Implementing Road and Congestion Pricing - Lessons from Singapore

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**ABSTRACT**

Singapore has enjoyed rapid economic growth and intensive urbanisation over the last few decades and this has translated into an increase in travel demand. To support the increased travel demand, the Singapore government has over the years planned and put many measures in place to ensure that our transport system is adequate, sustainable and relevant. Our overall land transport strategy hinges on four key areas namely integrating land use / transport planning, providing a quality public transport system, developing a comprehensive road network and maximising its capacity and managing demand of road usage through ownership and usage measures.

Our transport philosophy is to maintain a proper balance between the use of private and public transport and increases the efficiency of traffic flow on our roads. While most cities adopt the first three components, Singapore is one of the very few cities to have pursued travel demand management for the past 30 years and with a degree of success, as is evidenced by the respectable speeds along the city roads and expressways.

This paper will present the land transport measures that Singapore has taken to tackle traffic congestion with particular reference to demand management strategy.

**1 INTRODUCTION**

Singapore is one of the most densely populated and urbanised countries in the world today. We have a population of 4.2 million that is housed in an island of only 650 square km. Due to intensive urbanisation and rapid economic growth, our travel demand has increased tremendously over the last few decades. We recognised that this higher travel demand cannot be served by the mere building of roads and better traffic management. While they may offer temporary reprieve, they will usually attract more vehicles to use them. Furthermore, in land scarce country like Singapore, vast amounts of land cannot be devoted to roads. Today, roads in Singapore occupy about 12% of the total land area and this is a considerable figure compared to the 15% that is devoted to housing. Besides road building can never keep pace with the annual growth in vehicle population. In other words, supply will always outstrip demand.

To serve the increase in travel demand, Singapore has developed an efficient land transport system that is built on the following four key strategies:

- Integrating land-use and transport planning;
- Providing quality public transport system;
- Developing a comprehensive road network and maximising its capacity; and
- Managing demand of road usage through ownership and usage measures.

All four strategies work in tandem to achieve a sustainable transport system that would serve our economic and social objectives.
Our philosophy is to develop an efficient and sustainable land transport system that meets the needs and demands of a dynamic and growing city with a population that will increasingly expect high standards in services and infrastructures. Having a quality public transport system is a key thrust to this system. However, we recognise that given the convenience that private transport offers, improvements in public transport alone may not be adequate to persuade more motorists to give up use of their cars. For this reason, demand management measures are necessary to influence motorists to switch to public transport.

To manage demand, we restrain vehicle ownership growth as well as employ usage-based traffic management. Vehicle ownership control aims to keep annual vehicle growth to manageable levels. Vehicle usage controls aim to make the drivers aware of the cost of congestion that he is causing by driving his vehicle at a particular place at a particular time; and charge him this cost. Today, Singapore manages vehicle ownership growth via a mechanism known as Vehicle Quota System while tools such as the Electronic Road Pricing (ERP) system are employed to restrain vehicle usage. The ERP has been widely implemented in Singapore both to manage traffic into the city centre and also along congested corridors and expressways. Given the challenges and constraints that Singapore faces, there will be greater reliance on usage-based traffic management strategies in the future to manage traffic on our roads.

2 CHALLENGES FACED BY SINGAPORE

The Government’s mission is to provide Singaporeans with a high quality transport system that meets the needs and demands of a dynamic and growing city with a population that will increasingly expect high standards in service and infrastructure. A high standard of transport enhances the quality of life, is good for economic growth and helps Singapore maintain its competitive edge. In order to provide high quality transport infrastructure that is accessible and affordable to the majority of Singaporeans, the following challenges have to be addressed.

2.1 Limited Land Supply for Road Infrastructure
Singapore has limited land resource and therefore cannot afford to keep expanding the road network to meet unrestrained traffic demand. With a significant 12% of total land area already occupied by roads today, a figure comparable to the 15% of land area devoted to housing, it is clearly not tenable to continue to reply on road expansion to solve all our transport needs.

2.2 Explosive Growth in Transport Demand
Like many cities of the world, Singapore faces the challenges of an increasing population and the corresponding growth in demand for mobility. The number of vehicular trips grew by about 3 times from 2.7 million trips in 1981 to about 7.8 million trips a day now. This figure is expected to grow to more than 10 million daily trips in 10 years time. The increase is not surprising given rising levels of income, higher educational attainment, changes in lifestyle and a host of other demographic and social developments.

2.3 Higher Aspirations in Owning Cars
Economic growth has had an effect on Singaporeans in terms of car ownership. With an increase in the number of Singaporeans obtaining a tertiary education leading to a higher average per capita income, these young professionals aspire for a higher quality of living, including owning a car of their own. They will settle for nothing less than a public transport system offering service standards comparable to private transport. Today, we have a vehicle population of about 720,000 of which 58% is made up of private cars. As the vehicle population continues to grow annually up to the cap of 3%, it is envisaged that the car to population ratio is expected to be 1:7 in the long term, compared to 1:10 now. However, in land-scarce Singapore, it is not possible to continue building roads to serve the rising car population. Singapore will thus have to provide its people with enough high quality transport alternatives which offer convenience, reliability, comfort, competitive travel times and well-integrated seamless journey.

