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Transport Department

Agreement No. CE 39/2005 (TT)

Congestion Charging Transport Model - Feasibility Study

Final Report

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EXECUTIVE SUMMARY

E.1 INTRODUCTION

E.1.1 In April 2001, the Transport Department published the Final Report of the "Feasibility Study on Electronic Road Pricing (ERPFS)". The Study had concluded that Electronic Road Pricing would be technically feasible and a community consensus is an essential prerequisite. However, in the context of an economic downturn and sluggish growth in car ownership and road traffic at that time, it was recommended that further restraint measures were not warranted on traffic management grounds before 2006 and that, in the meantime, foreign developments in road user charging should be monitored while keeping a close watch on the traffic conditions and public views in Hong Kong.

E.1.2 Accordingly in February 2006, the "Congestion Charging Transport Model – Feasibility Study" was commissioned with the objectives of developing a computer-based transport model (the Congestion Charging Model) for the analysis of congestion charging and giving advice to facilitate the assessment of various congestion charging schemes and strategies for relieving traffic congestion in Hong Kong, giving due consideration to sustainable transport planning and public acceptance.

E.1.3 The Central and Wan Chai Districts were identified by ERPFS as having the lowest traffic speeds in the Territory and as being most liable to congestion. The primary focus of the Study was to develop a Congestion Charging Model to consider the applicability of congestion charging to a Study Area covering Central and Wan Chai Districts for the two design horizon years 2016 and 2021.

E.2 STUDY APPROACH

E.2.1 The Study was undertaken in two main stages. At the first stage, the Congestion Charging Model was developed based on the latest survey data, including behavioural research on the likely traveller responses to congestion charging. In parallel, a review of congestion charging in other countries was carried out, including the growing number of operational schemes and supporting technologies. At the second stage, a wide range of congestion charging scheme types and associated charging scenarios was investigated using the Congestion Charging Model to evaluate the potential impacts in the Study Area from traffic, social, economic and environmental perspectives. In addition, a review was made of the key implementation requirements to confirm feasibility. A preferred approach to congestion charging was developed for the Study Area while identifying a number of possible options drawing on the experience of other countries.

E.2.2 The Study provides a balanced assessment of the benefits and areas of concern that would be generated by the implementation of congestion charging in the Study Area. This document highlights the key findings of the Study.

E.3 FUNCTIONS OF CONGESTION CHARGING

E.3.1 Congestion charging is a traffic demand management measure. It is a form of road pricing specifically aimed at making road users pay for the costs of the congestion that their journeys place on other motorists and travellers – the "User Pays" principle.

E.3.2 Road user charging (or road pricing) is an "umbrella" term for the pricing of the use of roads and infrastructure for a wide variety of purposes. Road pricing can be regarded as a measure to collect revenue for the construction of road tunnels and bridges, to charge goods vehicles for the maintenance and environmental costs of motorway use, as in Europe; or to restrict traffic access into historic and environmentally sensitive city centres, as in Italy.

E.3.3 The Study focuses on congestion charging, and accordingly congestion relief is the leading objective in the scheme designs and evaluation. The resultant traffic reductions provide environmental and other broader benefits which are taken into account in the evaluation.

E.3.4 The idea behind congestion charging comes from a relationship between the number of vehicles travelling along a road and vehicle speeds, which is known to road users. With few vehicles on the road, drivers can choose their own speed within the legal speed limit without being much affected by other vehicles. Then, as there are more and more vehicles on the road, vehicles begin to bunch together, and the vehicle travel speeds decline gradually. However, as the number of vehicles on the road approaches the road capacity, traffic speeds tend to decline more sharply, stop-and-go traffic results and queues begin to form.

E.3.5 The intention of congestion charging is to make road users pay for travelling at congested times and in congested places, thereby encouraging travellers to switch to public transport, change their routes or retime their journeys. The results of these actions taken could help reduce traffic volume, enabling general road users to travel without undue delay.

E.3.6 From a transport operation perspective, the effectiveness of congestion charging schemes is judged in terms of the degree to which congestion is reduced and target traffic speeds are achieved, producing an acceptable level of service from a balance of community and technical considerations. Based on international experience, speed targets were derived from analyses of the network configuration, mix of traffic types, and adjacent land uses in the Study Area. A target range of 17 km/h - 20km/h was set for the District Road Network, 20 km/h -30km/h for the east-west trunk road corridor (Connaught Road Central/Harcourt Road/Gloucester Road/Victoria Park Road) and over 50 km/h for the Strategic Road Network (Central-Wan Chai Bypass (CWB)).

E.4 CONGESTION CHARGING EXPERIENCE IN FOREIGN COUNTRIES

E.4.1 Congestion charging schemes of various forms are now in operation in a number of cities as a network management tool for containing traffic volume, combating congestion and supporting overall sustainable development. Three basic forms of scheme in urban areas can be identified:

Cordon Schemes	-	Charging vehicles for crossing a cordon in/out of congested areas (e.g. Singapore, Stockholm)
Area Schemes	-	Charging vehicles for travelling inside a designated charge area (e.g. London)
Zonal Schemes	-	Charging vehicles for access to/egress from designated charge zones (e.g. Italy)

E.4.2 The different schemes apply a variety of charging scenarios by time period, direction, vehicle type, method and level according to the local traffic congestion patterns and broader social and environmental objectives.

E.4.3 Overseas experience reveals that road traffic levels can be reduced by 15%-25% in terms of vehicle kilometrage (in PCU[1] kilometres) in the charge area, bringing about speed improvements and reducing delays by 30% or more. Public transport travel is boosted and operating costs are reduced by the journey time savings and reliability improvements. The traffic reduction also leads to lower vehicle emission levels, lower accident rates and some savings in road maintenance. However, Hong Kong is characterised by a high public transport patronage and a low car ownership rate compared with other overseas countries. As a result, the anticipated reduction in road traffic levels and vehicle kilometrage due to congestion charging would be less significant.

E.4.4 The justification and need for congestion charging depends on the local situation from transport, economic, social and environmental perspectives. Extensive public consultation is essential to determining whether proposed schemes are supported.

E.5 TECHNOLOGY

E.5.1 Worldwide experience and technical advances have enabled congestion charging schemes to be successfully operated using a variety of technologies in different situations.

E.5.2 The most common approach is to use Dedicated Short Range Communication (DSRC) based systems which have evolved from the conventional automatic toll collection technology, such as the Autotoll system in Hong Kong. This enhanced system permits vehicle detection and communications in multi-lane free flow traffic and is working reliably as a toll collection facility in Singapore and Italy as well as for freeway toll facilities in Melbourne, Toronto and other cities. The DSRC technology was tested in the ERPFS field trials and was found to perform successfully in the Hong Kong environment. The On-Board-Unit (OBU) (like the Autotoll tag) could be equipped with a smart card (like the Octopus Card) to permit automatic payment while protecting the privacy of the driver. Alternatively, the OBU could be linked to an account for automatic payment (like the existing Autotoll).

E.5.3 An alternative is to use an Automatic Number Plate Recognition (ANPR) based system as in London. Motorists register the vehicle licence number by prepayment in a computerised database. Vehicle licence plates are then automatically checked using roadside cameras at control points during the charge period for prepayment against the database. Any vehicles not registered will be recorded and further checked and any potential violators issued with a penalty notice. This

[1] PCU is a factor used in traffic engineering to calculate the relative impact of different vehicle types on traffic flow compared to a car (as the basic unit).

approach is simpler and easier to install, obviating the need for in-vehicle equipment. However, it is more expensive to operate, and require substantial manual checks against potential violations. In the future, the ANPR system may be replaced by DSRC technology as part of the further expansion of the London scheme.

E.5.4 More advanced technologies such as satellite-based Vehicle Positioning Systems (VPS) or ground-based Cellular Phone Systems offer potential greater functionality and ultimately lower costs.

E.5.5 Today, a DSRC-based system would be most appropriate for a congestion charging scheme. However, in view of the timescale for implementation, other evolving technologies such as satellite-based VPS should be closely monitored. These may well become standard equipment in vehicles for vehicle guidance, insurance and security in the future, thereby lowering both the initial capital and the recurrent operational costs.

E.6 FUTURE TRAVEL CONDITIONS IN THE STUDY AREA

E.6.1 Traffic forecasts, prepared using the Congestion Charging Model based on the latest planning assumptions, have indicated that travel conditions in the Study Area would improve substantially following the opening of the planned railway lines, the CWB and Road P2 in the new reclamation area. The congested Connaught Road Central/Harcourt Road/Gloucester Road/Victoria Park Road corridor would be largely relieved and traffic speeds would increase significantly. However, congestion would still persist in the older District Road Network in Central, Wan Chai and Causeway Bay as well as at the northbound approaches to the Cross Harbour Tunnel.

E.6.2 Against this background of forecast and much improved travel conditions, congestion charging could be considered as a management tool for containing traffic volume and growth to achieve the following objectives.

E.6.3 From a traffic management perspective:

- Alleviate congestion in the older street systems of Central, Wan Chai and Causeway Bay
- Promote the role of the CWB as a bypass route
- Further relieve the east-west corridor of Connaught Road Central/Harcourt Road/ Gloucester Road/Victoria Park Road to promote its role as a primary distributor and public transport corridor
- Manage longer term traffic growth to be within network capacity

E.6.4 From a broader transport perspective:

- Secure an efficient operating environment for public transport and commercial vehicles
- Facilitate reallocation of road space for bus and tram priority, traffic calming and pedestrianisation
- Maximise economic benefits in terms of travel time and operating cost savings

E.6.5 From a sustainability perspective, by reducing vehicle kilometrage and encouraging public transport usage, it will bring:

- Resource & cost savings – accidents, energy consumption, road maintenance and land space
- Environmental improvements – reductions in emissions and health hazards
- Social improvements – improved travel conditions and accessibility for the majority of travellers and the public

E.7 POTENTIAL CONGESTION CHARGING SCHEMES FOR THE STUDY AREA

E.7.1 The Study evaluated a range of congestion charging scheme types and strategies and identified a preferred approach together with a number of possible options which could form the basis for further review. All the congestion charging schemes were formulated based on the assumption that the CWB would be available.

E.7.2 Scheme Form – A cordon-based scheme is preferred because it is straightforward for travellers to understand charging per trip. It offers flexibility and enables charges to be varied by time of day, vehicle type and direction. It can be expanded by adding new cordons or charge points and is well proven in Singapore, Stockholm and Norway.

E.7.3 Charge Area – The charge cordon is proposed to enclose the commercial areas of Central, Wan Chai and Causeway Bay, which are the principal locations of congestion. A single Cordon Scheme is preferred as it is simple to understand. Charge points may be added to contain traffic in Mid-Levels or across the harbour in the same way as is applied in Singapore.

E.7.4 Charge Period – Charging should apply during congested times and be set to maximise overall economic benefits. The technical analyses indicated that the charge period should run from 7:30 a.m. to 8:00 p.m. In order to encourage peak spreading and smoother traffic flow, charges should be gradually built up from 7:30 a.m. to 8:30 a.m. to peak charge levels and be scaled down between 7:00 p.m. and 8:00 p.m.

E.7.5 Vehicle Types – The principle of "User Pays" is adopted as the starting point applying charges to all vehicles. In practice, emergency vehicles may be exempted. The case for further exemptions or discounts for social, transport policy and environmental reasons should be the subject of debate and will be raised by various stakeholders and the community. While there may be good reasons for such exemptions, they will add to administrative costs and system complexity, and should be carefully considered on the principles of equity, efficiency and public acceptability.

E.7.6 Charge Movement – Charges would be applied in both directions to capture all traffic moving into/out of the congested area. Optionally, charges could be tidal, charging more in the peak flow direction. In line with those schemes in London and Stockholm, free passage could be granted to through traffic using the Strategic Road Network (the CWB and Canal Road Flyover) which does not enter the ground level road network.

E.7.7 Charge Rates – Under the "User Pays" principle, vehicles should be charged based on their contribution to congestion in terms of vehicle size and manoeuvrability, with cars and taxis paying less and buses and goods vehicles paying more.

E.7.8 Charge Levels – Charge levels should be set to achieve the target speed levels which produce the maximum overall economic benefits. The Congestion Charging Model analysis indicated that charges could be in the range of $20 to $30 for private cars depending on the different time periods and traffic demand growth scenarios.

E.7.9 In the absence of the proposed free, high-capacity alternative route of Central-Wan Chai Bypass, preliminary assessments indicate that the application of congestion charging would fail to provide an equivalent level of service even with charges of 3 to 4 times higher. Charges would have to be increased even further as traffic continues to grow in the future beyond 2016. It is unlikely that this would be acceptable to the travelling public and stakeholders.

E.8 IMPACT OF POTENTIAL CONGESTION CHARGING SCHEME

E.8.1 The modelling studies indicated that, under a "User Pays" approach, the traffic levels inside the charge area in the charge period are forecast to be reduced by 10% to 20% depending on the charge level between $20 and $30 applied to all vehicles.

E.8.2 Car and taxi travel was forecast to be reduced by 20% to 30% with travellers principally switching to public transport or retiming their journeys to travel before or after the peak periods. Goods vehicle operators largely paid the charges as most deliveries were essential, while a small proportion retimed their journeys.

E.8.3 The total amount of traffic levels passing through the charge area was forecast to decrease by 9%. The diverted traffic might be routed via the CWB.

E.8.4 Traffic speeds were forecast to be improved in the District Road Network and be in the target range of 17km/h-20km/h. Key congestion spots were generally relieved except a few locations.

E.8.5 Public transport demands in the charge area were forecast to increase by 2% - 4% owing to the fact that car and taxi travellers diverted by the congestion charge were attracted to switch to public transport by improved traffic speeds.

E.8.6 The forecast reductions in vehicle kilometrage produced a broad estimate of a 2% - 8% decline in emissions in the Study Area, largely in oxides of nitrogen and volatile organic compounds, as the petrol fuelled cars and liquefied petroleum gas taxis were most affected. The reduction in respirable suspended particulates was less because diesel powered goods vehicle traffic was reduced to a relatively less extent, and public transport could be increased marginally to meet the extra demands. However, the emission conditions of other areas might experience some local deterioration due to the overall redistribution of traffic. The reduction in emissions was equivalent to less than 1% on a territory-wide basis.

E.9 COMPLEMENTARY MEASURES

E.9.1 Congestion charging, as part of the overall transport strategy, should be complemented by a package of measures, including appropriate strengthening of public transport services; traffic management measures to cater for new traffic patterns, especially on the approaches to and around the charge cordon; and enhancements to public transport interchanges and pedestrian facilities to promote public transport usage. The existing and planned comprehensive rail and public transport network and Transport Information and Incident Management Systems would facilitate the implementation of congestion charging in the Study Area.

E.9.2 The congestion charging scheme technology and information could be integrated with intelligent transport system applications to provide real-time and historical data to assist in route guidance, fleet management and incident monitoring and alerts. The congestion charging technology could also be applied for automatic free-flow multi-lane toll facilities, enabling the existing toll plazas to be reduced in scale or removed completely if all vehicles were equipped with OBUs. This would release land space and smooth traffic flow, thereby reducing emission levels.

E.10 FURTHER DEVELOPMENTS

E.10.1 The Study focused on developing and applying the Congestion Charging Model to develop and assess a potential congestion charging scheme for the Study Area. Broader applications of congestion charging concept could be considered:

- Other district charging schemes, e.g. schemes for Tsim Sha Tsui;
- Strategic Road Network Charging schemes to regulate traffic movements between sub-regions and to achieve a more balanced usage of parallel strategic roads, for example cross harbour tunnels or roads connecting Kowloon and the New Territories; and
- Full Network Charging to cover all road traffic movements.

E.10.2 In recent years, there has been much debate on aligning tolls at the many road toll facilities to achieve a better balance in the usage of the transport infrastructure concerned. These initiatives have potential merits and may be coordinated with the development of congestion charging to produce an integrated territory-wide approach to road user charging.

E.10.3 If such future expansion is contemplated, then a fundamental review of technology is required during the planning stage. Furthermore, such broadening of congestion charging may enable a review to be made of the scale of vehicle ownership restraint, allowing more residents to own and enjoy the benefits of car use while managing their usage through congestion charging. This would not be possible with a single local district level scheme such as the one considered for the Study Area.

E.10.4 The Council for Sustainable Development has identified road user charging as a potential means to alleviate vehicle-related pollution. However, congestion charging is a travel demand management measure rather than an environmental protection initiative. Congestion charging and environmental charging serve different objectives, involve different stakeholders and require different charging and exemption strategies.

E.11 REQUIREMENTS FOR IMPLEMENTATION

E.11.1 The managing authority for the scheme should be a Government Department or Statutory Authority set up to implement and manage the scheme. The private sector could be involved on a contract basis (as for tunnel and bridge toll collection and maintenance). However, full privatisation would not be appropriate since charges would be set for traffic management purposes and not on a commercial "revenue risk" basis. The managing authority could be entrusted with implementing complementary measures and broader related intelligent transport systems at the same time.

E.11.2 The model tests indicated that the potential congestion charging scheme could generate an operating surplus after allowing for capital and operating costs. This income could be regarded as general Government revenues, as in Singapore, or alternatively could be re-invested in complementary transport or environmental improvements as part of the integrated land use/transport/environmental strategy. This approach was adopted in London and Stockholm and is well received by the travelling public as a fair application of the revenues.

E.11.3 The legislative requirements for implementing a congestion charging system would include a range of legal and contractual devices, including the composition and powers of the body responsible for managing the systems, setting up of the legal frameworks surrounding the legal restriction of access subject to payment, enforcement elements, and establishment of processes and evidence issues relating to violations, recovery of charges and related penalties, protection of privacy and management of exemptions. A congestion charge adjustment mechanism would need to be defined and to be explicitly related to travel conditions and traffic speeds in a way understood and accepted by the public.

E.11.4 If the Government is to proceed with the implementation of congestion charging in the future, it would take about six and a half years' lead time for a DSRC-based system plus the time taken to conduct public engagement and consultation to reach a consensus on the scheme design.

E.12 FINDINGS AND WAY FORWARD

E.12.1 The major technical findings of the Study are summarised below:

- Traffic forecasts for 2016 and 2021 indicate that the planned rail and road (including the CWB) infrastructure will bring substantially improved travel conditions in the Study Area.
- Congestion charging can make a significant contribution to managing traffic, bringing broad transport benefits and supporting sustainable development.
- As a specific management tool, congestion charging would enable further relief of congestion in the road system, and secure an efficient operating environment for public transport and commercial vehicles while giving scope for pedestrian and environmental improvements.
- The preferred approach to congestion charging would be in the form of a cordon-based scheme around the commercial areas of Central, Wan Chai and Causeway Bay – the Inner Cordon Scheme. Vehicles crossing the cordon would be charged in both directions with charges varied according to the traffic conditions during the charge period.
- The "User Pays" approach should be adopted as a starting point with all vehicles charged (except emergency vehicles). Charges should be levied based on vehicle size and manoeuvrability using the passenger car unit as a guide.
- A number of technology options are available and proven in operation. A DSRC-based system would be favoured today while satellite-based VPS and other developing technologies may offer more functionality and lower costs in the future. A "Smart Card" OBU would be preferred, offering privacy to motorists making valid payments.
- The existing public transport network can be adjusted to accommodate the additional demands and support the scheme.
- More broadly, congestion charging brings some useful reductions in vehicle emission levels, accidents, resource costs and improves accessibility.
- The siting of the charge points forming the cordon will require detailed studies at the design stage, taking account of local access, safety, engineering and traffic circulation.

