CONTENTS

EXECUTIVE SUMMARY

Background

i. In 1994, Government set up a Working Party to examine measures to tackle traffic congestion in Hong Kong. The Working Party proposed to continue to pursue the balanced transport strategy of building new infrastructure and managing vehicle use and ownership. A package of both long term and short term measures was put forward for consideration. One of the measures considered was the subject of this Study, Electronic Road Pricing (ERP), in view of technology advancement and its effectiveness in managing road use.

ii. Until the economic downturn in 1998, the vehicle fleet was increasing at a fast rate. Despite that, average traffic speeds in the urban areas have been maintained at about 20 km/h over the past twenty years. This has been achieved by a combination of ownership restraint measures such as First Registration Tax (FRT) and Annual Licence Fee (ALF), an efficient public transport system, road network improvements and effective traffic management schemes. Considering the high GDP per capita, these restraint measures had been successful. In Hong Kong there are less than 50 private cars vehicles per 1,000 population, compared to more than 100 in Singapore and Seoul, more than 200 in Jakarta and over 300 in Bangkok. Only about 11 per cent of daily person trips are made by private cars vehicles while 89 per cent use public transport. Nevertheless, it was considered that the adoption of the "user-pays" principle would offer a more efficient, equitable and flexible means of managing the road space particularly in congested areas during busy hours.

Study Approach

iii. The Feasibility Study on ERP (the Study) was commissioned in March 1997, with the objective of examining the practicability of implementing an ERP system in Hong Kong and assessing the need for such a system to meet transport objectives. The Study has evaluated ERP's essential components, cost effectiveness and consequences, giving due consideration to transport planning, systems technology and public acceptance.

iv. The Study reviewed worldwide development of road pricing, assessed future traffic conditions under a range of scenarios, considered alternatives to ERP, undertook field evaluation of the technology options, considered environmental impacts, considered legal and procedural issues, investigated system design issues, explored integration with Intelligent Transport Systems (ITS) applications and prepared an outline for public consultation.

ERP in Concept and in Practice

v. In a congested environment, each additional trip causes all other similar trips to be delayed. This delay to other users has a cost which is referred to as the "external" cost, and is much greater than the cost of the trip to individual users. The economic theory underlying road pricing is to bring these costs into consideration and, as a result, allocates road space more efficiently. Those prepared to pay obtain a higher quality of service, and the absence of those not prepared to pay benefits all remaining road users including public transport passengers.

vi. There are schemes being operated in the United States of America and Singapore which have proven that the concept is workable. At present, ERP is being considered in the Netherlands, United Kingdom and Japan.

Technological Options

vii. Various technological options were assessed by the Study under a set of criteria including capital and maintenance costs, system accuracy and reliability, limitations, security against fraud, integration with existing toll systems and smart cards, anonymity, etc. Two options, namely the Dedicated Short-Range Communications (DSRC) System and the Vehicle Positioning System (VPS), were selected for field evaluation.

viii. The DSRC system is based on an interchange of information between roadside readers and in-vehicle units (IVU) using low power microwave communication. This is similar to the operation of the existing Autotoll system at various toll facilities in Hong Kong.

ix. The VPS effects charges by an IVU based on the location of the vehicle using the satellite-based Global Positioning System (GPS). No roadside equipment is required at charge points but violation enforcement stations are required at strategic locations. A wireless data communication network is provided between the vehicles and the control centre for transaction data transmissions, database updating and enforcement verification.

Field Evaluation

x. Field trials were conducted at both off-street and on-street test sites for a period of two months in late 1998 under a range of conditions to determine the robustness and reliability of the systems. The results proved that both DSRC and VPS technologies could be adopted for an ERP system in Hong Kong. While both technologies achieved a high degree of accuracy for its charging function, the enforcement accuracy of both systems could be further enhanced by a vehicle-specific coding system.

xi. DSRC technology is more mature and available for implementation in the near future. However, it requires roadside equipment at every charging point. This makes DSRC less flexible and adaptable to changes in charging zones due to dynamic traffic conditions. It also presents installation difficulties because of the existing underground utilities making it progressively more expensive with the introduction of each change. In addition, DSRC can only communicate with the vehicle when it is directly under the charging station. This limits its adaptability to ITS and Transport Information System needs.

xii. VPS technology, on the other hand, offers greater flexibility and adaptability. It provides vehicle location information and wide area communications to the driver. It may also better fit future ITS and Transport Information System needs. Although the present cost of VPS is higher than DSRC, the projected cost of VPS is dropping at a rate faster than that of DSRC. Hence, taking into account various aspects such as adaptability, flexibility and better integration with ITS, VPS technology offers the best-balanced choice for ERP in the longer term.

Alternative Traffic Management Measures

xiii. Measures that could improve the functioning of the transport system may be categorised into supply management and demand management. Supply management are measures that increase the supply of road or rail capacity, add or improve public transport services. Demand management are measures that limit the number or usage of vehicles using the road network. There are two alternative approaches to managing traffic demand. The first one is ownership restraint by regulation and fiscal measures such as quota systems, parking policies, FRT and ALF. The second alternative measure is usage management that imposes restraints on the use of vehicles such as an "odd-even" number

plate system, restrictions on access or charging for usage. However, as the causes of traffic congestion differ from district to district, there is no simple solution that can be applied universally.

xiv. ERP and the alternative traffic management measures are not mutually exclusive. ERP can reinforce the effects of both ownership and usage restraints. It also provides the financial incentive for motorists to switch to public transport. The diversion and mode switch make more efficient use of the existing road network by reducing the number of vehicles on the roadway thereby delaying or eliminating the need to build more infrastructure.

Need for ERP

xv. The existing policy is that growth in the private vehicle fleet should not significantly exceed 3% per year. If the growth of the private vehicle fleet size is not greater than 3% per year, the traffic conditions will be similar to those experienced over the past two decades. As a result, additional restraint measures on the main east-west corridor on Hong Kong Island may not be warranted on traffic management grounds before 2006, although some localised traffic congestion may occur at the busy hours. Whether ERP will be required after 2006 depends on public acceptability of the forecast traffic conditions in terms of traffic speeds, control on the growth of the vehicle fleet, improvements to transport infrastructure and public transport services. The need for ERP will also diminish after 2010, as the completion of Central-Wan Chai Bypass will relieve the traffic congestion along the main east-west corridor. For Kowloon, additional restraint measures will not be required at least until 2011, the planning horizon of the current study.

xvi. It is worth noting that the projected traffic speed on the main corridors on Hong Kong Island in 2006 and 2011 are higher than those of present day Tokyo, central London and New York. Tokyo and London are currently considering road user charging systems to help alleviate traffic congestion during peak periods.

Possible ERP System for Hong Kong

xvii. The Study has looked into a possible ERP system for Hong Kong covering the following aspects.

xviii. Charging Method - A cordon-based charging scheme is preferred in comparison with distance-based, time-based and congestion-based for its simplicity in both operation and enforcement, and technology readiness. Directional charging, i.e. charging on entering in the morning and exiting in the afternoon, is preferred to bi-directional charge whereby charging will be imposed on both directions during the busy hours.

xix. Charging Zone - It should only cover areas that are perceived to be the most congested and well served by public transport to provide opportunities for road users to change mode of travel. A single zone encompassing Central, Wan Chai and Causeway Bay is preferred to multiple charging zones which will add complexity to the scheme.

xx. Charging Period - Charging periods are considered in terms of their overall economic benefits according to traffic volume at different times of the day. The analysis showed that peak hours charges should apply from 8:00 am to 9:00 am and from 5:30 pm to 7:00 pm and a slightly lower charge for the inter-peak hours. To reduce the problem of "bunching", shoulder periods at lower charge rates for 30 minutes before the morning and after the evening peaks are proposed. No charge is envisaged for the overnight period from 7:30 pm to 7:30 am or on Sundays and Public Holidays.

xxi. Charging Rate - The required level of charge is determined by the target traffic speed to be achieved. Based on the historical average traffic speed, a target speed of 20 km/h was adopted for the model tests. Charges under the test target speed range from $8 to $31 depending on the period of the day and the traffic demand growth scenarios.

xxii. Exemption - ERP provides the flexibility to differentiate charges by vehicle type and to exempt a particular vehicle type from charge. However, exemptions other than for emergency vehicles must be thought through carefully because all trips contribute to congestion. Any exemption to be granted has to be evaluated against the basic principles of equity, efficiency and public acceptability.

