



## ROAD PRICING – SINGAPORE'S 30 YEARS OF EXPERIENCE

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Singapore is an island-state with a land area of just over 690 square km, measuring 42 km across and 23 km from north to south. On this island live more than 4 million people, making it one of the most densely populated countries. Its transport needs are served with vehicles totalling 730,000, of which 420,000 are cars.

In the field of transportation, road pricing has long been associated with Singapore. Indeed, the practical application of road pricing started in Singapore in June 1975. Many changes have been made to the road pricing scheme since that time. Initially a manual scheme based on paper permits and applicable during the morning peak period only, it has evolved over the past 30 years to an electronic version that operates presently almost throughout the day.

Road pricing is an important component of Singapore's overall transportation strategy. While road capacity continues to be increased judiciously to meet rising travel demand, the strategy also calls for greater reliance on public transport usage and demand management. This is especially important in Singapore, given its limited land resource. One aspect of demand management is the restraint of vehicle ownership, either through the imposition of high upfront ownership costs or restriction on the actual growth of the car population. The former includes excise duties and vehicle registration fees, which amounted to 130 percent of the car's open market value presently, while the

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latter is managed through a Vehicle Quota System, where the net increase in vehicle ownership is capped at 3 percent per year. The other aspect of demand management is the restraint of vehicle usage through the levy – a charge on motorists based on the quantity, place or time of the use of their vehicles. Generally, the more one uses his car the more one has to pay. The road pricing schemes, petrol tax, diesel duty and parking charges are measured in this category.

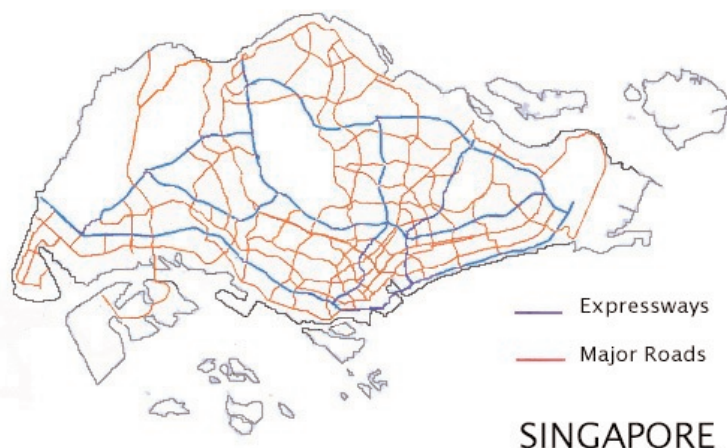
One of the goals set out in the demand management strategy of Singapore is to move away from relying predominantly on vehicle ownership costs to one of a better balance between it and usage costs. The resulting system would be a fairer and more equitable one. This paper looks at Singapore's experiences with road pricing over the past 30 years, from the manual scheme to the current electronic one.

### Manual road pricing scheme

The Area Licensing Scheme (ALS) was in place for 23 years before being replaced by an electronic version called the Electronic Road Pricing System (ERP). This manual scheme was based on the need for paper licenses to be purchased prior to their passage through control points set up on the roads.

#### *How the ALS worked*

The ALS covered the more congested parts of the Central Business District (CBD), designated as the



Restricted Zone (RZ). When the ALS first started, the RZ had an area of only 610 hectares; but over the next 14 years, it increased to 725 hectares eventually because of the inclusion of areas that had turned commercial in nature and the availability of reclaimed land at the sea-front. Prior to its demise in 1998, the RZ was demarcated by 31 overhead gantry signs at its control points.

To gain access into the RZ during the restriction periods, non-exempt vehicles needed to purchase and display an ALS area licence. The daily area licences could be purchased at roadside sales booths located at the approach roads to the RZ, petrol stations, post offices and convenience stores.

Enforcement personnel were stationed at the control points during the restricted hours to observe whether vehicles displayed the valid licences on their windscreens, or on the handle-bars in the case of motorcycles and scooters. Violating vehicles were not stopped at the gantries, but their vehicle licence numbers were taken down and their owners would receive a summons for entering the RZ without a valid licence. The checks for licences were made only at the control points, and vehicles were free to move around or leave the RZ without having the licences.