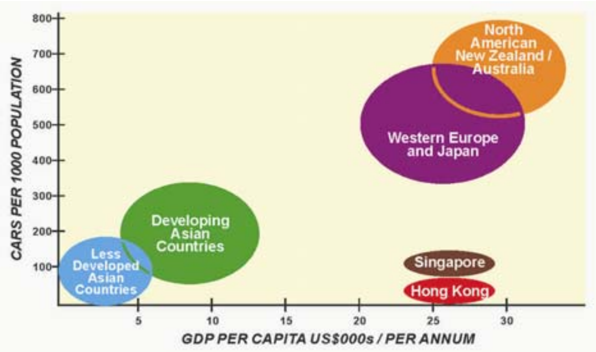
E.12.2 The way forward for congestion charging in Hong Kong is as follows:

- From a transport perspective, there are no strong arguments for introducing congestion charging in Hong Kong at present. In fact the current adverse economic conditions are likely to slow traffic growth in the near term to levels below those anticipated in the forecasting studies.
- A congestion charging scheme that aims to relieve traffic congestion can only be implemented equitably and effectively with the availability of free-of-charge alternative routes having adequate capacity for motorists to bypass the charging zone. This prerequisite is in line with international experience which indicates that the provision of free-of-charge bypass routes for through traffic enables schemes to gain public acceptance more easily.
- In the context of the traffic conditions in the Central Business District of Hong Kong Island, the most appropriate alternative route is the proposed Central-Wan Chai Bypass, the construction of which was supported by the Expert Panel on Sustainable Transport Planning and Central-Wan Chai Bypass (Final Report, October 2005). However, it would not be open to traffic before 2017.
- If a decision is made later to implement congestion charging on traffic grounds, the Government will carry out an extensive public engagement/consultation to solicit public views. The engagement process would involve a wide range of stakeholders as well as the travelling public and the community as a whole. Only when a consensus is reached will the Government press ahead with the implementation of congestion charging.

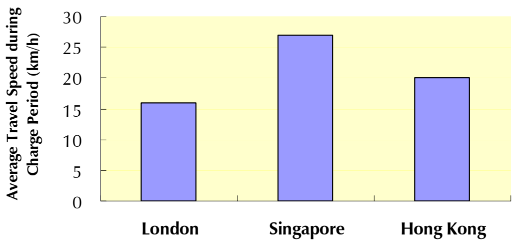
1. INTRODUCTION

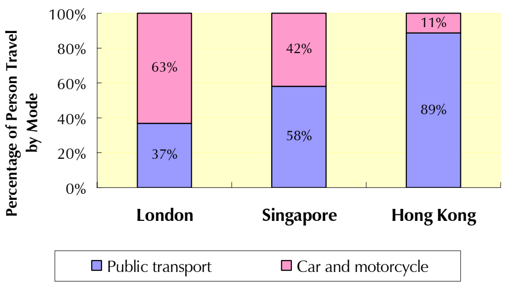
1.1 Background

1.1.1 Since the first Mass Transit Railway line opened in 1979, Hong Kong has developed a world-class transport system based on sustainable transport policies, giving priority to public transport while managing road traffic demands to maintain a balance with the prevailing network capacity. The comprehensive public transport system in combination with fiscal charges has contained private vehicle ownership to around 50 cars per thousand population, compared to more than 120 in Singapore, around 350 in London and over 600 in typical North American cities. As a result, today some 89% of person travel is by public transport (including 11% by taxi) and only 11% by car and motorcycle which, for an advanced city of 7 million population, enables Hong Kong traffic to move relatively freely.



Car Ownership in Cities Worldwide





Average Travel Speed and Mode of Travel in Cities Worldwide

1.1.2 Further transport infrastructure development is in the pipeline, including expansion of the urban railway and links to the boundary of Mainland China as well as enhancement of the Strategic Road Network which will provide the framework essential for sustainable development. However, in a space constrained city like Hong Kong, there is a limit to infrastructure building and network expansion. Increasingly, prime emphasis will need to be placed on securing the most efficient use of the transport system in the future by the application of transport supply management and travel demand management.

1.1.3 The Government is committed to transport supply management and is enhancing systems on all fronts, in particular leveraging on advanced Traffic Signal Control, Intelligent Transport Systems and Transport Information Systems. At the same time, a range of travel demand management measures is already being applied, including restraint of car ownership levels, parking management and prioritising the use of road space (such as bus lanes or pedestrianisation). To date, the combination of transport supply management and travel demand management measures has adequately contained traffic congestion. Since there is a limit to network expansion, these measures will need to be enhanced as part of the overall transport strategy in order to direct demands to use available resources more efficiently and to prevent congestion.

Congestion Charging

1.1.4 Congestion charging is a specific travel demand management measure applied to contain traffic demands by charging motorists for travelling in congested areas during congested periods. Congestion charging schemes are now successfully in operation in a number of cities worldwide, including Singapore, London, Italy, Stockholm and Norway, using a variety of scheme designs and technologies. Typically, traffic levels[1] have been reduced by 15%-25% and congestion significantly relieved.

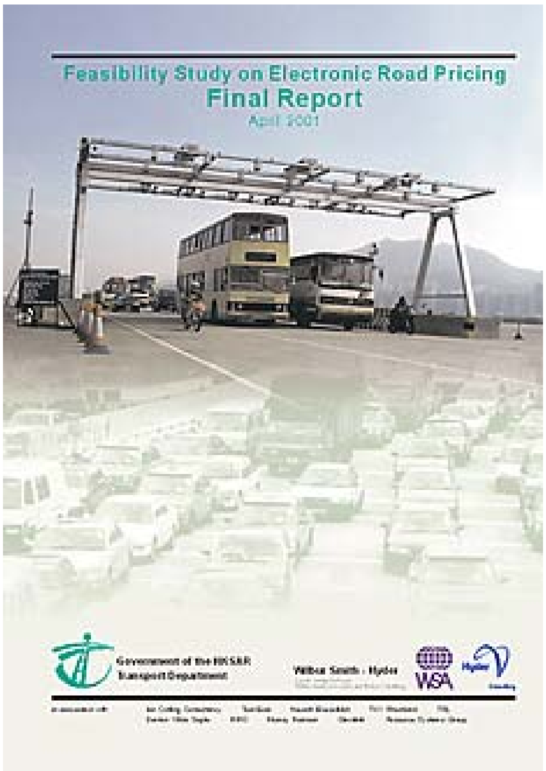
[1] In terms of PCU kilometres, the PCU (Passenger Car Unit) is a factor used in traffic engineering to calculate the relative impact of different vehicle types on traffic flow compared to a car (as the basic unit).

Electronic Road Pricing in Singapore

1.1.5 Electronic Road Pricing (ERP) was investigated in Hong Kong previously and found to be potentially capable of reducing peak traffic volume and relieving traffic congestion. The Electronic Road Pricing Pilot Study (1983-1985) confirmed the technical feasibility of congestion charging using the then technology. However, the protection of privacy was a public concern, particularly in relation to the limitations of the technology available at that time. The decision on implementation was deferred pending a period of sustained traffic growth and associated increased congestion.

Congestion Charging in London

1.1.6 In 1994, the "Report of the Working Party on Measures to Address Traffic Congestion" by the then Transport Branch put forward a range of transport supply management and travel demand management measures for consideration, including the need to review ERP following technological advances. Accordingly, the Feasibility Study on Electronic Road Pricing (ERPFS) was carried out in 1997-2001. The ERPFS reaffirmed the technical feasibility of ERP building on experience in Singapore and Europe. However, owing to the period of economic downturn after 1998 and the resultant low growth in vehicle ownership and traffic levels, it was considered that the prevailing traffic conditions in 2001 did not justify implementation and that a further review should be carried out in 2006.



Hong Kong Electronic Road Pricing Study (1997-2001)

1.2 The Congestion Charging Transport Model – Feasibility Study

1.2.1 "The Congestion Charging Transport Model – Feasibility Study" was commissioned in February 2006 with the objectives of developing a computer-based transport model (the Congestion Charging Model) for the analysis of congestion charging and giving advice to facilitate the assessment of different congestion charging scenarios for relieving traffic congestion problems in Hong Kong with due consideration given to sustainable transport planning and public acceptance.

1.2.2 The primary focus of the Study is on the development of the Congestion Charging Model for assessing congestion charging strategies and schemes for the Study Area (shown in **Figure 1.1**) covering Central and Wan Chai Districts for the two design horizon years 2016 and 2021. This area was identified by ERPFS as having the lowest traffic speeds in the Territory and as being most liable to congestion.

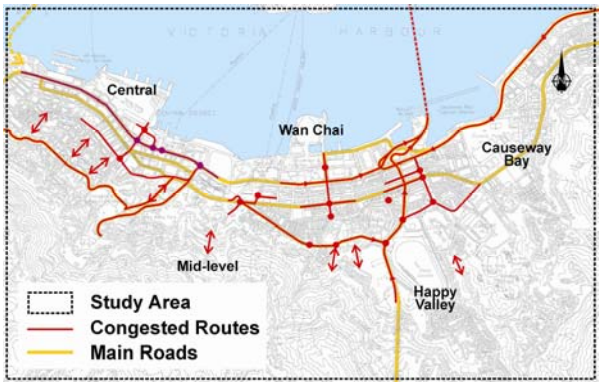


Figure 1.1 Study Area

1.3 Study Objectives

1.3.1 The specific objectives of the Study are as follows:

- To develop a Congestion Charging Transport Model;
- To provide advice to facilitate the assessment of different congestion charging scenarios for relieving congestion in Hong Kong;
- To draw up potential proposed charging scheme(s) within the Study Area; and
- To identify appropriate technology options.

1.3.2 The Study is a research study with the principal objective of developing a transport model based on traveller behavioural surveys which can be applied on an ongoing basis to assess travel conditions and the application of travel demand management measures, specifically congestion charging. Drawing on international and local Hong Kong experience, the Study has also identified appropriate technology options which could support congestion charging schemes. Based on this, the Study has compiled analyses to make an assessment of the applicability and potential role of congestion charging in the Study Area.

1.4 Study Approach

1.4.1 The Study approach is designed to provide a range of technical, practical, economic and financial analyses for the evaluation of the role of congestion charging in Hong Kong. The key steps in the Study are illustrated in **Figure 1.2** and include:

- Worldwide review of congestion charging applications and experience, as well as previous studies in Hong Kong.
- Preparation of a range of travel and traffic demand forecasts for the assessment of future road network operating conditions based on current policies, plans and programmes.
- Development of a Congestion Charging Model to forecast the likely responses of the travelling public to a range of congestion charging schemes and charging scenarios.
- Behavioural research surveys on the attitudes of travellers and goods vehicle operators towards the introduction of congestion charging to provide a technical basis, in conjunction with international experience, for developing the Congestion Charging Model.
- Review and identification of existing and future technology options which could support congestion charging schemes in Hong Kong.
- Assessment of a range of congestion charging schemes and associated charging scenarios considering traffic impact, travel conditions, congestion relief, economic and financial performance.
- Identification of a Preferred Congestion Charging Scheme(s) for the Study Area and associated charging scenario(s).
- Assessment of the potential contribution of congestion charging to promoting the sustainable development of Hong Kong in terms of environmental, social and economic objectives.
- Review of the broader legal, institutional and procedural issues associated with the implementation of congestion charging.
- Development of an integrated package of complementary transport measures to support congestion charging as part of the overall transport strategy.

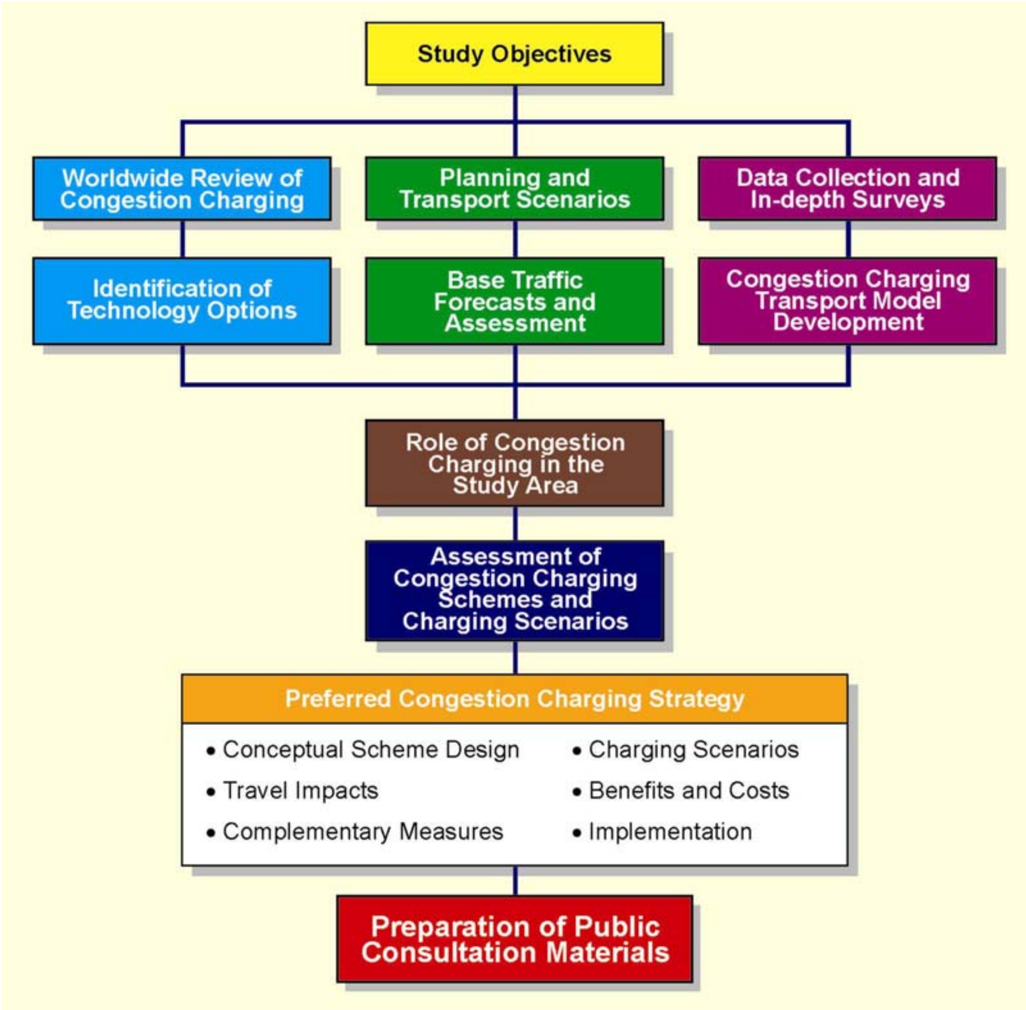


Figure 1.2 Study Approach

1.5 Final Report

1.5.1 This document is the Final Report of the Study which provides a summary of the findings. Following this introductory section, the following are presented:

Section 2	-	An explanation of the role of congestion charging and the level of service and traffic speed objectives set for major cities like Hong Kong.
Section 3	-	A worldwide review of existing congestion charging schemes, technology, performance and key implementation factors.
Section 4	-	An overview of the goals, objectives and policy directions for transport to support the sustainable development of Hong Kong.
Section 5	-	A summary of future travel and traffic forecasts for 2016 and 2021 identifying the potential role of congestion charging.
Section 6	-	A potential congestion charging scheme for the Study Area based on analyses of a range of scheme types and charging strategies.
Section 7	-	An analysis of the impacts of the potential congestion charging scheme from transport, economic, financial, environmental and social perspectives.
Section 8	-	Possible options for extending the Scheme including broader applications of road user charging.
Section 9	-	Outline of the key requirements for implementation and the preliminary programme.
Section 10	-	Way forward for congestion charging.

2. CONGESTION CHARGING

2.1 Role of Congestion Charging

2.1.1 Road User Charging (road pricing) is an "umbrella" term for the pricing of the use of roads and infrastructure for a wide variety of purposes. Congestion charging is a form of road pricing specifically aimed at making road users pay for the costs of the congestion that their journeys place on other motorists and travellers – the "User Pays" principle. Road pricing can also be used to raise revenue to fund infrastructure, such as road tunnels and bridges in Hong Kong; or to charge goods vehicles for the maintenance and environmental costs of motorway use, as in Europe; or to restrict traffic in historic and environmentally sensitive city centres, as in Italy, among others.

2.1.2 The Study focuses on congestion charging, and accordingly the relief of congestion is the leading objective in the scheme designs and evaluation.

2.1.3 As illustrated in **Figure 2.1**, the idea behind congestion charging comes from a relationship between traffic volume and speeds, which is well known to all road users. In light traffic, drivers can choose their own speed within the legal limit. Then, as traffic builds up, vehicles begin to bunch together and speeds decline gradually. However, as traffic volume approaches road capacity, traffic speeds tend to decline more sharply, stop-and-go traffic results and queues begin to form.

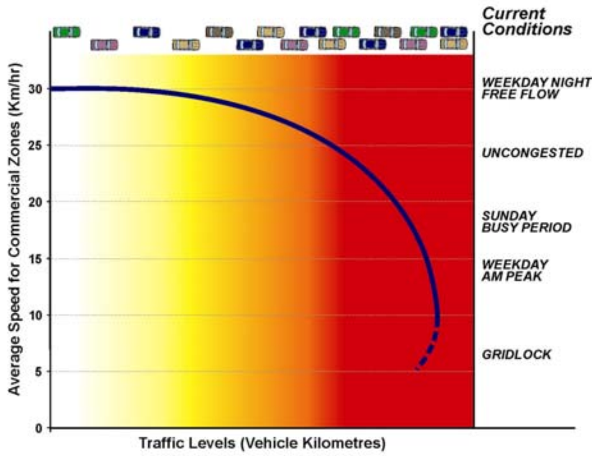


Figure 2.1 Relationship between Traffic Flow and Speeds

2.1.4 Congestion charging is intended to make road users pay for travelling at congested times and in congested places, thereby encouraging travellers to switch to public transport, or change their routes or retime their journeys with the objective of reducing traffic volume. This then enables general road users to travel without undue delay.

2.1.5 Congestion charging schemes form an integral part of broader multi-modal transport strategies comprising the development of a balanced network of rail, public transport and road infrastructure, and services essential for the sustainable development of large international cities. For example, Singapore, after nearly 30 years of traffic restraint policies including congestion charging (known as ERP), continues to expand its urban rail and strategic highway network.

2.1.6 Apart from the primary role of combating congestion, broader sustainability objectives are set for current international congestion charging schemes which include creating a better environment for walking and cycling in London, increasing accessibility and improving the environment in Stockholm, and reducing pollution and protecting historic buildings from the effects of pollution in Italy.

Road Speed Targets

2.1.7 From a transport operation perspective, the effectiveness of congestion charging schemes is judged in terms of the degree to which congestion is reduced and target traffic speeds are achieved, producing an acceptable level of service from a balance of community and technical considerations.

2.1.8 Singapore has managed congestion in the city centre since 1975, first through an Area Licensing Scheme, and since 1998 by ERP where vehicles are charged for crossing a cordon around the city centre and at points on selected main arterial roads and expressways. Charges are adjusted quarterly in order to contain traffic volume to meet the following average speed targets:

Arterial Roads (Trunk Roads)	-	20-30 km/h
Expressways	-	45-60 km/h

2.1.9 The London Area Congestion Charging Scheme was introduced in 2003. Vehicles are charged for travelling inside the city centre. The Scheme has raised all day average speeds in the Charge Area from 11-14 km/h to 16-17 km/h and has reduced congestion by an estimated 30%. Congestion levels are monitored by comparing the time to travel 1km (the "travel rate") during the Charge Period (7:30 a.m. – 6:30 p.m.) with free flow conditions measured in the middle of the night. In 2006, Stockholm, where traffic speeds were running 60% below the speed limits in the city centre, completed a comprehensive congestion charging trial using a single cordon scheme, reducing congestion levels by 35%, which was similar to London.

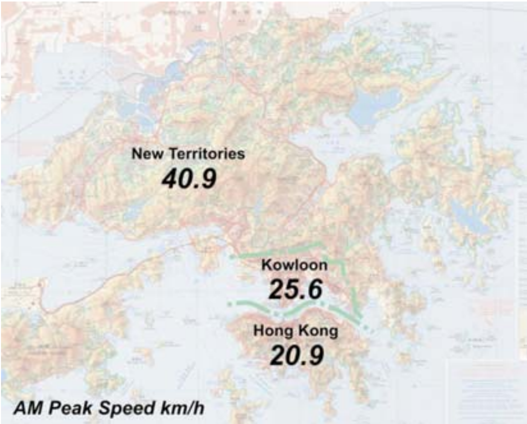


Figure 2.2 Traffic Speeds in 2005

2.1.10 In Hong Kong, traffic speeds vary by sub-region and are tracked by annual journey time surveys by the Transport Department. The results for 2005 are shown in **Figure 2.2**. The lowest speeds are recorded on Hong Kong Island, and as shown in **Figure 2.3**, speeds are even lower in Central, Wan Chai and Causeway Bay. The previous ERPFS set a 19km/h peak speed target for the Study Area.