Impact of Possible ERP Scheme

xxiii. It was estimated that 40% of car trips in the morning peak may be diverted to public transport and 10% may change time of travel. The remaining 50% may stay-and-pay the road user charges but will benefit from higher travel speeds and less congestion.

xxiv. While the ERP may bring about some improvement in the air quality in the charging zone, the environmental conditions of other areas show some deterioration due to the overall redistribution of traffic in reaction to the ERP charging zone.

Complementary Measures

xxv. ERP will divert car and taxi trips to public transport, producing a small percentage increase in overall demand for public transport. Complementary measures such as providing park and ride facilities, improving public transport interchanges, providing feeder services and improving public transport information system should be considered.

Implementation Strategy

xxvi. ERP offers a more precise tool to tackle traffic congestion in specific areas. Singapore experience indicates that a revenue neutral scheme would increase public acceptance. However, it should be noted that Singapore maintained a quota on the vehicle fleet. The implementation strategy may, for instance, include a reduction in FRT/ALF and use of the ERP revenue towards a traffic management and information centre and ITS applications to provide real-time information about existing traffic conditions to road users and suggest modes of travel for public transport.

Implementation Programme

xxvii. Singapore took about six years to implement the ERP system. Given that the DSRC technology has since become more mature, the lead time for the installation of a DSRC system in Hong Kong is expected to take about five years. The lead-time for VPS would likely be longer because there is no off-the-shelf product available in the market and the installation of the in-vehicle units may be more complicated. An estimated six years lead time would be required.

ERP & ITS Integration

xxviii. The Study identified potential areas that both DSRC and VPS technologies could be employed with other ITS applications in Hong Kong, most of which were demonstrated during the Field Evaluation. If ERP was not required to be implemented in the near future, the ERP technology could still be employed in fleet management, taxi dispatch, non-stop tolling, traveller information and integration with other ITS applications. These applications would have a positive economic benefit and provide for greater operational efficiencies that would benefit motorists and

public transport alike. The overall effect of integrating ERP with ITS is synergy. Together, ERP and ITS would provide a more robust, effective and cost efficient transport system than either could deliver separately.

Benefits of ERP

xxix. The *transport operation benefits* relate to reduced vehicular traffic, particularly during congested periods, reduced travel times, increased public transport use and higher car and taxi occupancy.

xxx. The *economic benefits* derive from reduced traffic delays accrued to all road users and to the community at large. The estimated net economic benefit resulting from journey time savings and lower vehicle operating cost is about $2 billion/year. On the other hand, the estimated cost for the proposed ERP scheme is $1 billion (including the cost of in-vehicle units for existing vehicles) with an annual recurrent cost of $200 million. ERP is forecast to generate annual gross revenue of $0.4 to 1.3 billion. If it is decided to adopt a revenue neutral scheme, this revenue can be ploughed back for transport infrastructure investment.

xxxi. The *environmental benefits* involve reduced vehicle emissions and reduced exposure to traffic noise inside the charging zone. However, the environmental conditions of other areas may witness some deterioration due to the overall redistribution of traffic. ERP therefore can assist in the overall improvement to the environment, but is not the sole solution to the complex issue of air quality and noise abatement. If ERP is to be used to meet environmental objectives, further studies will need to be conducted to define the parameters, benchmarks and related implementation details.

Public Consultation

xxxii. Implementation of ERP will not be possible without a general public consensus on the objectives and principles of the proposal. A well-planned and executed public consultation programme to demonstrate how ERP works and to allow public input into the development of system objectives can promote awareness of the ERP system as a measure to relieve traffic congestion and develop understanding in the community for its possible introduction. The public should be consulted specifically on the acceptable traffic condition in terms of traffic speeds, size of the charging zone, the charging level, the type of vehicles which may be charged and the use of the ERP revenue.

Findings and Recommendations

xxxiii. Major findings of the Study

- Both DSRC and VPS technologies can be adopted for a possible ERP system in Hong Kong.
- DSRC is more mature and ready for implementation in the near future with a lead time of about 5 years.
- VPS offers the best-balanced choice in the longer term because of its adaptability, flexibility and better integration with ITS and the lead time is about 6 years.
- ERP technology could be integrated with or employed in other ITS applications such as fleet management, multi-lane tolling and traveller information.
- ERP could generate transport operation, economic and environmental benefits.
- ERP and other alternative traffic management measures are not mutually exclusive.

- ERP could be used to support the funding of new transport initiatives and an integrated transport policy.
- While ERP can be so designed to achieve environmental objectives, a separate study will be required to define the parameters, benchmarks and implementation details.

xxxiv. Key recommendations of the Study

- Drastic restraint measures are not warranted on traffic management grounds before 2006 if the growth of the private vehicle fleet is no more than 3% per year.
- Closely monitor the GDP growth, vehicle fleet size and infrastructure programme.
- Actively monitor the development of ERP technologies and ERP projects in Singapore, USA, UK, the Netherlands and Japan.
- Initiate a public consultation programme to promote public understanding of the traffic congestion problem and how a possible ERP system will work in Hong Kong.

xxxv. Specific issues for public consultation:

- Whether ERP is needed after 2006 in consideration of acceptable traffic speeds, vehicle fleet size and expansion and improvement of transport infrastructures and public transport services?
- If needed, whether ERP should be implemented as a revenue neutral scheme.
- If needed, what should be the charging method, charging zone, charging period, charging rate and exemptions.

1. INTRODUCTION

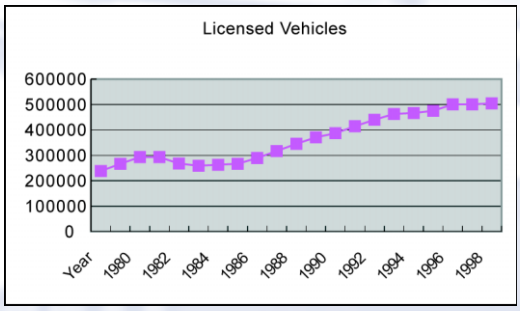
Background of the Study

1.1 The economic boom of the mid-1990s and the associated growth in transport demand threatened a rapid worsening of traffic congestion. Consequently, Government set up a Working Party in 1994 to examine measures to tackle traffic congestion in Hong Kong. One of the measures considered Electronic Road Pricing (ERP) was the subject of this study.

1994 Working Party Report

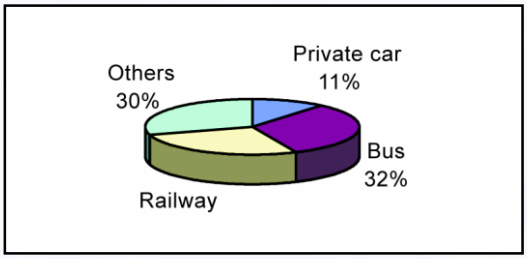
1.2 The Feasibility Study of ERP was commissioned in March 1997, with the objective of examining the practicability of implementing an ERP system in Hong Kong and assessing the need for such a system to meet transport objectives. The Study has evaluated ERP's essential components, cost effectiveness and consequences, giving due consideration to transport planning, systems technology and public acceptance.

1.3 Until the recession-induced slowdown in 1998, the number of vehicles on the roads at times was increasing at a rate faster than that we feel comfortable with. Nevertheless, average traffic speeds in urban areas were maintained at about 20 km/h over the past twenty years. This was achieved by a combination of ownership restraint measures including increase of First Registration Tax (FRT) and Annual Licence Fee (ALF), an efficient public transport system, road network improvements and effective traffic management schemes.



Growth of Vehicle Fleet in last 20 years

1.4 Recognising that the Hong Kong road network cannot accommodate an unrestrained number of vehicles, the growth of the vehicle fleet has been controlled in the past by means of occasional increases in FRT and ALF. These ownership restraint measures together with relatively high operating costs due to fuel taxes and parking fees have limited the growth of vehicles to provide Hong Kong with one of the lowest rates of cars per capita in the region. In Hong Kong there are less than 50 private cars per 1000 population, compared to more than 100 in Singapore and Seoul, 200 in Jakarta and 300 in Bangkok. Considering the high gross domestic product (GDP) per capita, these restraint measures were successful as approximately 11 per cent of daily person trips are made by private vehicles while 89 per cent use public transport.



