

# **Relationships with the Motorway Toll Collection Schemes: the cases of Florence and Rome in the experience of Autostrade SpA**

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*Restricted Access Schemes have many similarities with Electronic Toll Collection Schemes embodied in a toll motorway system, since they share technology, systems and some commercial practices. Nevertheless they present differences which may make it difficult to extend to road pricing purposes the experience and the track record of toll collection on a motorway. In all cases, it is needed to integrate the Restricted Access Scheme to the motorway system when the motorway system is a part of the urban infrastructure. This exercise in being applied by Autostrade in Rome and Florence, with some interesting issues with respect to technical, organisational and commercial aspects.*

## **Restricted Access Schemes and Toll Collection Schemes**

In general terms, road pricing applied to an urban context is the evolution of a Restricted Access Scheme. It is in fact usual to start with the implementation of a RAS, to test it in all its components, to “sell” it to the community and then to expand it into a comprehensive Road Pricing Scheme (RPS). The key point which defines the evolution of a RAS into a RPS is the definition of a set of tariffs associated to certain politics defined by the policy makers; it is certain a step ahead with respect to limiting the access to some part of a city, but the pre-condition for the application of any pricing policy is obviously a system in place, tested with accuracy and – let us say it once again – accepted by the community.

Which are the components of a RAS? Typically, there are:

- a) a system of gantries located on the points where access is restricted
- b) a radio transmission system for ground to vehicle communication
- c) the on-board units or transponders to be installed on each vehicle which make it possible the dialogue between ground and vehicles
- d) a vehicle detection/classification system
- e) a system used to acquire the image of the licence plate in case of non regular transit.

If we now look at a typical automatic toll collection system installed on a toll motorway, we may see that we also have a system of gantries, installed on the lanes of the toll stations (i.e. the places which allow the vehicle to enter or exit the motorway), a radio system based on the dialogue between vehicle (via on board unit) and ground (via gantry), a system that classifies vehicles by time and class in order to apply the correct toll, a violation enforcement system which identifies violators through a video system and prosecutes them by reading the car plate of the vehicles. AVI, or automatic vehicle identification and automatic toll collection systems are usually a part of the whole toll collection system of a motorway, which also foresees manned toll plazas or toll booths.

If we compare the RAS and the toll collection scheme of a motorway in more general terms, we may see that again the components are the same. Apart from the technical components, both systems imply the definition of the relationships with the rest of the infrastructural system, in the sense that they are part of a wider system with which they have to dialogue in an efficient way. A gate or some gates are set and out of that vehicles are not subject to special rules and regulation, whereas within the area defined by those gates vehicles must conform to the laws defined by the system.

So, in principle, we may think that the experience and the track record of a company which deals with toll collection in a motorway framework may be transferred without problems to a RAS situation. This is not true, however, because there are 3 main differences between a RAS or a RPS and a Toll Collection Scheme that is part of a toll motorway network. All these differences determine a set of consequences with implication in the design and operation of a RPS or a RAS.

1. The first difference is in the concept of restricted area itself. While a toll collection systems applies to a section, or a corridor, or a specific transit connected to the crossing of a natural obstacle such as a bridge or a tunnel, the restricted area is a perimeter based on concentric circles. The main purpose of restricting the access to an area is to protect it from an unlimited use by private vehicles; the typical case is the historical centre of a city and the goal of limiting the access is to ensure the conservation of the asset to the present and future generation and quality of life to the residents and the visitors.
2. The second difference is the co-existence within the RA of different players with different roles, attitudes, behaviours. Whereas the toll motorway is a place where only “professionals” drive, i.e. users with the motivation to drive between “A” and “B” in less time and better comfort conditions with respect to the free alternative, the restricted area hosts both residents and visitors, the former group being conservative, jealous of its prerogatives, generally close to the latter group. The driving patterns are different as well: in the motorway you may in general terms predict the driver’s behaviour and even the time of the transit, while in the restricted area you have to know much more about the driver’s purpose, place to see, length of the stay (if any), place where the vehicle will be parked, and so on.
3. The third difference is in the purpose of the infrastructure or the system. Tolling is one of the core activities of a toll motorway; the other activities are maintaining the infrastructure and patrolling it but if we focus on the typical life of an infrastructure, the process starts with an investment, passes through the supplying of a service based on the availability of the initial investment and ends when the investment and the debt have been repaid (in case of mixed debt-equity financing, which is the vast majority of cases), the investors’ equity has been remunerated. In general terms the core activity of a RAS is the preservation of an asset; even if we refer to a Road Pricing Scheme, in which the pricing factor plays a central role in terms of acceptance, “price” levels, externalities, etc., the purpose of the system is not to repay an investment – which is

negligible with respect to the benefits deriving from the system – rather to impose a regime based on the maximisation of the collective utility. In a toll motorway you pay for an individual better service and you always have a free alternative; in a road pricing scheme you pay for a worse individual service (you are not only restricted in the circulation of some parts of the city, you must pay for the circulation that is allowed), but for a better collective service. As it is widely known and recognised, the toll associated with the use of a toll motorway “pays” only a limited part of the overall economic benefits (the net sum of negative and positive externalities, which usually results in a positive balance), whereas the toll associated with a road pricing scheme pays most (or at least some) of the negative externalities.

Which are the consequences of these relevant differences? RAS and RPS are much more complex than TCS under all points of view, technical, commercial, managerial, political. At the end of the day, a toll road reflects a voluntary option, is a choice made by the user who considers the toll as fair vis-à-vis the benefits he gets from the use of the motorway. A restricted access or a road pricing scheme is a non-voluntary option, it must be imposed to the community and although the collective balance for the community is positive by definition (otherwise it would not be applied or proposed by the policy makers, unless we accept non rational results of the political choices, what we do not do in this context for sake of simplicity) there are always some groups which think they are penalised and lobby to defend their rights. Dealing with these groups is not easy because they are part of the system. A toll motorway has many enemies, of course, both in the design and construction phase and during the operational phase, but they are not a part of the system, they are outside the system.