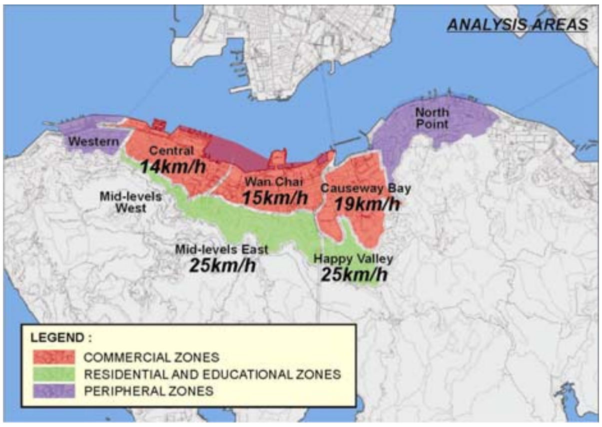


Figure 2.3 AM Peak (8:00 – 9:00) Traffic Speeds in the Study Area in 2005

Figure 2.4 Road Type Classification

2.1.11 The Study has put forward speed targets shown in **Table 2.1** by road type and these reflect a practical balance between road type, vehicle mix, and the surrounding street environment.

Table 2.1 Weekday AM Peak (8:00 – 9:00) Traffic Speeds in the Study Area (km/h)

Area/Road Type	2005 Base	Proposed Target
Commercial Zones		
District Road Network	17	17-20
Trunk Road Corridor	21	20-30
Strategic Road Network	43	Over 50
Overall	**19**	**20-25**

Note: See **Figure 2.4** for Road Type Classification

3. WORLDWIDE EXPERIENCE OF CONGESTION CHARGING

3.1 Scheme Types

3.1.1 Congestion charging schemes of various forms are now in operation in a number of cities worldwide and are being considered by many authorities at city, regional and national level as a network management tool for containing traffic volume, combating congestion and supporting overall sustainable development. Three basic forms of scheme in urban areas can be identified.

3.1.2 ***Cordon Schemes**:* Cordon schemes are the most commonly adopted/proposed form of road pricing for congestion charging purposes (e.g. Singapore ERP scheme, Stockholm). These involve setting up a cordon of Charge Points on roads around a defined (congested) area of a city. Road users are then charged (usually electronically) each time they cross the cordon. An advantage of cordon pricing is that each individual trip made into the defined area during the time of operation is subject to a congestion charge. Each trip is therefore the subject of a choice decision influenced by the level of the applied charge. Pricing of individual trips can be relatively sophisticated with variations by time of day and a range of vehicle types, at the point, time, location and direction of each crossing (e.g. Singapore and Stockholm in **Figures 3.1** and **3.2**)

3.1.3 ***Zonal Schemes**:* These types of pricing mechanisms are conceptually similar to simple cordons as road users are monitored each time they cross in or out of defined zone boundaries (e.g. in Italian cities). In practice, they are often applied as access control schemes to protect the environment in historic centres or residential areas, as well as for traffic management reasons. Zonal schemes can give a finer level of influence over travel patterns since the checkpoints can more closely reflect the problematic traffic movements that the scheme is seeking to address. Zonal schemes with multiple zones are more expensive to implement and more complex for the public to understand than simple cordon charging (e.g. Florence, Italy in **Figure 3.3**).

3.1.4 ***Area Schemes**:* In this type of scheme, charges are applied for the presence of a vehicle within a defined area during a defined time period. Users who wish to use their vehicles within the Charge Area during the Charge Period need to purchase and display a special permit (e.g. the earlier Singapore Area Licensing Scheme), or to make payment and register the vehicle licence plate number in a computer database (e.g. the London Congestion Charging Scheme in **Figure 3.4**).

3.1.5 A key advantage of area-based congestion charging is that for a small, simple scheme, it can be relatively easy for the public to understand and relatively straightforward to implement. However, a significant disadvantage is that charges are applied on a daily basis for access to the defined areas, rather than on the number or timing of trips, thus making it inflexible. Trip making decisions are therefore correspondingly taken on a daily basis, and there is no incentive to restrict the number of daily trips made once the daily licence has been purchased.

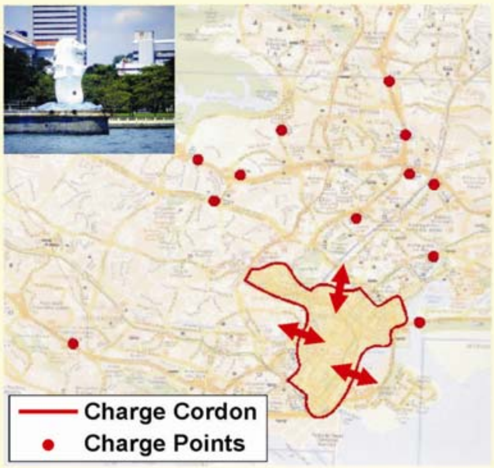
3.2 Application of Charges

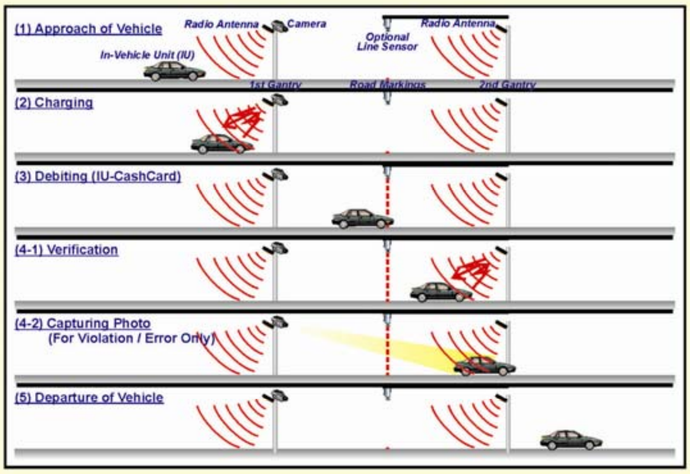
3.2.1 The existing congestion charging schemes take a range of approaches to the application of charges varying by time of day, direction, movement, unit and level.

Time of Operation

3.2.2 In principle, charges should be adjusted to moderate congestion during congested periods and promote peak spreading. Internationally, congestion charging schemes vary from a simple all day flat charge in the London Congestion Charging Scheme to varying charges by time period to reflect changing traffic conditions throughout the day, as in Singapore where charges are varied in small increments to prevent motorists racing or delaying to avoid high charge periods.

3.2.3 On weekdays, charge periods typically start between 6:30 a.m. – 7:30 a.m. and end between 6:30 p.m. – 8:00 p.m. The charging practice at weekends varies. No charge is levied under the London scheme partly because of the need to support retail business. In Singapore, charge was originally applied on Saturday morning but was later suspended. In Italy, the access restriction schemes vary according to local conditions.

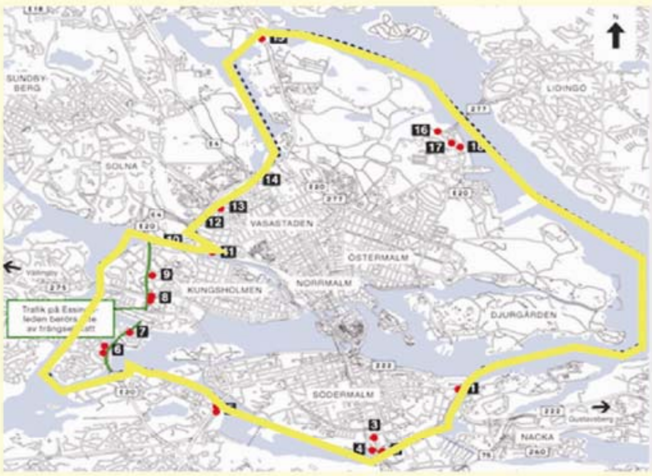




Singapore

Population	: 4 Million
Car Ownership	: 120 Cars per 1000 Population
Private Mode Choice	: 30%-50% (for charge area only)
Charge for car up to SG$2.50 per Entry	
Time Period	: 07:30 - 19:00 Weekdays
Modes Charged	: Cars, Motorcycles, Taxis, Goods Vehicles and Vans, Public Transport
Modes Exempt	: Emergency Vehicles
Technology	: Dedicated Short Range Communication Identification and payment / Automatic Number Plate Recognition Enforcement
Impact	: 16% traffic reduction in the AM peak
Integrated Strategy	: supported by ownership restraint with Certificate of Entitlement; multi-modal strategic rail and road investment
Through Traffic	: Point charging applied to strategic roads which are congested

Figure 3.1 Electronic Road Pricing Scheme in Singapore (2005-2006 Traffic Conditions)



Stockholm

Population	: 1.3 Million
Car Ownership	: 390 Cars per 1000 Population
Private Mode Choice	: 70% (for charge area only)
Charge for car up to HK$22 per Entry	
Time Period	: 06:30 - 18:00 Weekdays
Modes Charged	: Cars, Trucks and Taxis
Modes Exempt	: Public Transport, Emergency Vehicles, Disabled and Military Vehicles
Technology	: Dedicated Short Range Communication Identification and payment / Automatic Number Plate Recognition Enforcement
Impact	: 16% reduction in road traffic; 6% increase in public transport
Integrated Strategy	: expansion of commuter bus services and park and ride
Through Traffic	: Free passage on strategic expressways
Environment	: 14% reduction in vehicle emissions in charge area; 2% city-wide

Figure 3.2 Cordon Charging Scheme in Stockholm (2005-2006 Traffic Conditions)

Florence (Italy - Electronic Gateway Systems)

Population	**: 1.2 Million**
Car Ownership	**: 420 Cars per 1000 Population**
Private Mode Choice	**: 43% to 55% (for charge area only)**
Time Period	**: All day (except special event days and holidays)**
Charge	**: Day Pass at Euro 5 per day (max up to 3 day passes)**
Location	**: Zones align with City incorporated boundary**
Modes Charged	**: Cars, Vans and Goods Vehicles**
Exemptions	**: Residents, businesses and social services / visits, public transport**
Technology	**: Dedicated Short Range Communication identification / payment and Automatic Number Plate Recognition enforcement**
Impact	**: Typically 15%-25% reduction in traffic**
Integrated Strategy	**: Expansion of public transport and environmental management / pedestrianisation**
Through Traffic	**: Free passage on through routes - access control system**
Environment	**: Major reduction in emissions and improvement in street environment in heritage city centres**

Figure 3.3 Italian Cities Zonal Access Control Schemes (2005-2006 Traffic Conditions)

London

Population	**: 8 Million**
Car Ownership	**: 350 Cars per 1000 Population**
Private Mode Choice	**: 15% - 30% (for charge area only)**
Time Period	**: 07:00 - 18:00**
Charge	**: £ 8 per day approx.**
Location	**: Within Inner Ring Road**
Modes Charged	**: Cars, Vans and Goods Vehicles**
Exemptions	**: Public Transport, Taxis, Motorcycles, Emergency and Social Services Vehicles**
Technology	**: Automatic Number Plate Recognition with Prepayment**
Impact	**: 18% traffic reduction; 30% reduction in private cars**
Integrated Strategy	**: Expansion and upgrading of public transport, area-wide traffic management and environmental improvements**
Through Traffic	**: Free bypass route provided**
Environment	**: 10%-12% reduction in emissions, partly due to engine technology improvements**

Figure 3.4 London Area Charging Scheme (2005-2006 Traffic Conditions)

Directional and Point Charging

3.2.4 For Point charging schemes (Cordon and Zonal), charges may be applied directionally to reflect tidal traffic flows, for example, inbound to the city centre in the AM peak, and outbound in the PM peak. This type of approach is applied in Singapore where charges are varied by direction and location to reflect variable congestion levels. Directional charging sends a message to road users that charges are targeted on congested corridors.

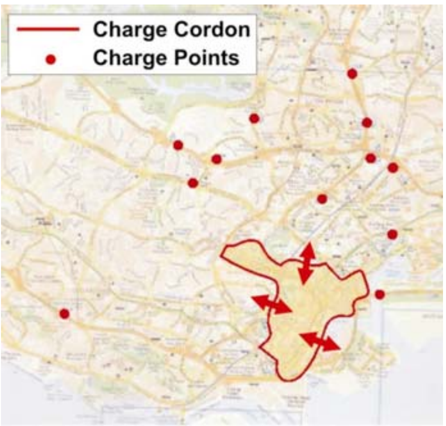


Figure 3.5 Electronic Road Pricing in Singapore: Cordon and Point Charging

Traffic Movements

3.2.5 Most schemes provide free-of-charge bypass routes in the interests of diverting traffic around the Charge Area without unnecessarily penalising travel between locations outside the Charge Area. London upgraded the Inner Ring Road and approach corridors to provide free bypass routes. Similarly, the Stockholm trial scheme permitted free-of-charge travel on the urban expressway through the scheme area and to some specific destinations isolating the cordon. Singapore initially did not charge bypass routes, but has evolved a Point charging system on expressways to manage peak congestion on an area-wide basis.

Figure 3.6 London Congestion Charging Scheme: Charge Free Ring Route

Vehicle Charging and Exemptions/Discounts

3.2.6 The policies on vehicle charging and exemptions vary significantly, reflecting different socio-economic and political environments as well as the core objectives of the schemes.

3.2.7 Singapore follows the economic idea behind congestion charging that the user pays the full costs and accordingly all vehicles (except emergency vehicles) are charged in relation to their contribution to congestion with the charges varied by vehicle size. The more basic London scheme only charges cars, vans and goods vehicles while public transport, taxis and emergency vehicles (ambulances, fire engines, etc) are exempted for a mix of transport policy, social, political and public acceptability reasons. A 90% discount is granted to vehicles registered by residents living inside the Charge Area and to environmentally friendly vehicles and those for the disabled. The trial scheme in Stockholm included a similar range of exemptions plus special exemptions for residents of a particular island isolated by the scheme. The Zonal schemes in Italy are effectively access control driven with some schemes charging for annual permits. Exemptions or discounts are granted to residents, local businesses and a range of social services.

Charge Unit

3.2.8 As noted above in a "User Pays" approach, charge levels should be related to vehicle size based on its relative contribution to congestion. Singapore follows this practice and charges larger vehicles more using a factor broadly based on the passenger car unit. London, with its simple scheme, charges cars exactly the same as trucks.

Charge Level

3.2.9 Charging methods and levels vary between Area and Cordon-based Point charging schemes. Area Charges are normally for a given Charge Period whereas Point charges are on a per trip basis. A vehicle may make one or many trips in the Charge Period. The charge applied in an Area Scheme is for the whole Charge Period and this needs to reflect typical trip frequencies – say 2 or 3 trips – and has to be set higher than for a trip-based Point charging scheme to achieve the same traffic demand impact.

3.2.10 Area charges in London are currently £8 per day for cars and trucks, permitting unlimited travel for the day after payment. Charges are applied on a per trip basis in Singapore ranging from HK$12.5 for cars to HK$18 for trucks, while in the Stockholm trial, the maximum charge was around HK$22 per trip with a maximum aggregate charge of HK$64 per day per vehicle after entering the Charge Area several times. *(N.B.: Relative comparisons should take into account the volatility of exchange rates)*

3.3 Congestion Charging Technology

3.3.1 Road user charging technologies have evolved from the paper-based Area Licensing Scheme in Singapore and manual toll collection using toll booths to various forms of automatic enforcement and toll collection using electronic communication and remote identification systems.

Paper-Based Systems

3.3.2 The original Area Licensing Scheme in Singapore was paper-based using pre-paid stickers placed on the front windscreen of the vehicle. Enforcement was by officials observing vehicles from booths at various checkpoints on a cordon around the Restricted (Charge) Zone. A simple flat charge was applied. This labour-intensive simplistic system, though effective in containing congestion, was costly to operate and subject to error and was replaced in 1998 by Point-based ERP using Dedicated Short Range Communication (DSRC) technology (See below).

Singapore Area Licensing Scheme (1975-1998)

Manual/Automatic Toll Collection

3.3.3 Manual and electronic payments have been in operation at toll booths for many years worldwide. While these systems are suitable for major highways and strategic routes, they require substantial space for toll plazas and create queues on approach roads. The toll road facilities in Hong Kong are typical examples and offer automatic toll collection (Autotoll using DSRC technology) and manual collection. Such an approach is not feasible for congestion charging at district road level, but could be used for major strategic corridors, such as cross harbour tunnels in Hong Kong. However, the current international trend is to use full free-flow systems for these types of facilities, enabling smoother traffic flow. They can be linked to automatic payment systems, reducing the size of toll plazas and saving land space.

Manual/Automatic Toll Collection

DSRC-based Systems

3.3.4 The DSRC-based systems have evolved from conventional automatic toll collection technology, such as the Autotoll system in Hong Kong. This has been enhanced to permit vehicle detection and communications in multi-lane free flow traffic and is working reliably in Singapore, Italy, Stockholm (trial) and the freeway toll collection in Melbourne, Toronto and other cities.

DSRC-based Charging

3.3.5 Vehicle detection and classification sensors and enforcement cameras are mounted on poles or gantries at the Charge Points. The vehicle is equipped with an On-Board-Unit (OBU) which communicates with the vehicle detection and classification sensors as the vehicle passes the Charge Point.

3.3.6 In Singapore, the OBU contains a smart cash card or an electronic purse. Charges are automatically deducted when a vehicle passes through a Charge Point. The driver has anonymity as the card is not linked to the vehicle or the card owner. If the card has insufficient funds, or no card is present, then the Automatic Number Plate Recognition (ANPR) camera-based enforcement system takes an image of the vehicle number plate and transmits it to the Control Centre for enforcement procedures. Alternatively, the OBU can have an account associated with it which, by transmitting the transaction information to the Control Centre, will then be debited by the payment system.

3.3.7 DSRC-based systems have been proven in Singapore and at other locations as being highly reliable at 99.5%, and they have the potential to be integrated with other payment and information systems.

ANPR-based System

3.3.8 The London Area Congestion Charging Scheme utilises the same ANPR technology to capture vehicle images at multiple screenlines and locations inside the Charge Area during the Charge Period. Each time a vehicle image is captured by the on-street cameras, it is checked to determine if the charge has been pre-paid for that licence plate number for entering the Charge Area that day. If payment is registered, the image is destroyed. If not, the image is passed to the Control Centre to commence enforcement procedures. As a consequence, a single vehicle is identified several times per journey, compared to a single transaction for a Point charge system.

ANPR-based Charging

3.3.9 The London Scheme was relatively cheap to install, requiring no in-vehicle equipment and using only on-street cameras for number plate recognition and vehicle type classification. However, the accuracy of video image capture and optical character recognition is normally at best 85% and the London Scheme is quoted at 70%. The handling of misreadings in combination with the multiple identification process results in substantial manual processing with associated high operating costs. This will be an issue when the contract is renewed for running the congestion charge. For this reason, the Transport for London conducted a detailed research/investigation into various available technology options for use in the Congestion Charging Scheme from 2005 to 2008. The DSRC-based technology was a potential technology candidate to be studied.

3.3.10 The Stockholm Trial Scheme (January to July 2006) was formed by a cordon of 18 Charge Points which were mainly at bridge crossings on the series of islands forming the city. A DSRC-based approach was utilised, achieving a high level of reliability. Even so, ANPR technology has been adopted for the permanent scheme for a number of reasons: (i) charging at bridge crossings facilitates the use of simpler technology while maintaining free flow, (ii) only domestically registered vehicles are charged using the well-established National Traffic Register as the database and (iii) there is no need to require motorists to install OBUs. In Sweden, for successful prosecutions, photographs of the front and rear licence plates of the offending vehicles are required (except in extreme weather conditions). In the trial of optical character recognition, an accuracy of 85%-90% was achieved and the target is to raise this to 94%-95% which is considered to be adequate. Based on the assumed level of accuracy, the operating costs are expected to fall from around HK$500 million in the initial years to around HK$250 million after the third year of operation.