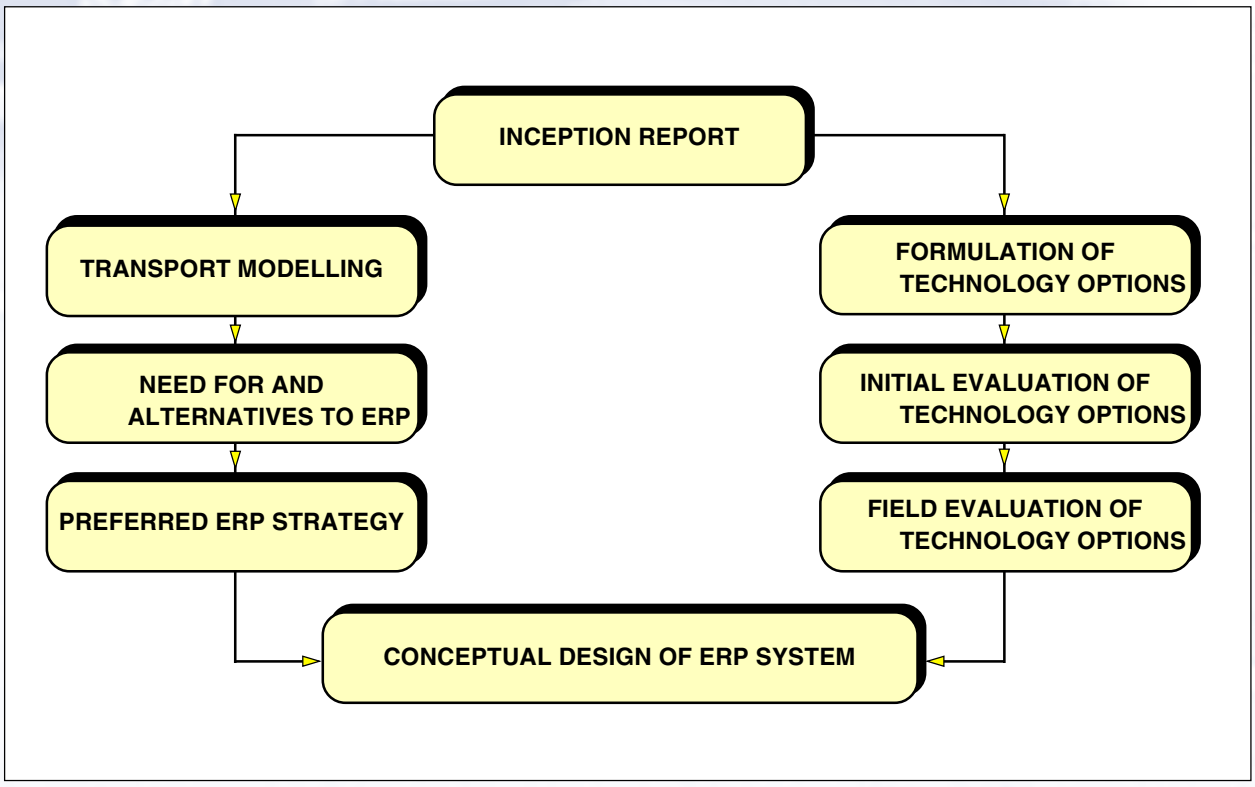
Distribution of Personal Trips

1.5 The Study evaluated means to improve the mobility of people and goods, based on the premise that the "user-pays" principle would offer a more efficient, equitable and flexible means of managing the road space. In addition to evaluating road pricing, alternatives to ERP were also considered to compare the effectiveness of such measures. To accomplish the project objectives, the Study also reviewed complementary measures that could be introduced in conjunction with road pricing.

Study Approach

1.6 The Study seeks to provide the definitive answer concerning the feasibility of introducing ERP in Hong Kong. The Study developed a structured framework that provides a sound basis for decision-making and public acceptance. To this end, the Study:

- reviewed worldwide development of the concept and application of road pricing;
- assessed future road network operating conditions under a range of future scenarios to determine the requirements for road pricing;
- considered the alternatives to ERP as approaches to manage or accommodate traffic growth;
- undertook field evaluation of the technology options;
- examined the effect of alternative ERP strategies under a range of economic and travel demand growth scenarios;
- considered how ERP might be used to achieve environmental objectives;
- considered legal and procedural issues surrounding the implementation of ERP;
- investigated system design issues including an assessment of the technology, resource implications of implementing and operating ERP;
- explored the relationship between ERP and ITS for possible cost savings and efficiency;
- prepared an outline of options for public consultation.



2. ROAD PRICING IN CONCEPT AND PRACTICE

Principle Underlying Road Pricing

2.1 Charging for the use of infrastructure is not a new concept. Tolled tunnels, bridges and highways have been in operation for centuries. Generally, tolls are collected to cover the cost of provision of the infrastructure or for funding new infrastructures. In Hong Kong tolls are levied on most road tunnels as well as in the Tsing Ma Control Area.

Autotoll System

2.2 Unlike toll road systems, ERP charges vehicles for usage of the road at times when its capacity falls well short of demand. It manages demand and, by varying charges to reflect the degree of congestion, smoothes out peak flows. Road users are encouraged to choose whether, when and where to travel, depending on the importance of the trip, and the alternative routes, travel times or transport modes available. They may decide to change mode, travel time, destination or not to undertake the trip. Those who choose to pay and travel as before benefit from an improved quality of service and more reliable travel times, due to the absence of those who choose not to pay.

2.3 The price of road space can be set to produce any desired level of service on the network, but clearly in order for road pricing to be implemented charges must be subject to a general consensus amongst users concerning acceptable levels. It is quite possible that as the benefits of congestion relief become apparent, the "tolerated" level of congestion will become lower.

Economic Theory for Road Pricing

2.4 On congested roadways, each additional trip causes all other similar trips to be delayed. This is because each vehicle reduces the speed of other road users. This delay to other users has a cost which is referred to as the "external" cost, and is much greater than the cost of the trip to the individual user. The economic theory underlying road pricing is that it is inefficient for these external costs not to be reflected in deciding whether to make the trip or not. Road pricing brings these costs into consideration and, as a result, allocates road space more efficiently. Those prepared to pay obtain a higher quality of service and the absence of those not prepared to pay benefits all remaining road users.

2.5 Motorists incur travel time and out-of-pocket costs for fuel, tolls and other vehicle operating costs associated with each trip they make. Although these costs may be substantial in congested conditions, a trip may still be made if the value derived from the trip outweighs these costs. However, if the value is less than the sum of the individual costs and the external cost imposed on others, then road users as a whole suffer.

2.6 By charging for the use of a congested road network, the motorist would only use the road if the value of the trip exceeded the sum of the road pricing charges and the other trip costs. In this manner, trip-making (for which the cost to society as a whole exceeds the benefits) can be deterred. Congestion costs also include other external costs, such as air pollution, noise and accident costs. Hence,

it can be argued that the price to be charged should reflect the overall social cost of congestion, environmental damage and accidents.

Worldwide Developments in Road Pricing

2.7 There are operational congestion pricing schemes on existing toll facilities in the USA including the SR91 and I-15 Congestion Pricing Projects in California, Lee County Expressway in Florida and Hardy Toll Road in Texas. Unique in approach is the California SR91 project, in which new lanes were added in the median. These new lanes are tolled in accordance with congestion or traffic levels on the free parallel lanes. As congestion of the free portion increases, the congestion charge for crossing over into the toll lanes also increases.

2.8 In other countries, road user charging has been introduced to generate a new source of funding for building additional infrastructure. In each case, traffic is charged on existing road space to generate a transport fund. This transport fund is used to build new transport infrastructure and services. Traffic congestion relief is a secondary benefit of road pricing. Examples include the toll rings in Bergen, Oslo and Trondheim in Norway. South Africa, Tasmania and New Zealand are planning a similar approach to Norway's. In South Africa's Gauteng Province, the motivating factor is also the lack of funding for transport and the attempt to make transport self-sustaining.

2.9 ERP can also be used as part of a sustainable and integrated transport policy. It acts to suppress demand while other components of the policy designate balanced land use and improve infrastructure supply and public transport services. Ultimately, it aims to balance these objectives while improving the environment. ERP's role is to support these initiatives by freeing valuable road space and thereby reducing the needs for road infrastructure and minimising environmental impacts. It plays a role in supporting public transport by diverting car and taxi users to bus, tram, and rail services. Examples included the proposed Rekening Rijden Scheme in the Netherlands, proposed Road User Charging scheme in London, Bristol, Leeds, Edinburgh and other cities in the UK, and road pricing studies in Dublin, Ireland and Tokyo, Japan.

