigh the costs of paying the toll.

Table 4 summarises the main impacts observed at the case study sites, and the following sections provide more comment.

2.2.1 Route change

With any TDM scheme that incurs some form of penalty on road users for using routes that previously had been penalty-free, there are bound to be negative effects. The main effect of road pricing in the EUROTOLL case studies was a change of route, this being dependent on the generalised cost of the alternative route being less than the tolled original route. Thus, more trips would be assigned to an alternative uncharged route if one were available, despite this route being previously too costly in terms of

Table 4 Summary of measured effects in EUROTOLL case studies

Case Study	*Expected effects*	*Detected*	*Comments*
A1 (France).	Trip re-timing.	Y	Smooth peak hour: -4.4 % on Autumn.
	Route change.	N	
	Trip reduction.	N	
A10/A11 (France).	Trip re-timing.	Y	Demand spreading: -12% during peak hour.
	Route change.	Y	Negligible : 0.5 % per weekend.
	Trip reduction.	N	
A5/A6 (France).	Route change.	Y	15-20% of the transferable users are on A5 (4-5% without TDM strategy).
	Trip re-timing.	Y	Decrease of the number of high peak periods.
	Trip reduction.	N	
A7/A75 (France).	Route change.	Y	Assignment rate of transferable users: 25% on A75 in summer peak period. In out of summer weekday the assignment rate on A75 is growing from 25% (1993) to 37% (1997), for light vehicles (LV).
	Trip re-timing (information campaign).	Y	Time shift: ranging from 12.7 to 20.8 % of users in 1998 (9 to 17% of users in 1997.
Normandy Tancarville (France).	Route change.	Y	Assignment rate on the new Normandy toll bridge : 90-95% for LV, 60-85% for heavy vehicles (HV), for origins-destinations from Le Havre to the West.
A11 Firenze (Italy).	Mode change.	Y	Shift from motorways to PT: 5% of drivers sample.
A12/A13 (Austria).	Mode change	Y	6% of the non-commuters shift from cars to PT.
	Trip reduction	Y	LV: +0 to -30% veh-kms, HV: +3 to -17% veh-kms.
	Route change	Y	LV: 33% of the commuters changed their route, HV-through traffic: 9%.
	Destination change	Y	HV, through traffic: 3%.
Stuttgart (Germany).	Mode change.	Y	3.2 to 4.7% of the relevant users switch from car.
	Route change.	Y	0.6 to 13.6 % of users (according to pricing phase).
	Destination change.	Y	Near zero.
	Trip re-timing.	Y	1.9% to 5.2% of trips.
Truck vignette (Germany).	Mode change.	Y	Relevant for 12% of users (switch to combined transport).
	Vehicle type change.	Y	Change in the fleet structure.
	Trip reduction.	Y	No change : decrease by 0.02 % of veh.km in time according to pricing scheme.
Leicester (UK).	Mode change.	Y	2.1% of the users shift from car to bus, and 14.9% shift to P&R facilities (all strategies).
	Route change.	Y	25.5% of the users change their route (all strategies).
	Trip re-timing.	Y	12.8 % change their time of travel (all strategies).

time of travel. Obviously, knowledge of the alternative would be required. Hence, regular road users travelling between i and j would be more likely to adjust their behaviour than infrequent travellers between i and j.

2.2.2 Trip re-timing

With higher tolls implemented at periods of higher demand, trip re-timing by car users was an observed effect in the EUROTOLL case studies. The shorter the high price period, the greater the ability of road users to adjust the timing of their departure to avoid the period of the higher toll. A distinction must be made between the urban case studies and the interurban case studies. In urban situations, higher tolls at periods of higher demand by default target those road users whose trip purpose has a schedule constraint. Most urban trips in the peak period are for commuting purposes, and thus have a travel time constraint, in that the individual needs to be at his/her place of work by a certain time. Hence the ability for trip re-timing under urban conditions is often limited. In interurban situations, trip purposes are generally less characterised by commuting, being distinguished more by leisure purposes. There is therefore less of a schedule constraint in these trip purposes, and hence less of a travel time constraint. Thus, there is a greater ability for trip re-timing. At one of the interurban case studies (the A1 Paris-Lille motorway), tolls applied when existing levels of demand were highest (particularly on Sunday afternoons/evenings as people travelled back to Paris after the weekend) indeed resulted in trip re-timing by many road users. However, this caused a potential hazard as road users waited at rest areas downstream of the charging location for the 'free period' to begin. These rest areas only have a limited car parking capacity.

2.2.3 Modal change

Modal change was most relevant in an urban context, but the propensity for change from car to public transport depended on the price/performance ratio. In the urban EUROTOLL case studies, public transport was often at capacity already; thus the price/performance ratio remained higher for car use than public transport use. It can be seen that the use of cars is relatively inelastic to price. However, the provision of an attractive alternative to car use, coupled with a high peak period toll, as in the Leicester case study, can encourage modal shift and thus partly achieve the objective of reduced congestion.

Figure 2 is a graph of the price differential between the road toll for car use and the park-and- ride fare against the modal split of journeys into Leicester on the reference route. The graph shows that with a toll equivalent to the park-and-ride charge, there would have been a 16% use of park-and-ride, and that to achieve a 20% use of park-and-ride a price differential of £1.97 is required. To double the park-and-ride share requires a price differential of £12.03, which in practice would be very difficult to achieve. The results support the idea that there is a substantial latent demand for park-and-ride, and also suggests that a rising toll charge increases the use of park-and-ride, but not at a substantial rate.

2.2.4 Freight transport

With regard to modal shift for freight transport, results from the Brenner case study appear to demonstrate that the potential for modal shift is quite low. Rather, routes and destinations are changed. This reflects the lack of flexibility of the alternatives to road use for freight transport. Rail transport can be quite effective for transporting bulk loads from A to B. However, transporting most goods requires a degree of flexibility, and road transport provides the most economical method. Freight transport has indeed shifted from being largely rail dominated to being largely road dominated, as economies in the developed world have evolved from being heavy industry based to more service and tertiary industry based.

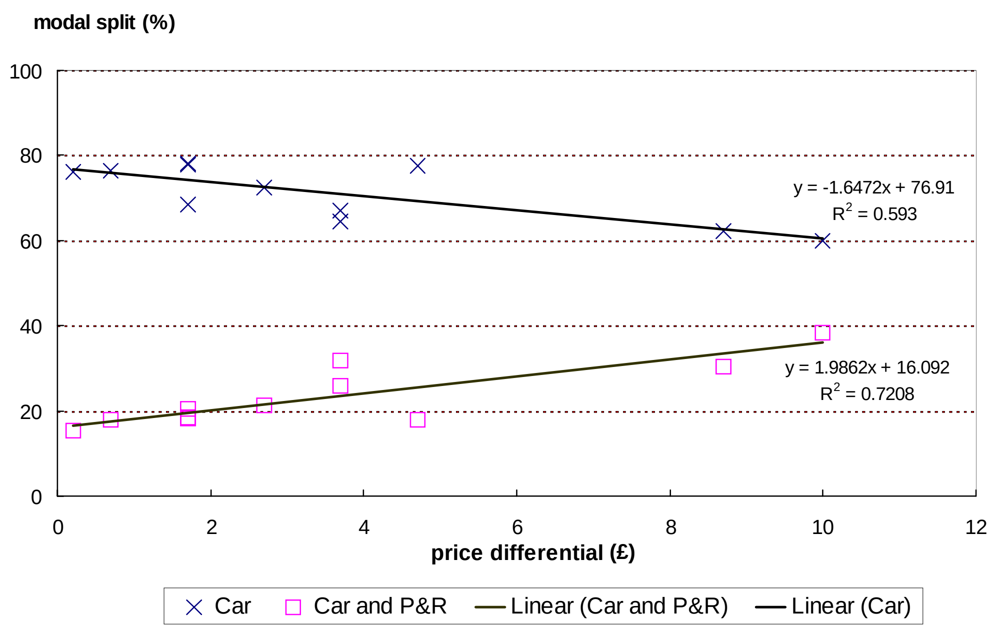

Figure 2 Linear regression of price differential in the Leicester case study

2.2.5 'Retransference' effects

For some road users who transfer to a new route because of a toll imposition on their current route, the conditions on the uncharged route may become unsatisfactory, perhaps due to the number of users who transfer onto it. This may encourage them to retransfer back to the original route, despite this route now being charged. This 'retransference' mechanism is notable when considering the long term impacts of a pricing scheme. In the Austrian case studies, a toll relating to 0.022 ECU per car-km resulted in an initial acceptance amongst users of 42%, and a final acceptance of 70%.

3 Role of information and pricing

Information on a transport system has the overall purpose of improving the efficiency of using and controlling the existing transport network, thereby contributing to the realisation of transport policy objectives. Users of the transport system can be made more aware of the alternatives to the car and of the possibilities for route change, scheduling change and modal change. In turn, supply can be allocated more efficiently with respect to demand. It is often stated that 5-10% of all vehicle mileage is wasted through incorrect routing and ignorance of traffic conditions.