The reason of a higher complexity associated to RAS and RPS with respect to TMS is not only the number of different users within the system. The administration itself, or the community, has different and often competing goals: the design and the implementation of a RAS is in most cases the great occasion for re-designing the mobility for the whole city, including public transport, private and collective parking policy, urban development and long term land use planning. Even if the community does not want to take the occasion for a new mobility planning, the RAS imposes at least to define a parking policy and a wider public transport supply. These measures have a wave effects which distribute their implications more or less up to the beginning of the non-urban system, i.e. the motorway accesses to the city.

And here we get to the key point of the experience of Autostrade and the contents of our contribution to the seminar. To which extent the automatic tolling system based on the Autostrade’s proprietary technology may be applied in Italy to urban accesses and pricing schemes? How it is possible to integrate a RAS with the existing motorway tolling schemes?

### **The Telepass technology and the Italian background**

Telepass system was developed in 1989 and initially deployed on the Italian Autostrade network in 1990. It was the world's first fully automatic smartcard based electronic tolling

system to enter service. Telepass is based on 5.8GHz beacons and in vehicle transponder technology together with the use of a non-contact prepayment smartcard. Telepass provides a flexible approach to toll collection and allows the system to offer a real time, non-stop payment facility which substantially increases the throughput of a toll plaza lane without the need for physical barriers. Operating at 5.8 GHz, Telepass was the first, second generation road tolling system, and is now installed extensively across the Autostrade network. There are currently over two hundred toll lane stations installed and in use, and some 2,7 million on board units. Still, 12 years after its introduction, it is the most widely used integrated system in use worldwide <sup>1</sup>.

As it has been made clear in many occasions by several speakers who have reported on the experiences of RAS in Italy, the Italian legislation foresees the creation of restricted access areas as well as the road pricing activity<sup>2</sup>. A national law and a presidential decree were passed between 1997 and 1999 in order to allow the creation of automated control accesses of historical centres of Italian cities. What is important in this framework is that the Presidential Decree 250/1999, which defines the conditions to install and to operate systems for access control in cities with historical centres and other limited traffic zones, sets (article 7) that Telepass is the standard system for digitalised images and dedicated short-range communication between vehicle and ground. More precisely, the Decree sets that the systems proposed by the municipalities for approval by the Ministry of Public Works must be conform to the same UNI norms (or national standards) used for the Telepass system. Any other system may be proposed, but its official approval is subject to extensive testing.

This does not mean that any application of RAS in Italy has been or will be based on a supply of equipment by Autostrade. First of all, as above explained, Telepass is based on the interaction of a radio system with a video system; the radio system is a proprietary technology of Autostrade, whereas the video system has been developed by Autostrade together with other suppliers (Elsag, Project Automation and Busi, formerly Elettronica Santerno). Furthermore, any system integrator may be able to supply a radio and video system (including gantries and on board units) consistent with the UNI standard.

This is just what happened in Rome, where the tender for the design & build procurement was awarded to an Italian company, Elettronica Santerno, which sub-contracted to Autostrade

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<sup>1</sup> For a more detailed description of the Telepass system, see Battiboia, "Italy's Telepass - an EFC Technology for ITS Application"s, in IBTTA, 2001 International Technology Workshop; see also the Company's website [www.autostrade.it](http://www.autostrade.it).

<sup>2</sup> Rome is a part of the PROGR€SS project, in which the experience of 8 cities across Europe in the fields of road pricing is compared and evaluated through the activity of key groups and the publication of reports. For a better description of the Rome experience, in addition to the documents available on the website [www.transport-pricing.net](http://www.transport-pricing.net), see two articles by Forestieri and Tommasini: "Ancient and Modern", in Traffic Technology International (June/July 1999) and "Access Control in Rome", in Traffic Engineering and Control, July/August 1999). See also by Trenta, Forestieri and Galvan "The Rome Experience", in Traffic Technology International and by Forestieri "Traffic demand management strategies, friendly mobility and support technologies in the City of Rome", in the Bremen European Conference 2000 "Reinventing Mobility" ([www.bremen-initiative.de](http://www.bremen-initiative.de)).

some components but was the sole contractor with respect to the client, the Municipality of Rome. In fact, this is one of the consequences of the sophisticated structure of a RAS above described: whereas in a toll collection scheme (typically, within a toll road concession company) the D&B contract for the tolling system is usually awarded to a general contractor, often responsible under a comprehensive responsibility also for the supply of the other systems, in a RAS several contractors are in place, each bearing the responsibility for a component of the system.

### **The Rome experience**

The experience of Autostrade with respect to the RAS of Rome is interesting also for other reasons. The Municipality of Rome and STA (the Rome Mobility Agency fully owned by the Municipality and other public entities who is responsible for the implementation and the management of the project) decided from the beginning that the system would allow not only the access to the restricted area but also to parking payment and possibly payment of public transport<sup>3</sup>. If you decide to adopt a comprehensive payment tool able to solve all the mobility needs of a visitor/resident, you must shift from an on board unit-based system to a OBU+Smart card system. In other words, if the drivers parks its car he may use the OBU, but if you want to have an unique payment tool also for mobility services outside the vehicle, you have to adopt a system in which a removable smart card is inserted in the OBU.

This solution has been adopted in Rome and in the other Italian cities where a RAS is or soon will be in operation.

For these purposes Autostrade has developed a second generation OBU (the High End Telepass), which allows both the use of a smart card and the reading of the state of the card through a display installed on the unit. Under this point of view the Rome experience has accelerated the testing of the second generation Telepass and this has broadened the positive effects of the new technology to different applications such as control of intermodal and logistic hubs which Autostrade is developing on different parts of its network<sup>4</sup>.

STA also required that the OBU could be rotated in order to allow an electronic interrogation by the traffic police and auxiliaries to ensure that sufficient payment has been made. This achievement is now shared between the client, the supplier, the system integrator and several other players – and this is an advantage for the entire community.

But together with some advantages, the application of the Telepass technology to the urban context of Rome has also brought about some problems, whose solution may be of interest for this audience. We will list two of these issues.

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<sup>3</sup> More details on regulations and guidelines for the management of the RAS of Rome are available on the website of the Municipality of Rome: [www.comune.roma.it/dipVIII](http://www.comune.roma.it/dipVIII).