Satellite-based Vehicle Positioning Systems (VPS)

3.3.11 Satellite-based VPS can be used to determine vehicle locations, to track the distance travelled and to levy charges using sophisticated OBUs. Data defining the charge areas, charge periods and routes are stored in the OBU. With the aid of the VPS, the OBU determines when the vehicle enters a charge area and levies the appropriate charge. The OBU can support payment by a smart card or be account-based using wireless communication to the Control Centre. No on-street equipment is required. At present, there are no VPS-based urban road user charging systems in full operation. Systems are in operation for inter-urban road user charging in Europe while in-vehicle VPS are being fitted for route guidance, safety and security applications in many countries.

3.3.12 ERPFS conducted trials of the then VPS technology and concluded that while there were still shortcomings to be overcome in respect of enforcement, it was potentially the best solution as and when fully proven. Based on the trials in 2006, Transport for London concluded that the best performing systems were sufficiently accurate to allow, at a later date, the introduction of satellite-based systems subject to a more detailed assessment and public consultation.

VPS-based OBU

3.3.13 VPS can be used to identify locations and, therefore, can be applied for Point charging, Area-based charging and more sophisticated distance-based charging which could reflect the actual road use in congested areas. This is an advantage over Cordon Charges and Area Schemes which charge road users the same charge regardless of distance travelled in the congested area, which tends to penalise short journeys.

Cellular Telephone and Pico-Cell Systems

3.3.14 Cellular Telephone and Pico-Cell Systems are based on a radio network made up of a number of radio "cells", each served by a fixed transmitter known as a cell site or base station. Pico-Cell technology is (in simple terms) a more concentrated cell network using smaller transceivers and so developing a cell network that provides a greater ability to locate mobile devices within the network. It is possible to use this type of network to locate properly equipped vehicles with a high degree of accuracy. Pico-Cell technology, when further developed may, like VPS, offer more sophisticated features to levy charges in relation to the distance travelled.

Cellular Phone Technology

Combinations

3.3.15 The majority of current road charging systems, including toll roads and urban charging and access schemes, use a combination of technologies to manage the collection and enforcement processes. These combined systems are capable of applying the most suitable technologies to specific tasks and achieve an optimum system overall. One of the most common combinations, as described above, is the use of DSRC-based OBUs as the primary payment and identification technology, and ANPR technology for enforcement and casual user transactions.

ERPFS Trials

3.3.16 Field trials of DSRC, ANPR and VPS technologies were carried out in ERPFS in 1998 to determine performance under a range of conditions in the Hong Kong environment. The evaluations indicated reliability of over 99% for charging vehicles directly by DSRC, which compares well with international experience. On the other hand, the accuracy of the ANPR enforcement system for DSRC was 70%, while the accuracy of the VPS was only 24% and thus was considered to require substantial improvement before application.

3.3.17 The ERPFS field evaluations confirmed that DSRC-based systems could support congestion charging in Hong Kong with ANPR for enforcement (as in the Singapore system) and that satellite-based VPS, with appropriate enhancements, could offer greater functionality.

3.4 Scheme Justification and Performance

Scheme Justification

3.4.1 Congestion charging schemes have been triggered and justified for a variety of reasons to meet specific objectives, including congestion relief, and environmental and heritage protection.

3.4.2 The Singapore schemes, the original Area Licensing Scheme and the current ERP Scheme, in conjunction with the car ownership restraint policy have been accepted by the travelling public as an integral part of Singapore's world-class transport system developed over a period of thirty years. The level of charges is explicitly linked to target traffic speeds and is adjusted upwards or downwards on a quarterly basis, according to the published observed traffic speeds.

3.4.3 In London, the business sector and members of the public recognised congestion as a leading problem for the city and pushed for its resolution. The scheme commenced in 2003 and was expanded to cover neighbouring Kensington and Chelsea in 2007. With congestion increasingly widespread in London, local authorities are actively looking at implementing congestion charging in other districts.

3.4.4 In Italy, the schemes have a mix of environmental, historical and congestion related objectives and many of them are located in the heart of cities with ancient street patterns of high heritage and cultural value. The electronic gateway schemes introduced several new ideas in controlling access to the historic business districts of the cities that have implemented such schemes. Acceptance of the schemes has been helped by the exemptions granted to residents and local businesses.

3.4.5 Toll rings have been in operation in a number of cities in Norway since the early 1990s and were originally aimed at generating funds for transport, mainly road investment. In practice, particularly in Trondheim, toll rings have also evolved into congestion charging measures, diverting travellers to public transport and to off-peak periods and have met with majority approval.

3.4.6 In Stockholm, the charge is regarded as a traffic congestion and environmental tax. The seven-month trial in 2006 was the subject of a referendum to enable the public to decide on the need and justification. The overall result was split almost equally for and against. Despite the split result, with central Swedish Government backing, the permanent scheme was implemented in August 2007 in conjunction with a commitment to a new outer ring road around the scheme cordon.

3.4.7 It is interesting to note that in most cases after initial resistance, the general public have recognised the travel benefits of congestion charging schemes. This is vital if many of the other key implementation issues and concerns are to be overcome.

Scheme Performance

3.4.8 The congestion charging schemes in London, Singapore, Italy and the trial in Stockholm have typically achieved a reduction in traffic volume in the range of 15%-25%, bringing about significant improvements in average speeds, bus reliability and reductions in vehicle emission levels.

3.4.9 The impact of congestion charging in Singapore has been spread over 30 years. The Area Licensing Scheme took the form of an all day Area Charge, permitting unlimited travel in/out/within the "Restricted Zone". The ERP scheme replaced it with a trip-based Cordon scheme. The net result was a 15% reduction in traffic volume in the ERP Charge Period and 16% at the peak[2].

3.4.10 The London scheme was introduced in 2003 and has produced stable impacts. Road users were required to pay a flat congestion charge of £5 daily for driving or parking a vehicle within the Charge Area. Private vehicle volume in the Charge Area went down by around 30%, goods vehicles and van mileage declined by 7% initially and total traffic volume went down by 15%-18%. Traffic volume on the bypass Inner Ring Road and approach corridors has been stable and traffic flow relatively smooth. The number of charge-exempt taxis and motorcycles in the charge area has increased by 22% and 6% respectively.

3.4.11 After the implementation of the London scheme, it was recorded that the traffic conditions in the Charge Area had deteriorated gradually with decreasing traffic speeds as shown in **Figure 3.8**. In order to sustain the effectiveness of the scheme and control the traffic levels in the Charge Area, the daily charge has been increased to £8 per day since July 2005.

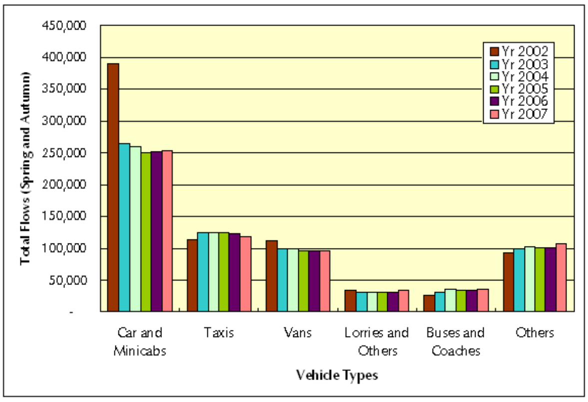


Figure 3.7 London Area Congestion Charging Scheme: Before/After Traffic Flows into/out of Charge Area

[2] Source: "ERP in Singapore – what's been learnt from five years of operations?" Traffic Engineering and Control, February 2004.

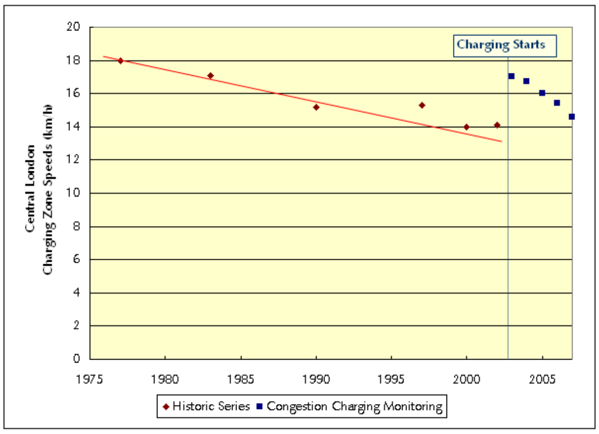


Figure 3.8 London Area Congestion Charging Scheme: Before/After Traffic Speeds

3.4.12 Buses are also exempted from charges and benefit significantly from faster speeds, and greater reliability. The patronage has increased by 30%, reflecting the impacts of fare reductions of 16% and an overcrowded underground railway system. Technical calculations indicate vehicle emission reductions of around 10%-12% overall, while improvements to engine technology have also brought about significant reductions. However, due to a number of external factors impairing on-street measurement, the assessment of the impact of the traffic reductions on measured air quality is inconclusive.

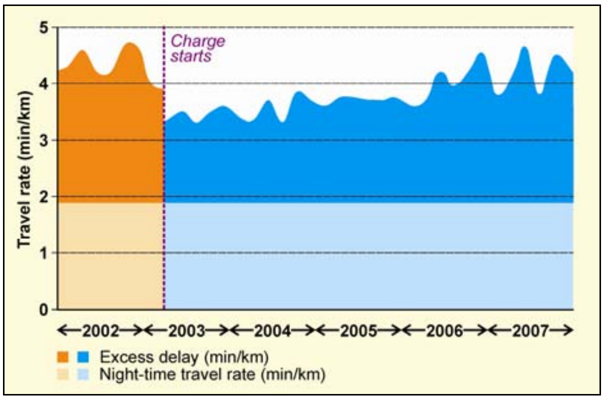


Figure 3.9 London Area Congestion Charging Scheme: Before/After Travel Rate and Levels of Delay

3.4.13 The Stockholm trial produced a 20%-25% reduction in traffic to/from the Inner City with queuing times shortened by 30%-50%. Vehicle emissions were reduced by 14% in the Inner City and 2.5% in the whole county, while noise levels were only marginally affected. Public transport speeds were improved and ridership increased by 6%, with Inner City bus ridership boosted by 9%. However, specially provided Park-and-Ride schemes were not successful as an alternative.

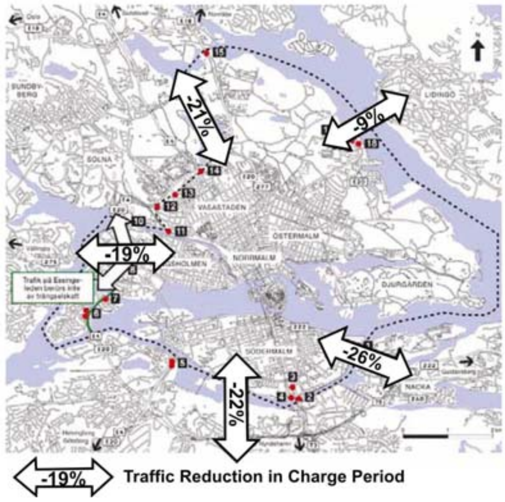


Figure 3.10 Stockholm Congestion Charging Scheme Trial - Traffic Reductions

3.4.14 Overall, the economic benefits of congestion charging schemes in terms of travel time, resources and accident cost savings and reduction in pollution have been calculated to give very high economic rates of return with scheme 'payback' within a few years.

3.4.15 Diverted through traffic has been accommodated on bypass routes using expressways (in Stockholm) or traffic management (London Inner Ring Road), while the reduction in traffic to and from the Charge Area has left spare capacity available in approach corridors. Significant overspill congestion has not occurred in London or Stockholm. While in Singapore, Point charging has been applied on Expressways outside the main Charge Area to prevent congestion in the strategic highway network.

3.5 Key Implementation and Operational Issues

3.5.1 Worldwide experience reveals that a wide range of factors is involved in the design, implementation and operation of congestion charging schemes. These must be resolved technically to suit the particular scheme requirements and to the satisfaction of the travelling public and the community as a whole.

Equity

3.5.2 As discussed above, congestion charging schemes incorporate different designs and charge regimes in order to address a range of issues raised by the public with respect to the distribution of benefits and fairness, affecting:

- Emergency vehicles
- Modal priorities
- Local residents
- Social services
- Through traffic
- Local businesses

3.5.3 Such issues, depending on the local environment, have been handled by the provision of alternative routes, exemptions and discounts. Policies range from no exemptions, the "User Pays" approach in Singapore, to a complex set of exemptions for local residents, businesses and social services as in Italian schemes.

3.5.4 In principle, congestion charging can be regarded as socially progressive since the benefits are transferred to the majority of the travelling public in terms of travel time savings for public transport and the charged motorists, and to the community as a whole in terms of resource savings and pollution reduction. The potential travel time disbenefits of congestion charging schemes would accrue to travellers who change their travel arrangements to, for example, a slower and less convenient mode or a longer route rather than paying the charge.

Complementary Measures

3.5.5 Most congestion charging schemes have been implemented as an integral part of the overall transport strategy. Singapore has developed a comprehensive rail and bus system, a strategic road network supported by advanced traffic management and Intelligent Transport Systems in parallel with the evolution of its congestion charging measures. London invested substantially in traffic management, raised the quality of the bus fleet and services before implementation and lowered bus fares. Cities in Italy upgraded public transport and traffic management to facilitate scheme implementation. Stockholm has invested in improving and expanding the already high quality public transport system before the trial and is planning to improve bypass routes as part of the permanent scheme implementation.

Application of Revenues

3.5.6 Congestion charging schemes can generate substantial revenues and operating surpluses covering capital and recurrent costs. Policies on application of revenues vary worldwide. In Singapore, some temporary reductions in the cost of vehicle ownership (through the Certificate of Entitlement) were granted for a period of five years. In London, the revenues were explicitly used for investment in complementary measures to improve public transport and traffic management associated with the scheme. From a traveller perspective, seeing money reinvested in providing alternatives and improvements is popular, although this raises political issues about consistency in the use of general Government revenues.

System Operations – Enforcement, System Integrity and Privacy

3.5.7 The past ten years have seen major advances in technology, communications and institutional structures supporting congestion charging schemes. Fund integrity and privacy concerns which were impediments to implementation previously (e.g. Hong Kong ERP Pilot Study 1983-1985) have been substantially resolved. The advanced electronic payment systems provide customers with a variety of channels offering convenience and security which are now in familiar use for a range of transport and other purposes and are part of modern daily life. Electronic toll collection systems are commonplace, including Autotoll in Hong Kong for toll facilities and Telepass in Italy used for both congestion charging schemes and motorway toll collection.

3.5.8 The use of the smart-card electronic purse, as in the Singapore ERP scheme, provides anonymity for compliant drivers, much like the Octopus card in Hong Kong. Only vehicles identified as not paying will have the number plate recorded by cameras and then tracked through the licensing records held by Government.

Land Use and Economic Impacts

3.5.9 Concerns have been expressed that congestion charging may deter travellers from visiting the Charge Area and may adversely affect businesses and property values. Reviews of the worldwide schemes have produced no strong evidence in any direction. The 2005 Annual London Congestion Charging Scheme Report indicated that Central London (businesses) performed better than other parts of the city and there was no conclusive evidence that congestion charging adversely affected the economy. There was no evidence from the Stockholm trial that business activity was affected. Other schemes have raised the attractiveness of the Charge Zones from accessibility and environmental perspectives as somewhere to visit and live, especially the tourism-oriented centres of cities in Italy.

Institutional Arrangements

3.5.10 The objective of a congestion charging scheme is to support the management of the transport system by charging travellers in order to modify their behaviour. The objective is not to raise revenue for commercial reasons. For this reason, congestion charging schemes are planned, owned and directed by Government departments which often set up special divisions such as the Land Transport Authority in Singapore, Transport for London, and local Government in Italy. The charge levels are set and revenues retained by Government. It is essential that the charges relate clearly to the quality of traffic conditions in order to secure public support. It would be contradictory to operate a congestion charging scheme on a revenue risk profit-making basis involving the private sector as a concessionaire.

3.5.11 The operational functions for payment, enforcement, communications, maintenance, and overall management can be contracted out to varying degrees, with London contracting out most operational functions under a single contract, while other cities make greater use of Government agencies and private sector sub-contractors. Difficulties can arise with contracting out equipment supply and operation if system expansion overlaps contract periods and overall technology upgrades are planned, as in the London expansion scheme.

Legislation

3.5.12 The implementation and operation of congestion charging or road user charging schemes require appropriate enabling legislation, including authorising the body responsible for the application to make and collect charges, grant exemptions, apply and enforce penalties, implement procedures for protecting privacy, install on-street equipment, install in-vehicle equipment, apply accounting systems and propose extensions.

Transport Economics and Finance

3.5.13 International experience indicates that the economic benefits are large in relation to capital costs and the recurrent costs, and schemes can deliver high economic internal rates of return and net present value over short time horizons. In practice, as discussed above, operating surpluses are generated which more than cover the congestion charging scheme depreciation and replacement costs and which can be redeployed for other transport, environmental or public works.

Public Consultation

3.5.14 Depending on the local political environment, worldwide experience indicates that comprehensive public/stakeholder engagement is essential in order to ensure that the scheme is appropriately designed, addresses the issues and secures support for implementation and operation with a high level of community consensus. In London, against a background of public dissatisfaction with the prevailing traffic congestion, the then Mayor Ken Livingstone included the implementation of congestion charging as a central policy initiative in his successful 2000 election campaign. The mandate received enabled him to drive it through to implementation by 2003. Whereas in Stockholm, following a consensus route, a seven-month full scheme trial and a referendum process were carried out to determine whether to introduce a permanent scheme.

3.6 Future Directions

3.6.1 Congestion charging scheme designs, applications and technologies are now well proven in operation in a number of cities with varying environments worldwide. Taking note of the effectiveness of congestion charging schemes in reducing congestion and bringing broader social and environmental benefits, many other cities are investigating the role of congestion charging, including those in Europe, North America, Australia, New Zealand and China.

3.6.2 Scheme designs have evolved to suit particular environments. The Singapore Congestion Charging Scheme is based on sophisticated charging strategies, matching charges with the prevailing traffic conditions and vehicle types with a quarterly monitoring system for charge adjustments. London, in the interests of quick implementation, adopted a simpler approach with a flat charge for a restricted number of vehicle types granting a number of exemptions. The Italian schemes are access control schemes granting exemptions to residents, local businesses and social services and charging “visitors”. Clearly, congestion charging schemes should achieve the objectives set for a particular city.

3.6.3 At present, DSRC-based systems for vehicle identification and charging supported by ANPR-systems for enforcement offer the most reliable and cost-effective solution and would form a suitable basis of a system for Hong Kong. However, future developments (such as VPS) potentially offering greater functionality and lower costs should be monitored as they may form a better alternative in the coming years.

3.6.4 System integrity, privacy and enforcement concerns have been substantially resolved and would be technically supported by legislation for the protection of privacy. The charge/payment process and systems associated with congestion charging schemes have been accepted by the public in London, Italy, Norway and Sweden, where the protection of personal privacy and individual freedoms are foremost.

3.6.5 Worldwide trends are for congestion charging to be considered as a component of travel demand management integrated with transport supply management, including Area Traffic Control, Intelligent Transport Systems and Transport Information Systems. A number of implementation factors must be proven technically and most importantly to the satisfaction of key stakeholders, the travelling public and the community as a whole. In this regard, the proposed congestion charging scheme must be:

- Recognised as an effective means of relieving traffic congestion;
- An integral part of the overall transport strategy with complementary measures;
- Based on proven technologies that secure system integrity and protect privacy;
- Cost-effective and resource efficient; and
- Fair and equitable.

3.6.6 Finally, a comprehensive consultation process is essential throughout the whole planning and development process to ensure that the congestion charging scheme takes into account the concerns of the public, a general consensus is achieved and any adverse impacts are mitigated.