The transport objectives will define the set of TDM measures that need to be applied, and will therefore define the type of information to be provided. TDM measures, by their nature, attempt to influence traveller behaviour in order to achieve the transport objectives that have been set out. Travellers will only adapt their behaviour if they have reliable and timely information that they can apply to the transport decisions they subsequently make. Hence, a road pricing system that has the objective of reducing traffic congestion may not fully achieve this objective if no information is provided to the car user.

Thus there are three general requirements for the provision of information:

- i *Comprehendability:* information must be comprehensive, complete and understandable to the user. The provider needs to be aware that different users of the information will have different levels of understanding. For example regular car users in an urban situation are more likely to have developed their own knowledge of the transport system and are thus unlikely to require much information to supplement this. However, more infrequent users will not have such a local knowledge base, and might therefore require information presented to them in a different manner.
- ii *Timeliness:* information must be provided when it is useful. It is only useful if it allows those road users it is targeted at to respond to it in an intelligent way.
- iii *Spatial appropriateness:* information must be provided where it is useful. Once again, the information must be provided in a way that allows the user to respond to it. For example, providing information to road users regarding public transport prior to information regarding road tolls would not allow the user to make an informed choice on which mode of travel to take.

Cutting horizontally through these issues are questions over what type of information should be provided. For example, should it be static information (published timetables, route maps, journey times, car parking fees) or dynamic information (real-time congestion, car parking availability, accidents), and should information be provided pre-trip or on-trip? Information provided prior to a trip being made could affect the timing of the journey, the route of the journey, and the mode of travel (and also whether or not a journey is made at all). On-trip information can affect the route of journey and the mode of travel. The static information can easily be obtained (information centre, leaflet, advert, radio, telephone, Internet, signing) whereas dynamic information requires more advanced equipment (VMS, monitoring system, Radio Data Systems – Traffic Message Channel (RDS-TMC)).

A variety of information measures can be taken to accompany the TDM strategy, but it is difficult to isolate the effectiveness of any one measure. Furthermore, the limitations of a TDM scheme cannot be enhanced by a good information scheme. For example, if car use is largely inelastic to price, a TDM strategy of road tolls accompanied with a park-and-ride alternative has a limited potential to induce a modal shift at the outset, regardless of the quality of information provision. If, in the same situation, alternative modes are given priority over the car, quality information can then play an important role in achieving overall transport objectives in such a situation.

Table 5 provides a summary of the information measures used to accompany pricing strategies in the EUROTOLL case studies. Experience from these case studies indicate that a minimum of information was necessary to understand any pricing scheme and be aware of alternative travel opportunities. Information should allow users to make their own decisions, and not have decisions forced on them. The less information there is, the easier it is to comprehend; additional information follows the law of diminishing returns.

It is vital that the user is aware of the objective of the TDM measure about which the information is being provided; the travel information is likely to be more effective if those who access it understand (and perhaps agree with) the purpose behind it. To establish and maintain the integrity of any information system, the information provided must be accurate; otherwise users will lose trust in its reliability to the possible detriment of the TDM measure.

4 Policy issues

4.1 The role of road pricing in reducing the environmental effects of transport

4.1.1 Economic principles

In an efficient market, the utility or welfare of any individual cannot be improved by changing production and consumption methods without resulting in a loss of utility or welfare for any other individual or individuals. Therefore, Pareto efficiency is achieved in a freely

Table 5 Information measures in the EUROTOLL case studies

Pricing strategy	*Case study*	*Character of the case study*	*Information measure*	*Role and content of information*	*Accompanying TDM-/ information measures*
Introduction of toll (cordon).	Stuttgart (DE).	Field trial.	Leaflets distributed before the next pricing phase. Variable Message Sign.	Information about toll tariffs and alternative mode (public transport, park & ride).	Payment for road toll and public transport ticket with one smart card.
Peak/off-peak hours tolling.	A1 (F).	Real application.	Press document, radio, leaflets distributed at the toll plazas, VMS, fixed signing.	Information about toll variation.	Pre- and on-trip: using telematic service MINITEL (3615 routes), telephone service, Autoroutes Info 107.7 MHz.
Peak/off-peak hours tolling.	A10/A11 (F).	Real application.	Press documents, radio, leaflets distributed at the toll plazas, VMS, fixed signing.	Information about toll variation and congestion situation.	Pre- and on-trip: using database MINITEL (3615 routes), telephone service, Autoroutes Info 107.7 MHz.
Introduction of toll (corridor).	Leicester (UK).	Field trial.	Signs located at start of demonstration corridor.	Information on toll charges, park & ride site, traffic and environmental conditions.	Local radio broadcasts, implementation of park & ride site and bus priority corridor.
Peak day tolling: Route toll variation.	A5/A6 (F).	Real application.	Press documents, radio, leaflets distributed at the toll plazas, VMS, temporary signing.	Informing about toll on A6 and A5 to make the route A5 better known.	Pre- and on-trip: using database MINITEL (3615 routes), telephone service, Autoroutes Info 107.7 MHz.
Different toll re-routes.	A7/A75 (F).	Real application.	Questionnaire	Support differential route tolling and level of service.	None.
Non-pricing measure.	A7.		Pre-trip information for the A7 through radio broadcasting during summer time since 1994.	Information on peak days and peak hours recommendation to shift trips from Saturdays to week days.	None.

competitive market when society cannot mutually improve the utility or welfare of every single economic agent acting within that society.[1]

Market failure occurs when the conditions necessary for market efficiency fail to exist. Subsequently, the market system left to itself is unlikely to operate efficiently, with some goods and services being produced too much, and others too little or not at all. This market inefficiency means that an increase in the utility or welfare of one individual results in a loss of utility or welfare for any other individual or group of individuals. Alternatively, the utility or welfare of any individual could be improved without reducing the utility or welfare of anyone else. The existence of public goods and externalities can lead to market failure.

A public good can be defined such that each individual's consumption of a public good leads to no subtraction from any other individual's consumption of that good. Pure public goods are non-excludable, meaning that no one can be excluded from consuming such a good, whether one likes it or not. Pure public goods can also be non-rival in consumption. This is the case when a good's marginal cost is zero, for example the cost of crossing an uncrowded bridge. With a public good, the addition of one or more consumers will not lead to a subtraction from any other individual's consumption. Therefore, non-excludable goods can be non-rival in consumption, but the opposite is not necessarily the case. For example, crossing an uncrowded bridge is a non-rival good (or service), yet the consumption of this good can be excludable by the imposition of tolls.

The presence of public goods therefore results in a market failure since there is no incentive to invest in the good or supply the good, because once the good has been produced, no one can be excluded from consuming the good, therefore there is no way to make a profit. Furthermore, no one is responsible for the by-products of that consumption – in the case of roads, air and noise pollution. The utility or welfare of the third party is reduced by these externalities. This is what David Hume in the 18th century called the 'tragedy of the commons'.

If the utility or welfare of this third party increased, there would be an external economy. Thus, road pricing is an attempt at 'internalising the externalities' of road use. The EUROTOLL project took two approaches to the evaluation of external costs:

i the damage approach, where those responsible for the externalities are directly taxed for the costs they incur;

ii the avoidance approach, where the revenues of pricing are used to contain the presence of externalities to their source.

There are thus two approaches to the internalisation of external costs. The process by which the costs are evaluated is highlighted in Figure 3. A low level of nuisance thus results in a low damage cost, but requires a high avoidance cost. The anticipated external costs are lower because they take into account the possible technical improvements in a car's operation. Thus, between now and 2010, it is possible to estimate that the pollutants emissions per vehicle will be reduced and that the accidents will continue to decrease. Technical reasons will allow the reduction in the physical volume of the external costs per vehicle.

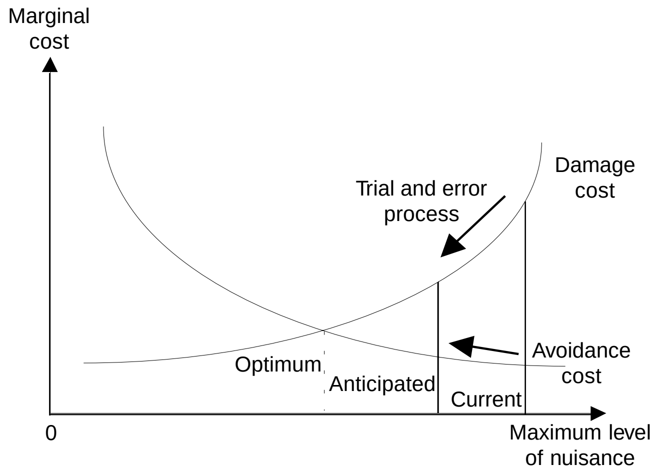

Figure 3 The trial and error process on the damage and avoidance cost curves

4.1.2 Internalisation with no reduction in traffic

In EUROTOLL case studies where a peak period road toll was applied, there was often no overall reduction in traffic. However, some traffic tended to shift to the times immediately preceding and following the higher toll period. Thus, the overall traffic flow was less congested, in terms of stop-start traffic. This was the case with a peak period road toll on the A1 motorway in France. With an improved traffic flow, vehicle emissions decreased, without an overall decrease in the amount of traffic. Internalisation of some externalities, without a reduction in traffic, can also be achieved by the use of tolls to finance programmes that aim to minimise the impacts of the external costs. These may include the construction of soundproof barriers, the installation of double-glazed windows at residences in close proximity to the road, and improved road surfaces and lighting to reduce the number of Road Traffic Accidents.