<sup>4</sup> Telepass is presently used to regulate accesses in the intermodal hub of Bologna and some other applications are under study.

First: whereas the Telepass system is a single-company single-purpose system (at least in its core use and in its primary application), the Rome mobility system has been developed by STA, the Municipality and other players and it is therefore based on a number of procedures, sub-systems and protocols which required time for getting to a full optimisation. In an urban context, the more the system is complex, the least it is efficient because it is usually managed with the view of the overall acceptance, which does not mean the highest efficiency. At the end, if compatibility is not designed from the beginning, it is a cost. In the Rome experience the final result was a good compromise, but it took some time to get to it<sup>5</sup>.

Second: the use of the toll motorway system by holders of an OBU issued by STA-Comune di Roma (i.e. residents, authorised payers, handicapped people and other groups). Obviously, the goal in this case was to allow the use of both RAS and toll motorway system by using the same OBU. Five situations have been identified:

1. RAS OBU holder who does not want to use the Telepass motorway service
2. RAS OBU holder who wants to be able to use its unit on the motorway network
3. Telepass OBU holder who wants to hold a RAS OBU
4. Telepass and RAS OBU holder who does not want anymore to use the Telepass OBU
5. Telepass and RAS OBU holder who is not anymore allowed to have a RAS OBU

All situations have been solved through an appropriate procedure which involves both STA and Autostrade. What is important to mention is that a certain number of structural differences exists between the situation of the Telepass unit holder and the RAS unit holder: a) the former is allowed to use its Telepass device only if associated to an active bank account, whereas the second, until a road pricing scheme will be in place, is not bound to this obligation; b) the Telepass account has no time limitation, whereas the administration of Rome has foreseen a 2-year check for each permit holder; c) the Telepass device is less complex than the RAS one, since it works without the use of a smart card; d) since either the Telepass or the RAS OBU have no switch it is not acceptable (and not only not efficient) to have two devices in operation. The solution which has been adopted is the issue of an Autostrade smart card to be inserted in the RAS OBU when the holder wants to use the AVI system throughout the toll motorway network.

In conclusion with respect to the Rome experience, the meetings with the Administration have made it clear that commercial issues are very delicate in all their implications. If we concentrate only on the commercial aspects of the transponders, such as distribution, substitution in case of misuse or damage, change of battery, new distribution in case of theft, etc., we may understand that much is required: know-how, procedures, people, premises, call

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<sup>5</sup> For a preliminary analysis of the issues related to tolling and road pricing on a new toll motorway, see "Briefing on the Birmingham Northern Relief Road and its Tolling Regime" ([www.bmf.co.uk](http://www.bmf.co.uk)). The BNRR is a greenfield toll road under construction in the UK, developed by Autostrade since 1991 in association with other partners (presently, Macquarie).

center, spare parts. Autostrade is now negotiating with STA terms and conditions of a contract of technical assistance based on the use of Autostrade people and “one-stop shop” assistance centres<sup>6</sup>.

### **The Florence experience**

The Florence experience of Autostrade in the area of restricted access and integration with the toll motorway system provides some additional information. The toll motorway network is in fact the ring road of the city. Between Firenze Nord and Firenze Sud traffic slows down and the typical mix of “professional” fast traffic and city slow traffic occurs. In 1997, on the occasion of the definition of the new concession contract, Autostrade has agreed to build the third lane on the Firenze section, together with many other investments on the motorway network (such as the additional link in the Firenze-Bologna section). Due to this strategic role in the mobility system of the city, Autostrade has decided to play a proactive role in the implementation of the RAS .

First of all three agreements have been signed with the Administration and other public agencies and entities. According to the first agreement Autostrade has installed free of charge on the basis of a commodatum the gantries according to the design of the RAS, carried out together by the Company and the Municipality as well as the system to operate the RAS. The second agreement has foreseen the co-funding of three commuting park areas in the semi-urban area with the purpose of operating them. The third agreement has committed Autostrade and other municipal entities to develop a common tool of payment for public transport, parking, toll motorway. Eventually, last year Autostrade has agreed with the Municipality to become shareholder of the municipal mobility agency, Firenze Parcheggi by providing additional investment in the areas of technology, infrastructures, integration.

The RAS of Florence is much smaller than the Rome one, as explained in the picture. The park areas to be developed and managed together with Firenze Parcheggi are close to the restricted area, so that an integrated management of park+ride based on the Telepass system may be put in place.

In the case of Florence the activity is based on a sort of partnership – defined by public agreement - between Autostrade and the Municipality for the implementation of comprehensive solution for the mobility. The RAS has been completed as far as system components are concerned, but is not yet fully operational. It is expected that the experience of Rome will allow both the Municipality and Autostrade to select the best solution to ensure a full integration between restricted access, parking, use of the motorway and other purposes set by the Administration.

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<sup>6</sup> In general terms, the above described issues will certainly play a key role in the short future: Autostrade expects the diffusion of Telepass to double from present 2,7 million owners to 5,5 million owners in 2005 (see Autostrade website, section “Investor Relations”, 2001-2005 Plan).

The strategy of the Company for Florence and other Italian cities where the system is under discussion at various levels of development (Bari, Bologna, Como, Milano, Perugia, Siena) is to propose an integrated turn key supply based on:

- lease of on board units owned and controlled by the Company inclusive of maintenance, assistance and substitution services
- supply of services in the area of system control and management
  - . gantry monitoring
  - . violation enforcement system
  - . data back-up
  - . traffic data processing
  - . invoicing services
  - . other commercial services

### **Concluding Remarks**

The market for restricted access and road pricing systems in Italy is very promising. Legislation is in place, technology is available without major barriers, the “federal revolution” makes mobility policies and pricing sub-policies a priority in the political agenda of the administrations. The toll motorway system still provides and will in the near future provide the standard, due to the need to integrate a motorway network which crosses in an uninterrupted system the whole country and the majority of the biggest metropolitan areas. The market requires system integration, supply of equipment, software, hardware, project management, planning, designing. All activities are based on public tenders and we see no obstacles to a strong development of the industry.