#### *Operating hours*

The ALS started in 1975 with the restricted hours of 7.30 a.m. to 9.30 a.m. daily, except on Sundays and public holidays. Three weeks later, the restricted hours were extended to 10.15 a.m. in order to restrain the surge in vehicle entries immediately after the lifting of the ALS at 9.30 a.m. The ALS operated for two and three-quarters hours each weekday during the morning peak period until June 1989, when major fundamental changes were made. They were triggered by a rapid growth of vehicle population during that period. The restriction period was extended to cover the evening peak hours of 4.30 p.m. to 7.00 p.m. on weekdays. The evening period was later cut back by half an hour to 6.30 p.m. to accommodate requests from residents who lived inside the RZ but worked outside, although this was subsequently extended back to 7.00 p.m. because of increased traffic congestion.

In 1994, more fundamental changes were made to the ALS scheme. The restricted hours were further extended to cover the inter-peak period of 10.15 a.m. to 4.30 p.m. on weekdays and the post-peak period of

10.15 a.m. to 3.00 p.m. on Saturdays. The Saturday restriction period was subsequently cut back to 2.00 p.m. due to improved traffic conditions within the RZ.

#### *Vehicles covered in the ALS scheme*

When the ALS started in 1975, taxis, public transport buses, goods vehicles, motorcycles, and passenger cars carrying three or more passengers (excluding the driver) were exempted from the scheme. Car-pooling was allowed under the scheme to optimise vehicle usage and to counter the charge that the scheme favoured only the rich. The exemption on taxis was subsequently removed in 1975.

In the review of June 1989, more vehicles were required to purchase licences prior to their entering the RZ during the restriction period. Motorcycles and goods vehicles, which together made up about two-thirds of the traffic entering the RZ, were no longer exempted.

Furthermore, exemptions for car-pools were also abolished. This was because private cars were picking up bus commuters instead of forming genuine car-pools. This constituted a form of pinching of bus commuters by motorists and defeated the intent of the car-pool exemption.

#### *Road pricing charges*

The licence fees had been revised upwards over the years to cater for inflation and to check the gradual upward creep in the number of restricted vehicles entering the RZ. Starting at \$3<sup>1</sup> per day for a licence for cars in 1975, this had crept up to \$5 per day in 1980. However, with the major review in 1989, there was a reduction in rates – essentially because more vehicles were required to purchase licences. The daily licence fee for a car was reduced back to \$3.

With the review in Jan 1994, there were two levels of fees for licences – the one that permits usage throughout the day, and the one that was applicable for use during the inter-peak period only. For cars, the daily licence fees were \$3 and \$2, respectively.

#### *Traffic impact*

The initial drop in traffic entering the RZ was 44 percent, but it crept up to a 31 percent drop by 1988.

<sup>1</sup> The fees mentioned in this paper are in Singapore dollars, and as at July 2005, the exchange rate is US\$1 = S\$1.65.

However, this was despite the growth by a third in employment in the city and by 77 percent in vehicle population during the same period. The drop in traffic was caused by the decanting of motorists whose destinations were not the city itself but had merely been using the city roads as a bypass, as well as by those who changed their journey start time to avoid paying the ALS fees. There was little evidence to suggest that motorists had transferred to public transport in significant quantities.

#### *Limitations of the manual scheme*

Being a manual scheme, the ALS had limitations. It was labour intensive: about 60 enforcement officers were required at all the gantry points and another 60 officers at the dedicated licence sales booths. Extending the schemes to other points would have needed even more people to run them. The enforcement job was tiring as long hours were spent under the sun and rain. The environment these people worked in was at the roadside, and this was dusty and noisy. The work also required considerable concentration because of the varied vehicle heights and categories of licences. There were 16 types of licences for the two schemes, divided into daily/monthly, peak/inter-peak and the different vehicle classes. Human enforcement by visual means was prone to error leading occasionally to wrongful summonses being issued.

Under the manual system, a licence offered a vehicle unlimited number of entries to the RZ or passage through the control points. Although it was not legally transferable between vehicles, it was tempting for such action to take place.

There was always a rush to enter the RZ just before or after the restricted hours because of the sudden change of licence fee from nothing to \$3 or vice versa. This resulted in sharp and short peaks of entering traffic volume. "Shoulder-charging", or having intermediate rates, would have smoothed out the peaks, but it was difficult to implement in a manual system. Having more categories of licences would make enforcement more difficult and more prone to mistakes.

#### **Electronic road pricing (ERP)**

With the shortcomings of the manual road pricing schemes, the search for a more efficient technology began in earnest in the early 1990s. Technology for an electronic road tolling system was emerging at that

time, and there were many learning visits to cities with such electronic tolling systems installed. After several years of discussions and prototype testing with potential suppliers, a contract for the installation of a Dedicated Short-Range Communication (DSRC) electronic road pricing system was awarded in 1995.

