Cape Peninsula University of Technology

THE FEASIBILITY OF A CONGESTION CHARGE FOR CAPE TOWN CENTRAL BUSINESS DISTRICT FROM A TRAFFIC ENGINEERING PERSPECTIVE

By

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To my Mom, for being a source of inspiration and strength in my life.”

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LIST OF ABBREVIATIONS

ALS	Area Licensing Scheme
BRT	Bus Rapid Transit
CBD	Central Business District
CFIT	Commission for Integrated Transport
CMC	Cape Metropolitan Council
CMTR	Cape Metropolitan Transport Region
ERP	Electronic Road Pricing
ETC	Electronic Toll Collection
HOV	High Occupancy Vehicles
IHT	Institute of Highways and Transportation
ITP	Integrated Transport Plan
ITS	Intelligent Transport Systems
LOS	Level of Service
MA	Moving Ahead Cape Metropolitan Transport Plan Par 1: Contextual Framework
MSDF	Metropolitan Spatial Development Framework
TDM	Travel Demand Management
TRB	Transport Research Board

GLOSSARY OF KEY TERMS

Travel Demand Management	A set of strategic and physical measures aimed at changing travel behaviour towards accommodating increased traffic volumes within the existing road infrastructure (Vuchic, 1990)
Intelligent Transport System	The application of information and communication technology to transport (including road) infrastructure and vehicles to manage traffic including vehicle loads, incidents, etc
Bus Rapid Transit	High speed bus system which makes use of right-of-ways (http://managed-lanes.tamu.edu/products/glossary.stm)
Capacity	The maximum flow rate, which can be achieved by vehicles (in the context of this study) traversing a point or segment of road during a specified time period under various conditions. (Transportation Research Board, 2000)
Congestion Charging	A type of direct road user charging for which motorists are charged for using a section of the road network, within a congested area (Institute of Highways & Transportation, 1997).
Enforcement	Relates to type of measure which will be used in ensuring compliance with the congestion charging measures. This could be through number plate recognition, video camera, etc. (Hinrichsen, 2007)
Interpeak	The period between the morning (AM) peak and the evening (PM) peak when traffic volumes are usually less than in the peak periods
Level of Service	The qualitative measure used to describe the operational conditions within a traffic scheme and is based on travel conditions like speed, travel time, traffic interruptions, etc. (Transportation Research Board, 2000)
Travel Demand Elasticity	The percentage change in trips as a result of a one percent change in trip costs.
Screenline	A virtual line used by the city to count the number of vehicles entering and leaving the City central area.
Variable Messaging	A form of Intelligent Transport System whereby live time information is provided to motorists by means of electronic messaging

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There is an ever increasing need to introduce travel demand measures as the ability to construct new and upgrade existing roads to accommodate additional traffic volumes decreases. The City of Cape Town, hereinafter referred to as the City, has forecasted that traffic in the city could continue to increase by two and a half percent per year. To mitigate against the increased traffic volumes, the City is proposing a number of travel demand strategies, including a park-and-ride facilities and high occupancy vehicle initiatives in the short term. The City's draft travel demand management strategy identifies congestion charging as a measure more possible implementation in the medium term. This study investigates the feasibility of introducing a congestion charge from a traffic engineering perspective. This entails determining if there could be a reduction in traffic entering the Central Business District, what type of congestion charge is most suited for Cape Town and what type of technology is most appropriate at this point in time.

In determining the type of charge and technology for introduction in Cape Town, international experience and trials were drawn upon in terms of case studies and research completed. These included developed and developing cities that had either introduced a

congestion charge or considered it. To determine the potential level of traffic reduction, transportation elasticities for road pricing/congestion charging were used. This method of calculating the traffic reduction has been used on similar studies and provides a reasonable indication of the potential percentage reduction which could be achieved. The elasticities were based on post-implementation studies undertaken in cities which had introduced a congestion charge or road user pricing. For this study, elasticities between -0.1 and -0.5 were used.

The study found that of the types of congestion charging available, a simple cordon charge, around the central business district (CBD) was most feasible. A cordon area would be more appropriate due to the small charge area involved, the flexibility that it allows and because it does not need to be visually intrusive in terms of roadside and enforcement equipment. The location of the cordon area also allows the key roads around the CBD to become the bypass route for vehicles that currently pass through the area.