2.4 Formations of Smaller Nuclear Families and Dispersed Business Activities
It is anticipated that future travel demand would be quite different. With the on-going trend in the formation of smaller nuclear families and dispersed business activities, travel demand would be much greater with important changes also in travel characteristics.
An understanding of the challenges mentioned above is important for developing sustainable strategies for transport development in Singapore. Tackling the land transport problem is not merely one of continually increasing transport capacity to meet unrestrained demand. Singapore has to address both the supply and demand sides of the problem. On supply, Singapore can expand her road network and exploit technology to maximise transport capacity. But budget restraints, environmental impacts and land constraints will set limits on how far this can go. Demand management measures have therefore to be implemented in parallel to ensure a sustainable solution to this challenge.

3 INITIATIVES TO IMPROVE SINGAPORE’S TRANSPORTATION SYSTEM

Singapore’s ability to achieve the vision of a world-class transport system will depend on the success in balancing the following goals:

- Accommodating the rising aspirations of Singaporeans for increased car-ownership while maintaining a congestion-free city; and
- Providing good infrastructure for economic growth that fits in well with the vision of a functional and beautiful city.

To achieve these goals, Singapore adopts an overall land transport strategy that is based on the following four key areas:

- Integrating land-use and transport planning;
- Providing a quality public transport system;
- Developing a comprehensive road network and maximising its capacity; and
- Managing demand of road usage through ownership and usage measures.

3.1 Integrating Land Use and Transport Planning

Land use planning plays a key role in creating a sustainable transport network. Planning can influence the need for travel, even the mode of travel. The importance of an integrated land use and transport planning approach cannot be over-emphasised. In Singapore, integration of land use with the various modes of transport is demonstrated strategically in the formulation of the Concept Plan 2001 (see Figure 1). This overall land use master plan which guides Singapore’s physical development is reviewed once every 10 years. In the recent review in 2001, the integrated planning approach set out a better mix of employment and residential uses with the intention to reduce the need to travel. In addition, a proper mix of development and the highest building densities were concentrated at and around train stations so as to guarantee maximum accessibility by public transport for commuters to key nodes of employment, housing and other social activities.

Besides planning at the strategic level, LTA also works closely with the urban planners at the micro-level to integrate land use around train stations as shown in Figure 2. In this way, the layout is planned carefully with the view to provide commuters with greater convenience, accessibility and comfort.
Figure 1 – Concept Plan 2001

Figure 2 – An integrated transport facility with commercial development
3.2 Providing a Quality Public Transport System

1. Providing an attractive public transport system is the cornerstone of Singapore's land transport strategy. To encourage people not to use their cars for work trips but travel by public transport, Singapore need a public transport system that is fast, efficient, comfortable, affordable and convenient. Today, about 60% of all daily motorised trips are made by public transport - 3 million by bus and another 1.3 million by rail. In the long run, our vision is to increase the percentage of public transport trips to 75%.

To achieve this target modal split, we will continue to expand our rail network, the backbone of our public transport system. Given it's larger carrying capacity, high travel speed and predictability of arrival and departure times, only rail system can meet the transport needs of heavy corridors for a compact city like Singapore. Complementing the rail system is our bus network. Although buses compete for road spaces, we have facilitated their movements on the roads using various bus priority schemes to so as to improve their service standards for the benefit of our commuters. In addition, we have also made improvements to other aspects such as air-conditioning our bus interchanges and providing more covered linkways to our bus stops so as to enhance the service quality of our bus system. An integrated contactless ticketing system for the entire public transport network was also introduced in the recent years so as to offer our commuters greater convenience through a seamless journey.

Please refer to Annex A for more details about our public transport system.

3.3 Developing a comprehensive road network and maximising its capacity

A comprehensive and efficient road network is essential to sustain economic activities and to provide better connectivity for all Singaporeans. Good connectivity will provide motorists a wider choice of routes and help distribute traffic flows, thus benefiting not only private transport, but also public transport such as buses and taxis. To serve the increased travel demand arising from economic development, new roads have been built while existing roads widened over the years. Apart from expanding our road network to make it more comprehensive, we also leverage on intelligent transport systems to maximise our network capacity. With rapid advancement in computer, telecommunications and information technologies, Singapore will continue to employ these technologies to make our road transport system safer and more efficient.

3.4 Managing Demand of Road Usage through Ownership and Usage Measures

After giving an overlay of the first 3 land transport strategies above, we turn to discuss Singapore’s demand management strategy, and will share our experience in road and congestion pricing, which is the thrust of this paper.