4. TRANSPORT DEVELOPMENT IN HONG KONG

4.1 Goals and Objectives

Transport Policy Directions

4.1.1 The document entitled "Hong Kong Moving Ahead: A Transport Strategy for the Future", prepared by the then Transport Bureau in 1999 following completion of the Third Comprehensive Transport Study, provides the key transport policy directions for Hong Kong founded on the so-called "5 Betters":

- better integration of transport and land use planning
- better use of railways as the backbone of our passenger transport system
- better public transport services and facilities
- better use of advanced technologies in transport management
- better environment protection

4.1.2 More specifically, a three-pronged approach was put forward forming three building blocks as follows: i) improving transport infrastructure; ii) expanding and improving public transport, and iii) managing road use. In this regard, the role of congestion charging is to contribute towards managing road use.

Transport Goals and Objectives

4.1.3 Against this policy background, the goal of congestion charging in Hong Kong is interpreted to be:

> ***"to improve the mobility of people and goods to support the sustainable, social, economic and environmental development of Hong Kong."***

Mobility Objectives

4.1.4 This overarching transport goal can be defined in mobility terms to:

- Secure uncongested traffic flow
- Utilise transport infrastructure and services more efficiently
- Achieve the highest economic benefits

4.1.5 The core objective of congestion charging is to secure a target level of service in the road network and to alleviate the adverse impacts of congestion. This will bring more efficient use of transport infrastructure and services, including the roads themselves, buses, taxis, and rail. An overriding objective is to produce the maximum economic benefits measured in terms of savings in travel time and costs to the travelling public, operators and community for a given road network associated with the congestion charging scheme.

Sustainable Development

4.1.6 The evaluation of congestion charging takes place at a number of levels ranging from strategic to operational. First, as part of the overall transport strategy, congestion charging must be considered in the context of the overriding social, economic and environmental sustainability goals and objectives set for Hong Kong and the Greater Pearl River Delta region. In Hong Kong, this has been defined as:

- finding ways to increase prosperity and improve the quality of life while reducing overall pollution and waste;
- meeting our own needs and aspirations without doing damage to the prospects of future generations; and
- reducing the environmental burden we put on our neighbours and helping to preserve common resources.

4.1.7 At the next level, congestion charging should be considered in terms of supporting physical development plans for Hong Kong, such as urban development and renewal in the Study Area, in the harbour area and in the Territory as a whole.

Sustainability Objectives

4.1.8 The sustainability dimension is represented by broad social, environmental and economic objectives to:

- Support economic development
- Ensure adequate and affordable travel for all sectors of the community
- Support environmental improvements

4.1.9 Hong Kong has grown to be a world city by placing prime emphasis on economic growth. This remains a core objective and any congestion charging strategy must still ensure that economic development is supported and net costs are not added to the economy. The Study Area contains the Central Business District, the economic engine of Hong Kong.

4.1.10 In recent years, as society has matured, more emphasis is being placed on social impacts and distribution of benefits and costs in the community. Accordingly, the impacts of congestion charging strategies and schemes on social groups, geographic areas, and various stakeholders need to be assessed and monitored, and any appropriate mitigation measures identified.

4.1.11 In recent years, Hong Kong has suffered a deterioration in its physical environment, particularly air quality, brought about by domestic and regional pollution. The present research Study focuses on congestion relief, reductions in traffic volume and smoother traffic flow which will bring some environmental benefits through reduced emissions. Therefore, the degree to which strategies support environmental improvements will feature as an objective. However, specific environmental charging strategies in relation to air quality are outside the scope of the Study. Environmental charging would involve a very different set of objectives, and would potentially require different scheme designs and charging systems. This broader role of general road user charging is being studied by the Council for Sustainable Development.

4.1.12 The promotion of land use/transport/environmental integration is the cornerstone of sustainable physical development planning in Hong Kong. At strategic level, this involves planning transport infrastructure in coordination with New Town Development, or major integrated rail/property development along the growing railway corridors and at local level, harmonisation of neighbourhoods with transport through traffic and environmental plans and pedestrianisation. Congestion charging supports land use/transport/environmental integration through containing traffic growth at all levels and brings new opportunities for the reallocation of road space.

Implementation Factors

4.1.13 The implementation of congestion charging schemes involves a range of factors. These are typically associated with infrastructure schemes such as technical feasibility and costs and a number of complex issues relating to enforcement, privacy, payment, legislation and institutional arrangements. These can vary from scheme to scheme and must meet with public acceptance. Therefore, as noted above, the findings of the Study will require extensive public consultation.

4.2 Transport Infrastructure Development Plans

4.2.1 Hong Kong has developed a highly sustainable transport system comprising an extensive and expanding railway network complemented by comprehensive modern franchised bus services and a wide variety of minibus, coach and paratransit services. In parallel, a hierarchical road network system has been developed, providing strategic links between the major districts, New Towns and key activity areas like the airport, container port and the boundary with Mainland China.

4.2.2 The existing and planned strategic road and railway networks in the Study Area are shown in **Figure 4.1.** The expanding railway lines will provide links to the whole Territory and reduce the need for road travel. The completion of Central-Wan Chai Bypass (CWB) will remove heavy traffic flows from the surface streets, relieve worsening congestion along the east-west corridor (formed by Connaught Road Central/Harcourt Road/Gloucester Road/Victoria Park Road) and provide opportunities for reallocating surface road space for public transport, pedestrianisation and environmental improvements.

4.3 Transport Supply Management

4.3.1 The planned transport infrastructure framework in the harbour area will largely be completed by around 2021. In the coming years, increasing emphasis will need to be placed on transport supply management in order to secure the efficient use of the network and services and to prevent traffic congestion.

4.3.2 A broad range of transport supply management measures has been implemented over the past 30 years, including Area Traffic Control, area-wide traffic schemes, bus lanes and priority schemes, pedestrianisation and traffic calming schemes, Journey Time Indication Systems and the future intelligent transport systems such as Transport Information and Incident Management Systems. All these measures both boost efficiency and promote the more economic use of the transport system and road space in the city. However, particularly in the Study Area, there is a limit to the scope for further capacity improvement through management measures alone.

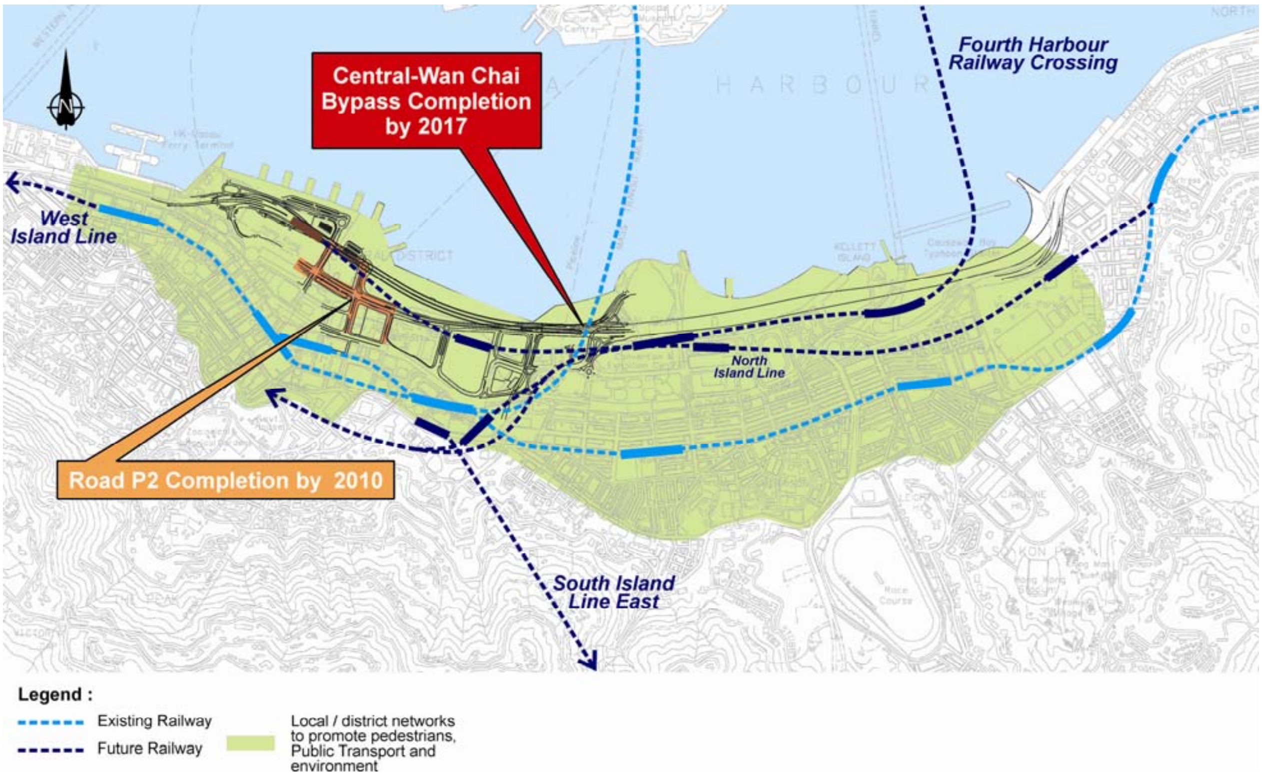


Figure 4.1 Transport Infrastructure Development in the Study Area

4.4 Travel Demand Management

4.4.1 Travel demand management measures are applied to contain and direct demands in order to secure the cost-effective use of resources and to keep congestion in check. They can be applied to have an impact on:

- Vehicle Ownership
- Vehicle Usage
- Travel Behaviour

4.4.2 The long-standing and effective policy of containing traffic through restraining private vehicle ownership by fiscal charges (First Registration Tax and Annual Licence Fee) will continue to be an essential cornerstone of transport policy for Hong Kong. Since their introduction in the early 1980s to halt worsening congestion due to traffic growth outstripping network development, a balance has been managed between vehicle ownership and network development, as illustrated in **Figure 4.2**.

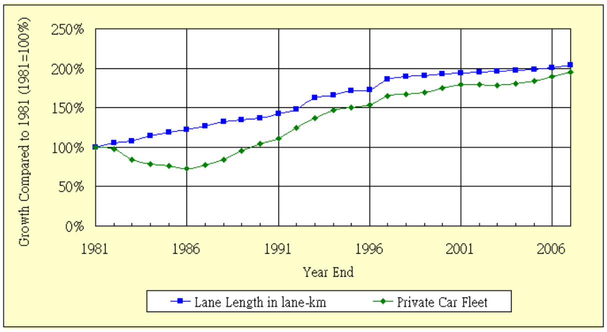


Figure 4.2 Managing Vehicle Ownership and Road Network Capacity

4.4.3 Planning for the next 15 years is based on containing the average annual increase in the number of cars to 2% per annum by application of fiscal charges which, as past history reveals, can vary significantly from year to year with economic conditions. This implies that the private vehicle fleet in early 2007 of around 390,000 cars and motorcycles may grow to 515,000 by 2021, just under 10,000 vehicles per year. By international standards, this growth rate is low compared to 3% for Singapore where ownership restraints are also applied, and over 10% for major cities in Mainland China where no restraint is applied (except Shanghai where ownership certificates at a high price are a prerequisite for owning private cars), resulting in major cities like Beijing experiencing huge increases in its vehicle fleet of over 300,000 vehicles per annum.

4.4.4 Vehicle usage is currently affected by fuel costs, road tolls and parking charges and availability. These contribute to the cost of motoring and can vary for specific journeys. Parking supply is kept in reasonable balance with network capacity and demands by application of the Hong Kong Planning Standards and Guidelines. However, Government has only limited control over parking demands and charges, as a large proportion of parking is in private hands and operated on a commercial basis.

4.4.5 The Study also reviewed a number of other travel demand management measures which could be strengthened or introduced, including car pooling, staggered working hours, telecommunications and Park-and-Ride. While these can make useful contributions, their impacts on road usage in the Hong Kong environment would be limited.

4.4.6 Congestion charging offers a more focused approach to managing traffic in congested areas and at congested times based on the "User Pays" principle for all vehicles. When conditions are congested, charges are higher. When traffic is flowing freely, charges are lower or zero. In this way, the roads are used efficiently and the travelling public can benefit from uncongested travel.

4.4.7 Congestion charging provides an additional means of managing traffic, complementing the control of overall vehicle ownership levels through fiscal charges and other travel demand management measures, by balancing traffic demands with local network capacity and parking availability and by providing opportunities for traffic and environmental management improvements.

5. FUTURE TRAVEL CONDITIONS

5.1 Base Travel Forecasts

5.1.1 Base travel forecasts were prepared for 2016 and 2021 using the Congestion Charging Model. These forecasts were based on the latest planning assumptions used for transport planning studies.

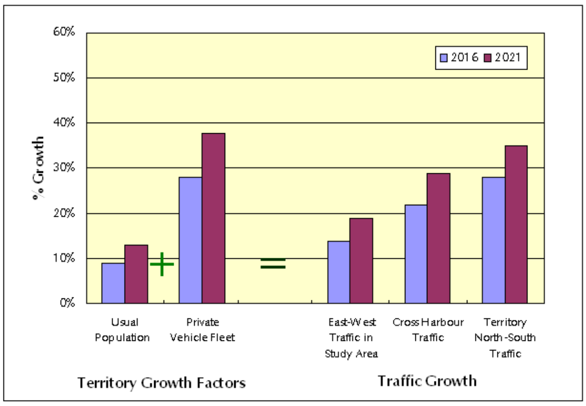


Figure 5.1 Base Forecast: Traffic Growth by 2016 and 2021

5.1.2 By 2021, the resident territory population is assumed to increase by 13% or 0.7% per annum. This forecast growth drives the overall increases in travel demands and private vehicle usage.

5.1.3 In the Study Area, new developments at North Central and North Wan Chai and redevelopments in the older established areas are assumed to increase employment by 5% by 2021, while population increases by 4%.

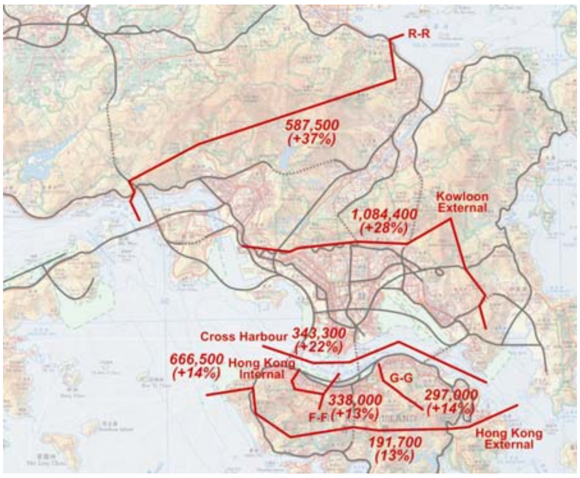


Figure 5.2 Base Forecast: Daily Traffic Growth across Screenlines by 2016

5.2 Base Forecast Travel Conditions

5.2.1 As shown in **Figure 5.2**, daily traffic volume in the main commercial areas is forecast to increase by around 10%-20% by 2016, with the main increases in the east-west corridors and across the harbour and with more stable conditions in the older established districts.

5.2.2 Travel conditions in the Study Area are forecast to improve substantially in the long run with the planned opening of the CWB, the West Island Line and the South Island Line (East). Average AM peak traffic speeds in the main commercial areas of Central, Wan Chai and Causeway Bay are forecast to increase from 18.8km/h in 2005 to 24.5km/h by 2016/2017, while conditions along the currently congested Connaught Road Central/Harcourt Road/Gloucester Road corridor would be significantly improved.

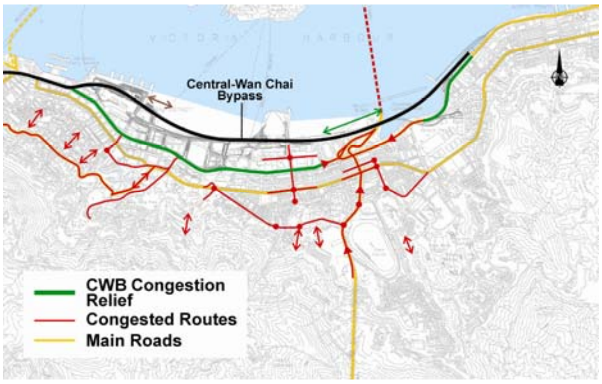


Figure 5.3 Base Forecasts: Traffic Conditions in 2016

5.2.3 While there are substantial improvements overall, the older District Road Network (such as Queen's Road Central, Fleming Road, Canal Road Flyover and other well-known congestion spots) remains under pressure. These areas contain major public transport volume and pedestrian activities. Traffic congestion at the northbound approaches to the Cross Harbour Tunnel is forecast to persist and continue to disrupt traffic operations along Gloucester Road and the Canal Road Flyover.

5.2.4 Traffic volume is forecast to continue to build up gradually to 2021, indicating that longer term traffic growth, if not contained, will place the network under increasing pressure.

5.3 Potential Role of Congestion Charging

5.3.1 The potential role of congestion charging in the Study Area includes specific traffic management objectives, more general transport improvements and broader sustainability directions.

5.3.2 From a traffic management perspective, congestion charging could be applied to maintain an overall balance between traffic levels and prevailing capacity. In the short term, congestion charging could ease the forecast traffic jams in the district distributors (such as Queen's Road Central and Fleming Road) and relieve bottlenecks in the network as a whole in the long term as traffic volume continues to build up.

5.3.3 At strategic level, congestion charging would promote the use of CWB and discourage through traffic from using the Connaught Road Central/ Harcourt Road/Gloucester Road/Victoria Park Road corridor which should be used as a primary route and public transport corridor. Furthermore, "Point Charging" as applied in Singapore could be used to contain traffic in the Strategic Road Network, including balancing demands by using the three road harbour crossings in order to relieve the congested Cross Harbour Tunnel.

5.3.4 In general transport terms, building on the opportunities brought by the CWB and containing overall traffic levels will present further opportunities for reallocating road space to public transport or pedestrian and environmental management schemes.

5.3.5 From a broader sustainability perspective, the potential reduction in traffic volume will reduce vehicle emissions, accidents and consumption of resources.

6. POTENTIAL CONGESTION CHARGING SCHEMES IN HONG KONG

6.1 Congestion Charging Scheme Options

Forms of Charging Schemes

6.1.1 Based on recent international experience and the specific travel characteristics of the Study Area and taking into account the Base Forecasts, three generic forms of congestion charging schemes (See **Figure 6.1**) were assessed using the Congestion Charging Model as follows:

(i)	Area	:	For vehicle presence inside the charge area (e.g. London)
(ii)	Cordon	:	For vehicles crossing a charge cordon around or approaching a congested area (e.g. Singapore)
(iii)	Zonal	:	For vehicle entry/exit to traffic zones in congested areas (e.g. Italian cities)

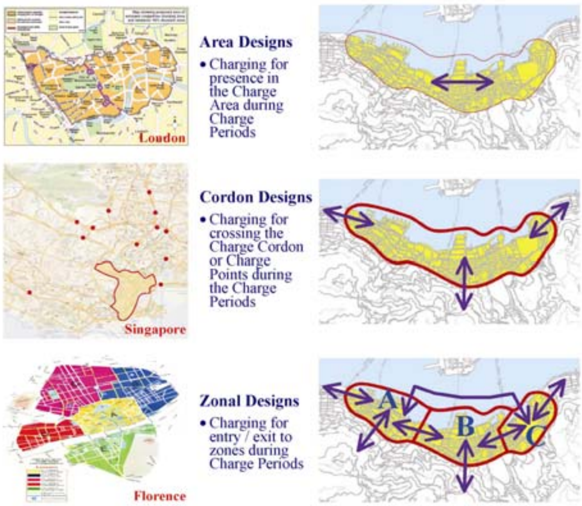


Figure 6.1 Congestion Charging Scheme Options

6.1.2 Three other charging options were considered but rejected for a mix of technical, operational and safety reasons:

- Distance-based – charging for the distance travelled in the Charge Area. Distance charging in theory could more precisely charge for the amount of travel in congested areas. However, the relatively short journey distances and the incentive to choose the shorter rather than less congested routes reduced its attractiveness as a charge method in the relatively small Charge Area. Distance charging would be advantageous if the scheme coverage was extended more widely in the Territory. Existing technologies, DSRC and ANPR are less effective for distance charging over short distances. Therefore, effective implementation must await VPS, satellite or cell phone-based or other advanced technologies coming into practical operation.
- Time-based – charging for the time spent in the Charge Area. This was rejected on operational grounds as drivers may "race" to reduce chargeable time or equally complain if congestion extends their chargeable time.
- Congestion-based – real-time charging for travel in congested conditions. This was rejected since it would be difficult to provide motorists with precise traffic information to make informed route choices in advance and to transmit congestion charge levels as traffic conditions change during a journey.