In terms of the charge payment system, it was found that presently, a manual payment system would be more appropriate for the city than a tag and beacon system. It would have less startup costs and would be easy for visitors to understand. Payment could be made online, through approved retailers, telephonically or at post offices. It is recommended that the current automatic number plate recognition (ANPR) system used by the City for the enforcement of the bus and minibus taxi lane on the N2 be extended to include the congestion charge in the CBD. This system would require the installation of primary cameras at the entry points of the cordon area and a few supplementary cameras at key locations in the CBD. It would not require additional infrastructure to be provided. Use could be made of existing traffic island and street lighting.

The reduction of traffic was calculated to be between 4.4% and 20.31% if a charge rate of ZAR50 were introduced. The average potential reduction was calculated as 12.56%. This is low in comparison to cities where a congestion charge has been introduced. The study also found that in order to achieve average traffic reductions comparable to other cities, it would need to be in excess of ZAR90, which is more than double the calculated travel cost to the CBD currently.

Although this study does conclude that congestion charging is feasible, it also highlights that before it can be introduced, the City needs to primarily overcome two challenges. The first is making the currently public transport system attractive to high income drivers. The second is to determine mitigating measures to the socio-economic impact that the congestion charge could have on middle and low income drivers.

CHAPTER 1
INTRODUCTION

As vehicle numbers and usage continually increase, Travel Demand Management (TDM) strategies are increasingly being applied throughout the world with varying success. Governments and local authorities have realised that the solution to reducing congestion is not only through the building of new roads and the upgrading of existing roads to create additional capacity. TDM aims to optimise existing and planned infrastructure. It also acts as a catalyst to encourage modal shifts and influence the time of travel.

The focus of this study is to determine the feasibility of congestion charging in Cape Town, South Africa as a TDM strategy. It is a form of direct user charging as a measure, which has been implemented increasingly in developed cities around the world, with the first in Singapore in 1975 (Gomez-Ibanez and Small, 1994). The primary objective of congestion charging is to reduce traffic congestion, with secondary objectives of revenue generation and reduction in air pollution.

1.1 Background

The first National Travel Survey in South Africa was undertaken in 2003. In the technical report (Department of Transport, 2003), the Department of Transport acknowledged that despite the car ownership rate in South Africa of 108 cars per 1000 people being substantially lower than the international rate of 450 cars per 1,000 people, further growth would result in demand pressure on the already restrictive road space in the country.

Since the late 1990's, the City of Cape Town (hereafter referred to as the City), in the form of the Cape Metropolitan Council (CMC), has been developing its Vision and Goals for the improvement and sustainability of its road based transport system. This development was necessary to comply with the National Land Transport Transition Act No 22 of 2000, which required South African cities, district municipalities and local municipalities to develop Integrated Transport Plans. One of the guiding principles of land transport policy in South Africa has been that of user charging where it is deemed appropriate and possible (Department of Transport, 1996). The White Paper on National Transport categorises user charging as an element of economic infrastructure and operation which provides a measurable economic or financial return on infrastructural investment. To date, this user charge has translated into fuel levies and tolling.

In 1998, the CMC published a discussion document, Moving Ahead Cape Metropolitan Transport Plan Part 1: Contextual Framework (MA) in which it set out the goals and visions for transport in Cape Town at the time. It also reported on existing and predicted population growth and the associated mobility demands.

Prior to the development of MA, a study by Liebenberg and Stander (1994) identified the need to restrain private car use, particularly during peak periods. This study recognised that improved public transport alone would not necessarily decrease congestion effectively within Cape Town. There was the need for travel demand management that might include congestion charging, High Occupancy Vehicles (HOV) lanes and Intelligent Transport Systems (ITS). Two of the goals developed as part of MA (1998:25), references the principles of travel demand management and, by association, road user charging, namely:

- *improved utilisation of existing and future transport resources and reducing the overall need for travel through a process of travel demand management; and*

- *financial sustainability through the establishment of secure sources of funding.*

In terms of user charging, the City acknowledged that within MA framework strides had been made internationally relative to peak period pricing and electronic toll collection.

The MA predicted that as a result of the population growth and a vibrant economy, there would be an expected increase in daily commuter trips of approximately 70% between 1995 and 2015. The report also recognised the important link between land use and transport. It found that the City was not a compact one, but one which developed linearly along its early main roads and later rail networks. It also found that the car ownership rate in the Cape Metropolitan Transport Region (CMTR) was 170 cars per 1,000 people, which was assumed to remain constant until 2015. The 2003 National Travel survey reported a national average car ownership rate of 108 cars per 1,000 people. When compared to the rest of South Africa, the Western Cape, and in particular, the metropolitan area, reportedly has the highest potential number of people travelling by car than any other province. This rate was higher than that of other cities in developing countries and approximately one-third of North American and European cities.