Demand management is an important component of Singapore's overall transportation strategy. In view of Singapore's land scarcity, it is not tenable for us to continue to expand our road network to meet unrestrained vehicle growth and usage. This limitation was recognised early with land transport strategies calling for aggressive management of travel demand. Demand management take two main forms: managing the ownership of vehicles and its use.

The restraint of vehicle ownership is managed either through the imposition of high upfront ownership costs or restriction on the actual growth of the car population. The former type includes the custom duties and vehicle registration fees, while the latter is managed through a Vehicle Quota System. The other aspect of demand management is the restraint of vehicle usage through levying 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 measures in this category. This strategy has been successful in managing traffic on our roads. Given the challenges and constraints that Singapore faces, greater reliance on usage-based traffic management strategies is envisaged in the future to manage traffic on our roads.
a) Vehicle Ownership Restraint

In 1990, Singapore decided to tackle the problem with ever growing vehicle ownership at source by introducing, as a long-term solution, the Vehicle Quota System (VQS). The system provides an effective mechanism to regulate the growth of the vehicle population to 3% per annum which was derived from the long term planning projections of the development of land uses and transport facilities. Under this system, the Government sets the number of new vehicles allowed each year based on prevailing traffic conditions.

The quota is allocated through tenders, which are conducted twice a month. Anyone who wishes to register a new vehicle has first to bid for a licence in the public tender. This licence is called the Certificate of Entitlement (COE) which is valid for 10 years. All successful bidders pay the lowest successful bid price, which is also the quota premium, and not the prices they bid.

All vehicles, except emergency vehicles such as ambulances and fire engines, and public buses, are subject to the VQS. This is because, from the land transport policy point-of-view, they all occupy road space, and all contribute to congestion.

VQS has worked well and over the years Singaporeans have come to accept the need for COEs. However, as a consequence of VQS, the price of cars in Singapore is much higher as compared to other countries. Having invested heavily upfront on a car that is relatively cheap to drive, the Singaporean motorist then “capitalises” on his investment and drives it as much as he can. VQS alone is therefore not enough to discourage people from using cars excessively. Recognising that this trend is not sustainable, the Singapore government has progressively reviewed and lowered the upfront ownership cost over the last few years in a bid to rectify the situation. To keep down the number of vehicles on the roads, Singapore has found it necessary to control vehicle usage. We are moving away from controlling vehicle ownership and towards restraining vehicle usage.

b) Vehicle Usage Restraint

The concept of road pricing is an important integral part of our demand management strategy and has come a long way in Singapore's transportation scene. Singapore started its road pricing system in 1975 with a manual paper-based system that was applicable during the morning peak period only for entry into a specific geographical zone. After three decades of evolution, the system has transformed into an electronic version that operates more extensively in terms of geographical and time zone.

Road pricing allows motorists to be more aware of the cost of congestion they impose on other people every time they use their vehicles. Road pricing will encourage motorists to consciously plan their trips and consider public transport alternatives. With more extensive road pricing, we can keep the crucial arterial roads and expressways linking our economic centres relatively smooth flowing, while sustaining a higher car population.

The subsequent section of this paper will discuss the underlying concepts throughout the evolution of our road pricing strategy since it started in the form of road pricing in 1975 to congestion pricing via ERP today.

i) Road Pricing System

**Area Licensing Scheme (ALS)**

Singapore first introduced a manual road pricing system called the Area Licensing Scheme (ALS) in Jun 1975. Under the ALS, an area encompassing the most congested parts of the Central Business District (CBD) with an area of 720ha is termed the Restricted Zone (RZ) shown in Figure 3. There is an imaginary cordon around the RZ, demarcated by 34 overhead gantries at the entry points into the RZ. The original concept of the ALS was to discourage the wide spread use of cars for commuting into the RZ during the morning and evening peak hours so as to manage congestion in the RZ. This scheme was implemented after a 1-year public dialogue on the details of the scheme and some modifications were made based on the feedback. The scheme was projected as part of an overall package of measures and this, in some way, helped it gained support from the public.
Under the ALS, motorists were required to purchase and display an area licence on their windscreens or handle bars (for motorcycles) prior to entering the RZ during the hours of operation. The area licences had to be bought in advance from post offices, petrol stations, area licence sales booths (located on the approach roads) or convenience stores prior to entry. With the same licence for a day, vehicles could make multiple daily trips into the RZ. For enforcement purposes, police constables were deployed at each gantry position to carry out visual checks on each vehicle. When a vehicle is spotted using the gantry without a valid licence, the police constables will note down the registration number of the violating vehicle and issue a summons via post to the registered owner of the vehicle. The offence for not displaying a valid area licence was a fine of S$70 then.
The implementation of the ALS saw a significant decrease in the total number of vehicles entering the RZ, largely attributable to a large decrease in car traffic (Figure 5). The use of public transport for the journey to work in the RZ, on the other hand, rose sharply from 33% before the ALS to about 70% by 1983. The implication of the ALS was however that some crosstown traffic was diverted to routes that bypass the RZ and this bypass traffic demands will need to be accommodated by expanding the capacity of the road network outside the RZ.