The fact that the standard has been derived by the existing technology developed by Autostrade and owned partly by Autostrade and partly shared with other suppliers has made it easier and cheaper to start to operate the systems by providing at the same time the necessary interoperability with the toll motorway system. We may expect that in the future the development of applications such as the Rome one will determine a strong development of the urban know-how associated to automatic systems and ITS in general. Protocols and procedures will probably be simplified with more emphasis on integration. Access of goods vehicles will become a critical issue and we may expect to see in place a sub-area of restriction associated to policies and procedures aimed at optimising the flow of freight vehicles through the city; a third generation Telepass is now under testing for these purposes<sup>7</sup>. The commercial issues, which are partially linked to the more general problem of social and political acceptance, will be a key factor of success and track record and experience in the customer service area will be an advantage for newcomers or incumbents.

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<sup>7</sup> A first application of a fully integrated system of private and goods vehicles is being implemented in Siena, based on Autostrade’s Telepass technology: see <http://challenge.vegasys.net>, in which some applications of this kind in Europe are described; see also [www.comune.siena.it](http://www.comune.siena.it).

## **Scheme Implementation - The Singapore Experience**

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### **Background**

In 1998, the manual congestion pricing systems that had been operating in Singapore since 1975 were replaced by an electronic road pricing system. ERP gantries replaced the overhead gantries at each entry point.

There are 28 ERP points at the entry points to an enclosed area of 720 ha in the city called the Restricted Zone (RZ) and 14 ERP points along congested stretches of expressways and major roads. ERP for RZ operates from 7.30am-7.00pm on weekdays and ERP on the other roads operate during the morning peak hour period of 7.30am-9.30am on weekdays.

The capital cost was S\$197 million (US\$110 million). The operating and maintenance cost is S\$24 million.

### **Aim of ERP**

The aim of ERP is to charge vehicles for the use of the road at times and at places when and where they cause congestion. Vehicles pay an ERP fee each time that they go under an ERP gantry.

The ERP is a congestion management measure and collection of revenue is incidental. The revenue goes into a common revenue pool. The ERP revenue is not earmarked for expenditure on transportation infrastructure and operations.

### **The System**

The ERP system works as a short-range radio communication system (DSRC) using a 2.40 GHz band.

The main components are:

- **The In-vehicle Unit (IU)**

This is a note-book sized device fixed permanently at the lower right hand corner of the windscreen of vehicles (the driver's seat is on the right). It gets its electric power from the vehicle battery. On motorcycles and scooters, the IU is on the handlebar. 98% of the vehicle population of 700,000 has fitted the IU, although it is not compulsory. There are different colour-coded IUs for different classes of vehicles because the ERP fees are different. Only

emergency vehicles are exempt from ERP and even they have their own IUs, because vehicles without IUs will be photographed by the cameras. These special IUs do not have to use a CashCard.

- **CashCard**

The CashCard is the mode of payment for ERP. A consortium of local banks looks after the sale and distribution of CashCard, which is a prepaid contact integrated circuit chip plastic card. It can be topped up with money at automatic teller machines up to a value of S\$500. There are about 3.5 million CashCards among the drivers. The consortium keeps the cash float from the sale of the cards and settles the account with the Land Transport Authority (ERP operator) at the end of each working day. The CashCard can also be used for buying petrol, groceries and for paying car parking charges.

- **ERP overhead gantries (or outstations) located at the control points**

A control point has two sets of overhead gantries at a height of 6m and set apart at 15m. The equipments on the gantries are antennae for communicating with the IU of vehicles, optical sensors to detect passing vehicles and enforcement cameras to take photographs of the rear license plates of violating vehicles. Data from the outstation is sent back to the control centre through dedicated telephone lines by the local controller.

- **Control centre**

The control centre receives the records of all ERP transactions, fault records of and digital photographs of violating vehicles from all the outstations. The control centre does the cash settlement with the CashCard operator, sends out summons demanding fines from violating drivers and invites drivers of vehicles experiencing errors to send their vehicles for free inspection. There is a 5 year warranty on the IU.

### **Working of ERP**

As the vehicle nears the first of the two ERP gantries at the outstation, the antenna interrogates the IU, determines its validity, classifies it and instructs it to deduct the appropriate ERP fee. Between the two gantries, the IU deducts the appropriate ERP fee from the stored value of the CashCard and confirms that it has done so to the antenna at the second ERP gantry. The enforcement camera takes a digital photograph of the rear licence plate of the vehicle with violations or errors, recording the reason for the photograph. The local controller at the outstation sends back the ERP fee deduction data and digital photographs to the control centre at regular intervals.

## Violations and errors

The violation and error categories are shown in the table.

<b>Violation</b>	<b>Error</b>
No in-vehicle unit	No power to in-vehicle unit
No CashCard	Faulty in-vehicle unit
Insufficient cash balance in CashCard	Faulty CashCard
	Communication error

Daily violations amount to 3 per 1,000 ERP transactions, showing that the compliance rate is high. 4 out of 5 violations result from having no CashCards in the IU. Daily errors amount to 3 per 10,000 ERP transactions, showing that the ERP system is very reliable.

## ERP fees

ERP fees can be changed for each half-hour at each gantry. The fees vary from 50cents to S\$3 for cars. The passenger car unit equivalent is used to designate charges to various vehicles. The pcu is the dynamic road space occupied by a vehicle and is a proxy measure of its contribution to congestion. The car, taxi and light goods vehicle are 1 pcu, motorcycle 0.5 pcu, heavy goods vehicle 1.5 pcu and large bus 2 pcu. So, if the ERP fee for a car is S\$1 for a particular half-hour, the fee for the motorcycle will be 50cents for the same half-hour.

ERP fees are reviewed at 3 monthly intervals based on average speeds along the priced roads. The aim of the fees is to achieve a balance between congestion and usage. The desired range is the upper end of traffic level of service E. In our case, this implies a speed range of 45kph-65kph for expressways and 20kph-30kph for major roads. If the measured average speeds on the priced roads remain within this range for a particular half-hour, there is no fee change. If the speeds exceed the range, the fee is reduced by 50cents (for 1 pcu) and if the speeds are below the range, the fee is increased by 50cents (for 1 pcu).