Commuter trip lengths in 1995 were reported to be between 14km and 17km for home-to-work trips. The transport trends predicted that there would be a 20% reduction in commuter trip lengths over the next 20 years, but would be dependant on the successful implementation of the Metropolitan Spatial Development Framework (MSDF). This framework promoted the creation of corridors and local nodes, which would encourage people to travel shorter distances for non-work based trips rather than to regional centres.

The modal split reported in MA was 49:44:7 (public:private:walk/other) and the private transport proportion is comparable to that of the Greater London Metropolitan Area at the time, which was approximately 45%. According to the Green Paper on Western Cape Provincial Transport Policy (1996), a suitable modal split target for Cape Town in 2005 would be 54:34:12. This level of targeting was later omitted in the publication of the White Paper on Western Cape Provincial Transport Policy in May 1997 However, it stated that a modal split in favour of public transport was to be actively pursued.

In comparison to the modal split reported in MA of 1998, the 2006 split, calculated at 48:39:13, indicated that there was a decrease of one percentage point in the users of public transport and a more significant decrease in private car trips to be gained by other modes of transport, including walking (City of Cape Town, 2006). The 2006 modal split however, did not meet the target set in the Green Paper on Western Cape Provincial Transport Policy.

In the determination of factors which affected the decision of choice of mode for trips, the MA found that the following were considered as the primary determinants:

- Income level;
- Land use patterns;
- Availability and quality of public transport; and
- Lifestyle factors.

Factors such as cost, congestion and availability of parking were not considered as important as the above factors. The exclusion of the factors relating to traffic conditions implied that people had become accustomed to long travel times and the inherent cost of travelling by private car. Another reason for the exclusion could be that none of these factors were an issue because there was no choice in distance travelled owing to apartheid policies.

Subsequent to the publication of MA, the City developed a travel demand strategy, Influencing Travel Behaviour towards a Travel Demand Strategy, in August 2006 (TDMS), which is currently in draft format for comment and discussion. The TDMS found that traffic volumes in the City had been on the increase at an average rate of 2.5% per year for the previous 15 years. This trend was incorporated in the updated EMME/2 traffic model of the City. The EMME/2 model predicted that by 2021 there would be a substantial increase in traffic volumes in the morning peak (AM PEAK) period which was the only period modelled. The present road network around the Central Business District (CBD) did not have the capacity to accommodate the current demand, leading to an increase in congestion levels, travel time and the extension of the peak hour to a two hour peak period.

The TDMS identified road pricing as one of the measures that the City could implement, even though rated as a medium priority, allowing for further investigation of congestion charging for the City. The TDMS identified the challenges to congestion charging as:

- Technology, in terms of payment collection;
- Location of payment zones in terms of the position of zonal boundaries, the impact on land owners and business; and
- Opposition of user groups.

Arguably, these challenges could be overcome given the technological advances that have been made in terms of enforcement and payment. Opposition from user groups is to be expected especially when users had never paid for these types of services before.

1.2 Problem Statement

The problem being investigated may be stated as follows:

Based on the findings of several studies, traffic volumes in the City of Cape Town have consistently increased at 2.5% per annum for the past 15 years. It is assumed that this trend is set to continue, resulting in the existing road network in and around the Cape Town Central Business District (CBD) being unable to accommodate the anticipated traffic volumes. As it is unlikely that road capacity will increase through the provision of additional infrastructure, the City considers Travel Demand Management strategies such as congestion charging as a means of reducing traffic volumes.

1.3 Hypotheses

The hypotheses to be tested in this study are:

H1: Congestion charging will reduce the number of vehicles daily entering and passing through the Central Business District (CBD).

H2: Of the available Travel Demand Management strategies congestion charging is technically appropriate for Cape Town.

H3: Not all congestion charging technological systems can be implemented in Cape Town.

1.4 Research Objectives

The primary objective of the study is to determine whether congestion charging, as a TDM strategy, is an effective means of reducing daily traffic volumes within the CBD with emphasis on:

- The level of traffic reduction which can theoretically be achieved;
- The type and extent of congestion charge that would be suitable for Cape Town; and
- The congestion charging technological systems that can be practically implemented in Cape Town.