In Jan 1994, the ALS was extended to the whole day to even out traffic flow between 7:30 am and 6:30 pm to achieve a better utilisation of the RZ road network throughout the day and allow for a higher volume of traffic to be carried without congestion. On a secondary note, the whole day ALS also prepared the motorists for more extensive use of road pricing in the years that follow.

![Figure 5 – Effect of ALS on CBD Traffic](image)

Though without the technological sophistication of the ERP system, the ALS had effectively control congestion in the RZ for more than twenty years. It had successfully maintained the traffic flows within RZ during the morning and evening peak hours despite an increasing vehicle population from about 100,000 in 1975 to 230,000 in 1994.

**Road Pricing Scheme (RPS)**

Following the success of the ALS, a similar manual pricing system called the Road Pricing Scheme (RPS) was introduced progressively in the 1990s to six locations along congested sections on three expressways to manage the morning peak hour traffic from 7:30am to 9:30am on Mondays to Fridays. The three expressways were namely the East Coast Parkway (from 1 June 1995), Central Expressway (from 5 May 1997) and the Pan Island Expressway (from 5 May 1997). Under the RPS, vehicles with the whole-day ALS licence could be used at the RPS gantries along PIE and ECP during the morning peak hours except the CTE that required a separate licence as it is a heavily utilised expressway.

The intention of the RPS was to help spread traffic to other times and alternative routes. The RPS resulted in better traffic distribution between the expressways that lead into the CBD (where traffic congestion is developing) and the parallel arterial roads during the morning peak hours. It also led to better utilisation of these roads after the morning peak.
In tandem with road pricing, we have also introduced other usage restraint measures. One such measure is the Weekend Car Scheme (WEC) which was introduced in May 1991 and subsequently replaced with the Off-Peak Car Scheme (OPC) in September 1994. The OPC Scheme offers all existing car owners as well as new car buyers another option to own cars at lower costs, if they are prepared to use their cars sparingly. The scheme basically served to introduce a very crude form of usage-based pricing to complement road pricing but remains a blunt tool that does not target specific time / place of congestion. However, we have kept the scheme as it serves the needs of a minority group who do not need a personalised mode of transport everyday but aspires to own a car.

In contrast to the OPC scheme, both the ALS and RPS worked well particularly in the city as well as along expressways improving speeds dramatically. However, both the manual schemes mentioned above have limitations as charges are on a per license basis regardless of the number of times motorists enters the RZ. This is not a true reflection of the cost of driving to time and congestion levels. Therefore, in the late 1980s, we started to look for a more flexible road pricing scheme. The new scheme should have merits over the ALS in term of ease of payments, be flexible enough to enable price changes in accordance with varying traffic conditions and be complemented with an effective enforcement framework that is less labour demanding. Above all, it has to be a reliable system that the motorists have confidence in. After 10 years of planning, testing and preparation, the Electronic Road Pricing (ERP) system was launched in September 1998. The ERP marked the next era of our road pricing strategy as we enter into the phase of congestion pricing.

ii) Electronic Road Pricing System (ERP)

Concept

Singapore introduced electronic road pricing (Figure 7) in September 1998 to fully replace the manual road pricing scheme that had been in operation since 1975. Apart from automating the manual system, the introduction of the ERP revolutionised our concept of road pricing and Singapore’s usage restraint strategy move into the era of congestion pricing. The objective of the ERP scheme is to charge vehicles for the use of the road at places and at times where and when they cause congestion. Therefore, the main difference between ERP and the earlier ALS / RPS is the pay-when-you-use.
principle which is vastly different from the old scheme where charges are on a per license basis regardless of the number of times that motorists enter the RZ or passes the expressway gantries.

Rationale
Our ERP system works on the rationale of optimal average speeds. Based on a research effort with the Centre for Transportation Studies, Nanyang Technological University, it was established that the optimal average speed for expressways should be between 45-65 km/h and between 20-30 km/h for arterial roads. Based on these optimal average speeds, the ERP charges are reviewed at 3 months intervals to optimise the utilisation of the roads to avoid congestion or under-utilisation. Decisions to vary charges are ascertained by prevailing speeds being experienced at the RZ or expressways at half-hour interval. Probe vehicles, about 7,000 taxis fitted with global positioning system receivers, are used to determine the average speed along the roads. The ERP charge will be lowered if the prevailing speeds are higher than the optimal average speed and vice versa.

This concept of tying ERP rates to speeds has gained public acceptance and reinforces the fact that ERP is a congestion relieving measure rather than a revenue raising measure. Such a philosophy has allowed ERP to be scrapped totally on Saturday for the city after operating it for seven months. There are also slots within the ERP period where there are zero charges. Today, ERP charges vary for different half-hours from $3.00 for a car during rush hours to 50 cents during the quieter periods. A total of 45 ERP gantries are in operation presently and their operation timing are as shown Table 1.

