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THE MAKING OF SINGAPORE'S ELECTRONIC ROAD PRICING SYSTEM

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SYNOPSIS

The article describes the reasons for changing from a manual road pricing system that has been operating since 1975 to an electronic road pricing system. The two options considered were the passive system with a central billing used for many electronic toll collection system; and an active system using a stored value smartcard. The active system was selected for a variety of reasons. Various technologies were considered before settling for the two gantry system, which best emulated the manual system.

We treaded cautiously on two counts because our ERP would be the first kind of its system in the world. On the first count, the prospective tenderers were required to tailor-make and demonstrate a working system with their bids. For this demonstration, they were paid, as otherwise they would have just shown us only the equipment they already had. The results of the demonstration also helped in the evaluation of the tenders and the selection of the consortium to implement the ERP project.

On the second count, extensive testing simulating various traffic conditions encountered on our roads were carried out to prove the reliability of the various parts of the ERP system.

The massive programme that followed the successful tests to fit electronic gadgets to the vehicle population had to be carefully planned and executed.

Finally, an extensive publicity and public relations programme to familiarise motorists with the ERP and to attend to problems before they cropped up were instituted just prior to the start of the ERP at two points in April 98. The painstaking way with the way that the whole ERP project was planned and executed over nine years ensured that it was implemented for the first time in the world without much fuss and adverse reaction from motorists.

1 BACKGROUND

1.1 Singapore introduced a manual road pricing system called the Area Licensing Scheme (ALS) in 1975. Under the ALS, an area encompassing the most congested parts of the city with an area of 720 ha is termed the Restricted Zone (RZ). There is a cordon around the RZ, demarcated by 34 overhead gantries at the entry points. During the daylight working hours on weekdays and half-days on Saturdays, vehicles wishing to enter the RZ need to purchase and display an area licence. The area licences come in monthly and daily forms. They are available for purchase at post offices, petrol stations and special daily licence sales booths set up at approach roads to the RZ. The licences come in various shapes and colours to make them readily distinguishable for the police who man the entry points. Various categories of vehicles are charged differently with the cost of the licence being higher during the morning and evening peak hours, as compared with the off-peak hours in-between. Policing is only at the entry points. Vehicles are free to move around or leave the RZ. Offending vehicles are not stopped nor are they able to purchase the area licences at the entry points i.e. it is not a toll system. Violators get a notice to pay a fine for entering the RZ without displaying a valid licence.

1.2 The ALS has been largely instrumental for keeping our transportation problems in the city within manageable levels.

1.3 In the mid-90's, the same concept was extended to 3 expressways during the morning peak hours and requiring separate licences. This system for expressways is called the Road Pricing Scheme (RPS)

2 NEED FOR AN AUTOMATIC SYSTEM

2.1 The ALS and RPS are both labour-intensive in that they require many people for the sale of the area licences and the policing. In total, more than 70 persons are required for licence sales and 78 persons for enforcement.

2.2 ALS started off in 1975 in a simple manner by having restrictions for cars and taxis only, during the morning peak hours. As it was subsequently extended to cover the whole day with different rates for different vehicle classes and lower rates during the off-peak hours, the number of licences mushroomed. While the regular motorists who buy licences often have no problems, the occasional user faces confusion.

2.3 With the introduction of RPS, new licences were required and this was another avenue for confusion. Before the introduction of ERP, the motorist has a choice of 14 licences to choose from, which is considered too many. Further extensions of the road pricing will add more licences to the melee.

2.4 With the paper licence, motorists can make unlimited number of entries into the controlled area. This is not keeping in the spirit of the concept of congestion pricing, which is meant to make the driver pay for the use of the road at times and places when and where they cause congestion. The fairest way will be to make the motorist pay each time he uses the controlled area.

2.5 Therefore, a search for an automatic alternative started in 1989 when technologies for electronic toll collection started appearing. This is how the Electronic Road Pricing (ERP) started.