1.5 Study Limitations

This study will focus only on the technical traffic engineering aspects of congestion charging and not on the political and social aspects. Although the latter two aspects are of importance for successful introduction, and will be mentioned in context, they will not be researched as part of this study due to the current unpredictable and fluid nature of politics within the City. The study is further subject to the following limitations, namely:

- The 2007 origin destination matrix extrapolated from the City's EMME/2 model will be used in calculations. This data is based on the 2004 Cape Town Household survey, with input from the 2001 Census data. This data was then factored up to 2007 taking into account forecasted traffic growth as well as known developments. Although dated, the data are appropriate for use in this study as they are considered relevant and used and updated by the City for strategic transport planning;

- Only data for the morning peak period (AM Peak) are used as it is the only dataset available. It is therefore not possible, at the time of this study, to compare the impact of an all day charge and a variable charge;

- This study should provide an indication of the possible reduction in traffic that could be achieved in Cape Town. However, to gain a better understanding, a more indepth study is required using a strategic traffic modelling tool such as EMME/2;

- Based on current fuel prices, the direct cost of car travel, excluding personal time, will be used to determine the economic impact that a congestion charge would have on drivers. Personal time will not be included in the cost as the data available only gives a percentage indication per income group; and

- As far as could be established no documentation exists which reported on the testing of a charge based on the time travelled.

1.6 Assumptions

The study is based upon the following assumptions, namely:

Available data is accurate and representative of the current status of traffic volumes. The data set to be used is acquired from the City. It contains volumes entering and leaving the CBD at a macro level and is assumed to be fit-for-purpose. It is recognised and accepted that it is secondary data, and that it would be difficult to verify as the data is based on various, City-wide traffic and household surveys.

For this calculation, transportation elasticities, based on a similar study in a developing country will be used, as well as international studies of developed countries, where appropriate. The elasticities used reflect the cost of travel, car ownership and the quality and provision of public transport. Where car ownership is predominantly within high and middle income earners and the public transport poor, the elasticities are low. This is not always the case, as Singapore has a mixture of the two. Further, travel costs based on fuel costs will be used.

The introduction of a system of congestion charging will not require any major infrastructural changes such as the installation of gantries or traffic islands.

The study also recognises that, in order for any type of congestion charging to be successfully implemented, there needs to be alternative transport modes, which would be considered viable by motorists. The City has plans to improve public transport services and introduce park-‘n-ride facilities as well as HOV lanes. This study will investigate the feasibility of congestion charging with this in mind, as it is acknowledged that these are critical to successful implementation.

A currency exchange rate of ZAR14 to £1 is assumed for application in this study and is considered to be appropriate and conservative in the 2008 financial climate, where the Rand has fluctuated between ZAR13 and ZAR17 to £1.

1.7 Preliminary Literature Review

Travel Demand Management can be defined as a set of measures which are introduced with the primary objective of altering travel behaviour (preferable through modal shift) without increasing road and highway infrastructure to accommodate the ever increasing traffic volumes (Vukan Vuchic (1999) and Papacostas (2000)).

One of the primary objectives of TDM is the reduction of traffic or a modal shift by means of various mechanisms which do not entail an increase in road infrastructure than what is already existing or planned and committed. The most common TDM tools include, *inter alia*, direct user charging, increase in parking levies, encouragement of car pooling, restricting the level of vehicle ownership through higher registration fees and tax. It can be argued that the implementation of just one of these measures, in itself will not achieve a feasible shift in mode choice, but a combination of the measures could (Institute of Highways and Transportation (IHT), 1997).

Papacostas and Prevedouros (2000:279) define congestion charging as: "*the imposition of a direct charge on motorists for the true cost of their trip.*" This definition is essentially consistent with that of Vuchic (1999), IHT (1997) and Gomez-Ibanez and Small (1994). The Transport Research Board (TRB) takes it one step further by saying that this cost is, at its most ideal level, based on prevailing traffic conditions, time of day and length of trip (Gomez-Ibanez and Small, 1994).

It is important to note that there is a difference between road taxes and road user charging. The former is compulsory and not based on congestion levels and designed to collect money to be used for various programmes. Road user charging, on the other hand, is primarily designed to bring about a change in trip behaviour and is usually based in areas where heavy congestion occurs, and usually has a fixed cost to the driver. The funds accumulated are used for transport improvements (Gomez-Ibanez and Small, 1994).

According to Mattsson (2003) there are three objectives to the introduction of congestion charging, namely:

- The reduction of traffic congestion;
- The reduction in the impact on the environment; and
- The raising of funds for transport infrastructure improvements that could make congestion charging more politically palatable.