ERP Test in the Netherlands

ERP System in Singapore

2.10 In September 1998 Singapore became the first city in the world to implement an ERP system. Prior to the implementation of ERP, Singapore had a manual Area Licensing Scheme (ALS) in operation since 1975. The most congested parts of the city of about 720 ha was designated as the Restricted Zone (RZ) and an imaginary cordon was demarcated on the approach roads leading to it by 33 overhead gantries. This area, which is about 1.2% of the total area of the state of Singapore, is served by a good arterial road network and has a ring road skirting it. To enter this RZ during the period of 7.30am to 7.00pm on weekdays and 7.30am to 2.00pm on Saturdays, vehicles (other than emergency vehicles such as fire engines, ambulances and police cars) had to purchase and display an area licence on their windscreens or handle bars (for motorcycles).

2.11 Area licences came in monthly and daily forms and were coded by colour and shape

for easy identification by enforcement personnel stationed at the entry points at the overhead gantries on the approach roads. 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 the entry. They could not be bought at the entry points, as in the case of a toll road.

Electronic Road Pricing in Singapore

The area licences had different prices for different categories of vehicles and also for peak and off-peak usage.

2.12 Enforcement was carried out at the entry point. Police stationed at the entry points during the hours of operation of ALS visually checked whether the vehicles displayed a valid area licence. Violators were not stopped, but the details of the vehicles were noted and they were sent a notice to pay a fine for entering the RZ without a valid licence. There was no policing within the RZ. Vehicles were free to move around or leave the RZ. Using the same area licence vehicles could make multiple trips daily into the RZ.

2.13 In the 1990's, following the success of the Area Licensing Scheme, a similar manual pricing system called the Road Pricing System (RPS) was introduced progressively along congested sections on three major expressways to operate on weekdays from 7.30am to 9.30am. Vehicles had to purchase and display special road pricing licences to pass under these charging points on the three expressways during the hours of operation.

2.14 The ALS for the Restricted Zone (RZ) and the manual RPS for the expressways had been successful in keeping traffic congestion within manageable levels on the Singapore road network. The ERP System was implemented on 1 September 1998 to replace the two manual systems. The ERP system has the following advantages over the manual system in these areas:

Area Licence Scheme in Singapore

- it is easier to assign different rates to different vehicles
- it is easier to change rates
- it is easier to change the hours of operation
- it is relatively easier to include more areas under pricing or to remove areas from pricing

2.15 The Singapore ERP System employs dedicated short range communication (DSRC) technology using microwave wireless communication for interchange of information between overhead readers and the in-vehicle units (IVU). Gantries were installed at all charging points for supporting the overhead charging and enforcement equipment. Each vehicle passing through is detected and classified by the system, and the appropriate charge is sent to the IVU through the DSRC link. The IVU then deducts the amount from a smart card inserted in the

IVU. If the charge is made successfully, there is no need to record the vehicle's identification or its location. If there is insufficient balance on the smart card or intent to evade payment, the enforcement cameras will capture an image of the vehicle's number plate for enforcement.

2.16 As complementary measures, rebates on annual licence fees were offered, an estimated 15,000 to 20,000 additional Certificates of Entitlement (CoE is a document required for purchase of a vehicle) was made available over a three year period, and park and ride facilities at MRT stations and bus interchanges have been introduced.

2.17 After the change of ALS to ERP, there are significant reductions in the number of vehicles entering the RZ during the morning peak hours and for the rest of the day. The daily reduction for the ERP period after one year of operation as recorded in August 1999 is 15%, while the reduction for the morning peak traffic period of 7.30am to 9.30am is about 16%.

2.18 ERP rates in Singapore are reviewed at quarterly intervals. Changes are triggered by the prevailing traffic speeds along the roads within the RZ and the expressways during each half-hour interval. The ERP rates will be adjusted if the prevailing traffic speeds fall outside the optimal ranges of 20 to 30 km/h and 45 to 65 km/h in RZ and the expressway respectively. When the average prevailing speeds on the affected section of the expressway or selected roads in the RZ was below 45 km/h or 20 km/h respectively, the ERP rates will be raised. Similarly, when speeds exceeded the higher value of 65 km/h or 30 km/h, ERP rates will be reduced. These speed figures for rate adjustments are made public and such adjustments of ERP rates have found favour with the motorists. In essence, the motorists' behaviour decides the ERP rates. Since the start of the scheme, ERP rates for the RZ have been revised twice within the first year and the charges on Saturdays discontinued.

Pilot Scheme on ERP in Hong Kong

2.19 Hong Kong conducted a Pilot Scheme on ERP from July 1983 to March 1985. It demonstrated that ERP was technically feasible and could produce economic benefits. The then-proposed technology tested over a six-month trial period was a form of automatic vehicle identification, in which each vehicle had an electronic number plate, the size of a videocassette tape, mounted underneath. This device was queried when it passed over a power loop embedded in the road, relaying the vehicle's identification number to a roadside computer. Closed circuit television identified vehicles whose automatic number plates were faulty or tampered with. There were eighteen toll sites around the Central Business District (CBD) on Hong Kong Island and 2,500 vehicles were fitted for the trial. A central accounts computer produced a billing for each vehicle.

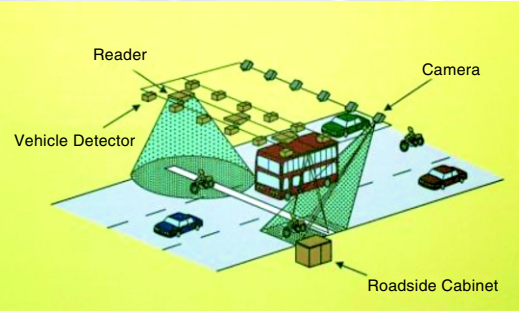
2.20 For a number of reasons, ERP was not implemented and the Study was shelved. One of the factors was the improved traffic conditions resulting from the tripling of ALF and the doubling of FRT and fuel tax in 1982. There was an economic downturn at the time of the Study that raised concerns over the addition of another perceived tax on the road user. Another influence was the opening of the Island Line which provided better public transport and improved travel times. The combination of these factors provided a general sense of improved transport operating conditions and undermined the need for further restraint measures. In addition, there was strong objection against the possible invasion of privacy resulting in a low level of public acceptability.

3. TECHNOLOGICAL OPTIONS FOR ERP SYSTEM

Desktop Review

3.1 A desktop review of worldwide road pricing and related experience together with survey on ERP components currently available in the market or under development were conducted to identify technological options that may be suitable for implementing ERP in Hong Kong.

3.2 The various technological options were then assessed under a set of 20 criteria including capital and maintenance cost, system accuracy and reliability, limitation, security against fraud, integration with existing toll system and smart cards, anonymity, etc. Two options, namely Dedicated Short Range Communication (DSRC) System and Vehicle Positioning System (VPS), were selected for field evaluation.



The Dedicated Short-Range Communications System

3.3 The DSRC system is based on an interchange of information between roadside readers and in-vehicle units (IVU), using 5.8 GHz microwave communication between the IVU and overhead readers over short distances and low power emissions. This is similar to the operational characteristics of the existing AutoToll system operating at various toll facilities in Hong Kong.

3.4 Gantries or steel frames attached to flyovers or other overhead structures are installed at the charge sites for supporting the roadside equipment. Each vehicle passing under the gantry is detected and classified by the system, and the appropriate charge is sent to the IVU through the DSRC link. The IVU then deducts the amount from a smart card or transmits an account number for debiting the charge to a centrally-held account, if the motorist opts for it. If the charge is made successfully using a smart card, there is no need to record the vehicle's identification or its location. The privacy of the individual is thus protected.

DSRC In-Vehicle Unit with Smartcard

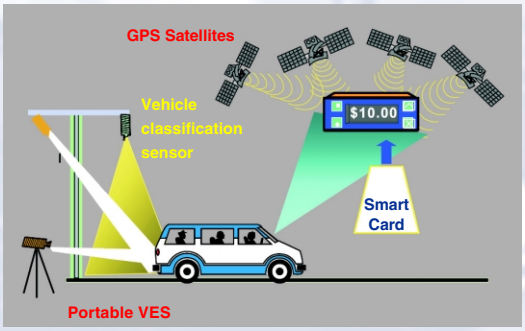
3.5 If there is insufficient balance on the smart card or intent to evade payment, the violation enforcement system (VES) installed at the charge site captured an image of the vehicle's license plate for enforcement.