Scheme Area

6.1.3 The Preferred Congestion Charging Scheme covers the commercial areas of Central, Wan Chai and Causeway Bay, i.e. the principal locations of congestion on Hong Kong Island (See **Figure 6.2**). Certain congested routes in Mid-Levels, such as Bonham Road/Caine Road, would also be considered for inclusion into the congestion charging scheme. In addition, specific Charge Points would need to be set up to prevent overspill traffic from bypassing the scheme area and adversely affecting traffic conditions in upper Mid-Levels and Happy Valley. Additional Charge Points could be considered to address the imbalance of usage of the cross harbour tunnels; or to contain traffic from the south of Hong Kong Island and in the longer term to contain traffic levels in the Strategic Road Network.

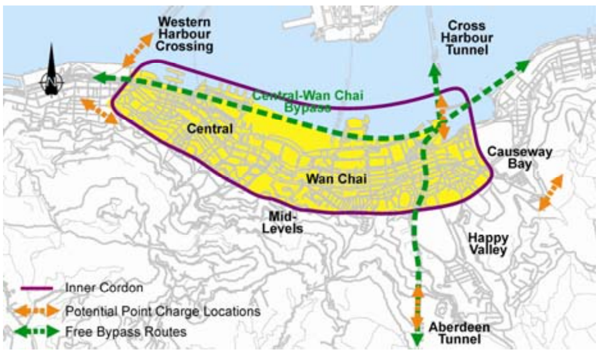


Figure 6.2 Preferred Congestion Charging Scheme Area and Type

Scheme Types

6.1.4 The functionality of the Cordon, Zonal and Area Scheme types in terms of the flexibility of charging methods to focus on congested times, locations and traffic movements is compared in **Table 6.1**.

Table 6.1 Functionality of Congestion Charging Scheme Types

	Cordon	Zonal	Area
Charging Scenario			
Time Period	√	√	X
Vehicle Type	√	√	O
Direction	√	√	X
Movement (CWB Free)	√	√	√
Charge Unit	√	√	√
Charge Level	√	√	O
Expansion	√	√	X

Functionality: √=High O=Limited X=Low

6.1.5 A Cordon-based approach is favoured because it is straightforward for travellers to understand charging on a per trip basis, which offers a broad range of functionality, enabling charge variations by time of day, vehicle type and direction. In addition, the scheme can be expanded to incorporate new cordons or to add specific Charge Points to manage overspill traffic or local bottlenecks.

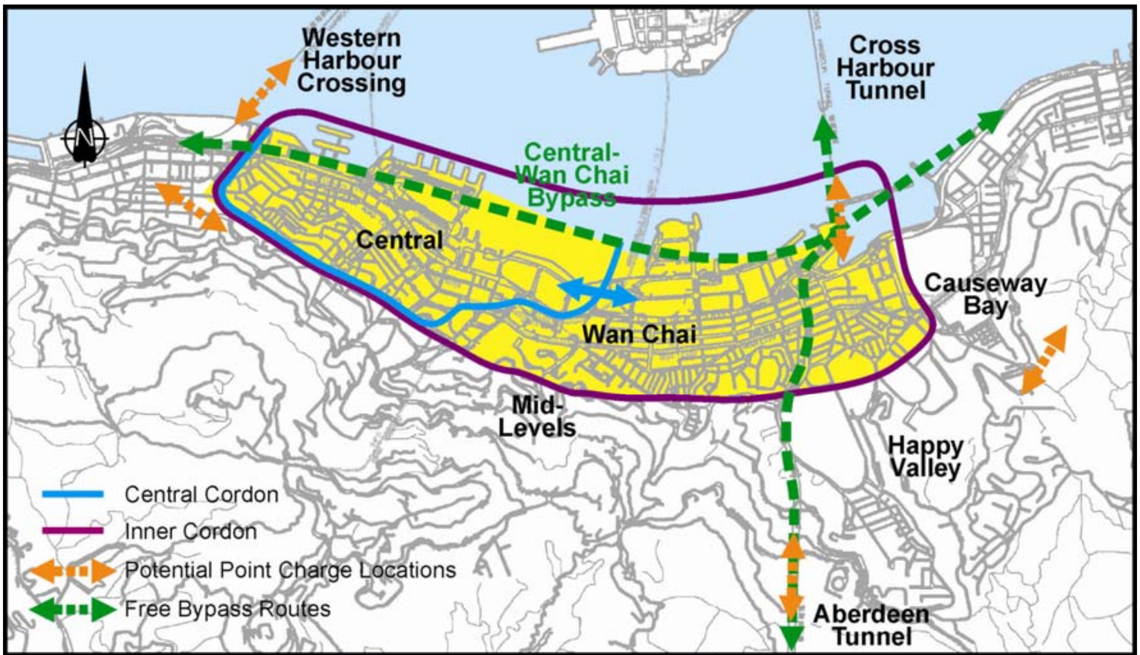
6.1.6 The preferred scheme is formed by a cordon enclosing the commercial areas of Central, Wan Chai and Causeway Bay – **the Inner Cordon Scheme.**

6.1.7 While a Zonal Scheme could offer a range of functionality, it was considered to be unnecessarily complex for the relatively small Study Area from an operational and traveller perspective.

6.1.8 Area Schemes offer some advantages of simplicity from a traveller viewpoint, but are considered to be a more inflexible approach by charging for a time period and not per trip. Furthermore, in the case of taxis, it would be difficult to establish a charging mechanism for passing the daily charge on to passengers in a fair manner. Also, based on the London Congestion Charging experience, the expansion of area schemes will only enlarge the original zone coverage and not flexibly create new charging areas with alternative charging structure such as multiple charges across multiple zones.

Congestion Charging Scenarios

6.1.9 The Preferred Congestion Charging Scheme and Charging Scenarios are formulated based on the assumption that the CWB would be made available as a free bypass route. The details are summarised in **Figure 6.3**, together with a list of possible key options which could be considered from technical and broader policy, social, and practical perspectives.



Scheme Description	Preferred Approach	Possible Options
Type	Cordon	Additional north-south cordon between Central and Wan Chai
Location	Inner Cordon: around Central, Wan Chai and Causeway Bay	Additional Charge Points Mid-Levels: east-west traffic Cross Harbour: Cross Harbour Tunnel/ Western Harbour Crossing/Eastern Harbour Crossing South Island: Aberdeen Tunnel/ Wong Nai Chung Gap Road
Phasing	Inner Cordon	Initial Central Cordon
Charging Scenarios Time Period	Charge Period: 07:30 - 20:00 hrs Build Up: 07:30 - 08:30 hrs Scale Down: 19:00 - 20:00 hrs	Inter - Peak Discount
Direction	Bi-directional	Directional Tidal Charges
Vehicle Types	User Pays Principle - All Vehicles Charged.	Not Applicable
Exemptions / Discounts	Emergency Vehicles. Through Traffic via Central-Wan Chai Bypass and Canal Road Flyover.	Franchised Public Transport, Non-Franchised Bus (including Red Minibus, School Bus Residents Coach, etc.), Environmentally Friendly Vehicles and Disabled Vehicles
Unit	Vehicle Size Based Charge per Trip	Charge per Cordon Crossing Cap on Daily Charge for Goods Vehicles
Level	Set to achieve target level of service/traffic speeds by area/road type	Not Applicable

Figure 6.3 Preferred Congestion Charging Scheme

6.1.10 Time Period – The variations in the proposed Charge Levels and traffic demands are illustrated in **Figure 6.4**. The most effective charge period was identified as between 7:30 a.m. and 8:00 p.m. on weekdays when traffic is the busiest. Charges would be built up between 7:30 a.m. and 8:30 a.m. and scaled down between 7:00 p.m. and 8:00 p.m. in order to reduce the traffic impact and to encourage motorists to retime their trips to spread the peak demands. Discounts may be offered between the rush hours if traffic conditions permit to further spread the peaks. However, there may be limited scope as the road network remains very busy throughout the working day in the commercial areas.

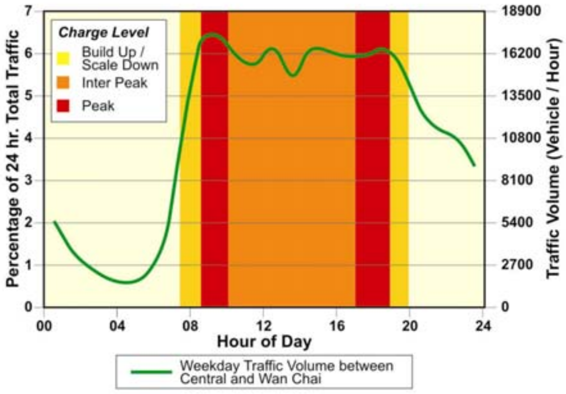


Figure 6.4 Variation in Charge Levels and Traffic Demands

6.1.11 Traffic on Saturdays is also heavy throughout the day, and particularly during lunch time. On traffic grounds, congestion charges should apply. However, the impact on retail and leisure activities needs to be considered. At present, traffic conditions on Sunday would not merit charging except in a few local congestion spots.

6.1.12 Charge Directions – Charges should be applied in both directions in order to be fully effective. The option exists to charge by direction to reflect tidal demands or to apply charges only once per journey.

6.1.13 Traffic Movements – Through traffic using the Strategic Road Network (i.e. the CWB or the Canal Road flyover) which does not enter the Charge Area would not be charged, which is in line with the London Congestion Charging Scheme and Stockholm trial. In the longer term, if congestion arises, charges could be applied to the Strategic Road Network, as in Singapore. (See **Figure 6.5**)

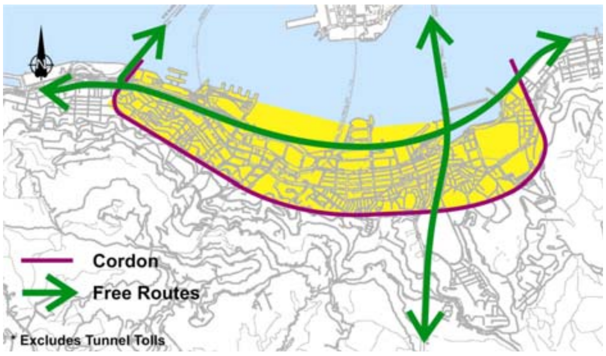


Figure 6.5 Proposed Free Bypass Routes

6.1.14 Vehicle Types and Exemptions – Under the "User Pays" principle, all vehicles are charged as this generates the highest community benefits on a fair basis for the lowest overall charges. In practice, emergency vehicles may be exempted from charges. This is the approach taken in Singapore and is put forward as the basis for a Hong Kong scheme. However, in other cities like London, a range of exemptions and discounts is granted for policy, social and operational reasons. These exemptions include those for public transport to encourage usage as a transport policy measure; or discounts for local residents or environmentally friendly vehicles. While such exemptions and discounts may have merits, they can cloud the effectiveness and fairness of the scheme and inevitably place higher costs and greater restraints on the remaining travellers paying the congestion charge. Exemptions and discounts will need to be considered during public consultation.

6.1.15 Charge Units – As part of the "User Pays" approach, charges should be applied in relation to vehicle size and manoeuvrability as this represents the relative contribution to traffic congestion. Large trucks and buses should pay more than smaller cars and taxis. This principle is applied in Singapore, whereas a flat charge for cars and trucks is applied in the simpler London scheme. In practice, a compromise may be to cap the daily total charges to contain the impact on commercial vehicles.

6.1.16 Charge Levels – International experience indicates that charges in the range of HK$20 – $30 would bring a reduction in traffic levels of about 10% – 20% in the charge period in the Study Area and generate the highest net economic returns, such as the schemes in London, Singapore, Stockholm and Italian Cities. For this Study, the charge impact in the range of HK$20 – $30 were analysed and documented in Section 7.

6.1.17 In the absence of the proposed free, high-capacity alternative route of Central-Wan Chai

Bypass, preliminary assessments indicate that the application of congestion charging would fail to provide an equivalent level of service even with charges of 3 to 4 times higher. Charges would have to be increased even further as traffic continues to grow in the future beyond 2016. It is unlikely that this would be acceptable to the travelling public and stakeholders.

6.2 Preferred Congestion Charging Scheme

6.2.1 The basic functional system architecture for the Preferred Congestion Charging Scheme using a DSRC/ANPR combined system comprises the On-Street Facilities to identify, charge and enforce the scheme; an OBU containing a smart card for payment mounted on the vehicle dashboard (like the Autotoll unit); and Back Office facilities for payments and accounts management, customer services and penalty notice issue and collection.

On-Street Facilities

6.2.2 The basic functional design of the DSRC/ ANPR solution comprises a system of point charging and enforcement sites. These would be equipped for vehicle detection, vehicle classification, DSRC processing, and ANPR image capture. The Preferred Congestion Charging Scheme is formed by the Inner Cordon around the commercial areas with potential Charge Points in Mid-Levels. A possible cordon between Central and Wan Chai/Causeway Bay and additional Charge Points for the cross harbour road tunnels should be considered in any further development stages.

6.2.3 Each site will include facilities with the capability to detect and classify all passing vehicles, communicate with DSRC-based OBU, and will be equipped with ANPR cameras to collect and process licence plate images from vehicles that fail to complete a valid payment response. The equipment would be mounted on simple poles in local streets and on gantries across multi-lane roads where possible using existing infrastructure (e.g. footbridges).

6.2.4 Detailed analyses of each site would be required if the scheme was to progress to the preliminary design stage, including local site environment and utilities, access and frontage, signage, traffic management and pedestrian activities and facilities.

Charging Users

6.2.5 Each vehicle would be equipped with a DSRC-based battery-powered OBU fitted with a facility to use a smart card. Charges would be taken directly from the smart card at the Charge Points, removing the need for accounts and optimising the level of privacy for users. Payment is essentially effected through anonymous smart cards (similar to the Octopus smart cards in common use in Hong Kong). Provision could also be made for motorists wishing to maintain a direct debit payment account similar to that of Autotoll today for the toll road facilities in Hong Kong. This removes the advantages of anonymity of the smart card, but provides the driver with a personal account and records.

6.2.6 In taxis, the OBU would be linked to the meter and the congestion charge and taxi fare shown to the passenger for payment. Charge-exempt vehicles (such as emergency vehicles) would be supplied with special payment cards linked to the vehicle OBU. This is similar to the existing Singapore system and facilities used in some toll road applications. (See **Figures 6.6** and **6.7**)

Figure 6.6 DSRC OBU with a Smart Card

Figure 6.7 Taxi OBU – Singapore

6.2.7 The system design assumes that the majority of vehicles would use the base level OBU and smart card to pay charges. For infrequent users, three options can be considered: i) require all vehicles to be fitted with an OBU regardless of frequency of travel; ii) require casual users to fit a temporary (battery operated) OBU rented from a registered outlet; or iii) provide an alternative payment system, possibly using the ANPR enforcement system (as in the London Congestion Charging Scheme). The best approach will depend on the scale of the scheme and any integration with other payment systems for road tolls and public transport fares in Hong Kong.

6.2.8 Casual users include cross-boundary Mainland registered vehicles with a dual licence. Such “foreign” vehicles would be required to pay a deposit and acquire a temporary OBU at the Boundary and receive a refund on return of the OBU on departure from Hong Kong. This requires the charging and payment records to be connected to the Boundary facility to ensure that the OBU is returned and no charges are outstanding. The ANPR enforcement system would be used to cross-check number plate records.

6.2.9 Enforcement of the potential initial system would be through an ANPR and image capture system. Any vehicle passing a Charge Point that does not complete a valid payment (this may include insufficient funds or incorrect class of payment) would be recorded as a violation, and images of the vehicle concerned and its number plate would be recorded. These would then be used to pursue payment from the registered owner of the vehicle.

Back Office

6.2.10 A Back Office facility would need to be established to process all of the DSRC transactions and ANPR checking of any that are incomplete. All potential offenders would then be pursued in conjunction with Government agencies using the Vehicle and Driver Licensing Integrated Data (VALID) System to issue penalty notices to the registered owners of violating vehicles.

6.2.11 In addition to the main Back Office systems, OBU distribution and contract management would be required to provide the public with OBUs through outlets and to manage the ongoing maintenance and operation of this part of the system. A payment and accounts management facility would also need to be established to deal with all the financial transactions, and a customer service operation for user enquiries and to manage the task of informing and educating the public on the operation and use of the scheme.

6.3 Complementary Measures

6.3.1 The Preferred Congestion Charging Scheme would be fully integrated with ongoing land use/transport/environmental planning for the Study Area and the Territory as a whole (See **Figure 6.8**). The direct effects of the scheme would bring new requirements and opportunities, and would include:

- Diversion of travellers to other modes, principally to bus and rail.
- Diversion of travellers to other routes.
- Reduction in overall traffic levels in the Charge Area during the Charge Period.
- Additional traffic in periods before and after the Charge Period.

6.3.2 The forecast shift in demands could be comfortably absorbed by the existing and planned rail and public transport system.

6.3.3 Potential complementary measures which both mitigate any adverse impacts and support the congestion charging scheme as part of the overall transport strategy are illustrated in **Figure 6.8** and include:

- Traffic management measures to support the modified traffic patterns, especially around the cordon boundary and in approach corridors.
- Public Transport Enhancement – promotion of public transport, such as by bus and tram priority measures and frequency adjustments to meet additional demands where necessary.
- Bus/Rail and Bus/Bus interchange – improved interchange to give motorists alternative journey options.
- Park-and-Ride – encourage Park-and-Ride for longer distance journeys (although this has not been successful in Singapore or in Stockholm).
- Pedestrian Network Improvements – to promote rail and public transport usage and create a people dominated high quality environment integrated with the tram, escalator and strategic pedestrian network.
- Intelligent transport systems – integration of information and data to support intelligent transport systems, including Incident Management System, Route Guidance and Planning System for the public and commercial operators.