4.1.3 Internalisation with a reduction in traffic

Internalisation of externalities can also occur when there is an absolute reduction in road traffic. A set of TDM measures combining road tolls with improved public transport can encourage a modal shift towards public transport. Thus, under this scenario, the emissions per passenger-journey are less than with no reduction in car traffic. In the Stuttgart case study, considerable reductions in the emissions of carbon monoxide, benzene, hydrocarbons and methane were achieved by an absolute reduction in traffic.

4.2 Congestion pricing

It is noted above that there is a market failure with the provision of roads, due to collective action problems on the part of 'free-riders'. Road users do not, at present, take into account all the effects of their decisions, and thus external diseconomies are produced. Governments can intervene to make the market for the provision of roads as efficient as possible by implementing road pricing. This road pricing would be most effective at reducing market inefficiency at times of traffic congestion, and thus road pricing is commonly referred to as congestion charging.

The design of optimal government policies is an exercise in the theory of second-best, since the first-best optimum is when the market acts perfectly competitively. Thus, government policy instruments aiming to reduce inefficiencies and distortions in the economy are likely to introduce other inefficiencies and distortions into the economy. However, one can improve, if not optimise, the resource allocation for road use, providing that the cross elasticities of demand are very small. For instance, the dispersal of population and activities from our towns and cities has, to a certain extent, been due to the space needed to garage cars and the levels of traffic congestion. Increasing the cost of travel on certain routes or in certain areas seems likely to accelerate this dispersal, an effect that is detrimental to the viability of public transport. Therefore, the design of optimal government policies needs to weigh up the allocative and distributional inefficiencies of the market without government intervention against the allocative and distributional inefficiencies created by government intervention.

The pricing rule that produces an efficient allocation of resources is that which equates price with the marginal cost. Charging for the use of a road at the marginal cost, as opposed to the average cost, produces an efficient allocation of resources and thus a net benefit in welfare[2]. In Figure 4 it can be seen that charging at the average cost (curve AC) results in Q_1 quantity of traffic, at AC_1 cost. Charging at the marginal cost (curve MC) results in Q_2 quantity of traffic, at AC_2 cost. Thus, the surplus loss S_2 attributed to those who no longer travel at the marginal cost is outweighed by the surplus gain S_1 attributed to those who continue to travel.

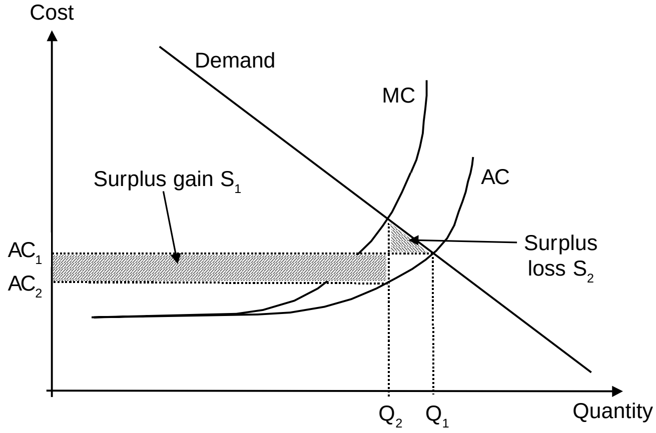

Figure 4 Pricing at the marginal cost – gains and losses of surplus

However, the net gain in surplus ($S_1 – S_2$) depends upon the elasticity of demand with respect to cost for car travel. If there were a low elasticity of demand with respect to price, the demand curve in Figure 4 would be very steep. Thus, the effect cost has on quantity would be very limited: a high cost would only result in a small reduction in traffic.

Not every road user, however, has an identical demand curve. For some, their use of the road will be relatively inelastic; for others, their road use will be more responsive to changes in the price of using the roads. Three categories of road user can be distinguished with respect to congestion charging:

i Those who place a high value on their time. For them, the price paid for the toll is lower than the time savings they gain.

ii Those for whom the price of the toll is higher than the welfare benefit gain as a result of journey time savings, but whose utility is still maximised by travelling by road.

iii Those who do not want to or cannot pay the toll, and who thus modify their travel behaviour.

Hence, two of the above categories would be absolute or relative losers under a congestion-charging scheme, and are likely to be the most numerous users. It is possible to make some initial losers gain, with particular reference to the third category above. Modulating the congestion charge, by applying lower prices around the peak period charge, can recapture some of the benefit lost for this category, and thus could make a congestion charging scheme more acceptable. This group is referred to as Targeted Road Users above.

In the interurban EUROTOLL case studies, the application of a time modulated congestion charge at existing flat-rate toll roads was an efficient and acceptable way of reducing congestion. In the urban context, the success of congestion charging was less forthcoming. Urban road users often have a schedule constraint for journeys, and therefore each journey has a time constraint. The car is the mode of travel that largely maximises utility, and thus the elasticity of car travel to price is relatively low.

4.3 Which pricing for which internalisation?

EUROTOLL defines four objectives of road pricing. These are:

i to cover the maintenance costs of the existing road network;

ii to finance the construction of new road infrastructure;

iii to achieve some level of traffic demand management;

iv to internalise the externalities of road use.

The following types of pricing might be applied to achieve these objectives:

i lump sum specific taxes, such as vignettes, area licences etc;

ii indirect taxes, such as on fuel;

iii tolls applied in space;

iv tolls variable in time.

The national network requires funding for maintenance only from general taxation. The installation of a toll network to provide finance for maintenance, with its associated costs of enforcement, would be exorbitant, particularly on a network where (and when) the traffic is not dense. General taxation cannot cover all the costs, however, particularly the environmental costs. Raising fuel taxes is a method of internalising these externalities, taking the damage approach. The funds collected can serve to mitigate, at the national level, the cost of the residual damage of the harmful environmental effects. The collection of road tolls would take the avoidance approach of reducing the harmful environmental effects: the funds collected could protect the surrounding environment from the source of the pollutants. Furthermore, tolls have the ability to provide new infrastructure that can ease congestion. New infrastructure is being funded by road tolls in the Norwegian cities of Trondheim and Oslo. However, building more road space, as a means to reduce congestion, is increasingly seen as being counterproductive; there is evidence that the provision of new roads induces more traffic. The demand for car travel thus highlights the characteristics of suppressed demand. Viewed in terms of the generalised cost of car travel in relation with the amount of car travel, building more road space initially reduces the time cost element of the relationship. In turn, as the cost is reduced, demand increases.

As stated above, the generally accepted pricing rule which produces an efficient allocation of resources, and thus a situation where the utility or welfare of every individual cannot be mutually improved, is that which equates price with the marginal cost. Thus the argument follows that to establish efficiency in the provision of roads, the marginal cost for using these roads should be charged. Hence, the external diseconomies produced as a result of the use of roads will become the responsibility of those who produce them. EUROTOLL recommends the application of a trinomial pricing system, combining simultaneously the various methods of pricing in order to take into account the various types of costs. This trinomial system might consist of:

i a fixed component in the form of an area-wide vignette, thus taking into account localised problems of pollution and congestion;

ii a component varying with fuel consumption (fuel taxation)[3];

iii a component varying in time and space, such as variable tolls in peak periods.

This is not strictly speaking an economist's view of marginal cost pricing. However, it would provide a means of making the price of travel vary according to its costs for society.

5 Conclusion

The objective of the EUROTOLL project was to undertake an in-depth investigation into the effects of road pricing and toll strategies on road mobility and transportation factors. The analysis was based on seven case studies and three modelled / trial case studies (See Appendix A).

A detailed review of TDM strategies aiming at a temporal or spatial redistribution or overall reduction of road transport demand was carried out. Analyses performed have shown the process by which transport policy goals could be translated in specific transport sub-goals and objectives and hence a TDM strategy designed. Particular attention was given to ways of improving the efficiency of TDM strategies. Firstly, it was shown that in order to facilitate the switching of road users out of congested situations, the more convenient alternatives should be provided. That is why the concept of Targeted Road Users was developed, which complements the Essential Road User concept. Secondly the evaluation of this potential transfer implies the requirement of obtaining a clear view of who the winners and losers are after the implementation of the TDM scheme. Consequently the items to be addressed in the conception of TDM strategies, bearing in mind the issues of Targeted Road Users and winners/losers, were listed with regard to each EUROTOLL case study experience.