VPS In-Vehicle Unit with User Interface

3.6 The VPS effects charges by an IVU based on the location of the vehicle using the satellite-based Global Positioning System (GPS). Positional accuracy is improved using Differential GPS (DGPS), dead reckoning through a solid-state compass and odometer

connection, and map-matching for parts of the network where GPS reception is impossible, such as tunnels.

3.7 Data defining the charging zones, charging periods and charge rates are stored in the IVU. When the IVU determines that it has entered a charging zone, it deducts the appropriate charge from the smart card without the need to communicate with any roadside equipment. If the smart card is charged successfully, there is no need to record the vehicle's identity or location, thus protecting privacy. Central accounting is specified as an alternative, in which case the identity of the vehicle together with accumulated charges are periodically transmitted back to the control centre for processing.



The Vehicle Positioning System

3.8 No roadside equipment is required at charge points. A wireless data communication network is provided between the vehicles and the control centre for transaction data transmissions, database updating and enforcement verification.

3.9 Enforcement for VPS is carried out at a few fixed enforcement sites and supplemented by portable and mobile equipment. The enforcement equipment consists of a Vehicle Detection and Classification (VDAC) sub-system and a Violation Enforcement System (VES). Images of the rear of vehicles identified as potential violators are transmitted to the control centre.

Field Evaluation

3.10 Field trials were set up at two off-street tracks at Kai Tak and five fixed on-street sites in Wan Chai. The trials took place over a two-month period with 75 equipped vehicles. The test programmes were designed to assess the suitability of each system as the basic technology to implement ERP in Hong Kong. Tests included a range of conditions designed to provide information about the performance of the system in adverse conditions and to determine their robustness and reliability.


Vehicle testing under Gantries at Kai Tak

Performance of Trial Systems

3.11 The performance of an ERP system is measured by its ability to charge vehicles correctly and to detect violation vehicles. In the field evaluation, an overall weighted average accuracy of 99.24% and 99.25% was achieved for transactions under DSRC and under VPS systems respectively. With fine-tuning and system adjustments, supplementary testing suggested that 99.99% accuracy was achievable with both technologies.

3.12 Both DSRC and VPS systems use a vehicle detection and classification sub-system (VDAC) and vehicle enforcement sub-system (VES) for enforcement. The camera will be triggered to take an image of the vehicle licence plate if a proper transaction cannot be verified. The accuracy of the enforcement system for DSRC was 70%. The accuracy of the VPS enforcement system tested in the field

evaluation at only 24% was far from satisfactory and required substantial fine-tuning of the system. It is expected that the accuracy of the VPS enforcement system will improve with better system integration and technological advancement in the coming years.

3.13 The accuracy of both enforcement systems should be able to be improved to over 90% by including a vehicle specific coding system, in which a unique serial number is assigned to each in-vehicle unit. If a valid transaction cannot be made, the roadside computer will read the serial number of a violation vehicle and extract its identity from the database kept by the operator.

3.14 The field evaluations demonstrated that technology exists to implement an ERP system while still protecting the privacy of the individual as defined in the Personal Data (Privacy) Ordinance (see 3.4 - 3.9). However, if a higher accuracy rate (above 70%) of the DSRC or VPS enforcement system is considered necessary, a vehicle-specific coding system is required. The coding system can help to identify the violation vehicle but may also expose the identity of the motorists. Consideration will need to be given as to how privacy issues should be balanced against enforcement accuracy.

Technological Option for Hong Kong

3.15 Field evaluations proved that both ***DSRC*** and ***VPS*** technologies could be adopted for an ERP system in Hong Kong. DSRC technology is more mature and available for implementing ERP in the near future. It has been used successfully for the ERP systems in Singapore and free-flow, non-stop toll collection systems in the United States, Canada and Australia. However, it requires overhead and/or roadside equipment at every charging point. This makes DSRC less flexible and adaptable to changes in the charging zone. It also presents programme issues for installation because of the prevalence of utilities along sections of the existing road network. The dynamics of traffic and the need to adjust and/or expand the charging zone over time also make it progressively more expensive with the introduction of each change. In addition, DSRC can only communicate with the vehicle when it is directly under the communications antenna. This limits its adaptability to Intelligent Transport Systems (ITS) and Transport Information System needs.

3.16 VPS, on the other hand, offers greater flexibility and adaptability. It provides vehicle location information and wide area communications to the driver at a lower systems cost. It also better fits with future ITS and Transport Information System needs. However, while such a system has been tested in Germany, New Zealand and Tasmania, there is as yet no working VPS based ERP system. Furthermore, the present cost of VPS is higher than DSRC, but the projected cost of VPS is dropping at a rate faster than that of DSRC. It is estimated that VPS will be about 2% more expensive than DSRC in the immediate future. Hence, taking into account various aspects such as adaptability, flexibility and better integration with ITS, VPS-based technology offers the best-balanced choice for ERP in the longer term. It is recommended that the VPS technology be actively monitored over the coming years.

3.17 Locally, Global Positioning Systems (GPS - the core system upon which the VPS system is built) are finding more applications. The CityBus Company has used GPS location system for their bus fleet management for Route No. 11. Both the Fire Services Department and Police are installing their fleet management and dispatch systems using GPS. Although their applications are different from the VPS based ERP system, their experience should also provide valuable insights into the use of positional location technology over the next several years.

4. ALTERNATIVE TRAFFIC MANAGEMENT MEASURES

Measures to Improve the Transport System

4.1 Measures which would improve the functioning of the transport system can be divided into two categories:

- supply management; and
- demand management.

Supply Management

4.2 Supply management includes measures that increase the supply of road or rail capacity, either through new construction or widening, or through techniques designed to maximise or enhance the capacity of existing infrastructure. The following measures have been considered:

- road infrastructure - unlikely to provide significantly increased capacity due to cost, environmental impact and social concerns particularly in built-up areas.
- public transport provision - spare road capacity as a result of shift from private to public transport is likely to be taken up by suppressed demand quickly.
- traffic management measures - probably scope for improvement at local spots adding little overall system-wide capacity.

Demand Management

4.3 There are two alternative approaches to managing traffic demand.

- ownership restraint addresses the congestion problem at source by discouraging or limiting the ownership of vehicles by
  - regulatory measures such as quota systems and parking policies (availability, controls and charges)
  - fiscal measures such as First Registration Tax (FRT) and Annual Licence Fee (ALF). Both are effective measures. ALF in particular causes car owners to re-evaluate the need for the vehicle regularly.
- usage management imposes restraints on the use of vehicles by
  - operating permits such as the "odd-even" number plate system.
  - restrictions on access such as pedestrianisation scheme.
  - public transport priority such as bus only lanes.
  - high occupancy vehicle priority to encourage car pooling.

4.4 Ownership or usage regulation may be supplemented by introducing incentives to encourage more efficient use of vehicles and the transport system in general. Such policies, classified as behavioural incentives, include:

- park and ride facilities at rail stations and major public transport interchanges;
- intelligent transport systems with a variety of measures to provide better information to the commuters;
- mode change incentives such as vanpooling subsidised by the employer;
- flexi-time or staggered working hours; and
- tele-commuting.

4.5 Finally, fiscal controls may be employed to supplement other policies by limiting vehicle use through pricing. Fiscal controls include:

- fuel tax; and
- road tolls at tunnels and bridges.

Alternative Measures to ERP

4.6 As can be seen above, different alternatives to ERP are available to tackle forecast traffic congestion. Fiscal measures such as FRT and ALF have been used to control vehicle ownership successfully in the past while traffic management measures such as bus priority schemes and park-and-ride schemes have been implemented to relieve local traffic congestion. The increased use of ITS will enhance the efficiency of the road network and thus better manage the available supply and smooth traffic flows without building more roads. As the causes of traffic congestion differ from district to district, there is no simple solution that can be applied universally.

4.7 Raising FRT and ALF are rather blunt but very effective measures in improving traffic conditions. Increasing them to high levels would have a significant impact on traffic volume at the busiest times and locations. Yet, it undermines people's desire to own a car for leisure trip and use it in areas which are less congested or at times when the traffic is less busy, e.g. on Sundays and Public Holidays.