3 CHOICE OF SYSTEM (ACTIVE VS PASSIVE)

3.1 Two systems were considered namely the passive system and the active system.

3.2 In the passive system, each vehicle is fitted with a unique passive transponder (an invehicle-unit), which is identified each time it goes under an ERP controlled point. At monthly intervals, each motorist receives a bill for settlement for usage of the road, in the same way that he is charged for the use of water and electricity. Vehicles without IUs are photographed and required to pay a fine for

each time they violate the system. The advantage of the system is that it is simple with readily available technology. Once the IU is fitted, the driver has little else to remember. He can enter the ERP controlled area without remembering to do anything else and he will not be a violator. It is the most common system used at many of the electronic tolling systems. The disadvantage is that the system of central monthly billing requires a large bureaucracy. Chasing bad debts incurred by some errant motorists is an arduous task and involves procedures that are cumbersome. Before long, a "credit card" syndrome may develop and motorists may end up paying the monthly charges without even looking at the figures- the deterrent of congestion pricing will have less of a bite. Besides, the central system will have to keep a track of all movements of the vehicle at ERP controlled points to generate the monthly bill. Some motorists may consider this tracking as an invasion of their privacy.

3.3 In the active system, each vehicle is also fitted with an invehicle-unit (IU). This IU has more intelligence than the passive IU used in the central billing system. Payment at ERP controlled points is by means of deduction of the charge from a prepaid stored value smartcard inserted into the IU prior to the start of the journey. As in the central billing system, vehicles without IUs or smartcards are photographed as violators and fined. The advantage is that the user is made aware of the payment, which he sees being deducted from the smartcard as he makes the journey- the deterrent of road pricing being more effective. Since there is no central billing, the question of bad debts does not arise. The records of vehicle transactions under the ERP controlled points are kept at the control centre only as long as they are needed to settle the payments with the banks that issue the smartcards. The records of the last 10-25 of these transactions are however kept in the smartcard with the motorist. The disadvantage is that the technology is more complex. Also drivers need to always keep the smartcards topped up with cash and are considered as violators if they inadvertently fail to insert the smartcard. Drivers also need to pay for the charges upfront by topping up the smartcard.

3.4 After much debate and analysis, we opted for the active system. This move was hastened by the government's intention to introduce a cashless society with the use of smartcards as electronic purses. An active system, which requires the use of smartcards for payments, was considered as a convenient vehicle for the widespread use of the smartcards to take off.

4 TECHNOLOGIES CONSIDERED

4.1 The method of charging for the ALS and RPS has always been on a per day basis. The initial electronic road pricing system was configured to replace the ALS and the RPS. Therefore, the other options of charging for distance traveled and time spent in the RZ were considered as secondary issues.

4.2 The technologies that were considered for ERP were

- 4.2.1 Video-imaging of all vehicles
- 4.2.1 Radio beacon based system
- 4.2.3 Global positioning satellite systems
- 4.2.4 Two gantries based system at entry point

4.3 A video imaging system takes photographs of the licence plate numbers of all vehicles entering the ERP controlled point, uses an optical character recognition system to read the number plates and sends monthly bills to the owners. This system was not considered further because it was a passive system with central monthly billing.

4.4 A radio beacon system uses strategically positioned radio beacons to switch on the invehicle-unit as a vehicle enters the ERP controlled zone. The driver is required to insert the smartcard as long as the IU is switched on, which in turn deducts the appropriate charges for the use of the road from the smartcard. Enforcement is by cameras located at strategic points, which takes photos of licence plates of vehicles not using smartcards or of those who have switched off/removed their IUs. Enforcement is not 100%. When the vehicle leaves the ERP controlled zone, the radio beacons switch off the IU. The

system is suitable where charging is by time spent in a system. But, there is the question of whether vehicles should be charged even when they are parked. It was not considered suitable for our system.

4.5 A GPS system works in a similar way to the radio beacon system. The ERP controlled zone is programmed into the IU and by use of GPS coordinates, the IU is automatically switched on when the vehicle enters this zone and switched off when it leaves the zone. Payment is by smartcard and enforcement is also random for those who do not use smartcards or have switched off/removed the IU. When we were considering the GPS technology at that period, the accuracy with which the GPS system would delineate the boundaries was in doubt. Hence technology was not considered mature enough to consider this option further.