EUROTOLL provided a detailed analysis of road user reactions to particular TDM measures. The following generalised road user reactions were identified:

- Where applicable, the most favoured reactions in response to a road-pricing scheme by road users were trip re-timing and route change.
- Trip re-timing largely depends on the duration of high toll charges and the level of tolls in the adjacent periods. Thus, where the duration of a high charge was relatively short, there was potential for some adjustment of journey timing to take place on the part of road users.
- With regard to route choice, TDM measures can make some routes that were previously perceived as too costly by some road users now appear more cost-effective. Thus, there can be a more efficient matching of demand with supply on the overall road network.
- The EUROTOLL case studies suggested that TDM schemes were less effective at inducing modal shift from car to public transport.
- In general, freight transport is expected to react with more rigidity to TDM strategies than non-freight transport.
- Due to EUROTOLL's focus on the short-term, the case studies did not study or detect changes of destination.

The importance of one reaction pattern in comparison to others varies in time. In the medium and long run other user reactions will become more prevalent.

6 Acknowledgements

The following participants all contributed to the EUROTOLL project:

Commission of the European Communities. Project Financer (Brussels, Belgium).

Ingénierie des Systèmes d'Information et de Sécurité. Project Co-ordinator (Lyon, France): Monika Bauz, Lionel Clement, Muriel Monsigny, Martial Chevreuil.

Department of the Environment, Transport and the Regions. Project Financer (London, UK).

Association des Sociétés Françaises d'Autoroutes. Project Financer and Partner (Paris, France): Pierre Boulanger, Jean-Michel Gambard.

Concessioni e Costruzioni Autostrade S. p. A.. Project Partner (Florence, Italy).

Dr Max Herry. Project Partner (Vienna, Austria).

Heusch/Boesefeldt GmbH. Project Partner (Aachen, Germany): Olaf Tegge, Arnold Nierderau.

Laboratoire d'Economie des Transports. Project Partner (Lyon, France): Odile Andan, Yves Crozet, Laurent Guihery, Elsa le Van, Grégoire Marlot, Charles Raux.

Service d'Etudes Techniques des Routes et Autoroutes. Project Partner (Paris, France): Patrice Danzanvilliers, Dominique Postel.

Trends Research n.p.c. Project Partner (Athens, Greece).

Transport Research Laboratory. Project Partner (Crowthorne, UK): Jonathon Smith.

Consorzio Intercomunale dell'Area Fiorentina. Project Partner (Florence, Italy).

Howard Humphreys & Partners Ltd. Project Partner (Surrey, UK).

Universität zu Köln. Project Partner (Cologne, Germany): Heike Höhnscheid, Herbert Baum.

University of Patras. Project Partner (Rion-Patra, Greece): Ioanna Giannouli, Konstantinos Zografos.

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Notes

[1] The Pareto principle in welfare economics is such that if a policy or project makes at least one agent better off and no agent worse off, then it is desirable and should be adopted.

[2] The average cost per unit of a good or service is the total cost, in terms of the sum of money payments incurred in the production of a given quantity of that good or service, divided by the number of units produced. The marginal cost is the addition to the total cost incurred by increasing the production of the good or service by a small amount, usually one unit. When average cost is rising, marginal cost must be above the average cost, and when the average cost is falling, the marginal cost must be below it.

[3] We might note that it is more strictly the environmental pollution generated which is important, with fuel consumption being a practical proxy for it.

Appendix A: Case studies — descriptions, objectives, outcomes

The A1 motorway Paris - Lille, France

Site name: A1 Motorway
Location: Inter-urban/suburban north of Paris.
In operation/trial: Toll motorway with time variation since 1992.

Country: France
Responsible partner: ISIS/ASFA.
Transport authority: SANEF.

Main features
Type of site: Corridor.
Traffic context: Periodic congestion.
Location: Inter-urban, suburban.
TDM scheme: In operation.
User information: Pre-trip, on-trip.

Objectives within EUROTOLL
Context: the traffic volume is high on Sunday afternoon and evening between the Chamant toll barrier and Paris. This is due to weekend returns (passenger cars) to Paris and returns from the ‘ Asterix entertainment park ’, that occur at the same time. This case study is interurban/suburban as the toll is implemented in an interurban section but part of the congestion problems to be solved take place in the Paris suburbs.

The objective of the TDM operation is to spread the Light Vehicle (LV) demand on Sunday afternoon (weekend returns to Paris) in order to decrease congestion and thus increase the network efficiency.

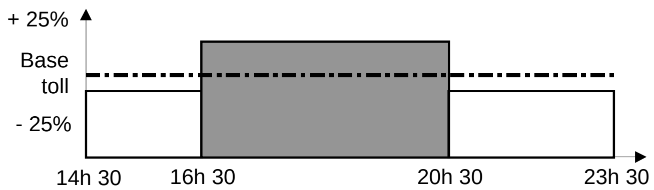
Transport policy goals
Sustainable mobility.
Increased network efficiency.
Increased network safety.
Fair pricing & harmonisation.

Transport policy sub-goals
Reduced congestion.
Balanced charges among users.
Essential road users (priority to certain user groups.

TDM Strategy implemented (Peak/off-peak hours tolls, Information + VMS)
Every Sunday afternoon since April 1992, there is toll tariff variation in time for LV returning to Paris.

Pricing scheme in A1 case study.

Example: Paris-Lille (1995): normal period 65 FF, 49 FF green period, 81 FF red period.



Results
The TDM operation was successful in smoothing out traffic in the peak hours: the traffic during red period (16:30 to 20:30) decreased (- 4.4% on Autumn 1992). The traffic was progressively transferred towards the green periods. The peak hour is now later (between 21:00 and 22:00) and not too congested, partly due to the opening of A16 motorway in 1994. The pricing scheme did not induce traffic transfer onto a parallel network due to existing bad traffic conditions on this parallel network

The impact on safety and congestion can not be measured. However, in a qualitative way, the global demand spreading from the red period to the two adjacent green periods induces less congestion on the network and limits the conflicts with traffic flows (especially with downstream flows from the Asterix Park).

The user acceptance and awareness is high thanks to the clearness and fairness of the pricing scheme and the information campaign. The users who accept to reschedule their trip have a compensation (lower price) and those less sensitive to the price or are captive to the red period gain from less traffic.

Remarks
- Need for accompanying measures to avoid undesirable results (i.e. pre-trip and on-trip information, police intervention, etc.).
- Impossible to exploit some of the data.
- The user acceptance is very positive but one must bear in mind that the previous situation was a toll motorway and the users are used to toll systems more than in other countries.

Assessment with respect to EUROTOLL goals
The demand spreading allows an increase in the network efficiency (in time): the demand is smoothed from peak to off-peak periods that leads to a decrease in the congestion at the conflict points. Fair pricing and balanced charging among users: toll fee is differentiated according to the vehicle classes. This TDM scheme assists in the aim of sustainable mobility due to:

1. Efficiency of the network, no side effects.
2. Inducing users to use roads more wisely/more awareness of the congestion problem.
3. No induced traffic.

Conclusion
This case study, with more than five years of existence, shows that toll variation in time is a good tool for demand management. The price effect is obvious and now that the operation is well known and understood, the users integrate the pricing scheme in their trip-making decision process, and no enforcement (when shifting from the red to the green periods) is necessary any more. The efficiency of such a TDM scheme relies on the identification of the essential road users.

The A10/A11 motorways, France

Site name: A10/A11 motorways
Location: Inter-urban/suburban south west of Paris
In operation/trial: Toll motorway with peak hour tolls implemented in 1996.

Country: France
Responsible partner: ISIS/ASFA.
Transport authority: COFIROUTE.

Main features
Type of site: Corridor.
Traffic context: Periodic congestion.
Location: Inter-urban, suburban.
TDM scheme: In operation.
User information: Pre-trip, on-trip.

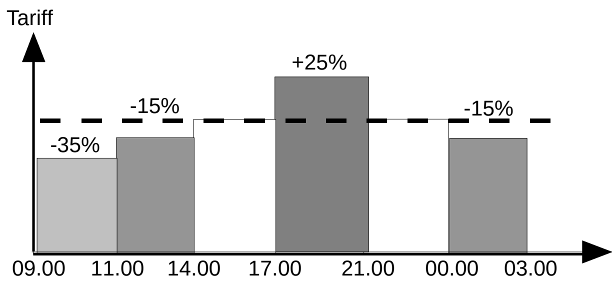
Objectives within EUROTOLL
Spread the demand on Sunday afternoon (weekend returns to Paris) in order to decrease congestion and increase network efficiency.

Transport policy goals
Sustainable mobility.
Increased network efficiency.
Increased network safety.
Fair pricing & harmonisation.