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<tr>
<th>Table 1 - Operating Hours of the ERP System</th>
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<tr>
<td>CBD</td>
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<td>Mondays to Fridays</td>
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<td>Saturdays**</td>
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<td>Eves of major Public Holidays</td>
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* Since 2 Oct 2000, the CBD gantries started operation from 8:00am instead of 7:30am (except a heavily utilised gantry at Nicoll Highway). From 2 Jan 2001, ERP charges were reduced to zero between 10am to 12 noon.
** Since 1 April 1999, Saturdays were exempted as traffic conditions improved.

Please refer to Annex B for details on how the ERP system operates.
**Effectiveness of ERP**

Demand elasticities are used by economists as an approximate measure of aggregate responses in the market. It is defined as the percentage change in demand over the percentage change in price. Therefore, it is logical that the elasticities for ERP to be negative i.e. a reduction in price would see an increase in traffic volume and vice versa.

Since the implementation of ERP, there is a gradual increase in the elasticities for ERP for both the city roads and the expressways with the latter increasing at a faster rate. This trend of increasing ERP elasticity suggest that motorists seem to have become more conscious of the change in ERP prices over the years and are today more willing to change their travel patterns and behaviour when they are confronted with a higher ERP charge. In other words, the ERP has made the drivers more aware of the true cost of their journey and encouraged them to make travel-related decisions based on cost, the importance of the trip, the alternative routes and alternative transport modes available i.e. the motorists can:

- Pay the ERP charge and enjoy a smoother drive
- Change the time of their journey to pay a lesser ERP charge
- Use an alternative road
- Use public transport

This is what the ALS and RPS could not have achieved as effectively in the past.

The implementation of the ERP has generally reduced the traffic volumes in the Central Area during the morning peak hours and off peak hours by about 7-8% as compared to the ALS era (Figure 8). This reduction is due mainly to a decline in the number of multiple trips made into the RZ. However, there seems to be an increase of 28% in the traffic volume during the evening peak hours and this could be attributed to the lower cost of driving in the evening compared to the cost incurred during the ALS era. Nevertheless, the roads in the RZ have sufficient capacity to cope with the traffic volumes during the evening peak hours.

On the other hand, traffic conditions along the ERP priced expressways and major roads are also able to achieve reasonable speeds with the introduction of the ERP. While there are short periods of congestion on the unpriced alternative routes, the motorists have adjusted themselves to the routes they prefer over the years.

Based on Year 2004 records, an average of about 260,000 ERP transactions are generated daily. Of this, a mere 0.5% of the transactions involve violation cases with "No CashCard" and CashCard with "Insufficient balance". With a strict preventive maintenance regime, LTA has managed to maintain an average system availability rate of 99.5% over the last few years of operation.
In terms of revenue, the annual revenue from ERP is about 80% of that collected from ALS and RPS. The lower revenue is because the ERP rates have reduced for almost all periods of the day and premium rates are only charged for the half-hour with the highest traffic flow. This fall in revenue has demonstrated that the road pricing system in Singapore is meant as a traffic management measure and not as a revenue raising measure.

The revenues collected from ERP transactions are channelled to the government’s consolidated fund for the government expenditures. It is not dedicated to only transport-related development and maintenance. The government pays LTA an annual management fee for the operation and maintenance of traffic systems and roads. New development and construction of transport infrastructures need to be justified and budgeted as capital expenditure funded by the government.

**Graduated ERP Pricing**

With the implementation of the ERP, there was a growing tendency amongst motorists to try beating the higher ERP rate by speeding up or slowing down and even waiting in front of the ERP gantry. Such actions not only threaten the safety of the other road users, it also compromises the capacity of our road network. To discourage motorists from doing so, LTA decided to make ERP charges more gradual and introduced graduated pricing for the ERP rates in Feb 2003. The graduation of ERP rates is to mitigate sharp changes in ERP rates between 2 successive time periods so as to help smoothen and optimise traffic flows at the boundaries of two successive ERP periods.

Since implementation, the graduation in ERP rates has been effective in alleviating the anxiety of motorists who try to beat the higher ERP rate by speeding and also reducing their incentive to slow down or wait for a lower rate in front of the ERP gantry. With graduated pricing, we have further revamped our ERP as a demand management tool. This refinement has also resulted in lower ERP charges which benefitted the motorists.

Please refer to **Annex C** for more information on how the graduated ERP works.

**iii) The Next Step**

Moving forward, we will continue to refine our road pricing strategies with the advancement in technology so as to keep it relevant to meet our needs. This section of the paper will briefly outline several enhancement concepts that could be considered.
Today, the ERP rates are based on cordon-pricing, supplemented by certain point pricing on expressways. We are exploring the feasibility of moving away from uniform pricing rates for roads within a specific cordon to ensure more effective distribution of traffic. However, caution will need to be exercised to ensure that the deviation in rates will not result in decanting of traffic into the surrounding road. This refinement in our ERP system, if implemented, is envisaged to help influence and distribute vehicle entries into the CBD. Also, in examining the current traffic situation, we do not preclude the possibility of introducing ERP beyond the current operating hours for areas where the average traffic speed continues to fall below the optimum average speed as explained earlier in this paper.