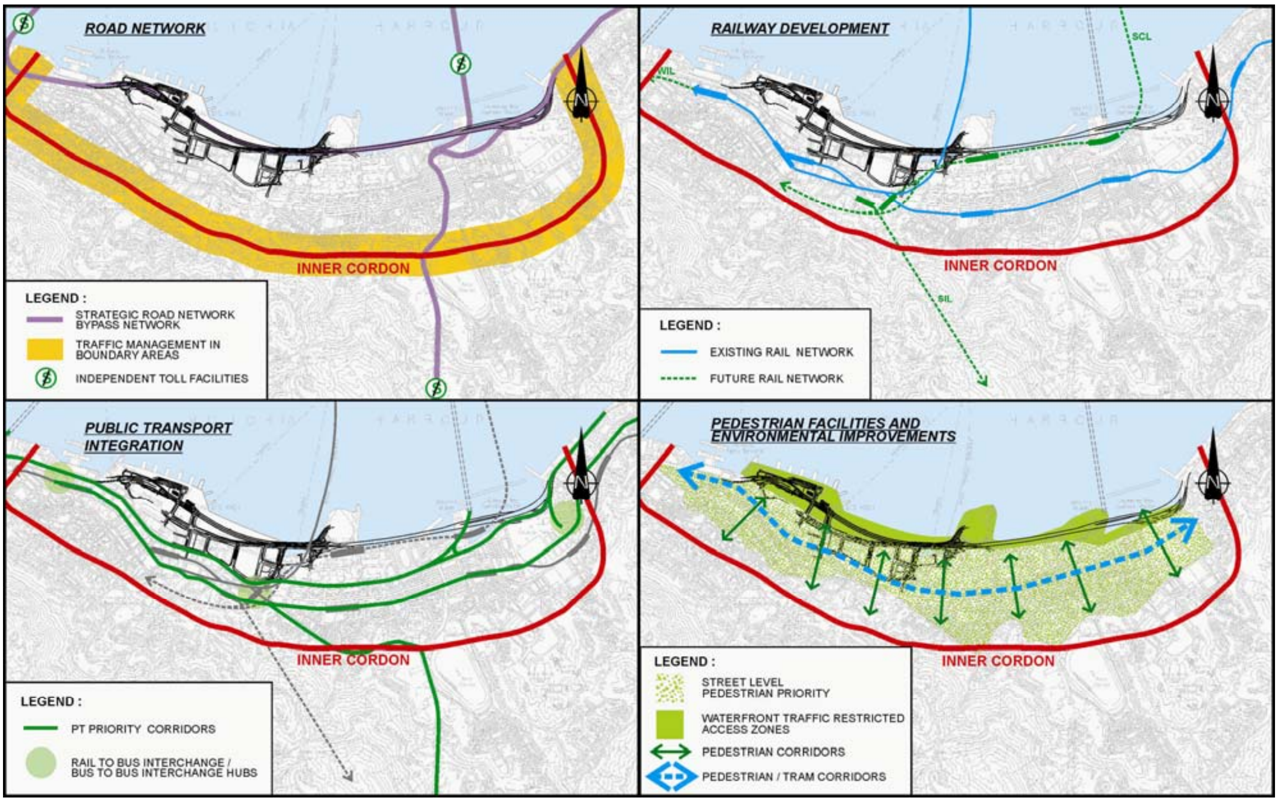


Figure 6.8 Complementary Measures

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7. IMPACT OF THE PREFERRED CONGESTION CHARGING SCHEME

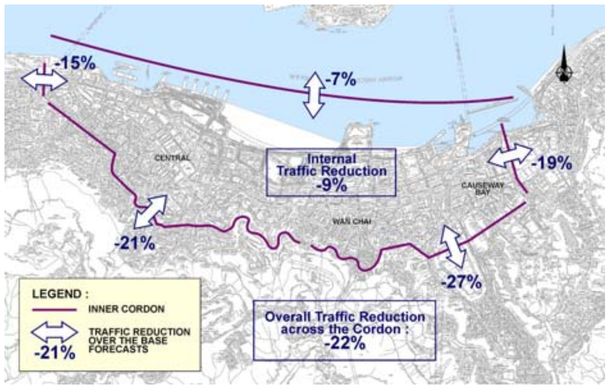
7.1 Traffic Impact

7.1.1 The forecast key travel demand impacts of the Preferred Congestion Charging Scheme – the Inner Cordon Scheme (relative to the Base Case: without the scheme) are as follows:

- The majority of travellers choose to pay and travel as before.
- Other travellers with destinations inside the Cordon principally switch to public transport or retime their journeys before or after the charge period.
- Some travellers, largely for shopping and leisure purposes, change their destination to outside the Charge Cordon.
- Taxi passengers are forecast to be more sensitive to charges than car users and largely switch to public transport.
- Goods vehicle traffic is largely forecast to pay the charge since most deliveries are essential, while some vehicles are forecast to retime journeys when possible.
- Through traffic can also opt to travel via the free (uncharged) Strategic Road Network (the CWB and the Canal Road Flyover) provided that the traffic concerned does not enter any ground level roads in the Charge Area.

7.1.2 Depending on the congestion charge level in the range of $20 - $30, traffic levels [3] inside the charge area in the charge period are forecast to be reduced by 10% to 20%.

7.1.3 Traffic levels inside the Inner Cordon comprise external traffic moving across the charge points/cordon and internal traffic movements within the charge area. The Cordon Scheme effectively suppresses the trips moving across the cordon while the internal traffic moving wholly within the charge area is not charged and does not decrease. As a result, the overall reduction in traffic levels inside the Inner cordon was forecast to be 9% although the volume of traffic across the charge boundary, including through traffic, was reduced by some 22% (See **Figure 7.1**).



Note: Preferred Congestion Charging Scheme for $20 car equivalent charge (in 2006 Prices). See Figure 6.2 for charging scenario details.

Figure 7.1 Preferred Congestion Charging Scheme: Forecast AM Peak Traffic Reductions in 2016

7.1.4 Traffic conditions are forecast to be improved as follows (See **Table 7.1**):

- Traffic flow in the East-West Trunk Road Corridor and the Strategic Road Network is uncongested and speeds are of a high standard (except at the Cross Harbour Tunnel northbound approach).
- Speeds in the District Road Network are raised from around 16 km/h -17 km/h to 18 km/h -19 km/h, which are better than London (15 km/h - 17 km/h). They are approaching the target range set by ERPFS and are in the range proposed by this Study (see Section 2).
- Except for a few locations, congestion spots are generally relieved.

Table 7.1 Preferred Congestion Charging Scheme[(1)] – Average AM Peak Traffic Speeds (km/h)

Area/Road Type	2005 Base	2016 Forecast		Target
		Base Forecast	Inner[(2)] Cordon	
Commercial Areas (Central/Wan Chai/Causeway Bay)				
District Road Network	16.8	17.6	18.6	17-20
Trunk Road Corridor	20.7	33.1	38.4	20-30
Strategic Road Network	43.4	56.4	62.6	Over 50
Overall	**18.8**	**24.5**	**26.4**	**20-25**

Notes: (1) Preferred Congestion Charging Scheme for $20 car equivalent charge (in 2006 Prices). See Figure 6.2 for charging scenario details.
(2) Average of the 2-way speeds

7.1.5 In the Base Case, the average AM peak traffic speeds in the District Road Network were forecast to be at the lower end of the target range in 2016. Speeds fell below target in the older street system south of the East-West Trunk Road corridor. Target speeds were achieved with the Preferred Congestion Charging Scheme.

[3] In terms of PCU-kilometres.

7.1.6 A slight decline in speeds in Mid-Levels is forecast owing to traffic bypassing the Charge Cordon. This indicates the need to add extra Charge Points to contain traffic volume.

7.1.7 An additional Charge Point for traffic using the Cross Harbour Tunnel on top of the congestion charge as part of the Preferred Congestion Charging Scheme was forecast to reduce tunnel queues and delays and improve operating conditions in Gloucester Road, Victoria Park Road and adjacent streets. The diverted traffic could be accommodated at the Western Harbour Crossing and Eastern Harbour Crossing and utilise the CWB for distribution in the Study Area.

7.2 Public Transport

7.2.1 Territory-wide, total public transport (rail, bus, public light bus and coach) travel is forecast to increase by 46,000 passenger boardings per day (under 0.5%) owing to travellers diverting from cars and taxis. The overall modal share of public transport was forecast to increase only marginally, indicating that congestion charging supports the policy directions to promote public transport.

7.2.2 Rail travel was forecast to increase by 28,000 boardings per day owing to car and taxi travellers diverted by the congestion charges. Franchised bus travel in the Charge Area was forecast to increase by 17,000 boardings per day owing to travellers being attracted by improved journey speeds.

7.3 Exemptions

7.3.1 The preferred approach is to adopt the "User Pays" principle and charge all vehicles (except emergency vehicles). The granting of further exemptions or discounts in line with various policy directions was considered for a number of options and the key impacts are summarised in **Table 7.2**.

Table 7.2 Preferred Congestion Charging Scheme – Impact of Charge Exemptions and Discounts in 2016

Exemption/Discount	% Discount	Traffic Volume[1]	Average Traffic Speed[2]	
			Charge Area	District Road Network
Base Case	N/A	100	24.5	17.6
Preferred Congestion Charging Scheme				
User Pays	0	82	26.4	18.6
Franchised Buses	100	82	26.5	18.7
All Road- based Public Transport[3]	100	82	26.5	18.7
Taxis	100	90	25.6	18.1
Taxis	50	85	26.1	18.4
Local Residents	100	82	26.4	18.7

Notes: (1) Two-way volume of traffic crossing the Charge Cordon in the AM peak as a percentage of Base Forecast.
(2) Average AM Peak Traffic Speed inside the Charge Cordon.
(3) Includes green minibuses, red minibuses, trams, franchised and non- franchised buses.

Franchised Public Transport

7.3.2 The preferred approach applied congestion charges to public transport services crossing the Charge Cordon, which were assumed to be passed on to passengers in terms of a relatively small amount of fare increase. Both public transport and rail travel was forecast to increase owing to the diversion of taxi and car travellers to avoid paying congestion charges.

7.3.3 The alternative of exempting franchised public transport was envisaged to result in a significant increase in the road-based public transport usage, including a diversion of rail passengers attracted by the improved bus speeds, as well as taxi and car travellers diverted by the congestion charge. As a consequence, rail travel was forecast to decline slightly, which is a counter to the policy of promoting rail as the backbone of the transport system. The forecast indicated AM peak average speed of 26.5km/h within the Charge Area, compared to 26.4km/h without exemptions.

Taxi Travel

7.3.4 Under the "User Pays" principle, taxis would be charged the same as cars. In practice, because taxi passengers are more sensitive to charges, it was estimated that a charge roughly half that for cars could potentially divert sufficient taxi travellers, and would discourage car travellers from switching to taxis. However, the forecasts indicated that exempting taxis altogether would result in car travellers switching to taxis to avoid paying the congestion charge, thereby producing a major increase in taxi travel which would undermine the effectiveness of the Preferred Congestion Charging Scheme. The forecast suggested that AM peak forecast speed could decrease from 26.4km/hr (Preferred Approach) to 26.1km/h (50% taxi discount) and 25.6km/h (taxi exemption).

Non-Franchised Public Transport

7.3.5 Non-franchised public transport covers a wide range of services and based on the “User Pays” principle, they should be charged under the Preferred Congestion Charging Scheme. Some vehicle types such as school buses may be regarded as a form of public services. Others such as tourist coaches are private services. Granting exemptions or discounts to these services would involve substantial administrative costs and management difficulties. At this stage in the research, they do not form a critical factor in the assessment. However, they will require a review if congestion charging is to be implemented. The AM peak traffic speed within the Charge Area was forecast to be similar to the case for franchised public transport exemption.

Residents

7.3.6 Under a Cordon-based Scheme, there is no strong case for granting discounts to residents since they, like other road users, only pay charges when they cross the Cordon. The case for exemption is stronger in an Area Scheme where residents have to pay for all journeys. A resident’s exemption was forecast to have a minimal impact in terms of AM peak level of service.

Environmentally Friendly Vehicles

7.3.7 A congestion charging scheme is intended to set charges to alleviate congestion. The traffic reductions will bring some environmental benefits. Granting exemptions or discounts to environmentally friendly vehicles, while supportive of sustainable development, should be carefully considered as it may undermine the effectiveness of congestion charging by encouraging vehicular travel. The direction in London is to extend the scheme to charge vehicles according to their broad impact on overall sustainability in terms of environmental impact and resources consumption. As discussed in Section 9 below, there is a clear merit in broadening the role of road user charging to address environmental problems within the overall integrated road user charging strategy. The alternative of imposing a lower annual licence fee on environmentally friendly vehicles seems to be more logical.

7.4 Sustainability

Social Impacts

7.4.1 Under the Preferred Congestion Charging Scheme, the majority of the benefits accrue to road-based public transport travellers and operators due to improved traffic speeds. Other road users, such as drivers of private cars, taxis and goods vehicles, who choose to pay the congestion charge, enjoy better travel conditions.

7.4.2 As discussed above, while a “User Pays” approach is proposed, certain vehicle types and traveller groups should be considered for exemptions on social grounds, including emergency vehicles and mobility impaired travellers. Discounts for other specific traveller groups, local residents, school buses and environmentally friendly vehicle types may have merits on social grounds but should be considered carefully as they will complicate administration, add to costs and may unavoidably attract further claims for discounts from a wide range of stakeholders and pressure groups and thus risks blurring the key role of congestion charging.

Economic Performance

7.4.3 Economic Evaluation [4] of the Preferred Congestion Charging Scheme indicates that the maximum economic returns would be achievable for a car equivalent charge of around $20 in 2016 and 2021. Substantial travel benefits are generated, amounting to the order of $450 million in 2016 (See **Figure 7.2**) and decreasing to $415 million by 2021 (See **Figure 7.3**), with a car equivalent charge of $20.

7.4.4 The majority of the benefits accrue to road-based public transport in terms of reduced travel times and resource cost savings for operators due to the improved journey times. While incurring the costs of the congestion charge, the charged road travellers, cars, taxis and goods vehicles also enjoy substantially better journey times and operating cost savings. However, applying very high charges, while marginally increasing overall benefits, would result in net disbenefits to private and goods vehicles, indicating that such levels would be unacceptable to the public.

[4] All monetary values are presented in 2006 prices unless otherwise stated.

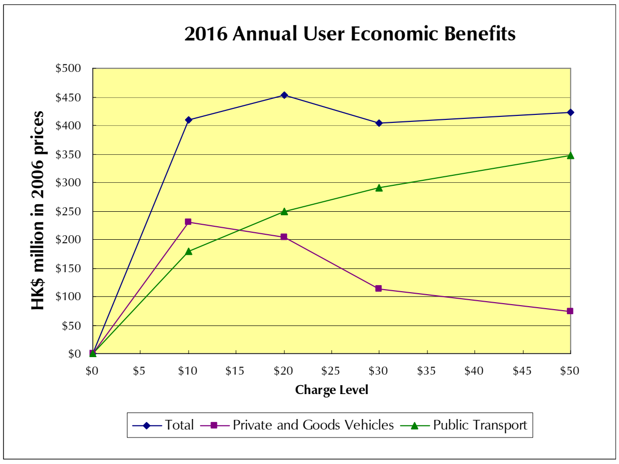


Figure 7.2 Preferred Congestion Charging Scheme: Relationship between Charge Levels and Economic Benefits in 2016

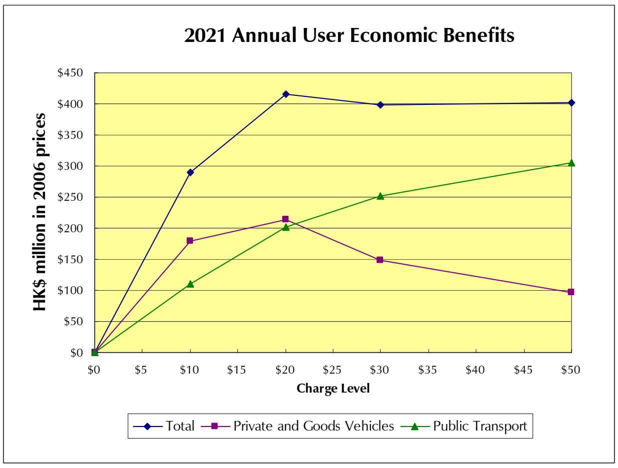


Figure 7.3 Preferred Congestion Charging Scheme: Relationship between Charge Levels and Economic Benefits in 2021

7.4.5 Based on the preliminary capital cost estimates for a charge level of $20 or more, an Economic Internal Rate of Return[5] (for the first 10-year operation) of the order of some 9%-12% per annum could be generated by the congestion charging scheme, indicating high value for money broadly similar to analyses for Stockholm and London. However, for a charge level below $20 (as shown in **Figure 7.4**), the economic benefit generated would fail to cover the total capital and operational costs. Thus, charge levels below $20 are not viable in terms of economic evaluation.

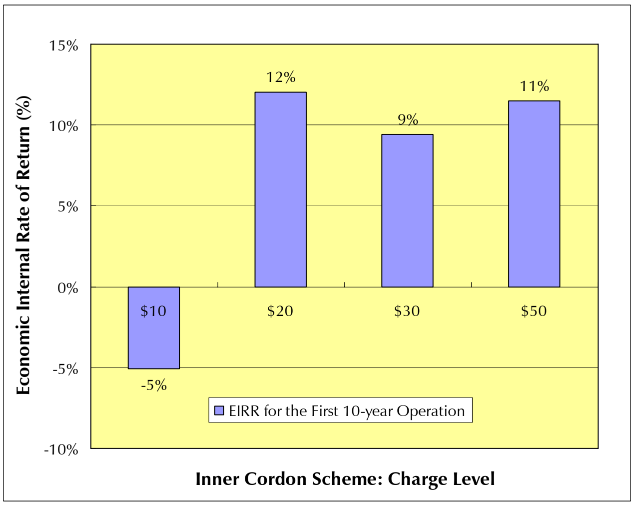


Figure 7.4 Preferred Scheme: Relationship between Charge Level and Economic Internal Rate of Return

7.4.6 According to international experience such as in London and Singapore, there is no strong evidence to indicate that congestion charging adversely affects business/commercial activities. In fact, the centre of London has enjoyed faster economic growth than the rest of the city. The forecasts for the Preferred Congestion Charging Scheme indicate that the vast majority of travellers will continue to travel to/from the Charge Area and benefit from the reduced congestion.

7.4.7 Under the "User Pays" principle, congestion charging would impact directly on the financial costs of commercial vehicle operators such as goods vehicles, taxis and road-based public transport vehicles. The congestion charges would increase vehicle operating costs which would be balanced against journey time, fuel consumption savings and improved reliability. The charges would be passed on to customers in the case of taxis, as in Singapore. For commercial vehicles and public transport, the congestion charges could be directly or partly transferred to customers or absorbed generally by the companies.

Financial

7.4.8 Depending on the scale of the scheme, the capital cost of the Preferred Congestion Charging Scheme is estimated to be of the order of $1 billion to $1.5 billion, including equipment, on-street installations, OBUs, Back-Office facilities and contingencies, but excluding other related complementary measures. In line with international experience, an initial assessment of operating costs and revenues indicates that a significant operating surplus could be achieved, depending on the charge level. The operating surplus would cover capital and

[5] EIRR is the rate of return that would be achieved on all project resource costs, where economic benefits and costs are measured in price unit. The EIRR is calculated as the rate of discount for which the present value of the net benefit stream becomes zero, or at which the present value of the benefit stream is equal to the present value of the cost stream.

replacement costs and could provide funds for complementary measures such as traffic and environmental schemes or public transport facilities.

Environmental Impact

7.4.9 Air pollutants at street level are mainly emitted by vehicles[6]. The reductions in vehicle travel due to congestion charging help to lower the roadside air pollution level and yield better air quality. Local residents would enjoy a better outdoor environment and a better living standard. More broadly, the better air quality would ameliorate the general image of Hong Kong and its attractiveness towards overseas professionals and enterprises for work and investment respectively which could help secure sustained economic growth.

7.4.10 At global level, the forecast territory-wide reduction in vehicle kilometrage is estimated to reduce the overall emissions by less than 1%. However, the reduction of individual vehicle pollutants may be up to 10% within the Charge Area depending on the charge level. It should be noted that the overall reduction in emissions would be less than that in vehicle kilometrage because congestion charging has a greater impact on the less polluting private cars and taxis.

7.4.11 The forecast level of reductions in emissions is in line with the experience for the London Congestion Charging Scheme and the trial in Stockholm. As overseas experience indicates, the introduction of improved engine technology and vehicle fleet modernisation can have far greater impacts, depending on the quality of the existing fleet. Therefore, road user charging would only be one of the measures in a broader strategy to address vehicle-related pollution.

7.4.12 The Council for Sustainable Development has identified road user charging as a potential means to alleviate vehicle-related pollution. However, congestion charging is a travel demand management measure rather than an environmental protection initiative. Therefore, charging schemes for congestion relief and those for environmental protection purposes serve different objectives, involve different stakeholders and require different charging and exemption strategies.

7.5 Integration with Intelligent Transport Systems

7.5.1 The Transport Department is actively pursuing the implementation of a comprehensive Transport Information System. The development of the congestion charging scheme and associated systems enables a range of complementary intelligent transport facilities to be implemented.

7.5.2 The Preferred Congestion Charging Scheme would introduce the opportunity to continuously monitor congestion, traffic flow and patterns in far greater detail, and so provide much improved information to travellers on traffic conditions, routes and options.