#### *Implementing the ERP system*

A comprehensive test programme was included in the contract, and this took place from December 1996 to August 1997. A section of an unopened stretch of expressway was converted into a test site, comprising 12 sets of ERP gantries. Using a fleet of 250 vehicles, each with a prototype In-vehicle Unit (IU) or transponder fitted, about 4.8 million ERP transactions were clocked before the test was considered a success. It was only after this exhaustive testing that the mass production of the IUs and the gantry equipment were allowed to commence.

The ERP system has three major groups of components. The first centred around the IU and the stored-value smart-card. While the IUs were produced specifically for the ERP system, the smart-cards were marketed by a consortium of local banks for multiple uses. Different IUs were produced for different classes of vehicles, with each type distinguished by different colours.

The second group of components comprises those installed at the on-site ERP gantries. These include the antennae, the vehicle detectors and the enforcement camera system. All these are linked to a controller box located at each of the site. Data collected is transmitted back to the Control Centre continuously through leased telecommunication lines.

The third group of components is at the Control Centre, and includes various servers, monitoring systems as well as a master-clock to ensure that the timing at all the ERP gantries are synchronised. All the financial transactions are processed here, before being sent to the banks for settlement. In addition, violation images are processed at the Control Centre, and letters and summonses are printed and sent out from here to all those that did not have valid ERP transactions.

#### **How the ERP scheme worked**

The ERP system is designed to be simple to use. Indeed, all that it required of the user is to insert the

smart-card into the IU, whereby a diagnostic check is automatically done to ensure that both the IU and the smart-card are in working condition. Should there be a problem with either the IU or the smart-card, the user will be alerted so that remedial action can be taken. The IU is also designed to have a low balance indicator, whereby the user will be alerted should the cash balance in the smart-card fall below a pre-defined amount.

When the vehicle passes through the ERP gantry, the appropriate ERP charge is deducted from the smart-card. There is a short beep, signifying a successful transaction, and the remaining cash balance in the smart-card is displayed momentarily. Should there be insufficient cash in the smart-card or should there be no smart-card in the IU, the enforcement cameras in the gantry will take a picture of the rear of the vehicle. Similarly, should the vehicle have no IU installed in it, the enforcement cameras will also take a picture of the offending vehicle. The picture is sent back to the control centre, where the vehicles' registration numbers are automatically read using OCR techniques. The owners of the vehicles are then issued with letters to ask for payments. For cases of insufficient cash balance or no smart-card in the IU, an administrative charge of \$10 plus the outstanding ERP charge is imposed. To promote electronic payments, this administrative charge is \$8 if payment is made on-line at a number of electronic kiosks or through the Internet. If this payment is not made within the prescribed 28-day period, a summons will follow. For cases where vehicles pass through the ERP gantry with no IU, summonses are issued immediately. Failure to pay the penalty can result in the offender being called up to appear in the courts.

#### *IU fitting programme*

There were two major programmes launched prior to the start of the ERP. The first was the installation of IUs on the then 680,000 eligible vehicles while the second was on publicity, to get motorists and motorcyclists aware and ready for the ERP system.

The IU fitting programme took 10 months, starting from September 1997. The 680,000 vehicles that were potential users of the ERP system were grouped into batches, and owners of each batch were invited to have IUs fitted at one of the 200 authorised IU fitting centres. This was spread out over the 10-month period, so that there would be no last-minute rush to fit IUs. To encourage vehicle

owners to keep to the schedule, the IUs were given away at no cost to them if they had their IU fitted during the allocated time period. Otherwise, a charge of \$150 was payable. The fitting of IUs onto vehicles was not compulsory – it was left to the individual to decide. Nevertheless, at the end of the IU fitting programme, more than 98 percent of the registered vehicles were fitted with IUs.

#### *Publicity programme*

Publicity was another important aspect and this started even before the start of the IU fitting programme and was in place for more than a year, all the way up to and beyond the launch date of the ERP system. All vehicle owners were sent brochures, detailing the ERP system, how it works and the differences between the ERP system and the then working ALS/RPS. Advertisements were also placed in the print media as well as on television to drum up awareness of the new road pricing system.

One of the differences between the ERP and the then ALS pointed out in the publicity programme was that, unlike the latter, the ERP system imposes a charge each time a vehicle passes through the control point. In the ALS schemes, the fee payable was a daily charge that allowed the vehicle to make unlimited number of entries into the RZ for that day.