To find out how the ERP rates were first established, we have to go back in history. When the first manual pricing system for the RZ was introduced in 1975, the aim was to reduce traffic volumes entering the RZ during the peak hours by 33%, which was equivalent to bringing the situation to off-peak conditions. As a first cut, since there was no previous experience, the daily licence fee was set at S\$3. At that time, S\$3 was the cost of daily parking in the city. In essence, this meant that the cost of motoring in the RZ had doubled. The initial results showed a large 44% drop in traffic volumes. Over the years, the traffic volume crept up and by 1998, it was equivalent only to a 10% drop in traffic over peak hour conditions but the scheme was still yielding reasonable speeds on the roads. Therefore, the initial ERP rates in 1998 were pegged at around S\$3 for the busiest half-hour during the morning peak hours for the RZ and

for the expressways. However, with a manual paper licence, vehicles could make multiple entries throughout the day while with an ERP, vehicles pay each time they pass an ERP point.

### **Foreign vehicles**

Foreign vehicles enter Singapore by two road routes from peninsular Malaysia. Those who frequently use Singapore roads could install permanent IUs. The occasional visitor who wants to enter the Restricted Zone or use the priced expressways could rent a temporary IU at some petrol stations and commissioning stations near the border.

### **Public issues on ERP**

- a) The paramount concern of motorists was the reliability of the technology. They had come to accept road pricing, albeit reluctantly because it had been operating for more than 2 decades in a manual form.
- b) To most drivers, the IU was something fitted to their vehicle to make them pay for the use of the roads, something they did not like. All existing vehicles in 1998 were given the option to fit a free IU at designated fitting centres. Each fitting took about 20 mins. It took 10 months to fit the vehicle fleet at 250 fitting centres. It was one of the most difficult phases of the ERP implementation.
- c) IUs were quite easily fitted on the windscreens of four-wheeled vehicles. It was more difficult to fit IUs to motorcycles because there was no standard design. The IUs had to be fitted on the handlebars, on top of the headlight or even on the front panel depending on the brand and make of the two-wheeler.
- d) To make the IU user-friendly, opinions were sought from motorists during the early ERP trials and these were used in deciding the functions of the IU. Each IU has backlit liquid crystal display (LCD) to show the cash balance in the CashCard. The IU carries out self-diagnostics on itself and on the CashCard when the card is first inserted. Different icons appear on the display with long beeping sounds to show errors. As the vehicle goes under the ERP gantry, the IU display shows the new balance in the CashCard, after the ERP fee deduction. If there are errors or a violation, the IU emits long beeping sounds. There is a low balance indicator icon on the LCD, which appears whenever an IU with a CashCard with a low balance goes under the ERP gantry. This gives forewarning to motorists to top up their cash balance.
- e) Most of the feedback is on the design of the IU. These are:-
  1. IU is too large and blocks the driver's clear vision of the road
  2. IU will become a projectile and hurt the drivers in the event of an accident
  3. IU will destabilise motorcycles when they go round bends
  4. The LCD of the IU display should always show the cash balance in the card (the display only lasts for 10 secs and then blanks off. This is meant to save battery life, LCD life and also to ensure that would-be thieves of CashCards do not see the value stored in them.)

5. As opposed to this, there was the other view that the IU should not have a part of the CashCard sticking out because this tempted would-be-thieves (part of the CashCard sticks out to indicate to the driver that the IU has a CashCard)
  6. IU should warn the driver if there is no CashCard in it or if the CashCard is not properly inserted
  7. IU should warn driver of the presence of ERP gantry well in advance
- f) Feedback on the ERP gantries
1. Gantries should show the time instead of the word “In operation”- the new ERP gantries show the clock time
  2. Even when drivers insert the CashCards at the last moment as they pass under gantry, there should be proper deductions.
  3. Gantries should show all the prevailing charges for the various classes of vehicles
- g) Feedback on the operations
- a. Motorists wanted the fine for CashCard violations to be reduced because the violation occurred as a result of forgetfulness. The fines were reduced for this category of violation
  - b. Some motorists want to cap the maximum ERP fee that they would pay each day, as in the old manual scheme
  - c. Some want a centralised system where they would get a monthly bill for the number of entries into the ERP areas. In this way, they do not have to remember to top up the CashCard or insert it into the IU. (This had been ruled out from the start because the motorist might not feel the full effect of pricing if they just settle a monthly bill)
  - d. Motorcyclists asked for exemption because they claimed that they did not contribute to congestion. About one-sixth of the vehicle population is made up of motorcyclists and they could not be exempted, but they only pay half the rate that cars pay because they contribute less to congestion.
  - e. Some claim that ERP charges would be increased and the ERP would be extended to other areas in an effort to extract more revenue from motorists. It has always made clear to motorists that ERP will be yet another tool of the many strategies to keep traffic problems within manageable levels. If there are other areas experiencing undue congestion, ERP may be extended to such places.

### **Ramifications of ERP**

- a) Traffic flow is more evenly spread over the working day, with no short and sharp peak periods and there is less congestion in the controlled area. The average speeds are within the acceptable ranges.
- b) There is a pre-ERP rush to beat the start and a post-ERP rush after the hours of operation. The post-ERP rush leads to traffic congestion on the roads for about 30- 45 mins
- c) The ring road that skirts the RZ and the alternative parallel unpriced roads have seen an increase in traffic volumes and there is localised congestion for short periods

- d) The half-hourly change of rates mean that some motorists loiter and slow down at the ERP entry points waiting for the lower priced half-hour to kick off. This has caused some safety problems especially along expressways.
- e) Advance notice is given of the ERP gantries and at most points, there is an escape route so that motorists are not forced unwittingly to enter the ERP area
- f) For the RZ, the traffic volumes dropped further by 13% when ERP was introduced from the situation in 1998 when a manual pricing was already operating before that. Interviews with motorists show that this drop is a result of them avoiding making multiple trips into the RZ, which they used to do with the old paper licence. Motorists are much more aware of the cost of congestion and plan their routes to avoid multiple trips into the RZ.
- g) Demand price elasticity values derived from the frequent changes to the ERP fee do not show any definite patterns. However, the values are much higher for motorcyclists than for others showing that they are more affected by price changes. This is understandable because they come from the lower income groups.
- h) The target set for ERP for RZ has been to keep traffic speeds within acceptable ranges. ERP was nothing more than automating the manual system and we expected the same reduction in traffic volumes as obtained from the manual pricing system. With ERP there is more room for making adjustments to suit traffic conditions.