The various types or methods of pricing are based on the definition of the congestion area and the structure on which payment is based. In their survey on international practice of congestion management, Gomez-Ibanez and Small (1994) as well as the IHT, identified the following:

- Point charging;
- Cordon charging;
- Zone charging;
- “Distance travelled” charging;
- “Distance and time” charging; and
- Increase in parking charges.

Various studies have been conducted around congestion charging in predominantly developed cities, but only a few have been implemented. The foremost reason for the low implementation rate is that authorities have not been able to overcome the political hurdles and public opposition (Gomez-Ibanez and Small, 1994). Vuchic (2000) opined that driver opposition could be overcome by informing them upfront what the costs would be. On the other hand, a paradigm shift would need to take place where the public was not used to paying directly for the use of roads.

The oldest congestion charging city in the world is Singapore, which implemented it in 1975. It was introduced because Singapore was experiencing an economic boom resulting in an increase in car ownership and traffic volumes into the central business district (CBD) as part of a travel demand management strategy (Gomez-Ibanez and Small, 1994). The primary objective currently is to make drivers aware of the cost, with the aim of promoting modal shifts (Commission for Integrated Transport (CFIT), 2007). The scheme was fairly simplistic from the onset; namely a paper based Area Licensing Scheme (ALS). Motorists were charged for entering the CBD during the morning (AM) peak period. When first introduced, high occupancy vehicles (HOV) carrying more than three passengers, taxis and motorcycles were exempt. Within three weeks of implementation, taxis were removed from the exempt list. It was reported that there was a 47% reduction in traffic volumes within the first month of introduction.

London introduced a cordon-based daytime congestion charge, namely 07h00 through 18h00 in 2003 to reduce traffic volumes into the city. In terms of the impact on traffic, there has been an average reduction of 26% in congestion (Transport for London, 2006). There has also been a 21% reduction in traffic volumes entering the charge zone. The income generated was and still is used to improve public transport services, non-motorised transport facilities and road safety.

Stockholm introduced congestion charging, albeit on an experimental basis between January 2006 and August 2006 to reduce traffic volumes. During the trial period, traffic volumes decreased by 22% (Local Transport Today, 2006).

Although congestion charging has predominantly been implemented in developed cities, Santiago in Chile implemented a toll road charge in 2004. It was introduced to firstly reduce air pollution in the city and secondly to generate revenue for transport improvements to alleviate congestion (CFIT). Charging was based on the distance and time of day travelled. This sophisticated level of charging in the form of electronic toll collection (ETC) technology, used electron tags in vehicles.

The São Paulo authorities in Brazil also undertook a feasibility study into the introduction of a congestion charge (Hook and Ferreira, 2004). Congestion charging seemed to be the next step for the city as they already had in use a licence plate based vehicle restriction within a cordoned area called a *rodizio* in 1996. This measure restricted vehicles, based on the last number on the licence plate, from entering the *rodizio* weekdays during the morning evening peak periods. Following the implementation of the licence plate restriction, there was an initial reduction of 20% in traffic volumes. However, by 2000, traffic volumes were back to pre-*rodizio* levels. The authorities saw congestion charging as a possible solution to, not only, the reduction of traffic volumes but also the generation of revenue needed to improve the public transport system.

Congestion charging, therefore, is a versatile TDM strategy which could be implemented and adapted over time to suit present and future traffic conditions, and suggests that a reduction in traffic volumes can be achieved. Although not implemented in a developing city yet, the interest of transport authorities such as São Paulo and Santiago has been piqued.

1.8 Research Design and Methodology

This study was predominantly empirical in nature using existing survey data and a selection of case studies to determine the technical feasibility of a congestion charge in Cape Town. Data assessed was predominantly travel information for the City as well as international experience regarding technology, implementation and enforcement.

As anticipated, Singapore and London was used as case studies in meeting the objectives related to technology and enforcement as well as the various types of charging considered for these cities and why they were discarded. This informed the type of congestion charge, which could be most applicable to Cape Town. It also provided insight into the various technologies which could be considered for application within the City.

Travel data was sourced from the City of Cape Town, which already has a wealth of historical traffic data. At this early stage, it was envisaged that by means of statistical analysis, an understanding of what the relationship between the various factors influencing travel are, and to what extent it would impact on travel choice. Anecdotally, the current poor quality of public transport could have some negative impact on the acceptability of congestion charging. The data was also used to indicatively calculate the level of traffic reduction which could be expected.