For the longer term, as technology advances, we could consider having a system that charge vehicles based on a combination of cordon, point and area-based charging. Such a charging framework will enhance the overall effectiveness of our system for congestion pricing. This strategy will provide us with a sharper tool in managing road utilisation when dealing with a larger vehicle population in future. This approach will allow us to manage traffic congestion more equitably as it addresses the problem we face today with congestion pricing in which motorists affected feel that they are unduly penalised relative to others.

In addition, we will also need to rely on other usage restraint tools. Today, car parking is used as a complementary tool to the ERP. Our current car parking policy is to stipulate the minimum parking provision standards to ensure that sufficient parking supply is provided to meet the demand. We could consider using car parking as a demand management tool to supplement ERP. This could be achieved by allowing developers greater flexibility to provide parking for their developments based on commercial considerations and market demands.

4 LESSONS LEARNT

Some of the lessons learnt from Singapore’s experiences in road pricing over a quarter century are:

- Road pricing was sold as part of an overall transport strategy to the public. The package of measures included others like building roads, sophisticated traffic management, priority for bus movements, and new rail system. All the parts of the package were seen to be done in parallel. This helped to reinforce the point that road pricing was not implemented just to raise extra revenue for the Government. Over the years, the public has accepted road pricing as an effective tool to manage traffic.

- Road pricing makes it expensive to use cars. Therefore acceptable alternatives are provided in the form of a reliable and quality public transport system. Public transport system can never provide the door-to-door convenience and will always lag behind in service as compared to the car. We have over the years been devoting effort into improving and upgrading our rail and bus systems.

- It is important to appreciate the local traffic conditions and to develop a customised road pricing system for local applications. Taking off-the-shelf designs and applying them without careful considerations may not achieve the desired results. Motor transport associations and fleet management companies should be consulted during the design phase for their operational and technical inputs. Design of the pricing system may create unnecessary operational inconveniences or constraints if not consulted. In addition, the system should also be configured to make them easy to understand and use.

- Once the design is finalised, it is important to carry out exhaustive testing to check for operational reliability. The system needs to be reliable to convince the public that they will not be penalised because of malfunction of any equipment. For example, prior to the actual implementation of the ERP system in Singapore, the system was subjected to numerous stringent tests. Five million transactions were generated over a 9-month period to verify the reliability of the system.

- Massive logistics and programme to equip the vehicle population should be carefully planned to minimise inconvenience to motorists. Staggered equipment fitting programme will help to avoid out-of-stock situations or last minute rush by motorists. A large number of equipment fitting centres throughout the country would also make it more convenient for the motorists.
• Extensive public communications and education efforts must be carried out long before the launch of the road pricing system to breed acceptance and remove unfounded apprehensions. For example, brochures on the ERP system were sent to all motorists prior to the actual implementation of the ERP system in Singapore. The ERP system was also switched on weeks ahead of start-date at “zero charge” for motorists to try and familiarise the system. In addition, a hotline was also set up to answer to public’s query on the system. Motorists’ feedback should be taken seriously with willingness to render assistance to those with equipment problems.

• To reinforce road pricing as a traffic management measure, the charges are reviewed and adjusted, if need be, at 3 months interval based on prevailing traffic conditions. Revenue from road pricing has never been the consideration for revising rates, and the charges have been reduced in many instances, when the speeds improve.

• The political will and perseverance to implement a road pricing system is as important as the technical and operational considerations.

5 CONCLUSION

Singapore has enjoyed rapid economic growth and intensive urbanisation over the last few decades. To serve the increase in travel demand, we have expanded our transport system over the years through careful forward planning and sustained implementation of integrated land transport policies which are based on the following four key strategies:

• Integrating land-use and transport planning;
• Providing quality public transport system;
• Developing a comprehensive road network and maximising its capacity; and
• Managing road usage demand through a judicial mix of vehicle ownership and usage measures.

Our experience shows that all four strategies are to be implemented in tandem to develop a sustainable transport system that meets our social and economic objectives.

The concept of road pricing is an important integral part of our demand management strategy. While we continue to increase our road capacity judiciously to meet rising travel demand, the strategy also calls for greater reliance on public transport usage and demand management. To manage demand, we control vehicle ownership growth as well as employ usage-based traffic management tools such as the Electronic Road Pricing (ERP) system. The ERP has been widely implemented in Singapore both to manage traffic into the city centre and also along congested corridors and expressways. Over the years, we have refined our ERP system to serve our needs better. Graduation in ERP charges is one such refinement.

Moving forward, we will continue to refine our road pricing strategies as technology advances, so as to keep it relevant to meet our needs. We will also look at other tools, such as car parking, to restrain vehicle usage.