### **Other operational issues**

- a) The taxi commuter has to pay the ERP fees incurred during his journey. This means that a taxi driver who enters the RZ empty has to meet the ERP fees for each entry. Commuter waiting times at taxi stands in the RZ did increase. However, taxi fares are now deregulated and the taxi companies are at liberty to fix their fares to take such factors into consideration.
- b) Non-IU vehicles such as bicycles and three-wheeled trishaws (which are mainly used by tourists for sightseeing) and even pedestrians are photographed if they pass under ERP gantries. The few images that are collected at the control centre are discarded.
- c) There have been no reports on fraud or swapping of IUs between vehicles. There are some cases of motorcyclists getting off their machines near the ERP gantry and pushing the vehicle along footpaths to get into the RZ without paying.
- d) Maintenance teams are on standby to attend to faults in outstations and central control equipment to keep downtime to a minimum. The monthly availability ratio has been around 99.8%.

### **Issues related to congestion pricing**

The manual road pricing scheme had been operating since 1975. Therefore, the main issues on pricing were dealt with in those days and did not complicate the change to ERP. The main issues then were:-

1. the suspicion that the scheme was meant merely to raise revenue for the government.
2. require more road building rather than pricing as the solution.
3. inadequate alternative because public transport was not good enough.
4. a concern that the city would lose its vibrancy and firms would move out
5. the cost of doing business in the city would go up
6. unhappiness from residents who lived within the RZ.
7. a call to give exemption from the restrictions to those who needed to use the car to go to the city.
8. scheme would not solve congestion but merely shift it to other roads.
9. scheme would result in underutilisation of the roads that were built at a great cost

### **Overcoming resistance to congestion pricing**

This initial resistance to the manual scheme were dealt with by selling congestion pricing as a part of an overall package of transport measures which also included new roads, traffic management and improved public transport. Although sceptical at first, the motorists noticed that the words were followed up by deeds over the next two decades. The road building and traffic management programmes have continued; new urban rail systems have been built and the bus services have been upgraded. The congestion pricing has indeed been only one of the measures and not the only measure to contain the transportation problem.

For the introduction of ERP, the issue was one of reliability of technology. A massive publicity campaign to inform and educate the motorists did in some way mitigate the negative image of the ERP.

It would be audacious to say that motorists like the ERP, but many have come to accept it as a necessary nuisance.

# **Developing implementation plans for urban transport road pricing schemes**

**Ian Catling and David Crawford, Ian Catling Consultancy (UK)**

The major part of this paper is based on the results of a study on Urban Road User Charging Scheme Design conducted by Transport and Travel Research Ltd and Ian Catling Consultancy for the then Department of the Environment, Transport and the Regions.

## **Introduction**

Urban road pricing (RP) is on the agenda across Europe, to an extent unseen since the late 1980s/early 1990s when cities in Norway were the first to deploy electronic fee collection (EFC) to fund road improvements. Subsequent EFC implementations have been overwhelmingly on inter-urban routes, bridges and tunnels rather than on urban road networks, but the pendulum is swinging back.

London is now committed to a central-area congestion charging scheme (CCS), the largest in Europe to date. Congestion reduction remains the most commonly cited aim for urban RP (as in the pioneering Singapore initiative), with environmental improvement as a related and - politically - increasingly important objective. While initially relying on conventional pre- and post-payment, enforced by cameras, London would be a natural site for later migration to a more advanced scheme using vehicle positioning systems (VPS) technology.

VPS, using GPS or other locating systems, is the basis of the ambitious Netherlands 'kilometre-levy' distance-charging initiative. Designed to cover all roads, urban and non-urban, this envisages every one of the country's eight million vehicles being equipped with a 'Mobimeter' on-board unit by 2006. At the 20 March 2002 launch of the scheme's 'market dialogue' in Amsterdam, Dutch Transport Minister Tineke Netelenbos made it clear that she saw it laying down a 'marker' for the rest of Europe - if not the wider world.

VPS is also expected to be the technological basis for inter-urban charging schemes for heavy goods vehicles (HGVs) in Germany, Austria and, potentially, the UK.

With current levels of interest in Europe in urban RP – and a strong emphasis on using advanced EFC technology – it is important for all actors to recognise the need for comprehensive advanced planning. Based on twenty years of experience from around the world, this needs to cover five main areas:

- The political context;
- Public involvement;
- Scheme design issues;

- Scheme appraisal; and
- Implementation and operational issues.

### **The political context**

Experience from Austria, the Netherlands and the UK has underlined the importance of creating the right political context. All three have encountered strong resistance from powerful motoring lobbies to proposals to charge for road space to which their supporters previously enjoyed “free” access, and the first two eventually abandoned initial schemes in which they had invested considerable research efforts.

The Netherlands has now come back with a new scheme embodying important concessions such as fiscal neutrality for the average driver and the availability of value-added services ahead of implementation. The market dialogue is due to conclude by October 2002, with a view to an end-year green light if all the signs are positive.

One political issue that has attracted considerable attention in the UK is the hypothecation of revenues from urban RP schemes, of which a number are being explored with Government encouragement. Hypothecation has historically been resisted by the UK Treasury (Ministry of Finance), whose commitment to a 10-year minimum ring-fencing concession is still regarded as too short by some public authorities.

The importance of the political context underlines the relevance of gaining public support.