4.8 The adoption of the "user-pays" principle would offer an efficient and flexible means of managing the road space. ERP applies the "user-pays" principle for managing road traffic demand. It complements the continued "supply-side" oriented infrastructure programme by managing demand to balance traffic volumes with available capacity. It allows a pricing structure to be applied that is ***time and congestion sensitive***. Charging on a time and distance basis relates the charge to the frequency and duration of use. Other alternatives tend to be less precise in managing traffic congestion where it occurs.

4.9 ***ERP and the alternative traffic management measures are not mutually exclusive***. ERP can operate with existing policies, in conjunction with the other alternatives or as the primary measure. It reinforces the effects of ownership restraints such as ALF, FRT, usage restraints such as parking policies and charges, and modal priority measures such as public transport priorities, and park-and-ride. ERP, like FRT and ALF, provides the financial incentive for motorists to switch to public transport. It also provides the incentive for drivers to use a park-and-ride facility rather than incurring ERP charges. The diversion and mode switch make more efficient use of the existing road network by reducing the number of vehicles using the roadway. This effect can delay or eliminate the need to build more infrastructure.

5. NEED FOR ERP

Traffic Forecast

5.1 An ERP Traffic Model (ETM) was developed to establish traffic forecast and assess the impact of ERP on traffic demand and performance of the road network. ETM is compatible to the model developed in the Third Comprehensive Transport Study (CTS-3) except more detailed zoning and road network are included to better represent traffic characteristics in the urban areas.

5.2 The Study adopted a range of possible growth scenarios in forecasting future traffic demand. Each scenario comprised different assumptions on socio-economic factors including Gross Domestic Product (GDP), population and employment, private and goods vehicle fleet sizes and infrastructure provision.

5.3 The Study identified that depending on the growth of the private vehicle fleet the average traffic speed in Central, Western, Mid-Levels, Wan Chai and Causeway Bay

would be 17.8 to 19.7 km/h in 2006 and 20.6 to 23.9 km/h in 2011 as a result of infrastructure projects expected to be completed by then. The average traffic speed in Kowloon would be 23.4 to 25.9 km/h in 2006 and 23.0 to 25.3 km/h in 2011. In comparison, the average traffic speeds in the urban area have been maintained at about 20 km/h over the past twenty years.

Need for ERP

5.4 The existing policy is that growth in the private vehicle fleet should not significantly exceed 3% per year. If the growth of the private vehicle fleet size is controlled to no more than 3% per year, the forecast travel speeds will be towards the upper end of the average speed ranges noted in 5.3 above. The traffic condition will be similar to that experienced over the past two decades. As a result, additional restraint measures may not be warranted on traffic management grounds before 2006 although some localised traffic congestion may occur at the busy hours. Whether ERP will be required after 2006 depends on public acceptability of the forecast traffic conditions in terms of traffic speeds, control on the growth of the vehicle fleet, improvements to transport infrastructure and public transport services.

Traffic Conditions in London

The need for ERP will diminish by 2010, with the completion of Central-Wan Chai Bypass that will relieve the traffic congestion along the main east-west corridor.

5.5 The community needs to decide whether those projected speeds are acceptable. If growth in the private vehicle fleet size is not greater than 3%, the forecast traffic speeds in Hong Kong in 2006 and 2011 are higher than the existing traffic speeds of 18.5 km/h in Tokyo, 16.0 km/h in central London and 11.0 km/h in New York. However, the traffic speeds in Tokyo and London has already raised the attention of their respective Government who plans to consult their citizens on a package of measures to relieve congestion, including a possible ERP system.

5.6 There is therefore a need to consult the public on tolerable traffic speeds and closely monitor the GDP growth and vehicle fleet size as well as the infrastructure programme.

5.7 Furthermore, lessons can also be learnt from the development of road pricing projects currently under consideration in the Netherlands, Japan, the United Kingdom and the United States.

6. POSSIBLE ERP SYSTEM FOR HONG KONG

Conceptual Design of ERP Scheme

6.1 The Study has looked into a possible ERP system for Hong Kong. The definition of an ERP scheme involves specifying the following parameters:

- type of charging system
- geographic extent of the charged area
- number of charging zones
- time periods to be charged
- vehicle types to be charged
- charge levels by period and vehicle type
- complementary measures to be introduced.

6.2 The Study has considered different types of charging methods, including

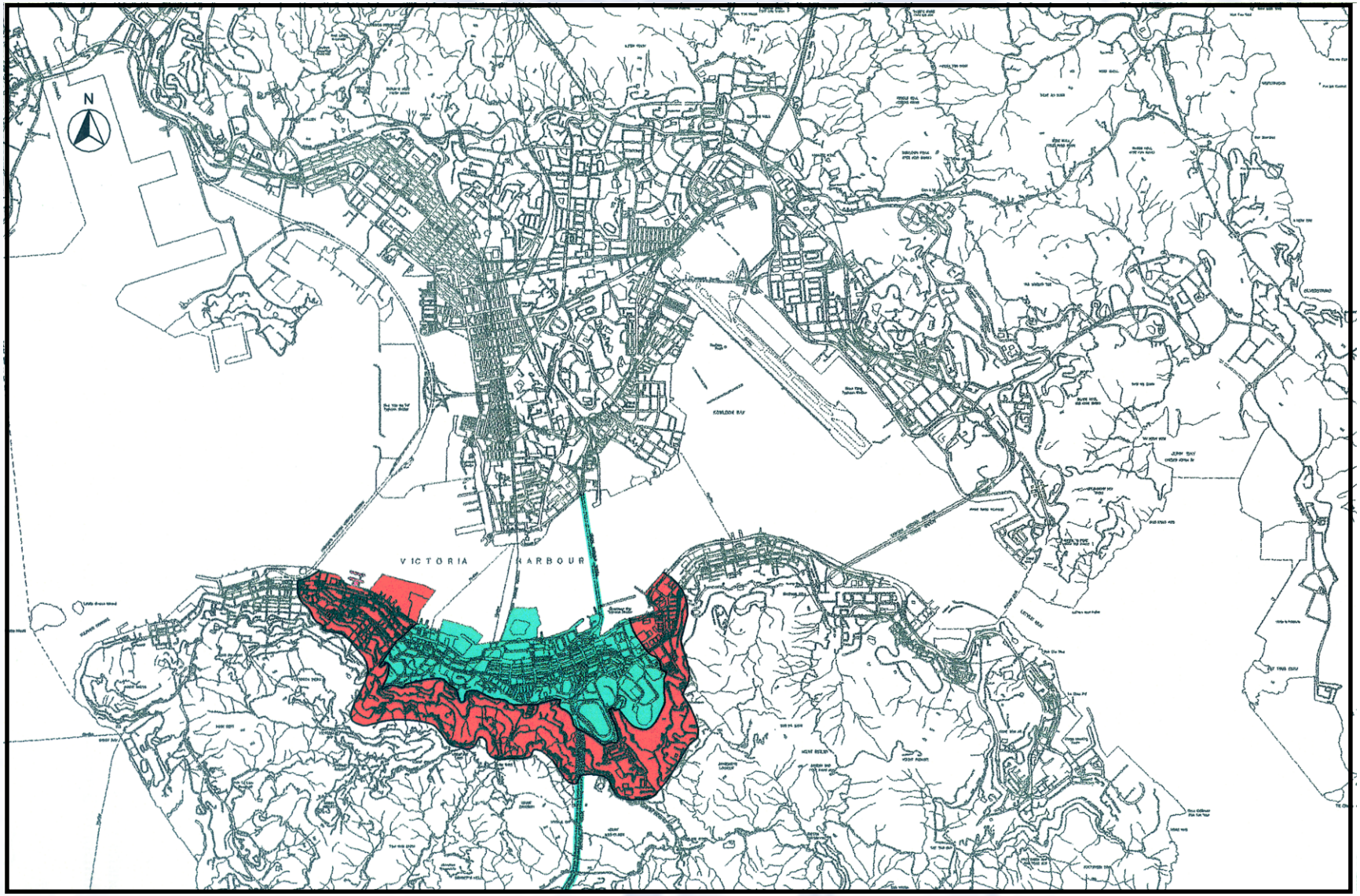
- Cordon-based: vehicles are charged each time they pass an operational charging point.
- Distance-based: charges are related to the distance travelled within the area during the charging period.
- Time-based: charges are related to the time spent within the charged area: either the time the vehicle is in operating mode, or the total time (including inactive time).
- Congestion-based: charges are related to the time spent in the charged area while travelling below a set (congested) speed for longer than a set time

6.3 Time-based and congestion-based charging are not preferred because they may encourage dangerous driving, as motorists seek to minimise the time spent in the charged area. Secondly, the charge for the same daily trip may vary and cause confusion on the cost of the trip. A cordon-based charging scheme is recommended for its simplicity. Although both technological options can be adopted for distance-based charging, proper enforcement may be difficult and DSRC will also require additional connection to the odometer. Directional charging, i.e. charging would only be imposed on motorists entering the charging zone in the morning and leaving the zone in the afternoon, is preferred to bi-directional charging whereby charges would be imposed on both directions during the peak periods.