4.6 The overhead gantry system requires these to be placed at the entry points for identification of IU by radio waves, debiting by the IU on the smartcard and enforcement by overhead cameras. The system is eminently suitable for charging per entry and enforcing 100% at the point of entry. It best emulates the current ALS and RPS systems. The disadvantage is the fairly large overhead structures with all the paraphernalia that would be required at each entry point.

4.7 After studying the options, we opted for the overhead gantry system. If we required 100% enforcement, none of the systems mentioned that we evaluated could dispense with some type of overhead gantries. We did consider the alternative positioning of enforcement cameras on lamp-posts or even buried under the road surface. Practical difficulties made these options of the placing of cameras unsuitable.

5 FUNCTIONAL REQUIREMENTS

5.1 The Singapore system is a road pricing system, not a toll collection system. The functional requirements that were spelt out were

5.1.1 It should be a multi-lane system with no toll booths.
5.1.2 There would be no manual payment.
5.1.3 There would be no need to slow down at the ERP entry points.
5.1.4 There is a possibility of more than one vehicle passing simultaneously under the entry point.
5.1.5 Vehicles may straddle lanes as they pass under the gantry.
5.1.6 Vehicles could travel at speeds of up to 120kph.
5.1.7 The Invehicle-Unit (IU) should do a self-check and a check of the smartcard before the journey starts. The self-diagnostics should include icons to alert the driver to faults in the system.
5.1.8 Appropriate displays on the IU should inform the driver of the cash balance on the smartcard when he first inserts it and also when a deduction has been made.
5.1.9 Audible signals on the IU are to complement the visual displays.
5.1.10 The IU should warn the driver when the cash balance in the smartcard become low.
5.1.11 The IU should preferably draw its power from the vehicle battery.
5.1.12 The IU should be permanently fixed to the vehicle and the fitting exercise should be simple and not take more than 20 mins.
5.1.13 The IU should carry a five-year warranty against manufacturing defects.
5.1.14 The enforcement photographs should be transmitted back to the control centre within 15 mins and initially checked by an optical character recognition system.

These were the major considerations against which the design was to be based.

6 METHOD OF PROCURING THE ERP SYSTEM

6.1 This was the first ERP system of its kind to be introduced in the world. There was a need for the prospective tenderers to tailor-make a system to our requirements and to show that it performs to the

required reliability, before we could consider the award of the tenders. If we had just asked them to show a working system, they would just have shown us the electronic toll collection systems that most of them were already marketing.

6.2 The first step was to invite technical and costed proposals from pre-qualified tenderers for the ERP system based on our functional specifications. There were 5 tenderers. Each tenderer was offered a sum of $1.5 million to tailor-make a mini-system consisting of one ERP working gantry point (Outstation) and a simulated central control system. Three of them who accepted the offer were each allotted a test site and asked to arrange test run with vehicles fitted with their proposed IUs and using the smartcards. The results of the reliability figures from the demonstration tests were taken into consideration in the final evaluation of the three tenders.

6.3 Based on the technical proposals, the cost and reliability figures of the demonstration, a successful contractor was chosen for the project. The whole tendering exercise took a period of 2 years, whereas a normal process of tendering for major projects would not have taken more than a year.

6.4 We believe that being thorough and by insisting on a tailor-made system to suit our conditions, we got a better deal from the tenderers. Before we went out to award the tender, it helped us to gauge that it was possible to have a system to meet our requirements and specifications. It was also fair to the tenderer as he was able to gauge his ability to meet our specifications. It gave him a chance to fine-tune his design requirements for the system, even prior to getting the contract.

7 SYSTEM QUALIFICATION TESTS

7.1 On award of the tender, the contractor submitted his Final System Proposal for approval. The FSP was a complete design proposal with the final details. However, before he was allowed to start with the manufacture of the IUs and outstation equipment (i.e. overhead gantry equipment), he was required to carry a System Qualification Test to show that his final system met the reliability standards that had been specified. If he could not pass the SQT, the contract was to be aborted.