### **Public involvement**

Public involvement is a critical component in the implementation of urban RP, which is seen as a new and radical concept by most people. The process comprises three stages:

- Public acceptance;
- Public consultation; and
- Public relations (PR) and media relations

The challenge of securing public acceptance should not be underestimated. It requires those affected to feel a degree of ownership of the scheme and to be adequately consulted. Surveys typically show high levels of agreement with statements that urban congestion and pollution pose serious problems and are likely to worsen. At the same time, stated support for RP as a solution is often much lower. This can, however, be raised by addressing public concerns effectively, through public consultation and information programmes.

The issues to which public acceptance is most sensitive are:

- The scheme objectives (eg merely demand management, or a wider brief including environmental gains);
- The overall package, including supporting measures and the use of revenues generated;
- Demonstrable consideration of alternatives (eg new road building, which can be shown to be too expensive and a physical threat to settled communities);
- Scheme details and charging methods; and
- Equity considerations.

Presentation of the overall package needs to emphasise the availability of adequate alternatives to the car, notably improved public transport. Assurance that RP revenues will be used to fund these – if necessary, by hypothecation - is a significant factor in gaining public acceptance. In the 1998 ELGAR RP trial in Bristol (UK), 20% of respondents said they would be happier with implementation if they were sure revenues would be spent in ways they thought worthwhile.

Scheme details and charging methods need particularly careful presentation. In general, the initial scheme should be reasonably simple to understand, and the technology selected both appropriate and comprehensible. (There is, of course, a trade-off here, since a simple scheme which helps gain public acceptance may not be the best for meeting the scheme objectives).

Consideration of equity issues involves early identification of major ‘losers’ and planning measures to minimise their discontent.

Public consultation is a central mechanism for gaining acceptance. Different countries have different procedures, but the key common requirements of an effective consultation plan are early decisions on:

- The phasing of the process;
- Who will be consulted;
- What issues they will be consulted on; and
- The methods to be used.

Finally, effective PR and information campaigns can materially influence attitudes and help maximise support and minimise opposition. UK trials and focus groups have confirmed that, while initial public attitudes may be negative, they can become more positive when the issues and alternatives are explained and openly discussed.

Once an RP charging scheme is operational, there is a need for ongoing PR to reinforce acceptance, pick up areas of concern and smooth the way to any amendments needed to fine-tune the scheme, as has happened in the lengthy experience of Singapore.

The main challenge is to secure an adequate level of acceptance in both the early scheme design and the later implementation stages. This should pay off in terms of long-term support later. (In Trondheim (Norway), early negative responses fell markedly after implementation.)

## **Major scheme design issues**

### *Charging scheme options*

The choice of the basic RP charging scheme can be made from a range of options including:

- a) Area licensing;
- b) Entry permit;
- c) Cordon charging;
- d) Multi-cordon/zone charging;
- e) Distance-based charging;
- f) Time-based charging; and
- g) Time-in-congestion-based charging.

Area licensing schemes (a), such as the London CCS (where a £5 payment allows multiple trips within the charging zone), are relatively simple and cover stationary as well as moving vehicles without distinction, but are relatively unsophisticated in influencing travel patterns because the typical daily basis of charging does not discourage multiple trips. Examples of b) are the original (1978) Singapore scheme (confusingly called the Area Licensing Scheme, whereas in fact it was an entry permit scheme), and the schemes being considered in Edinburgh. c) is the model adopted in the Norwegian cities of Bergen, Oslo and Trondheim and, since 1998, in Singapore. It has been, until recently, the most commonly proposed form of EFC for urban RP and requires some form of on-board unit in the majority of vehicles using the scheme. d) offers prospects of highly-refined influence over travel patterns, but is relatively expensive to implement and complex for the public to understand. e), for which EFC is a prerequisite, is the model proposed for the Netherlands urban RP scheme (and also being considered by the EU as the basis for a new approach to the taxation and regulation of HGVs). e) and f) are alternative approaches to the taxation and regulation of HGVs being considered by the UK Government, with the balance of probability in favour of e). Research suggests that f) and g) could encourage drivers to drive less safely and would be less acceptable to the public due to the unpredictability of charges.

### *Charging mechanism options*

The main options are:

- Cash payment;
- Paper licences;
- Automatic number plate recognition (ANPR); and

- Electronic fee collection (EFC).

The table below shows their applicability.

<b>Charging mechanism Type of scheme</b>	<b>Cash payment</b>	<b>Paper licences</b>	<b>ANPR</b>	<b>EFC</b>
Area licensing		Yes	Yes	
Entry permit		Yes	Yes	Yes*
Cordon charging	Yes			Yes
Multi-cordon/zone charging				Yes
Distance-based charging				Yes
Time-based charging				Yes

\* Possible, but unlikely to be cost effective.

Cash payment is most likely to appear in conjunction with EFC, rather than as a stand-alone. Paper licensing is quick and easy to set up, but potentially labour-intensive and so expensive when it comes to distribution and enforcement. Until the London CCS becomes operational, ANPR has yet to be used as a primary charging mechanism, though the Toronto (Canada) Highway 407 and Melbourne (Australia) City Link include the capability. EFC is becoming increasingly common round the world, with new autonomous VPS-based self-locating systems emerging as alternatives to DSRC-based infrastructural ones.

Choosing the most appropriate charging mechanism requires a fully-structured assessment, involving some 20 criteria, before procurement specifications can realistically be prepared. Interoperability is an important issue in densely-populated countries such as the Netherlands and the UK, where major urban areas merge into each other (as in the Dutch Randstad).

### ***Charging areas***

Determining the location and size of the charging area needs consideration of a number of factors, the most important of which are:

- The extent of congestion or pollution;
- Simplicity;
- Impact on through traffic;
- Avoidance of multiple crossings
- Availability of alternative transport modes;
- Equity and land use issues;
- Increased activity at the boundary and
- Costs and revenues.

The charging zone should only include congested areas, as far as possible, and have simple, easily-recognisable boundaries which:

- Do not have to be re-crossed on typical journeys;

- Offer convenient ‘bypasses’ for through traffic;
- Allow the use, or introduction, of convenient modal interchanges as part of a ‘package’ of complementary transport measures;
- Do not unfairly penalise people who live or work just on the other side;
- Do not encourage ‘drop-off’ activity which cannot be satisfactorily accommodated; and
- Have beneficial rather than adverse effects on costs and revenues.