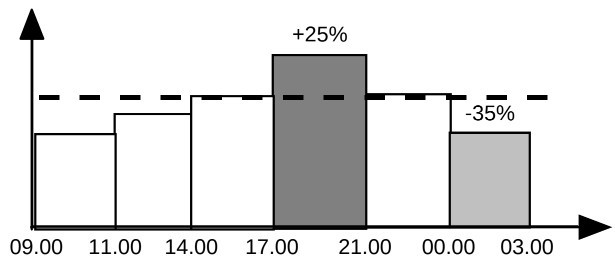
Transport policy sub-goals
Reduced congestion.
Balanced charges among users.

TDM strategy implemented (Peak/off-peak hours tolls, Information + VMS)
From March to November 1996, toll tariff variation was implemented for LV and HV returning to Paris The TDM scheme according to the type of vehicle and the time during the day is as follows (4 toll levels for LV, normal, red, green and super green, and 3 for HV, normal, red and super green):

Light vehicle pricing scheme



Heavy vehicle pricing scheme



Result
- Demand spreading: -12% during peak period, during heavy weekends the traffic transfer is lower in percentage terms but almost equal in absolute terms.
- Congestion has decreased by half.
- Traffic transfer on parallel network: 0.5% per weekend.
- It seems that there is no negative effect on safety.
- 50/50 of the users are in favour/ are not in favour of the operation.
- HV: good acceptability.

Remarks
- Longer series of data is required to draw any reliable statistic conclusion regarding safety.
- Heavy vehicle drivers had a good acceptability of the TDM strategy but in terms of HV traffic volume distribution, the impact is very weak (reminder that HV are not allowed to travel on Sundays, with some exceptions).
- No reliability in congestion data.

Assessment with respect to EUROTOLL goals
The demand spreading allows an increase in the network efficiency (in time): the demand is smoothed from peak to off-peak periods leading to a decrease in congestion at the conflict points downstream. Fair pricing and balanced charge among users: toll fee differentiation according to the vehicle classes. This TDM scheme assists in the aim of sustainable mobility due to:

1 Efficiency of the network, no side effects.
2 Inducing users to consume more wisely/awareness of congestion problem.
3 No induced traffic.

Conclusion
This case study shows that toll variation in time is a good tool for demand management but it is under the conditions of user acceptance and understanding. These two items which are linked, can be improved in that particular case. An easier pricing scheme would lead to more understanding and likely to more acceptance. The targeted users are clearly identified (LV, weekend returns to Paris on Sunday) in a specific context so the strategy and accompanied measures must be designed to reach them.

The A5/A6 motorways Paris - Beaune - Lyon, France

Site name: A5/A6 motorways *Location:* From Paris to Beaune. *In operation/trial:* toll motorway with specific pricing scheme implemented in 1995, 1996 and 1997.	***Country: France*** *Responsible partner:* ISIS/ASFA. *Transport authority:* SAPRR.

Main features
Type of site: Network.
Traffic context: Periodic congestion (during winter holidays).
Location: Inter-urban.
TDM Scheme: In operation.
User Information: Pre-trip, on-trip.

Objectives within EUROTOLL
The A6 motorway links the area of Paris (Ile-de-France) to Lyon, on the way to the Alps (Southeast). There is periodic congestion on this motorway during winter holiday departures and returns because of a high level of demand.

Since December 1994, the A5 motorway provides an alternative route to A6. But the A5 route is 71 kilometres longer than the A6 motorway between Paris and Beaune and the A5 is more expensive, which does not make it very attractive. Furthermore, as a new motorway, the A5 is not well known.

The objectives of this case study are:

- Shift traffic from A6 to A5 (15 - 20 % of transfer expected).
- Reduce congestion on A6.
- Maintain the level of revenue for the operator, make the A5 motorway more attractive and well known to users.

Transport policy goals Sustainable mobility. Increased network efficiency. Increased network safety. Fair pricing & harmonisation.	***Transport policy sub-goals*** Reduced congestion. Balanced charges among users.

TDM strategy implemented (Variable toll tariffs/routes, Information campaign)
During winter holidays and Easter weekend, differential toll tariffs are implemented for LV (passenger cars) in favour of A5 motorway.

It consists of a 50 FF cheaper toll for the Paris-Beaune trip on the A5-A31 itinerary compared to the A6 itinerary. This price difference is obtained both by increasing the toll level on A6 and decreasing the toll level on A5.

Example in 1996:

A6: Increase from 90 to 102 FF (+12FF which means +13%).
A5: Decrease from 111 to 52 FF (-59FF which means -53%).

This action is completed with an important communication campaign.

Results
Spatial effect: The TDM operation had an impact on route choice: 15-20% of the traffic concerned with route choice is on A5 whereas it is 4-5% without TDM operation on heavy traffic days (spontaneous choice of A5). This effect represents about 7000 vehicles transferred to the A5 per weekend (and per direction).

Time effect: During the TDM operation, despite an increase of the long distance traffic (Paris – Beaune), there is a decrease of the duration of peak periods.

Users main purpose for route choice:

- A6: Shorter trip, and from habit.
- A5: Free flowing

User claims:
⇒ only 6-8% of the users claim they are against the tariff increase on A6.

Remarks

- Toll price is not a major criterion for route choice because this is an occasional long trip and people have already included the toll in their holiday budget.
- Signing is not clear enough, in particular to find the A5 from Paris.
- No reliability of safety and congestion data.

Assessment with respect to EUROTOLL
The TDM operation is a success considering the increase of network efficiency: the transfer of traffic on A5 balances the traffic volume among the two alternative routes. As a consequence, the congestion is reduced on A6.

Fair pricing and balanced charge among users: toll fee differentiation according to the vehicle classes.

This TDM scheme assists in the aim of sustainable mobility due to:

1. Efficiency of the whole network, better balance among the two routes.
2. Inducing users to use roads more wisely/ increase awareness of congestion problem.
3. No induced traffic.

Conclusion
In such an inter-urban case with two alternative routes, one is attractive in terms of length (network feature), the other one in terms of free flowing (level-of-service). It is clear that the pricing scheme needs the support of an information campaign. Stressing the difference in price would make the A5 route known and attractive. The signing appears to be very important especially for a new route (complex network in Paris area).

The A7 A75 motorways, France

Site name: A7 A75 Motorways *Location:* France. *In operation/trial:* In operation.	***Country: France*** *Responsible partner:* SETRA. *Transport authority:* ASF + Min. of Transport.

Main features
Type of site: Network.
Traffic context: Periodic congestion.
Location: Inter-urban.
TDM scheme: In operation.
User information:

Objectives within EUROTOLL
The objective is to analyse the consequences of opening the A75 untolled motorway on transport demand with respect to the A7 in the Rhone valley. This case study provides information on user route choice and particularly the effect of tolls. The traffic transfer is estimated according to periods and congestion levels on the A7.

Transport policy goals Sustainable mobility. Increased network efficiency. Increased network accessibility.	***Transport policy sub-goals*** Reduced congestion. Essential road users (priority to certain user groups).

TDM strategy implemented (different tolls according to route; information campaign)
The A7 toll motorway in the Rhone Valley is a part of the route between the north and south of France, carrying high levels of traffic from northern Europe to the Mediterranean coast and Spain. This route is highly congested in summer time. In the west, across the Massif Central, the A75 free motorway between Clermont-Ferrand and Béziers/Montpellier (350 km) is now open. The A75 motorway will be in complete operation in 2001. This free motorway is already providing an alternative route for long distance travellers (from Paris to Montpellier or Paris to the east of Spain). These users have the choice between two different motorways (A6/A7/A9 and A10/A71/A75). User route choice is made according to different route characteristics e.g. distance and toll fare, traffic flow conditions.

The opening of this motorway is helping traffic transfer from the A7 and is expected to reduce congestion in the Rhone Valley for the following reasons: the route A71/A75 is more direct for several origin destinations, and is free between Clermont-Ferrand and Montpellier/Béziers.

Results:
- Assignment of transferable flows: in 1997, the traffic breakdown on the 2 routes is variable according to the period. The assignment rate on the A75 route is estimated at about 25% in summer peak period when the congestion level on the A7 is highest. It is likely to be lower during summer weekdays (19%). Out of the summer period, it is estimated that the assignment rate on A75 is highest (about 40% for passenger vehicle) whereas no congestion is observed on the A7, but a small number of vehicles are involved. The assignment rate rose significantly between 1993 and 1997.
- Knowledge of alternative route: Most A7 transferable users don’t know the A75 route and the characteristics of this route (toll fare, level of service), so the number of users in a state of real and rational route choice is lower than the number of transferable users.
- Reasons for route choice: the first reason for an A75 route choice is the tourist attractiveness (25% to 35%). Cost (including toll charge) as a route choice reason is provided by only 14% of users in the summer peak period, 12% on summer week days and 15% on October week days. Moreover, it is noted that out of the summer weekday period, 22% of A7 users don’t pay the toll charge themselves. This fact has to be taken into account when forecasting user reactions.
- Assessment of transfers (passenger vehicles only) from A7 to A75 : it varies, according to periods, from 130 veh/day (October week day) to 2700 veh/day (summer peak).
- Cheaper toll charge on the A75 route must be considered as a largely secondary reason of route choice. Between 36% and 60% according to period have given a positive answer to the question ‘ Does the toll influence your route choice?’
- Congestion on A7: There is no appreciable increase in congestion on the A7, in spite of a global summer traffic increase of 10 % from 1993 to 1997. This congestion stability is largely due to the communication campaign of the operator A.S.F. to encourage users of the A7 to drive during weekdays instead of weekends. Long distance travellers between Languedoc-Roussillon, Spain and Paris and Northern France are influenced by the measure during the summer period. Out of summer periods, few people are involved, but those who are influenced are mainly retired people.