7.5.3 Providing high quality traveller information services is recognised as one of the most effective intelligent transport tools for managing regular transport demand and the effects of incidents. The integrated application of these types of facilities with the congestion charging scheme and other incident management systems will be a significant asset.

7.5.4 Extensive information would also be available to fleet managers to provide historical data for planning and real-time data for operations.

7.5.5 Examples of the types of applications that may be developed include:

- Real-time information on the current congestion levels and comparisons with alternative modes provided through the Internet, phone (text and/or Closed Circuit Television video images) and radio
- Historical information provided through the Internet and other channels to assist in route, mode and journey planning for commercial operators and motorists of private vehicles
- Live incident-related congestion monitoring and alerts

7.5.6 The congestion charging technology could permit multi-lane free-flow toll collection and replace the existing systems. Potentially, if all vehicles are equipped with OBUs, toll plazas and approaches to the toll tunnels and bridges could be redesigned to reduce size.

[6] As highlighted in the invitation and response document *"Clean Air – Clear Choices"* issued by the Council for Sustainable Development in June 2007.

Transport Information System

8. FURTHER DEVELOPMENTS

8.1 Future Expansion

8.1.1 The Study focuses on developing a Preferred Congestion Charging Scheme for the commercial and adjacent residential areas within the Study Area on north Hong Kong Island. Broader applications of congestion charging could be considered for other busy areas of Hong Kong on three principal fronts (See **Figure 8.1**):

- District charging schemes as developed for the Study Area, for example, Tsim Sha Tsui;
- Strategic Road Network Cordon Charging schemes to contain traffic movements between sub-regions and to achieve a more balanced usage of parallel strategic roads, for example, cross harbour or between Kowloon and the New Territories; and
- Full Network Charging to cover all road traffic movements.

8.1.2 If such future expansion is contemplated, then a fundamental review of technology is required during the planning stage. In this case, VPS, Pico-Cell or similar technologies should be considered along with distance-based charging. This could lead to Full Network Charging where charges are applied to all road traffic movements, an approach which is now under planning and research in the UK, Europe and the USA. In this case, a comprehensive review on the scale of vehicle ownership restraint could also be carried out since the usage charges would be territory-wide. This may permit ownership restraint to be relaxed to give more people the opportunity to enjoy the benefits of motoring while applying usage charges to contain network-wide congestion.

8.2 Road User Charging Applications

8.2.1 The Study is specifically considering congestion charging, i.e. the application of road user charging strategies for traffic management purposes. As discussed in Section 2, road user charging can be applied to achieve other objectives, including reducing vehicle emissions or toll collection to raise revenues to fund infrastructure.

8.2.2 In recent years, there has been much debate on aligning tolls at the many toll road facilities to achieve a better balance in traffic usage. More recently, the Council for Sustainable Development has identified road user charging as a potential means of helping control vehicle-related pollution. While congestion charging and environmental charging all have potential merits, they serve different objectives, involve different public and private organisations and accordingly are likely to pursue different strategies and charging scenarios. It is therefore vital that these initiatives are coordinated technically and administratively to produce an integrated approach. The details are beyond the scope of this Study and further studies may be considered in the future as appropriate.

8.2.3 If it is envisaged that in the future the District charging schemes are to be expanded or a move is made to Full Network Charging, then a much broader assessment should be made of all aspects of road user charging in a comprehensive framework.

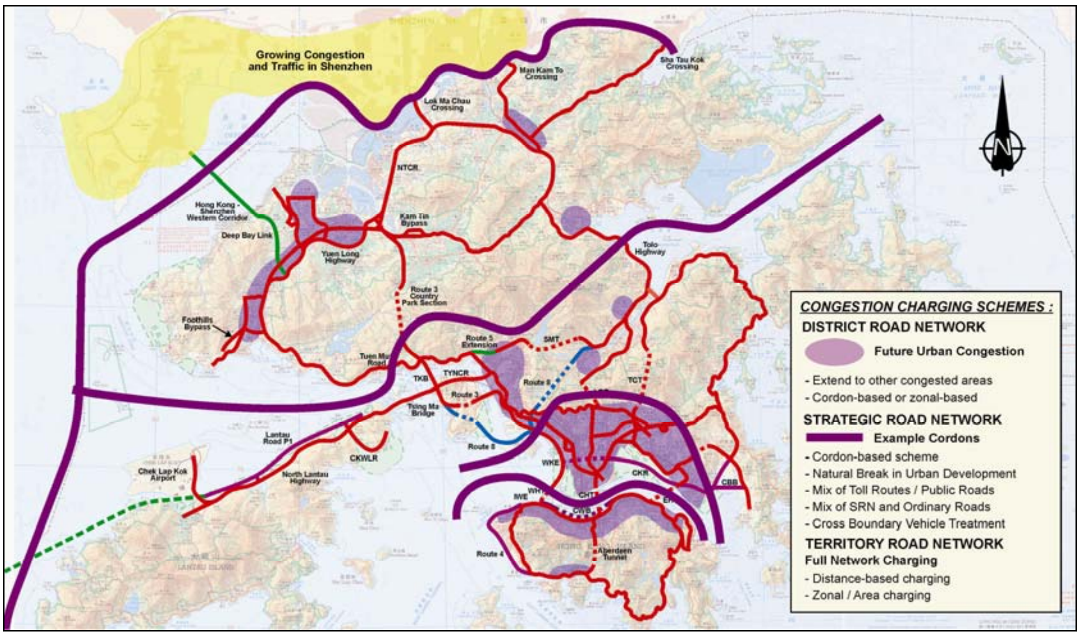


Figure 8.1 Potential Expansion of Congestion Charging in Hong Kong

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9. REQUIREMENTS FOR IMPLEMENTATION

9.1 Policy, Strategy and Regulation

9.1.1 The Preferred Congestion Charging Scheme would form part of the overall territorial transport strategy. The Government would take the lead in defining the congestion charging scheme objectives in terms of congestion relief, level of service and operating speed targets. The Government would also need to confirm adjustments to congestion charges proposed by the scheme operator and the managing authority in order to maintain the level of service targets.

9.1.2 The Transport Department would be the executive arm of the Government responsible for regulating and monitoring the performance of the scheme operator in terms of system performance, achievement of objectives, safety and costs. The Transport Department would also provide support and interface with other transport and related agencies and stakeholders on behalf of the Government. Continued strategic planning of the system expansion or further integration with ongoing transport developments would be a related task of the Government.

9.2 Operations

9.2.1 The managing authority for the scheme could be a Government Department or statutory authority set up to implement and manage the scheme. The private sector may be involved on a contractual basis (as for tunnel and bridge toll collection and maintenance). However, full privatisation is not appropriate since charges would be set for traffic management purposes and not on a commercial “revenue risk” basis. The managing authority may be entrusted with implementing complementary measures and broader related intelligent transport systems.

9.3 Legislation

9.3.1 The legislative requirements for implementing a congestion charging system will include a range of legal and contractual devices, including the composition and powers of the body responsible for managing the systems, setting up of the legal frameworks surrounding the legal restrictions of access subject to payment, enforcement elements, and establishment of processes and evidence issues relating to violations, recovery of charges and related penalties, protection of privacy and management of exemptions.

9.3.2 A congestion charge adjustment mechanism needs to be formulated which is explicitly related to travel conditions and understood and accepted by the public. In Singapore, the performance of the Scheme against Level of Service targets and adjustments to charges (up or down) are published quarterly. In London, comprehensive annual reports are published. However, charge adjustments are less explicitly linked to performance.

9.3.3 Protection of privacy must be paramount. However, pursuing violators will require access to the VALID System and appropriate procedures will need to be put in place (as currently for the enforcement on speeding, red light jumping and toll tunnels).

9.4 Key Implementation Factors

9.4.1 The technical analyses revealed the potential benefits of introducing congestion charging in the Study Area in the long run. However, these benefits need to be weighed against a number of political, social and operational factors which need to be addressed to the satisfaction of key stakeholders and the general public prior to implementation. These factors were identified in the review of international experience and are now considered specifically for the Study Area in Hong Kong.

Scheme Justification

9.4.2 The case for introducing congestion charging rests firmly on the public consensus that there is a serious traffic congestion problem and that a congestion charging scheme can make a significant impact as part of the overall strategy. The forecasts indicate that the implementation of the CWB and railway expansion will bring about major improvements to the travel conditions in the Study Area between 2016 and 2021. Implementing congestion charging would have an incremental impact, raising average AM peak speeds in the Charge Area from 24.6 km/h to 26.4 km/h. While congestion charging would generate significant benefits, the public may regard the extra improvement as small and unnecessary on top of a much improved situation. The view may be taken to wait and see before imposing charges on the travelling public.

9.4.3 As discussed in Section 4.4, the Study also reviewed a wide range of strategic, tactical and behavioural travel demand management measures. The existing fiscal restraint of private vehicle ownership is fundamental to containing territory-wide traffic growth. Vehicle usage is affected to a degree by fuel costs, parking charges and tolls. However, these policy instruments and charges have relatively global impacts on traffic levels and are not focused specifically on the congested areas or the times of day. The Government could opt to increase restraints by raising fiscal charges even higher which would affect all residents in all parts of the Territory and would therefore not specifically target congested areas.

9.4.4 Counter-arguments in favour of congestion charging which can be invoked are based on the high economic returns, broader transport benefits and environmental improvements. Most importantly, the charges can be adjusted to ensure that the public are only charged when and where justified and to ensure that traffic growth is contained.

Scheme Location

9.4.5 The Study has been at a preliminary feasibility stage and indicated the potential benefits of congestion charging. However, implementation will raise many local issues in the siting of the Charge Points, especially in Hong Kong's dense street system with many one-way roads. These will include impacts on local residents and businesses.

9.4.6 Residents and businesses adjacent to the cordon may be adversely penalised because travellers may have to cross the cordon to make journeys because of traffic circulation even though they are not heading for the Charge Area or are only travelling a short distance.

9.4.7 If the scheme is allowed to proceed to the Design Stage, detailed traffic circulation and management studies will be required, together with local site investigation of frontage, building access, and road safety in conjunction with the public consultation process. In addition, public consensus should be reached before proceeding to the Design Stage.

9.4.8 In London, residents inside and those adjacent to the Charge Area have been granted 90% discounts (for one registered vehicle). On the contrary, in Singapore, all vehicles are charged and a stronger "User Pays" line is taken. In Italy, the access control schemes include granting a wide range of exemptions to residents and businesses. Given the prevailing political sentiments in Hong Kong, it may take a long time before consensus could be reached on the details of charging.

Vehicle Exemptions

9.4.9 A "User Pays" approach is put forward as the starting point based on equity and to secure scheme effectiveness. A long list of exemptions may be considered on social and economic grounds, including:

- Emergency vehicles (fire engines, police vehicles and ambulances)
- Government service vehicles
- Public transport – franchised and/or non-franchised
- High capacity vehicles (passenger vans)
- Taxis
- Environmentally friendly vehicles
- Local residents, mobility impaired persons
- Commercial vehicles

9.4.10 If more exemption were to be granted, a higher charge would be required to further reduce the traffic volume. This is a complex balance of social equity and scheme effectiveness.

9.4.11 The analyses in **Table 7.2** indicate that the scheme would still be effective if, in addition to emergency vehicles, public transport vehicles were to be exempted. However, the analyses also indicate that exempting taxis overall runs the risk of undermining the scheme as taxis comprise one-third of the vehicles in the Study Area. Therefore, taxis may be charged possibly at a lower rate, reflecting the lower value of time of their occupants. The disbenefits of exempting taxis would be greater for the future design years.

Privacy Protection

9.4.12 The 1983-1985 ERP Pilot Scheme attracted considerable concerns over protection of privacy with the then technology. Over the past 20 years, technology has advanced substantially. Automatic cashless payment systems have become part of normal daily life and legislation has been put in place to protect the privacy of the individual. This is the case in London, Stockholm, Singapore and other cities with congestion charging schemes and in Hong Kong with its Octopus cards and Autotoll systems.

9.4.13 The favoured DSRC/ANPR technology offers full privacy for travellers using the "smart card" OBU as there is no personal or vehicle identity record of the card itself.

9.4.14 Vehicles potentially in violation will have their number plates photographed and the vehicle keepers will be tracked through the VALID System. Procedures can be put in place to destroy all records as soon as payment has been made. During processing, records would remain protected under privacy protection until such a time when an offence is committed by refusal to pay. Travellers could opt to hold accounts, as is the case under Autotoll systems used for automatic collection of tunnel tolls.

9.4.15 Future technological developments will bring broader benefits in terms of vehicle-to-vehicle communication and safety systems. The satellite-based VPS is being used for vehicle security, insurance pricing (based on kilometrage, location, time of day) and fleet management. In the future, these functions will be extended and travellers may increasingly regard them as just another payment system. Even so, the ability to track vehicles more comprehensively and precisely may raise new public concerns and require matching privacy protection.

9.5 Implementation Time Frame

9.5.1 If the Government is to proceed with the implementation of congestion charging in the future, a preliminary implementation programme is recommended in **Figure 9.1**. It would take about six and a half years' lead time for a DSRC-based system plus the time taken to conduct public engagement and consultation. The programme indicates the likely elapsed time for technical studies, design, acquisition, installation and testing. Public consultation is included in the programme with three key consultation stages during different milestones, depending on the time to gain public consensus on the way forward and to secure any necessary legislative and administrative support.

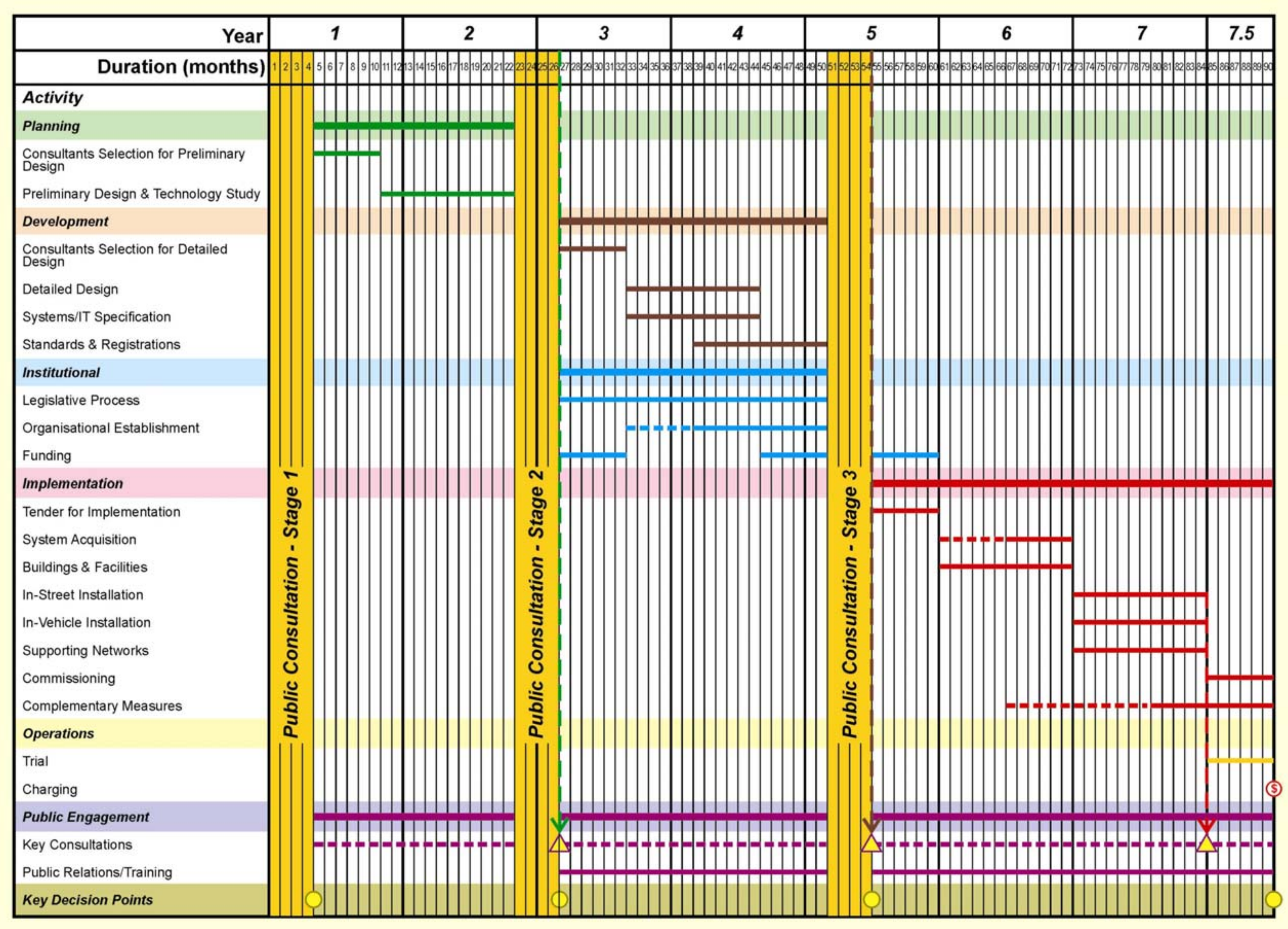


Figure 9.1 Preliminary Implementation Programme

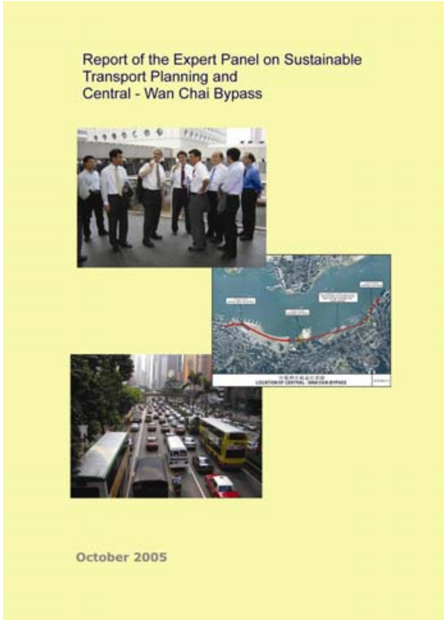
10. WAY FORWARD

10.1 The Study has confirmed that congestion charging could make a contribution to managing traffic in the busier districts of Hong Kong in the long run. However, it is also clear that the achievement of a world-class transport system requires major infrastructure and services development, and the present plans for the Study Area and Hong Kong as a whole will provide that framework. Congestion charging will help ensure that the benefits of the structural investments are captured and congestion is prevented, and in particular long-term traffic growth can be properly contained. Congestion charging alone cannot secure the socio-economic benefits and level of service provided by the planned railway extensions and the CWB. This balanced approach is essential to securing the long-term sustainability of the social and economic activities in the Study Area, which are vital for the well-being of Hong Kong.

10.2 A congestion charging scheme that aims to relieve traffic congestion can only be implemented equitably and effectively with the availability of free-of-charge alternative routes having adequate capacity for motorists to bypass the charging zone. This prerequisite is in line with international experience which indicates that the provision of free-of-charge bypass routes for through traffic enables schemes to gain public acceptance more easily. In the context of the traffic conditions in the Central Business District of Hong Kong Island, the most appropriate alternative route is the proposed Central-Wan Chai Bypass, the construction of which was supported by the Expert Panel on Sustainable Transport Planning and Central-Wan Chai Bypass (Final Report, October 2005). However, it would not be open to traffic before 2017.

10.3 From a transport perspective, there are no strong arguments for introducing congestion charging in Hong Kong at present. In fact the current adverse economic conditions are likely to slow traffic growth in the near term to levels below those anticipated in the forecasting studies. Even so the Government should continue to monitor traffic growth as the economy recovers and the Harbour Area of Hong Kong continues to develop.

10.4 If a decision is made later to consider the implementation of congestion charging on traffic grounds, the Government will need to carry out an extensive public engagement/consultation to solicit public views. The engagement process should involve a wide range of stakeholders as well as the travelling public and the community as a whole. Only when a consensus is reached will the Government be able to press ahead with the implementation of congestion charging.



Report of the Expert Panel on Sustainable Transport Planning and Central-Wan Chai Bypass

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