7.2 When the SQT took place from December 96 to August 97, it was the most ambitious test in the world for an ERP system. A section of an unopened stretch of an expressway was handed over to the contractor. He erected 12 sets of ERP gantries (Outstations) and fixed 250 prototype IUs to hired vehicles. These vehicles were from all classes such as cars, taxis, motorcycles, light goods vehicles, heavy goods vehicles, buses and trailers. A simulated central control system was set up at the site to record transactions, faults and violations and to collect violation photographs. The test vehicles with the IU's with the smartcards inserted went round the test site throughout the day chalking up about 120,000 transactions a day.

7.3 The initial SQT was helpful in bringing out weaknesses in the system that had not been tried out anywhere else in the world. There was interference from a trunk radio system that operated on the third harmonic of the radio frequency allocated to the ERP system. Some older motorbikes exhibited electronic spikes that also interfered with the radio frequency. The smartcard plastic was too pliable and warped or melted in the hot sun. The ergonomic design of the IU left much to be desired, as many of the drivers, even though they were familiar with the test sequence did not insert the cashcards properly.

7.4 Resolution of these problems took time, which delayed the contract. But when they were resolved, the SQT passed. Out of a total of 4.8 million passings, there were very few communication errors which more than met our specified requirements of permitted errors. In addition, the vast majority of the violations were captured by the enforcement system, as per our specified requirement.

7.5 During the SQT, we also simulated many of the traffic conditions experienced on our road network. These included vehicles speeding up to 120 kph, stop-start conditions, vehicles straddling lanes, motorcyclists riding two abreast, vehicles switching lanes or making oblique passes under the gantry,

vehicles breaking down under the gantry and vehicles reversing and stopping after going through the first gantry. In every one of these cases, the anticipated ERP system made successful deductions or took violation photographs, as appropriate.

7.6 As a result of the tests, the smartcards were made more robust with a sun logo with plastic that could withstand the much higher temperatures experienced in vehicles parked under the sun in tropical climates.

8 ERP CONFIGURATION (SEE FIGURE 1)

8.1 Outstation
An ERP controlled point uses two overhead gantries at a height of 6 m above road level and spaced at about 11m apart and. Each gantry has two radio antennae per lane meant to communicate with the IU by radio frequency. A set of optical vehicle presence detectors (optical line sensors) is on the second gantry to detect passage of vehicles. Two charge coupled device (CCD) cameras are placed on the first gantry to cover each lane to take electronic photographs of the rear licence plates of the violating vehicles. The whole setup, which is controlled by a local controller, is termed the Outstation. Each outstation is connected by telephone cables to a central computer system at the control centre.

8.2 The IU is about the size of a small pocket diary and is powered by the vehicle battery. It is fixed permanently to the right bottom corner of the vehicle's windscreen by a bracket glued on by very high bond tape. The motorcycle IU that has a protective covering to prevent rainwater seeping in is fixed permanently to the front of the machine (e.g. on handlebar). The IU needs a direct line of sight to the radio antennae on the two gantries for effective communication. Each IU has a small backlit liquid crystal diode (LCD) display.

8.3 The IUs are colour coded for different types of vehicles because the ERP charges vary for them and we do not want the IUs to be switched around. The vehicle classes are cars, taxis, motorcycles, light goods vehicles, small buses, heavy goods vehicles, large buses and emergency vehicles. The emergency vehicles are exempt from the ERP charge.