6.4 A practical and publicly acceptable ERP scheme should only cover areas that are perceived to be the most congested. The charged area should also be well served by public transport to provide opportunities for road users to change mode. Different options for the charging area have been studied. A typical charging zone encompassing Central, Wan Chai and Causeway Bay is shown overleaf. The zone includes wings to discourage the use of Mid-Levels as a bypass to the charged area. Both the Eastern Harbour Crossing and Western Harbour Crossing are excluded from the charging zone and act as alternative routes for North-South movement.

6.5 The use of multiple charge zones would allow lower rates to be charged on each cordon, thereby reducing the equity problem associated with high charges for short trips across a single zone boundary. Secondly, it would intercept trips wholly within the charging area of a single zone system, which would otherwise be free of charge. The main disadvantage is that it adds complexity to the scheme, thereby reducing public acceptability.

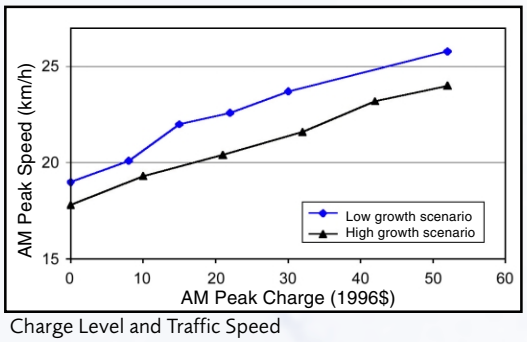
6.6 The Study evaluated alternative charging periods in terms of their overall economic benefits. Typically, there is a steep rise in traffic volume towards the morning peak. The same traffic volume remains throughout



Typical Charging Zone

the inter-peak and evening periods, followed by a gradual tapering in the evening. The traffic speed in Central and Western is lowest in the inter-peak period as a result of on-street activities. This, however, could be countered by other means. The analysis showed that the morning peak charge should apply from 8 am to 9am, with an evening peak charge from 5:30pm to 7pm, and a slightly lower charge for the inter-peak hours. To reduce the problem of "bunching", or vehicles rushing into the charge area just before the commencement of morning charging, or delay their trip until the end of evening charging, shoulder periods at lower charge rates for 30 minutes before morning and after evening peaks are being proposed. No charge is envisaged for the remaining overnight period from 7:30 pm to 7:30 am or on Sundays and Public Holidays.

6.7 The required level of charge is determined by the desired amount of traffic diversion/ suppression or the target traffic speed to be achieved. A range of charges has been tested, with variations among vehicle classes and in distance travelled. In general, lower charges would entail lower traffic speed. The following figure illustrates the trade-off between the charge level and average speed in the morning peak hour. Using private cars as an example, charges ranging from $8 to $17 might be required to achieve a target speed of 20 km/h in the morning peak period in 2006. Charges might not be required for the evening peak as the baseline speed is expected to exceed 20 km/h, and the choices



Charge Level and Traffic Speed

made by drivers on trips to the charged area in the morning peak will also affect flows during the evening peak when the reverse trip is made.

6.8 ERP provides the flexibility to differentiate charges by type of vehicle and to exempt a particular vehicle type from charge. However, there are a number of issues concerning exemptions which must be thoroughly thought through before deciding, namely:

- in a congested area all trips contribute to the congestion
- if there are any exemptions it becomes difficult to define which types should and should not be charged ("exemptions breed exemptions")
- some vehicle classes are more efficient passenger carriers than others
- exempting classes will have an impact on public acceptability (positive or negative impacts, depending on the policy)

Complementary Measures

6.9 There are a number of possible complementary measures to provide additional or improved transport services for people affected by ERP. Over 10 million trips are made daily on public transport, accounting for nearly 89 per cent of all trips. Wide ranges of services are operated without direct Government subsidy. ERP will divert car and taxi trips to public transport, producing a small percentage increase in overall demand for public transport. Support measures that address this increase include providing park and ride facilities, improving public transport interchanges, providing feeder services and improving public transport information system.

6.10 ERP and ITS are synergistic and together can help resolve congestion by spreading

demand and smoothing traffic flow. Road congestion is both demand and incident related. ERP manages demand, while ITS advanced traffic management (ATM) systems address incident management and detection. Both should work together to reduce congestion and improve the flow of traffic in and around the ERP designated zone. ERP is itself a form of ITS and can support the further development of ITS. Road users would be the main beneficiaries of ITS. The ERP control centre could function as a traffic information centre to both operate the ERP system and provide road users with real time traffic information.

Stated Preference Survey

Impacts of Potential ERP Schemes

6.11 A stated preference survey was conducted to test the impact of alternative specifications for the ERP scheme. A total of 1,344 car, motorcycle and taxi users were interviewed to establish their probable response to ERP. The alternative responses available to road users following the introduction of ERP are to:

- find an alternative route to avoid the charge
- use an alternative mode of transport
- change the time of the trip to a lower charge or free time period
- travel with friends or relatives and share the cost
- drive to a park and ride facility and complete the journey on public transport
- eliminate, defer or combine the trip
- pay the charge and travel as planned

6.12 The stated preference survey indicated that, for travellers willing to change routine, the most frequent responses were to change the time of the trip or to divert to public transport. The survey results suggest that 40% of car trips in the morning peak may divert to public transport while 10% of those surveyed would change time of travel. The remaining 50% would stay-and-pay the road user charge.

6.13 The air quality modelling shows that overall emissions **within the charging areas** would be reduced by up to about 4 per cent. The reduced emissions of carbon monoxide, nitric oxide and respiratory solid particles for a typical ERP scheme are 604 (4%), 27 (2%) and 3 (0.4%) tonnes respectively compared with the baseline.

6.14 The noise modelling shows that for most ERP schemes tested in the Study people **within the charging areas** would experience traffic noise reduction.

6.15 While the ERP may bring about some improvement in the air quality in the charged areas, the environmental conditions of other areas show some deterioration due to the overall redistribution of traffic in reaction to the ERP charging area.

Implementation Strategy

6.16 ERP is a more precise tool to tackle traffic congestion. Singapore experience showed that implementing ERP as a **revenue neutral scheme** will increase public acceptance of the scheme. The implementation strategy may, for instance, include a reduction in FRT/ALF and use of the ERP revenue towards a

traffic management and information centre and ITS systems to provide real-time information to road users. However, it should be noted that Singapore maintained a quota on the vehicle fleet with a 3% growth per annum.

Implementation Programme

6.17 Singapore took about six years to implement the ERP system (three years for tendering and three years for installation). Given the DSRC technology has since become more mature, the lead time for the installation of a DSRC system in Hong Kong is expected to take about five years, including one year for pre-qualification, demonstration and tendering; 2.5 years for system design, construction of gantries, acceptance test, manufacturing and installation of in-vehicle units; and 1.5 years for public consultation and the legislative process. The legislative process may take place in parallel with some of the preparatory activities, which may shorten the lead-time by approximately six months.

6.18 The lead-time for VPS at this time would most likely be longer than DSRC because there is no off-the-shelf product available in the market and the installation of the in-vehicle units may be more complicated. An estimated six years lead time would be required for tender and installation of a VPS system, including an 18-month period allowed for the public consultation and legislative process.

7. ERP & ITS INTEGRATION

7.1 The Study identifies potential areas that the ERP technologies can be employed with other ITS applications in Hong Kong, most of which were demonstrated during the Field Evaluation. Both the DSRC and VPS system can be integrated with ITS to support ITS applications but the use of DSRC for ITS integration is dependent upon the number of gantries installed. If ERP was not required to be implemented in the near future, the ERP technology could be employed in fleet management, taxi dispatch, non-stop tolling, traveller information and integration with other ITS applications.