#### *Traffic impact*

Traffic volume into the CBD had reduced by about 10 to 15 percent during the ERP operation hours, as compared to the ALS scheme. This was in spite of the road pricing charge being lower at between \$0.50 and \$2.50; the charge for the ALS was \$3.00 for peak periods and \$2.00 for the inter-peak period. The major difference is that the ERP charge is applicable for each passing, while the ALS charge allowed multiple entries for that day. Hence, the ERP had influenced particularly the behaviour of those who made multiple trips into the CBD – and this was estimated to be about 23 percent of trips that entered the CBD during the ALS days. Many of these multiple trip-makers cut down their number of trips, e.g. office workers no longer use their cars to attend mid-day meetings or lunches – more relied on the public transport system instead.

#### *Varying the road pricing charge*

The ERP system allowed more frequent changes to be made to the road pricing charges, so that it can better



optimise road usage. Speed-flow curves were established for two different types of roads – urban roads with side friction and traffic signals, and expressways. The intent of ERP is to optimise road usage, i.e. flows should be near the maximum possible. From the speed-flow curves, it was decided that speeds on selected roads should be between 20 km/h to 30 km/h while that for expressways, the speeds should be between 45 km/h to 65 km/h. When speed goes above the upper threshold, too few vehicles are deemed to be using the roads and hence, the road space available is not being optimally used. Hence, the road pricing charge can be reduced to allow more vehicles to use the roads. Conversely, if the speed falls below the lower threshold, too many vehicles are on the roads and this is a signal that the road pricing charge can be increased. Other considerations do come in when deciding on the final road pricing charge, e.g. the effect of traffic diverting to other roads.

#### *Other issues*

There was the inevitable issue of privacy. There was a lot done to allay the fears of motorists. Being an active system, there was no necessity for the central computer system to keep track of vehicle movements since all charges were deducted from the inserted smart-card at the point of use. Records of such transactions were kept in the memory chip of the smart-card that belonged to the individual. The authorities also took a further step to assure the public that all records of transactions required to secure payments from the banks were erased from the central computer system once this was done – typically within 24 hours.

Radiation from the system was also a concern. However, this again was a non-issue since the IUs are non-radiating – they reflect what it receives from the antenna, which is positioned 6 metres above the road surface. The radiated power from the antenna is more than a thousand times less than what is allowable by the International Agencies on Radiation Protection.

The ERP system allowed a finer graduation in rates and this can potentially have the ERP charges set at levels that commensurate better with the prevailing traffic conditions. This also helped to reduce, but not eliminate, the problem of motorists waiting for the road pricing to end for the day, as the savings that could be made by motorists have now become less significant.

The issue of the ERP system as a revenue tool for the Government was also raised. However, ERP has always been positioned as a traffic management tool and revenue was and is never a consideration. Indeed, with the ERP system replacing the ALS, the revenue collected today is still only about 80 percent of what used to be collected with the ALS. This is in spite of there being more ERP gantries in operation. The reduction in revenue collected is due to lower charges and operating hours that came about because the ERP system is a more flexible tool.

#### *Extending ERP*

As vehicle ownership continues to increase, more pockets of congestion on the road network becomes inevitable. Hence, more ERP gantries have been erected since its launch in 1998. Starting with 33 gantries when it was first introduced, this has increased to 45 by 2004. An additional 3 gantries are planned for 2005. One of these gantries is on the out-bound direction of a major expressway from the city and to be operational during the evening peak hours, while the other two are to create two separate pricing cordons for the CBD. Having two separate cordons allows a more targeted approach towards the setting of ERP charges as the characteristics of the zones covered by these two cordons are slightly different – one being more of a shopping zone while the other being more of an office zone.

#### **Conclusion**

Road pricing in Singapore has been effective in managing congestion on roads in the CBD since its inception in 1975, and in recent years on expressways and other major roads outside the CBD. Technology had helped to make the expansion of the original road pricing scheme possible; and the authorities are still keeping tab on new developments in technology, e.g. the GPS-based system for heavy vehicles in Germany, to further enhance and refine road pricing in Singapore.

#### **References**

- Menon, A. P. G. and K.-K. Chin (1998), "The Making of Singapore's Electronic Road Pricing System", Proceedings of the International Conference on Transportation into the next Millennium, Singapore.
- Low, Y.-D. and C. L.-Y. Tee (2000), "Singapore's Experience with Road Pricing: From Manual to Electronic", Technical Report at the 5th ASEAN-Japan Workshop-cum-seminar on Urban Transportation.
- Menon, A. P. G. and K.-K. Chin (2004), "ERP in Singapore – What's Been Learnt from Five Years of Operation?", Traffic Engineering & Control (tec) 45 (2).