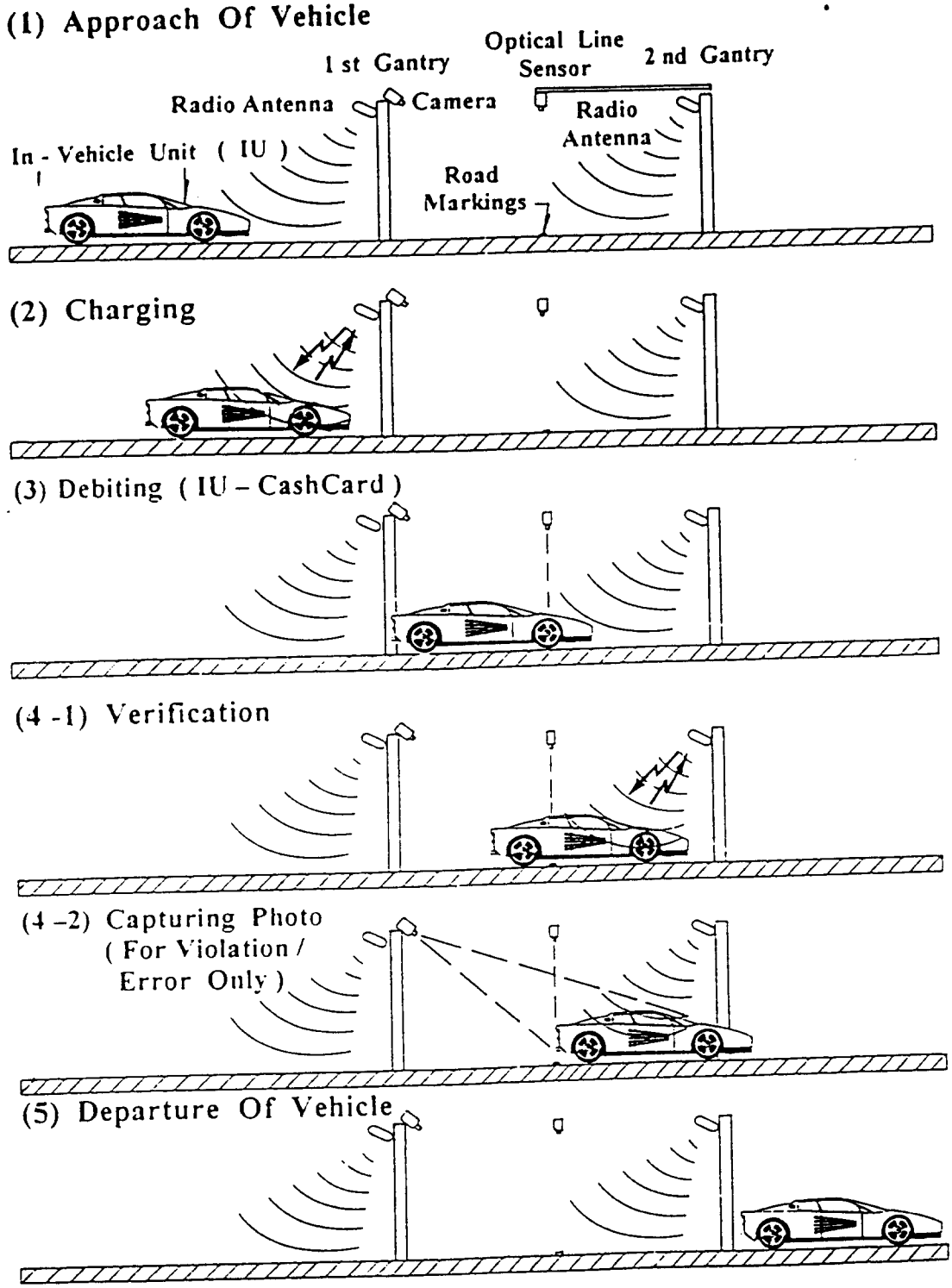
8.4 The stored value smartcard is issued by NETS, a company owned by a consortium of seven local banks. It is a contact smartcard and is called the CashCard. The stored value can vary from S$20 to S$500. There is a $2 deposit fee, which is refundable if the card is returned. The card is available at banks, convenience store and petrol stations. It can be topped up at many of the automatic teller machines. The CashCard plastic for use in the ERP system (shown with a sun logo) is able to withstand the high temperatures (e.g. 4 to 5 hours continuously at high temperatures) experienced inside the vehicle, when it is parked under the hot sun for long periods of time. Existing CashCards without the sun logo may also be used for ERP but there is no guarantee that they would not warp nor melt under the hot sun.