Remarks
- For HV the transfer between the two alternative corridors cannot be concluded for statistical reliability reasons.
- There is a significant increase in congestion on the A75 route because the motorway was not completed in 1997 (Millau black spot). Nevertheless, new surveys should be conducted in 4 or 5 years when the A75 route is completed, in 2002.

Normandy and Tancarville bridges, France

Site name: Normandy and Tancarville bridges *Location:* France. *In operation/trial:* In operation.	***Country: France*** *Responsible partner:* SETRA. *Transport authority:* Chamber of Commerce Le Havre + Min. of Transport.

Main features
Type of site: Bridge.
Traffic context: No congestion.
Location: Inter-urban.
TDM scheme: In operation.
User information:

Objectives within EUROTOLL
The objective is to analyse the consequences of the opening of the Normandy toll bridge on the transport demand across the Seine river and to analyse user behaviour on route choice in response to tolls and time saved.

Transport policy goals	***Transport policy sub-goals***
Increased network efficiency. Increased network accessibility.	Balanced charges among users. Eessential road users (priority to certain user groups).

TDM strategy implemented (different toll re route)
The pricing system is not really a toll based TDM strategy.

The opening of a second toll bridge crossing the Seine provides a new route choice for users.

The distance cost (especially toll charge) and time of a trip may be greater or smaller via the Normandy bridge depending on the location of trip origins and destinations. Toll charges and the toll system are different on the 2 bridges (33FF on Normandy Br., 18 FF on Tancarville Br.

From the north of France, the A29 toll motorway is directly linked to the Normandy bridge.

Results
The following effects have been observed after opening of the Normandy bridge in 1995:

- Annual average growth of total traffic crossing the Seine changed from 3.9% per year (before 1995) to 4.5% per year (after 1995) for LV, from 3.4% to 4.4% for HV.
- Induced traffic due to the opening of the new bridge can be estimated at between 20 and 25% of its traffic. It is linked to increased mobility essentially for short trips between the banks of the Seine.
- Assignment on Normandy toll bridge is better for LV than HV: from Le Havre to west of the left bank: 90% to 95% for LV when 60% to 85% for HV.

Toll reaction:
- The toll reaction depends on trips and user characteristics: users who don't pay the trip themselves and professional users accept the toll more easily. The high number of users who do not pay for the toll themselves when they use a toll infrastructure should be noted.
- It can be generally observed that the assignment rate on Normandy bridges is slightly lower on Sundays than on workdays. This is due to trip purposes (more leisure trips on Sundays). Time saved is not a major criterion for leisure trips.
- User interviews have shown that about 70% of users do not calculate their trip cost, 23% take into account essentially fuel cost and toll.
- The revealed time value is linked with toll reaction: the higher the time value, the higher the toll acceptance. Time value for users who don't pay the trip themselves and professional trips is higher than average user time value. This fact needs to be taken into account in assignment forecasting.
- In the case of free bridge, the toll effect on traffic transfers has been estimated (from modelling) between +1700 and + 2500 veh/day (20% to 30% of transferable flows) in comparison to the current situation (33F).

Feeling of companies:
- The toll fare on the Normandy bridge appears too expensive especially for trips towards the south (motorway connection is not completely in operation). The companies declare that the most significant effects of this bridge are time and distance saved. A small number of interviewed companies are thinking of developing their activity after opening of the bridge

The A12/A13 corridor motorways, Austria

Site name: A12 / A13 Motorways *Location:* Brenner corridor. *In operation/trial:* In operation /trial.	***Country: Austria*** *Responsible partner:* HERRY. *Transport authority:* ASG.

Main features
Type of site: Corridor.
Traffic context: Daily congestion.
Location: Inter-urban.
TDM scheme: Scenario.
User information: (Pre-trip).

Objectives within EUROTOLL
The Austrian Case Study on the Brenner Corridor has a lot of objectives, such as:

- Integration of road pricing into traffic management.
- Impact analysis of road pricing on an international, national, local level for:
  - transport impacts.
  - socio-economic impacts.
  - environmental impacts.
  - changing externalities.
  - policy impacts for passenger and freight transport.
- Analysis of the toll system as a tool to change the modal split in favour of the railway system.
- Development of the toll system, the eco points system and the impacts on traffic demand.
- Development of the toll systems and their impacts on the international diverted traffic as well as the respective strategies.

Transport policy goals	***Transport policy sub-goals***
Sustainable mobility. Increased network efficiency. Fair pricing & harmonisation.	Co-operation between modes. Reduce congestion. Recover infrastructure cost. Internalise external costs. Balanced charges among users. Increased public transport share. Reduce pollution/ environmental friendly.

TDM strategy (implemented) (generalisation and differentiation of toll on corridor)
The Brenner corridor consists of the A12 and A13 motorways and links Germany (A12-North) and Italy (A13-South). These two motorways are heavily used by transit-traffic, especially by HV. At the moment the A13 is tolled (mountainous motorway with a lot of high bridges), the A12 – longer route – is not tolled (plain motorway).

Reference scenario/case: Situation on the corridor A12/A13 in the year 1995
A12: no toll for light and heavy vehicles.
A13: toll for light and heavy vehicles, but not differentiated tariffs during the day (day-night is the same tariff).

3 alternative scenarios with and without TDM schemes:

Alternative scenario 1: Scenario in operation; situation on the corridor in the year 1996 after implementation of a new toll-system:

- A12: no toll for light and heavy vehicles.
- A13: same tariff for light vehicles as reference scenario; higher tariffs for heavy vehicles, especially for 'noisy' lorries and lorries driving at night (between 11 p.m. and 5 a.m.-new night tariff: two times as high as during the day).

Alternative scenario 2: Situation after implementation of a toll on the total corridor (A12 and A13):

- Toll depending on trip purpose and driven length for light vehicles (low amount: 0,50 ATS per km).
- Implementation of Alpine clause 1 for heavy vehicles at the value of 130 ECU (average tariff – that means same tariff of 1.150 ATS during day and 1.800 at night), collected on the total corridor Kufstein - Brixen.

Alternative scenario 3: Situation after implementation of a toll on the total corridor (A12 and A13):

- Toll depending on trip purpose and driven length for light vehicles (high amount: 0,80 ATS per km).
- Implementation of Alpine clause 2 for heavy vehicles at the value of 148 ECU (1.800 ATS on the Austrian corridor during day and night), collected on the total corridor Kufstein – Brixen.

Results in pricing, veh.km., total revenues and total costs:

Changes of investigated parameters of *total light vehicles* on the Brenner corridor for all scenarios in percent, price base 1996:

	Tariff	*Veh-km*	*Revenues*	*Costs*
Alternative scenario 1	0,0%	0,0%	0,0%	0,0%
Alternative scenario 2	27,9%	-18,1%	18,9%	4,0%
Alternative scenario 3	46,1%	-30,9%	21,2%	3,5%

Changes of investigated parameters of *light vehicles – commuters* - on the Brenner corridor for all scenarios in percent, price base 1996:

	Tariff	*Veh-km*	*Revenues*	*Costs*
Alternative scenario 1	0,0%	0,0%	0,0%	0,0%
Alternative scenario 2	50,0%	-27,3%	3,3%	-0,2%
Alternative scenario 3	50,0%	-27,3%	19,1%	10,0%

Changes of investigated parameters of *light vehicles – non commuters* - on the Brenner corridor for all scenarios in percent, price base 1996:

	Tariff	*Veh-km*	*Revenues*	*Costs*
Alternative scenario 1	0,0%	0,0%	0,0%	0,0%
Alternative scenario 2	14,6%	-13,8%	23,9%	5,9%
Alternative scenario 3	32,6%	-32,6%	21,9%	0,5%

Changes of investigated parameters of *total heavy vehicles* on the Brenner corridor for all scenarios in percent, price base 1996:

	Tariff	*Veh-km*	*Revenues*	*Costs*
Alternative scenario 1	30,5%	3,2%	39,0%	1,1%
Alternative scenario 2	25,0%	-3,3%	56,9%	4,3%
Alternative scenario 3	80,0%	-16,9%	75,9%	3,1%

Changes of investigated parameters of *heavy vehicles – day traffic* - on the Brenner corridor for all scenarios in percent, price base 1996:

	Tariff	*Veh-km*	*Revenues*	*Costs*
Alternative scenario 1	20,0%	10,0%	48,9%	7,8%
Alternative scenario 2	20,0%	-4,9%	70,1%	2,6%
Alternative scenario 3	80,0%	-23,1%	83,3%	-6,1%