We believe that our road pricing system that has evolved over the years and which is progressively refined today, underpinned by our other land transport strategies, will make our land transport system sustainable and adequate to serve our needs in the future.
References

1. Land Transport Authority, Singapore (1996) - *White Paper for a World Class Transport System*


7. Unpublished figures from Land Transport Authority, Singapore
Annex A – Singapore’s Public Transport System

The public transport in Singapore comprises the following: -

a) The Rapid Transit System (RTS)

The backbone of our public transport system, the RTS is a rail-based public transport with its own right-of-way. Presently our RTS network comprises of the Mass Rapid Transit (MRT) and Light Rail Transit (LRT) which complements the MRT. In the city area, the RTS is underground while outside the city the system runs on elevated tracks. Inclusive of the Punggol LRT system that commenced operation recently on 29 Jan 2005, our RTS network has a total route length of 138km and 109 stations presently (see Figure 1).

Work is already ongoing to expand our RTS network. We are currently constructing the Circle Line (see Figure 1), an orbital line that will improve inter-suburban connectivity and enhance the connectivity of the RTS network. The CCL, which is 33km with 29 stations, will be built in five stages and is expected to be completed by 2010. There are also plans to extend the existing East-West MRT line beyond the current terminating station of Boon Lay, into the Jurong / Tuas area (see Figure 1). Once completed in 2009, this 4 km elevated rail extension with 2 stations will enhance the public transport accessibility into the Jurong region. With the expansion, our RTS network will have a total route length of 175km and 140 stations.

![Figure 1 – Our RTS Network by 2010](image)

ii) The Bus System

Today, Singapore’s basic bus services are provided by two operators, SBS Transit and SMRT Buses Pte Ltd which operate a total of 270 bus routes with a fleet size of 3,500 buses. Complementary non-basic services include express and rapid services, premier services, night services and supplementary services that are operated by the other bus operators, provide additional capacity during peak hours. Bus services operate from 5:30 a.m. to 1:00 a.m. the following day. Majority of our buses is today air-conditioned to improve the level of comfort of bus commuters.
To facilitate their movements, several measures are put in place to give the buses more priority on the roads. This includes the ‘B’ signals at junctions, which will come on before the green light for other vehicles, thus giving buses a ‘head start’ and allows them to filter across lanes. In addition, surveillance cameras have been installed in buses to take photographs of bus lane violations. This has helped deter motorists from encroaching into bus lanes and keep lanes clear during peak hours. Today, we have a total bus lane of about 113km across the island.

To keep pace with rising commuter expectations, bus stops are equipped with shelters to provide shade and shelter from inclement weather. In some cases, covered walkways have been provided to link bus stops to adjacent buildings. Some pedestrian overhead bridges are also provided with shelters for the comfort of bus commutes. In consideration of our hot and humid climate, our bus interchanges are today built with air-conditioned facilities. In addition, we also provide real time information on bus and train services to our commuters.

![Bus priority measure](image1)
![Covered walkways](image2)
![Bus information](image3)
![Air-conditioned bus interchange](image4)

Figure 2 – Improvements to Bus System

### iii) Taxis

At the high end of the spectrum of public transport modes, taxis play an important role in offering personalised car-like service. To date, there are about 20,400 taxis serving Singapore with an average of about 0.9 million trips per day. Taxis are operated by seven taxi companies: Comfort Transportation, CityCab, SMRT Taxis, Trans-Cab Services, Premier Taxis, SMART Automobile and Yellow-top Cab, as well as a small number of individual driver-owners.

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1 Bus lanes are road lanes for the exclusive use of buses during the bus lane operation hours. By giving buses a clear way during bus lane operation hours, bus lanes allow buses to bypass the heavier traffic on the other lanes during peak hours and travel smoothly without unnecessary disruption. This helps them to adhere to their schedules and enhance service reliability.
To further improve taxi services and optimise usage, a few measures were introduced in 1996. A Global Positioning System (GPS) was used to improve radiophone service to better match demand and supply. This was further complemented by the introduction of Share-a-Cab scheme at some taxi stands for passengers. These measures have helped to achieve faster customer request response times, shorter waiting times at taxi stands and overall better utilisation of taxis. In September 1998, taxi fares were deregulated, allowing the taxi companies to set their own fares. This provides more flexibility for operators to respond to changes in market conditions, to implement differential pricing to balance supply and demand at different times of the day, and to introduce and set prices for innovative services.

v) Integrated Ticketing System
An integrated contactless smart card ticketing system, known as the EZ-Link card, was introduced in 2002 for the entire public transport network to create a seamless travel experience for our commuters. This swift payment system has helped to reduce transaction time and thus boarding time by about 60%. This would provide greater convenience for commuters, as they would be spared the hassle of fare enquiries, searching for change or inserting the farecard into the validation machines. The smart card is today also used for a multitude of other purposes, such as for making calls at pay phones and retail purchases, thus increasing the convenience for the commuters.