8.5 The CashCard can also be used for other cash transactions in supermarkets, petrol stations etc.

9 HOW DOES THE ERP WORK? (ALSO SEE FIGURE 1)

9.1 When a motorist inserts a CashCard into his IU, it checks the health of the IU and the CashCard. If everything is in order, there will be a short beeping sound and the cash balance of the CashCard will be shown on the backlit LCD display of the IU for 10 seconds. A green light emitting diode (LED) will light up on the IU and remain lit until the CashCard is removed. If the system is not working when the CashCard is inserted into the IU, an "Err" message appears on the IU display with a long beeping sound and a red LED lights up on the IU. In such cases, one or more of the small icons may also be shown on the display, to indicate the type of error e.g. CashCard error, IU error, and low CashCard balance. Another indication of a faulty system is a blank display.

FIGURE 1
SYSTEM OPERATION



9.2 At the ERP controlled point, the first gantry recognises the presence of an IU and its class and instructs it to debit the CashCard with an appropriate amount. This amount is determined from a table of prevailing charges for the various classes of vehicles loaded into the outstation by the central computer. Between the first and second gantries, the IU debits this amount from the CashCard. If the debiting is successful, the second gantry queries the IU and then gets such a confirmation. The driver hears a short beep and sees the new CashCard balance on the IU display for 10 seconds.

9.3 If the IU is unable to deduct because of an error in the system or because there is no CashCard (or an invalid card) or insufficient balance in the CashCard to meet the amount, the driver hears a long beep, sees a red LED on the IU and "Err" appears on the IU display. With an error, he may also hear the long beep and see a blank display on the IU.

9.4 Meanwhile, the vehicle presence detector detects the passage of a vehicle. The antennae at the two gantries, the vehicle presence detector and the IU together with the logic in the local controller decide whether a complete successful transaction has been made.

9.5 If not, there has been a violation or an error. The cameras are instructed to take a photograph of the rear licence plate of the offending vehicle.

9.6 Violations are committed by vehicles that have no IU, no CashCard or an insufficient balance in the CashCard to meet the cost of that passing under the ERP gantry. Errors occur when there is a faulty IU, no power to the IU from the vehicle battery, faulty CashCard and partial communications between the IU and the antennae.

9.7 When a photograph is taken, the system attaches information on why it was taken, so that technical errors and violations are differentiated. Errors do not result in prosecution of the motorist.

9.8 The information from the outstations on successful transactions, violation and error records and the photographs are sent periodically by telephone lines to the control centre. Another control centre monitors the state of all outstation equipment.

10 THE IU FITTING PROGRAMME

10.1 On successful completion of SQT, we undertook a 10-month programme for mass fitting of the IUs to vehicles. Two agents were appointed and they commissioned more than 200 authorised workshops to fit the IUs. The contractor held a two-day course for all workshop mechanics with instructions and hands-on experience on the method of fitting and testing of the IUs. The IUs that came from the assembly line were programmed with an IU code and dispatched to these workshops by the agents.

10.2 All the 680,000 registered vehicles were issued with notices for a free IU with free installation at any of the workshops of their choosing. Drivers were encouraged to make an appointment with the workshops before presenting the vehicle for the fitting. To spread out the fitting exercise over ten months and to avoid a last-minute rush, the notices were staggered and each vehicle allotted a specific one-month period to complete the fitting.

10.3 The IU is held in place by a bracket fixed to the windscreen of vehicles or the handlebar/ front panel of motorcycles. The IU is powered from the vehicle battery, either with a 6 V battery or 12 V battery. Some of the very heavy vehicles, which had 24 V batteries, needed a transformer. Special battery packs are provided for the older motorcycles with no batteries. The process of fitting took between 20 to 30 mins. The alternative idea of powering the IU by dry cell batteries was dropped when tests showed that batteries tended to leak at the high temperatures. Dry cell batteries are only used for temporary IUs for hire to foreign vehicles.