### ***Charging levels and periods***

Setting correct charge levels and charging periods from the outset is critical for success. The two key factors are:

- The likely effects on travel behaviour, and
- Public acceptance.

One option is a phased approach, to allow people gradually to adjust.

Charging periods need to take into account the possible effects at charging area boundaries. The original Singapore scheme suffered from motorists trying to ‘beat the charges’ by entering the restricted zone early. EFC systems can reduce the impact by offering reduced-rate ‘shoulder’ periods, eg of 30 minutes.

### ***Integration of urban RP with other ITS applications***

RP system using in-vehicle equipment for EFC could also be used to:

- Monitor traffic, and so assist traffic management operations;
- Deliver information to drivers and their passengers; and even
- Actively control the vehicle (subject to attendant legal liability implications).

The value-added services implicit in the second of these form an important component of the current Dutch scheme.

### **Scheme appraisal**

Tools and processes that are typically required to appraise a transport scheme include:

- A transport model (land-use dimension optional);
- An environmental impact assessment;
- A cost-benefit analysis; and
- Geographic information systems (GIS) for presentational purposes.

The model needs to be able to quantify likely changes in travel behaviour and conditions, and costs. The most likely reactions to an urban RP package will be:

- Switching to alternative travel modes (eg via park-and-rides);
- Adjustments to trip times;
- Route changes;
- Trip suppression; and
- Increased vehicle occupancy.

Models should at least be capable of addressing the first three, to allow effective assessment of both likely improvements and adverse impacts.

There are potential long-term impacts on local environments, economies and land use patterns. One major concern is that RP will deter people from visiting city centres for shopping and leisure. Admittedly limited evidence from Norway suggests these fears are unfounded.

Estimation of both implementation and ongoing operating costs is obviously a key part of the appraisal process. In socio-economic terms, benefits and disbenefits need to be identified for all categories of road users; while operators need to be able to model the impact of changes in revenues and operating costs.

In financial terms, RP schemes need both to be self-financing and to generate additional revenue for the transport improvements that are politically essential for gaining public acceptance.

### **Implementation and operational issues**

Key practical implementation and operational issues that need to be considered from the outset include:

- Opportunities for public-private partnerships;
- Exemptions and charge privileges;
- Methods of handling non-equipped vehicles;
- Enforcement procedures; and
- Tariff review procedures.

### ***Opportunities for public-private partnerships (PPPs)***

The key political issue is the relative timing of the ‘carrot’ and ‘stick’ elements. However well PR is planned, there will inevitably be an adverse reaction to charging for what was formerly free. Drivers can be certain of the compensating benefits.

If an RP scheme is implemented wholly within the public sector, there will be a delay in realising these. A public-private partnership (PPP) provides the means of securing 'up-front' investment in improvements or new services before the imposition of RP. It can also be used as the procurement mechanism, as an alternative to conventional public-sector purchasing. (Concession arrangements involving the private sector in the development and operation of tolled motorways are, of course, already well-established in France and Italy).

This is the rationale behind the 'market dialogue' recently launched by the Netherlands Transport Ministry to pave the way for the planned introduction, by 2006, of the world's first universal RP scheme, applying to all vehicles on all Dutch roads (not just those of the heavily-urbanised Randstad).

Naturally, the risks as well as the benefits of PPP have to be evaluated, as do the contractual and legal issues, in the absence to date in Europe of operational experience of their performance in urban RP. (London offers a particularly topical warning, with Mayor Livingstone, whose RP scheme is now going ahead, actively opposing a PPP for upgrading the London Underground system). It could realistically take up to two years from the start of informal discussions to signing of PPP contracts, and the Dutch experience will obviously be extremely helpful.

### ***Exemptions and privileges***

These are important for achieving social inclusion and public acceptance. Both have to be vehicle-specific to make them abuse-resistant and enforceable, implying a need for databases that are updated regularly and periodic re-registration.

### ***Handling non-equipped vehicles***

Available options are:

- In EFC schemes, temporarily equipping visiting vehicles;
- Providing licence-plate registration for occasional use (as with Melbourne City Link's 'day-pass', which can be issued following telephone payment, or retrospectively, within one day of road usage);
- Using ANPR to require post-payment (as on Toronto's Highway 407); and
- Providing for cash payment (as in the Norwegian cities of Oslo and Trondheim; though cash lanes take significantly more land).

### ***Enforcement procedures***

A clearly-defined strategy needs to take into account:

- The cost of deploying technological enforcement or on-street personnel';

- A strategy for pursuing violators (including the capacity of police forces and/or law courts; and:
- Overall cost considerations.

Adequate penalty levels need to be set to discourage violation, in the wider context of related penalties.

ITS-based enforcement obviously needs to be seen to be fair, to avoid loss of public confidence in the system, with inbuilt manual checks.

### ***Procedures for reviewing and updating charge tariffs***

Finally, it is essential to anticipate the need for adjusting charge levels and carrying out regular performance reviews of RP schemes – not least to take account of changing travel patterns. As the first urban RP scheme designed to control congestion, Singapore has the most experience to offer. When electronic road pricing (ERP) was introduced in 1998, to replace the long-established area licensing scheme, the Government made a commitment to regular reviews to match the scheme's performance against pre-defined objectives. Singapore charge rates are now adjusted according to traffic speeds on different types of road.

Traffic speeds are probably the easiest instrument to use, both for measuring performance and as a publicly-understood mechanism for adjusting charging levels. Other parameters could include public transport speeds or occupancy levels. Periods during which, or days on which, charges apply can also be adjusted.

The incidence of charge reviews periods need to be calculated to allow users to react and settle in to new travel behaviour patterns. Singapore's commitment is to quarterly reviews.

### **Conclusion**

This paper has summarised some of the key issues in the development of implementation plans for urban road pricing schemes. Perhaps the key element, which cannot be over-emphasised, is the importance of public consultation and public acceptability. Experience over twenty years has shown that without carefully planned programmes of involving key actors and members of the public, the political aspects of any scheme may lead to the cancellation of even the best-laid technical plans.