Figure 3 – EZ – Link Card
Annex B – The ERP System

Components of the ERP
The ERP system comprises of the following 3 major group of components:
• In-Vehicle Unit (IU) and CashCard;
• On-site ERP gantries; and
• Control Centre.

The IU is an electronic payment device fitted on the windscreen of vehicles to facilitate payment of ERP charges by microwave and Integrated Circuit (IC) card technologies. When the stored-value IC card, known as CashCard here, is inserted into the IU (see Figure 4), money is deducted electronically via the IU when the vehicle passes through the ERP gantry. The CashCard is a common bearer stored-value card and not a dedicated transport card and is issued by a card management company formed by a consortium of local banks. It can store up to a maximum balance of S$500 and can be topped up at any automated teller machines of local banks, selected petrol stations or convenience stores when the balance runs low.

There are 6 different types of IU for 6 categories of vehicles (see Figure 4), namely motorcycles, passenger cars, taxis, goods vehicles below 16 metric ton or buses with less than 30 seats, goods vehicles above 16 metric ton or buses with more than 30 seats and emergency vehicles. Emergency vehicles like marked police cars, ambulances and fire engines are exempted from the ERP scheme. To date, more than 99% of the local vehicles are fitted with IU. Foreign vehicles driving into Singapore can choose to either purchase / rent an IU to pay as they use or pay a flat fee of S$10 per day for unlimited use of the ERP system.
The second group of components comprises those installed at the on-site gantries (see Figure 5). These includes the antennae, the vehicle detectors and the enforcement camera system. All these are linked to a controller at each of the site. Data collected is transmitted back to the Control Centre continuously through leased telephone lines.

![The antennae](image1.png)  ![Vehicle detectors](image2.png)  ![Enforcement cameras](image3.png)

Figure 5 – Components on the ERP gantry

The third group of components is at the Control Centre (see Figure 6) and includes the various servers, monitoring systems as well as 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 printed and sent out from here to all the offenders.
How the ERP Worked
The ERP is designed to be simple to use. All that is required of the driver is to insert his CashCard into the IU, whereby a diagnostic check is automatically done to ensure that both the IU and the CashCard are in working condition. Should there be a problem, the user will be alerted so that remedial action can be taken. The IU is also designed to have a low balance indicator that will alert the user should the cash balance in the Cash Card falls below a pre-defined amount.

When the vehicle passes through the ERP gantry, the IU in the vehicle will communicate with the antenna on the first gantry. The Vehicle Presence Detectors fitted on the second gantry will measure the size of the vehicle and the antenna on the same structure will confirm that the appropriate deduction by the CashCard was properly carried out and capture the electronic receipt generated by the CashCard for verification. There is a short beep, signifying a successful transaction and the remaining balance in the CashCard is displayed momentarily. Should there be insufficient cash in the CashCard or there is no CashCard, the enforcement cameras fitted on the first gantry will take a picture of the rear or the vehicle. Similarly, should the vehicle have no IU installed in it, the enforcement cameras will also take a picture of the violating vehicle. The picture is sent to the Control Centre where the registration number of the offending vehicles is read automatically using an Optical Character Recognition technique. A pictorial illustration of how the ERP system work is shown in Figure 7.
As the vehicle approaches the gantry, the IU communicates with the ERP antenna.

The Vehicle Presence Detector confirms the size of the vehicle and an appropriate ERP charge is deducted.

For cases of violation, the enforcement camera will capture photo of rear licence plate.

Figure 7 – How the ERP System Works
Annex C – The ERP System

To discourage motorists from trying to beat the higher ERP rate by speeding up or slowing down and even waiting in front of the ERP gantry, LTA decided to make ERP changes more gradual and introduced graduated pricing for the ERP rates in Feb 2003. The graduation was in the form of shoulder pricing and is applicable when the change in ERP rates from one half-hour period to the next is at least $1 per Passenger Car Unit, and to the period where the rate is higher. The graduated ERP rate was introduced in the first 5 minutes of the next period, if there is an increase in ERP rate, or the last 5 minutes of the current period, if the next period has a lower ERP rate. In an event where the ERP rate reaches a pinnacle, graduated pricing is applied to both the first and last 5 minutes of the same half-hour time slot. The shoulder rate will be set at a mid-way of the rates of the two successful time slots, i.e.:

$$\text{Shoulder Rate} = \text{Prior rate} + 0.5 \times (\text{Later rate} - \text{Prior rate})$$

As an example, the ERP rates for cars at the Ayer-Rajah Expressway gantry for the two half-hour periods from 8am to 9am are $0.50 and $1.50 respectively. As the difference in rates between the two consecutive time periods is $1.00, graduated pricing was applied to the period with the higher ERP rate, i.e. 8:30am to 9am. With graduated pricing, the ERP rate for the time period from 8:30am to 8:35am will be $1.00. The full rate of $1.50 will only kick in from 8:35am onwards.