Changes of investigated parameters of *heavy vehicles – night traffic* - on the Brenner corridor for all scenarios in percent, price base 1996:

	Tariff	*Veh-km*	*Revenues*	*Costs*
Alternative scenario 1	130,0%	-28,1%	-1,7%	-29,5%
Alternative scenario 2	80,0%	3,8%	2,2%	12,4%
Alternative scenario 3	80,0%	11,8%	45,6%	45,7%

Changes of investigated parameters of *total light and heavy vehicles* on the Brenner corridor for all scenarios in percent, price base 1996:

	Tariff	*Veh-km*	*Revenues*	*Costs*
Alternative scenario 1	16,1%	1,3%	18,9%	0,6%
Alternative scenario 2	33,4%	-12,2%	35,3%	28,4%
Alternative scenario 3	74,1%	-25,3%	44,8%	3,3%

Stuttgart field trial, Germany

Site name: Stuttgart *Location:* Stuttgart. *In operation/trial:* Trial/model.	***Country: Germany*** *Responsible partner:* Heusch/Boesefeldt. *Transport authority:*

Main features
Type of site: Network.
Other modes: Inter-modal aspects.
Traffic context: Daily congestion.
Location: Suburban.
TDM scheme: Scenario.
User information: Pre-trip, on-trip.

Objectives within EUROTOLL
The objectives of the integration of the Stuttgart case study into the EUROTOLL investigation programme were as follows:

- To describe user behaviour in detail as a function of external and internal parameters
- To evaluate the MobilPass-Project from the EUROTOLL perspective (e.g. essential road users, modal split) and lay stress on environmental aspects to make data and experiences available to EUROTOLL

Transport policy goals Sustainable mobility. Increased network efficiency.	***Transport policy sub-goals*** Interconnection and interoperability. Cupertino between modes. Reduce congestion. Increased public transport share. Reduce pollution/ environmental friendly.

TDM strategy implemented (cordon pricing, Park + Ride)
The MobilPass field trial has tested five pricing-phases, each lasting two months, and altogether being embedded in reference phases without pricing schemes. From phase to phase, the levels and dynamics of the prices varied. In addition, a spatial component was included in pricing phase 5. In EUROTOLL, for three of the five pricing schemes, the effects on user behaviour were investigated following the EUROTOLL approach and subsequently modelled in order to quantify effects of pricing schemes which might occur as a result of corridor and/or cordon pricing. The scenarios under investigation in EUROTOLL are to be characterised by:

- General price level.
- Design of peak period pricing scheme.
- Spatial pricing design.

Results

- Simulations based on the MobilPass data have shown that, in principle, a corridor toll which is characterised by peri-urban roads accessing the Stuttgart city will result in greater transport reductions and emission reductions than a cordon toll does. This is caused by the fact that, in the case of a cordon, once the toll is paid, any subsequent trips within the cordon are not influenced by the pricing scheme. Instead, reaction patterns are to be expected (like building trip chains within the cordon), leading to increased mileage. With a corridor toll, however, the effect of pricing schemes will be noticed directly.
- The design of a cordon, namely the shape and the length of the network, will therefore influence its efficiency in terms of reductions in veh.km.. The smaller a cordon, the more significant effects are to be expected. Instead of having a big inner-city cordon, several small cordons, being interlinked, may well be an option.
- It has to be noticed that in opposition to the expected effects as stated by the MobilPass users the simulated environmental effects are considerably higher.
- Extrapolation from the MobilPass data to simulate the transport behaviour in a cordon made clear that spatial aspects in tolling are very difficult to predict, and are from time to time contradictory. Generally, transport is a self-controlled system, optimising transport time and costs, and thus users only choose alternatives and necessarily longer routes in case of considerable advantages in travel time.
- The use of pricing schemes for TDM have to clearly focus on accepted goals such as reduction of congestion, reduction in mileage or reduction in emissions. Furthermore, it has to be considered in which part of the network the effects are to be reached. In general, a distinction has to be made between access corridors and the inner city cordons.
- A pricing scheme, which tries, to effect route choice in the short term is somehow questionable, as re-routing effects increase mileage and compensate the effects from other responses.

Remarks

- Medium- and long-term effects are difficult to assess from the trial data, whereas e.g. in the case of car-pooling a medium-term effect is to be recognised as the pooling rate increases over the time of the application rather than as a result of toll variations. To some extent the same is true in the case of modal shifts, whereas in the Stuttgart trial a saturation seems to be reached at approx. 5% of all trips.
- Working days, Saturdays and Sundays show significantly different user reactions on pricing schemes. The examinations within EUROTOLL have concentrated on working days in order to allow comparisons with other cases under investigation, such as the Leicester scheme.

Truck Vignette, Germany

Site name: Truck Vignette *Location:* Germany. *In operation/trial:* In operation since 1995.	***Country: Germany*** *Responsible partner:* Heusch/Boesefeldt. *Transport authority:*

Main features
Type of site: Network.
Other modes:
Traffic context: No congestion.
Location: Inter-urban.
TDM scheme: In operation.
User information:

Objectives within EUROTOLL
The case study 'Truck Vignette' is chosen to analyse the impacts of road tolls on road freight transportation within EUROTOLL. Apart from the general assumption that road freight transport is insensitive towards tolls since they play a minor role in comparison with the other cost elements, no examination has been undertaken yet to verify this hypothesis.

In general, the study had to meet the following objectives:

- to identify and estimate the effects on freight transport in Germany and to assess whether a vignette is an instrument to influence road freight transport behaviour;
- to evaluate the effects of a truck vignette on road freight transport in the light of being a first step to an interoperable tolling system in Europe;
- to estimate effects and acceptance of alternative vignette pricing designs;
- to learn from existing instruments about future road pricing designs.

Transport policy goals Fair pricing and harmonisation.	***Transport policy sub-goals*** Recover infrastructure cost. Balanced charges among users.

TDM strategy implemented (vignette or tolling)
Truck vignette in Germany Germany, the Benelux countries, and Denmark introduced a truck vignette in January 1995, while Sweden joined the group in January 1998. The vignette has to be purchased for trucks exceeding a total max. weight of 12 tons. In Germany the vignette is obligatory for the entire motorway network. It also allows for the use of tolled roads in the other four countries. The price for the vignette varies between:

- 6 ECU/day for trucks/truck combinations with 3 axles and 12t total weight or more; and
- 1.250 ECU/year for truck/truck combinations with four and more axles and 12t total weight and more.

The vignette was introduced as an instrument to allow a fairer allocation of motorway infrastructure costs between heavy vehicles than vehicle taxes and fuel taxes can do. Thus, the principle of territoriality in recovering infrastructure costs in road freight transport was enforced. To compensate the increase in costs for the companies, the vehicle tax in Germany was reduced, taking into account the emission class of the vehicle. Thus, a stimulus towards the use of Euro I/II-vehicles was given.

Besides the vignette design which is in operation, two scenarios have been examined:

Scenario 1 (modified tariff structure for heavy vehicles (as proposed by EC in 1997)) The proposal of a more detailed pricing scheme is based on annual payment and includes a differentiation concerning vehicle emission class, total weight and constructive features of heavy vehicles, which are responsible for road damage. Prices vary between:

- 750 ECU/year for trucks with 7,5t total weight or more, Euro II engines, and pneumatic suspension (Class I of road use), and
- 2000 ECU/year for trucks/truck combinations not having Euro I/II-engines, but more than 4 axles and a total weight about 33t in case of conventional suspension or in case of pneumatic suspension with about 5 axles and a total weight about 40t (Class III) *Scenario 2 (distance related toll for heavy vehicles)* In this scenario the vignette is replaced by a standard tariff of 0,13 ECU per kilometre, being charged for vehicles exceeding 12 tons on motorways only.

Results

- In principle, the introduction of the truck vignette has met the goal to achieve a fairer allocation of costs among freight transport actors that are using German motorways.
- A vignette cannot be regarded as an instrument for TDM in road freight transport.
- In the current situation in Germany, approx. 10 million vignettes are sold for a period of a year (Even when having no vignette available, it is possible to buy a vignette for a short period in Germany).
- Once having bought a vignette, no pre-trip decisions to change the transport behaviour is to be expected.
- Sales statistics in Germany show that a trend to use short-term vignettes instead of long-term validation is taking place. Obviously, the companies are sensitive towards vignette costs and thus plan and calculate their demand. This does not automatically lead to a change in transport behaviour. Nevertheless, the analysis in EUROTOLL shows that especially owners of small fleets in own account transport tend to change transport behaviour. Nearly 20% of all users choose lower classified roads from time to time to avoid buying a vignette. Even more (23%) try to increase the loading factor of the truck to save mileage.
- A more detailed design of the vignette reflecting emissions, number of axles, net-max weight and suspension will improve responsiveness significantly: Some 52% will change roads from time to time, and 19% will use motorways without having bought a vignette. These reactions seem to be mainly taken by small companies operating in short-range transportation.
- An increase in short and medium-term reactions like 'subcontracting commercial transport', 'use of non-obliged vehicles, if available' and 're-scheduling of trips if vignette-equipped vehicles are available' will be found mainly with the small own account fleets. Long term-effects like 'change in fleet composition' also have to consider economic situations of the companies and depreciation periods for the vehicles.