10.4 The lower right hand corner of the windscreen was chosen as the best location for the IU because the motorist could glance at any display that appeared without taking his eyes off the road. Furthermore,

as most people were right-handed, they would also find it easy to insert the CashCard. For a taxi IU that had two displays, one for the driver to check the balance in his CashCard and the other to indicate the cumulative ERP charge that the commuter had to pay, the best position was the lower middle of the windscreen.

10.5 Some of the problems associated with the IU fittings were:

10.5.1 Poor battery connections resulting in no power to IU.
10.5.2 Poor location of brackets so that the IU did not face the antennae at the gantries.
10.5.3 Poorly fitted brackets that dislodged.

10.6 When these were identified, the mechanics were retrained and quality control inspectors made random checks on the fitting work at the workshops. The quality of works generally improved after that.

11 PUBLICITY

11.1 Road pricing has been in existence in Singapore for the past two decades. Nevertheless, a mass publicity campaign was undertaken to inform and educate motorists on the ERP scheme.

11.2 After SQT had passed, pamphlets were sent to all motorists explaining the workings of the ERP system and the names of the IU installation centres. With the notices for the free installation of IUs, motorists received another booklet explaining the workings of the IU. At the IU installation centre, they are given another booklet on how it worked and on simple trouble-shooting tips.

11.3 There were frequent articles in the newspapers, on television and radio on ERP. Public forums were held with with grassroots organisations to explain the ERP scheme and posters appeared at community centres. The publicity programme intensified during the last two months in advance of the implementation.

11.4 An important event was the test drive that was initiated three months prior to ERP. By this time, most of the vehicles had their IU's fitted and the Cashcards were readily available. Most of the ERP points were switched on with zero charging for the period 7am-7pm. Motorists were advised to check their IUs and the CashCards by driving under any ERP gantry that was in the test mode.

11.5 Motorists were advised on the steps to check the correct working of the IU and the CashCard. In this way, they would become familiar with ERP before it became operational. The only difference during the test drive was that they did not have any deductions made from their CashCards. Motorists experiencing problems with their IUs or CashCards were advised to return to the workshops to have their IUs checked or to exchange their faulty CashCards with new ones.

11.6 In addition, we set up IU clinics on the last few Sundays before ERP was implemented. At these successful and popular IU clinics, motorists could come for a Sunday outing, see an ERP exhibition, have their IUs checked, and buy CashCards or exchange faulty CashCards.

11.7 These measures were necessary because they showed a sincere desire to ensure that motorists would have few problems when ERP started.

12 ISSUES RAISED

12.1 The IU clinics were widely reported by the press. Such wide publicity invited many letters from readers expressing their concerns on ERP. This gave us an opportunity to answer many questions and clarify many doubts. The issues that were brought up were:-

12.1.1 In ERP, payment is for each entry made into the Restricted Zone. Under the old manual system, the area licence gave unlimited entries. So most motorists would end up paying more with ERP. The answer was that the ERP better reflected the maxim "you pay for the actual use of the road". Furthermore, our studies with the manual pricing system showed that the majority of the motorists use the area licence only once a day. The average number was about 1.4 trips per licence. Taxis made about 4 trips with a licence, but the ERP charge would be paid by the commuter. It would of course discourage the taxi driver from empty cruising on the roads.

12.1.2 Will the motorist be penalised if the system failed and he was considered as a violator? Photographs will be taken of the vehicle if a violation took place or there was a technical error. In all cases, the reason for taking the photograph will be attached to the photograph. Violators will be penalised, but those with errors will only have to go for an inspection.

12.1.3 Will the IU, which was fitted on the windscreen, become a projectile in the event of an accident and injure the driver? Crash tests carried out with IUs in cars proved that the IU did not detach itself, even at collisions of speeds of up to 100kph.

12.1.4 Are the radiations harmful? The IU in the vehicle is a non-radiating device. It just reflects what it receives from an antenna, which is 6 m above the road surface. The radiated power from this antenna more than a thousand times less than what is allowable by the International Agencies on Radiation Protection.