7.2 ERP technologies can directly be used for Automatic Toll Collection and Fleet Management systems. These applications

ERP Subsystems	Traffic Control and Surveillance System	Area Traffic Control	Automatic Toll Collection	Emergency Notification System	Transport Information System	Fleet Management
Location system	✓ as vehicle probe	✓ for modelling	✓	✓	✓ as vehicle probe	✓
Data communication link to vehicle	✓ for exchange of information	✓ for exchange of information	✓	✓	✓ for exchange of information	✓
In-vehicle unit & driver display			✓	✓	✓ for display of information	✓
Vehicle classification	✓ for traffic statistics		✓			✓
Vehicle enforcement			✓			✓

Table 7.1

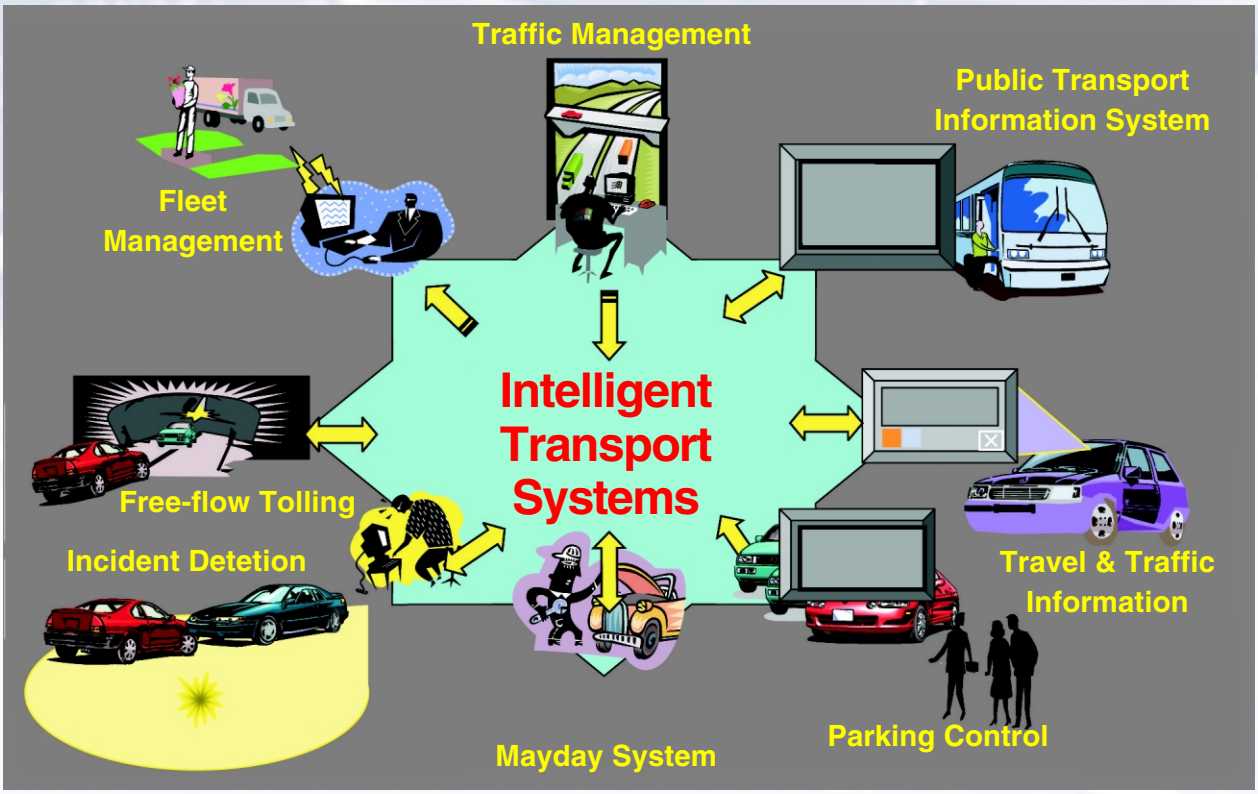
would have a positive economic benefit and provide for greater operational efficiencies that would benefit motorists and public transport. The use of the VPS technology to act as vehicle probes in a continuous manner along the road sections provides a wealth of data that will enhance and expand TIS functionality. Another advantage of VPS is the added capability of knowing the vehicle location which is a core component of fleet management, car navigation and dispatch systems. Table 7.1 provides an overview of the usage of ERP system elements in other ITS applications.

7.3 The overall effect of integrating ERP with ITS is synergy. Together, ERP and ITS would provide a more robust, effective and cost efficient transport system than either can deliver by themselves. However, to employ ERP technology in other ITS applications in Hong Kong, it may be important for all vehicles to be equipped with the IVUs.

8. BENEFITS OF ERP

8.1 ERP could be used to support new transport initiatives and an integrated transport policy. Charging for road use is consistent with a policy of according priority to rail and integrating the transportation system. It promotes greater efficiency in road use while encouraging both greater uses of public transport and higher vehicle occupancy for private transport. ERP charges directly influence driver behaviour, as demonstrated in Singapore to recognise the cost of each trip into the designated ERP zone.

8.2 The **transport operation benefits** of ERP relate to reduced vehicular traffic, particularly during congested periods, reduced travel times, increased public transport use and higher car and taxi occupancy. For the charging strategies tested in this study,



Integration with Intelligent Transport Systems

vehicle kilometres in the charged zone were forecast to reduce by between 2 and 17 per cent. Vehicle hours were forecast to reduce by between 5 and 36 per cent. The average reduction in travel time for vehicles in the charged zone was between 2 and 25 per cent. The forecast increase in public transport passenger trips to and from the charged zone was between 1 and 5 per cent.

8.3 The **economic benefits** of ERP derive from reduced traffic delays accrued to all road users and to the community at large. Those who use public transport enjoy more reliable service and reduced travel times. Those who change modes, travel times or trip frequency may enjoy financial savings from any reductions in other charges such as FRT and ALF, as charges become usage-focused rather than ownership-focused. Those who pay the charge enjoy reduced delays, travel times and fuel consumption. These in aggregate result in substantial savings in travel times and in vehicle operating costs. The estimated net economic benefit of ERP resulting from journey time saving and lower vehicle operating cost is about $2 billion/year.

8.4 The estimated cost for the proposed ERP scheme is $1 billion (including the cost of in-vehicle units for existing vehicles) with an annual recurrent cost of $200 million. ERP is forecast to generate annual gross revenue of $0.4 to 1.3 billion. If it is decided to adopt a revenue neutral scheme, this revenue can be ploughed back for transport infrastructure investment.

8.5 The **environmental benefits** involve reduced vehicle emissions and reduced exposure to traffic noise. This reduction corresponds directly to the decreases in traffic volumes because of ERP. While the ERP may bring about some improvement in the air quality in the charged areas, the environmental conditions of other areas show some deterioration due to the overall redistribution of traffic in reaction to the ERP charging area. ERP therefore can assist in the overall improvement to the environment, but is not the sole solution to the complex issue of air quality and noise abatement. If ERP is to be applied to achieve environmental objectives, a separate study will be required to define the parameters, benchmarks and implementation details including charging method, charging zones, charging period, charge levels and possible exemptions.

8.6 Both the DSRC and VPS system can be integrated with ITS to support ITS applications but the use of DSRC for ITS integration is dependent upon the number of gantries installed. If ERP is not required to be implemented in the near term, the ERP technology could be employed in fleet management, taxi dispatch, non-stop tolling, traveller information and integration with other ITS applications.

9. PUBLIC CONSULTATION

9.1 The need for ERP depends on public acceptability of the projected traffic speeds and its effectiveness in relieving traffic congestion in comparison with other alternative measures. According to the findings of the Study, drastic restraint measures are not warranted on traffic management grounds before 2006.

9.2 Implementation of ERP will not be possible without a general public consensus on the objectives and principles of the proposal. There will likely be public resistance to ERP arising from suspicion about the government's motive, the reluctance to accept new initiatives and road users' resentment about the imposition of new charges. A well-planned and executed public consultation programme to demonstrate how ERP works and to allow public input into the development of system objectives can promote awareness of the ERP system as a

measure to relieve traffic congestion and develop understanding in the community for its possible introduction.

9.3 It is recommended that a public consultation programme be initiated to increase public understanding of the traffic congestion problem and to encourage public discussion of possible use of restraint measures and alternative solutions including ERP. The public should be consulted specifically on the acceptable traffic speeds.