- In comparison with a distance-based toll, route choice effects will again increase to 81%, but the analysis cannot quantify the transport effects.
- Changing to combined transport is relevant for 12% of the users. In own account transport, 50% are in favour of distance based tolling, 50% prefer a differentiated time based vignette as proposed by EC in 1997. In commercial transport one third has no preferences, whereas of the rest just a slight majority is in favour of a distance-based system.

Remarks

- For EUROTOLL it is far more interesting to look in detail at users reaction patterns. All results given below are based on questionnaires rather than on measurements, and thus have to be regarded as tendencies.
- It is to some extent doubtful whether the high responsiveness stated in the survey is solely a result of the pricing scheme.
- Detailed information about absolute changes in veh.km. and travel frequency is not available. The sample size does not allow confident statistical analysis.
- No information about the changes in average annual mileage of vehicles is available.
- No statistically sound information is available for the companies concerning general changes in the following cost elements: distance related costs, time related costs, additional administration cost for the vehicle fleet, and additional cost for equipment like the purchase of PCs.

Feedback for conceptual research

As expected, only little information for conceptual research in TDM behaviour in freight transport can be made available. All data on reaction patterns has to be carefully interpreted in the light of the current economic situation of the companies. Therefore, it is inevitable to separate in own account and commercial transport, and to consider the size of the fleets.

Florence, Italy

Site name: Florence *Location:* Florence *In operation/trial:* Trial	***Country: Italy*** *Responsible partner:* AUTOSTRADE SpA. *Transport authority:*

Main features
Type of site: Corridor
Other modes: Inter-modal aspect
Traffic context: Daily congestion
Location: Suburban
TDM scheme: In operation
User information:

Objectives within EUROTOLL
Objectives of Florence case-study according with the EUROTOLL programme were:

- to test a Smart Card Multiservice (electronic purse), an Integrated Payment System (IPS) shared with other mobility operators in an interurban area between Florence and Prato, in order to extend eventually the integrated payment system to the whole ATAF's network and to validate technical and operational aspects;
- to evaluate the VIAPASS card from a EUROTOLL perspective (e.g. modal split, ..), describe users' behaviour (e.g. users acceptance for the Smart Card Multiservice);
- to promote the use of public transport, aiming to shift trips from private vehicles to Public Transport (PT), and reduce congestion and vehicle emissions;
- to collect data and experiences useful for EUROTOLL project.

Transport policy goals Sustainable mobility. Increased network efficiency. Increased network accessibility.	***Transport policy sub-goals*** Interconnection & interoperability. Cupertino between modes. Reduce congestion. Essential road users (priority to certain user groups). Recover infrastructure cost. Balanced charges among users.

TDM strategy implemented (integrated payment system, i.e. tolls, PT tickets, parking fee)
Scenarios:

- The introduction of Advanced IPS *Telematics technologies* to support road demand strategies and traffic management demand (TDM).
- The use of VIAPASS as a means to meet road-users needs and encourage the use of alternatives to the car: comparison between acceptability before and after the experimentation *(user acceptance*).
- Availability of a smart card mutliservice for *different transport operators and modes* along a road corridor, which represents a border line between the motorway network and the urban area: in fact road infrastructures are not adequate to respond to the daily traffic flow, therefore real bottlenecks take place, especially at peak hours.
- Since the beginning of the EUROTOLL project, no toll reduction was implemented by Autostrade to car drivers at any time of the day, due to the experimental design and no complementary actions (e.g. advertising).

Results
General results:

- The introduction of the VIAPASS card has allowed it to be tested as a multiservice mobility card and the validation of *technical and operational aspects.*

  Having in mind the complexity of the demonstration site, the *sample reaction* was positive: private cars drivers, urban and extra-urban public transport users, have welcome the smart card which is perceived as an encouraging factor in favour of modal shift.
- Modal Shift from private cars (Autostrade Toll Stations) to Public Transport has been observed.
  - users shifted from motorway to Public Transport *5%;*
  - users shifted from Public Transport to motorway *negligible.*
- Concerning acceptability, a before-after analysis revealed that 'after' the EUROTOLL experimentation:
  - 22% of the total sample have been affected by the card under test conditions;
  - 7% of the car drivers (Autostrade users) have been affected by the card;
  - 15% of the PT users have been affected by the card (ATAF users 9% , other operators users 6%);
  - Little changes of attitude have been obtained.
- As expected, although not many advantages have been confirmed by the field test, the users' reaction has to be considered positive, the VIAPASS card being the first Italian example of transport multi use card.

Topics to be reconsidered:

- Accessibility.
- Economic advantages for users.
- Marketing and advertisement campaign.
- Restricted actions in space and time according to municipalities.

Remarks

- Reliability and efficiency of the technology, procedures, and ground equipment have been evaluated during the testing phase:
  - 90% successful validations (as for hardware).
  - 10% failures (as for hardware).
  - 3 % failures (software) as for registration of transaction data in field test.
- Users have pointed out during the testing phase:
  - No advantages for the user from an economical point of view.
  - Little accessibility.

Feedback for conceptual research
The Florence case study provides little information for conceptual research, mainly input for the following aspect:

- Demand reactions (i.e. on field test collecting data).
- Integration of pricing (i.e. user acceptance, impact and user reaction).
- Interurban/urban conflicts (i.e. congestion, pollution).

Leicester, United Kingdom

Site name: Leicester Real site but demonstration only *Operation:* August 1997 – May 1998	***Country: UK*** *Responsible partner:* Howard Humphreys *Transport authority:* Leicester City Council

Objectives within EUROTOLL

This is a demonstration site taking place in a corridor that includes peri-urban and urban areas and is characterised by congestion during weekday peak periods. This is attributable to commuters using private cars to travel to the city centre. The bus services are delayed by general traffic congestion. General objectives: to examine driver response to road tolling

Specific focus in EUROTOLL: short term reactions of users especially modal shift and route choice. The objectives of the road-tolling scheme are to reduce road traffic congestion and improve network efficiency by encouraging drivers to use enhanced public transport facilities that include a park and ride facility and bus priority measures. The scheme will also encourage trip re-timing and reductions in total journeys. These measures should lead to reduced air pollution and a more pleasant urban environment.

TDM strategy implemented

Leicester is pioneering the development of urban road pricing using electronic toll technology. Within the LERTS (Leicester Environmental Road Tolling Scheme) project, the reaction of volunteer drivers to road charges is recorded to reveal possible patterns and methodologies for encouraging travel mode shift. The project simulates an actual tolling application by charging for car journeys made into central Leicester along a demonstration corridor and to provide an attractive public transport alternative. A 300-space car park and ride site has been constructed with a frequent shuttle bus service to the city centre (the parking is free for those that transfer to the bus). In addition, bus lanes and other priority measures have been introduced to form a continuous corridor between the park and ride site and the centre of Leicester.

As part of LERTS a trial has been conducted with around 100 drivers. Observations have been made about their daily journey patterns before and after the installation of the road tolling equipment, and assessments made of their sensitivity to changing tolling rates. Evaluation concentrated on the response of subjects over a long period of time to allow the behavioural responses to be evaluated. Each scenario ran for a sufficient length of time to ensure that drivers have time to adapt their travel behaviour.

Results

Nine different 4-week toll strategies implemented with charges at different levels applying to peak and off-peak periods, including two strategies related to environmental conditions in the City of Leicester.

Main reactions were mode shift and transfer to alternative routes. Transfer to park-&-ride varied from 18% at toll charges of £2.00/£3.00 to 38% at charges of £10.00. Up to 40% of drivers use routes avoiding the toll stations at charges of £10.00. There was little evidence of trip re-timing during peak toll periods.

Provision of improved public transport offering an attractive alternative to road user charges is seen as essential.

Abstract

The EUROTOLL project was designed to obtain a better understanding of road user reactions to Transport Demand Management (TDM) measures in both urban and interurban situations. The measures that were assessed consisted principally of road user pricing and improved public transport alternatives. The findings aim to assist local authorities in their assessment of the potential of TDM strategies.

The principle findings of the EUROTOLL project confirmed expectations that road users adopt avoidance strategies in response to road pricing schemes. Thus, road users focussed on maintaining a degree of car mobility while minimising the financial burden of pricing. In urban areas, it was noted that most road users have a higher value of time than for interurban trips. Thus, some road users would be willing to pay a high toll in order to save time. Others would shift modes to public transport (particularly park and ride) if this was given some priority over private vehicles. In both interurban and urban situations, modulated road pricing could induce a modal shift or a re-timing of the journey, in order for the road user to minimise the financial burden of the TDM scheme.

Related publications

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