12.1.5 Will vehicle movements be tracked? The system will only take photos of the rear licence plate if a vehicle violates the system. Information on valid transactions and hence on the vehicles that passed under each gantry will be kept only as long as they are required to settle the daily claims with the banks. There are also strict controls on who would have access to such information. However, the CashCard will have the details of the last 25 transactions. The motorist could print out the last 10 transactions at any of the automatic teller machines. With special card readers, he could print out the last 25 transactions.

12.1.6 What would happen if the IUs (especially on motorbikes) are vandalised or stolen? Stolen IUs will be invalidated once a police report is made. Photographs will be taken if an invalid IU passes under any gantry. As for vandalism, this would be the responsibility of the motorist himself, as with any other part of his vehicle's equipment.

12.1.7 What should a motorist do if he detects that his IU is not working before the start the journey? The motorist is to call at the installation centres to repair the equipment. Some of these centres will be open from the early mornings.

12.1.8 Will the motorist be allowed to have a negative balance in the CashCard? This is not necessary because the system gives an early warning on low cash balance and the motorist is expected to top up his CashCard with sufficient value once he has been warned. At the low cash balance point, the motorist will still be able to make one or two trips without violating the system.

12.1.9 Will the motorist be excused if he has forgotten to insert the CashCard? This is considered as a violation. Motorists are advised to make it a habit to insert the CashCard before starting their journeys and to remove it at the end of the journey. The latter served two purposes-to remind the motorist that CashCard was equivalent to money and to ensure that the CashCard was not left too long in the sun.

13 THE CHANGEOVER

13.1 The physical change over from the manual road pricing system required much planning.

13.2 All redundant signs had to be removed and the new relevant signs put in place.,

13.3 The old manual road pricing gantries had to be brought down because some of them were blocking the ERP gantries.

13.4 Real test runs were conducted with different classes of vehicles to ensure correct deduction and the correct workings of the ERP charge table. In the Test mode, ERP gantries were doing zero charging.

13.5 Signs were put up at the daily and monthly licence sales booths to inform motorists of their closure.

14 OPERATION OF ERP

14.1 The first ERP gantries on an expressway were switched at 2 locations (out of the final tally of 33) on April 1st 1998 between the hours of 7.30am-9.30am. From the word "go" the system worked smoothly. The widespread publicity had ensured that most motorists had become familiar with the system.

14.2 The traffic monitoring showed that traffic volumes on the expressway reduced by 15% and speeds increased from 35 to 55 kph during the ERP hours.

14.3 Violations accounted for about 0.7% of vehicle transactions. The majority were by motorists who had forgotten to insert CashCards.

14.4 Operational errors accounted for a very small number of transactions, mainly by carelessness of motorists. Some had not checked that their IUs were powered by the vehicle batteries; some inserted the CashCard wrongly especially when they did it in haste at the last moment at the approach to the ERP gantry. There were a few genuine IU-CashCard incompatibility problems.

14.5 Some motorists tended to slow down as they approached the ERP gantry. When questioned, they said that they wanted to make sure and see on the IU display that the correct deduction had been made. There were a very small number of reckless drivers who came to a stop just before the gantry to insert the CashCard at the last moment.

14.6 In summary, the ERP system has more than met our expectations. It is easily understood by the motorist, easy to use, technically sound and reliable. It has attained its objective of restraining traffic flow.

15 LESSONS LEARNT

15.1 A system needs to be tailor-made to fit local traffic conditions. Off the shelf equipment will not be adequate.

15.2 The success of the system depends much on its perceived reliability. Therefore, exhaustive testing is necessary to check its operational reliability.

15.3 The fitting programme for the gadgets (IU) has to be planned carefully and executed without causing unnecessary hassle to the motorist.

15.4 Much effort has to go in educating the users and to help remove some of their unfounded apprehensions.

15.5 Motorists' feedback should be taken seriously and there should be a willingness to help motorists who are having problems with their equipment.

15.6 Traffic monitoring is necessary to understand exactly what is happening and to take remedial measures.

15.7 The implementation of the ERP has been an exciting and rewarding experience for the many who were involved in it. It is a pioneering effort.

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REFERENCES

Various unpublished reports of the Land Transport Authority.