1.9 Chapter Outline

The thesis is structured as follows:

Chapter 1: Introduction

This chapter gives a brief outline of the principles of road user and congestion charging and the environments in which it is considered. It also reports on the historic travel trends and the potential of further economic growth in South Africa as well as in the City. The chapter includes the scope of the study comprising of the hypotheses, objectives and research methodology.

Chapter 2: Literature Review

This chapter explores international studies undertaken around congestion charging; the methods of charging used the impact on traffic volumes, lessons learnt, and other related issues.

Chapter 3: Research Methodology

This chapter sets out the research methodological approach that includes the testing of the hypotheses. It details the process of data collection as well as how this data will be analysed. Limitations of the data sets will be reported.

Chapter 4: Analysis of Data and Findings

The data analysis and findings are discussed in this chapter and compared against the literature reviewed. It reports on the outcomes of the research in meeting the objectives set at the onset for testing the hypotheses.

Chapter 6: Conclusions

This chapter concludes the study, summarizes the key findings and proposes recommendations and future study.

CHAPTER 2
LITERATURE REVIEW

2.1 Introduction

In this chapter literature is reviewed that will conceptualize the problem statement, hypotheses and objectives of the study. In particular this literature review will include reference to travel demand management, types and objectives of congestion charging, and the experiences of Singapore and London, which implemented congestion charging for the purpose of reducing congestion levels and traffic volumes.

2.2 Travel Demand Management

Vuchic (2000:268) defines Travel Demand Management (TDM) '*as a set of measures, including legally mandated programs, developed to provide solutions to the problem of increasing highway congestion by reducing the volume of travel rather than by traditional approaches that focused mostly on increasing the supply side – highway and parking capacities. TDM encompasses a broad set of activities such as limitations on parking supply and encouragement of taxi ride-sharing'*.

The primary objectives of TDM, as set out by the Institute of Highways and Transportation (1997:286) are as follows:

- *"To reduce congestion and thereby improve economy efficiency;*
- *To improve the quality of life through improvement of the local environment;*
- *To provide stimulus for the local economy ; and*
- *To reduce the local and global impacts of atmospheric pollution."*

There are various types of TDM measures, each of which can be applied in isolation, with varying success, to reduce congestion. To enable a more successful reduction in congestion, a combination of TDM measures, that apply the 'carrot and stick' philosophy, should be introduced (IHT, 1997) given that the measures complement each other. These include:

- Increasing parking control and charges;
- Road-user pricing;
- Increase in fuel and vehicle tax;
- Promotion of the use of high occupancy vehicles (HOV)
- Improvement and promotion of public transport as an alternative to the private vehicle;
- Intelligent transport solutions such as, for example, variable messaging;
- Land use and development controls;
- Encouraging alternative modes of transport (eg. Walking and cycling);
- Telecommuting;
- Restriction of vehicle ownership; and
- Physical traffic reduction measures such as, for example, traffic calming.

2.3 Congestion Charging

For the purpose of this study, differentiation needs to be made between congestion charging and the current use of the term “road pricing”. Congestion charging is introduced with the primary or sole objective to reduce congestion by drivers/companies paying for the delay that they inflict on other road users. It has the secondary benefits of revenue generation and emission reduction. Road pricing is currently interpreted as having the primary objectives of revenue generation and the reduction of environmental impacts caused by traffic. In the case of road pricing, it is sometimes not in the interest of the relevant road authority to reduce the volume of traffic on roads if the primary objective of the charge is revenue generation. However, in this study the terms are interchangeable meaning that road pricing is congestion charging.

The case for road pricing goes back several decades, with the Smeed report being one of the first to support its introduction (United Kingdom Department of Transport, 1964). The main objective of the study was to determine the technical feasibility of a road pricing system and whether it can reduce congestion through economic justification. The study, however, did not take into account the social and political issues that inevitably need to be overcome in order for a pricing system to be introduced. It is interesting that the Smeed research team held at the outset of their study that congestion charging would in itself not solve congestion and that investment into road infrastructure would still be required.

The Smeed report identified the following operational requirements, which have been expanded over the years to take into account improvements in technology as well as changes in driver and societal behaviour (May, 1992 and Foo, 2000). The requirements can be summarised as follows:

- The cost of the charge should be related, as closely as possible, to the cost to the driver as well as the cost that she/he imposes on other road users;
- The technology should be highly reliable so as to ensure that the public perceive it to be trustworthy;
- The charge, at its optimum, should be based on distance and time travelled;
- The payment system should be user friendly;
- It should be easy to use and understandable by infrequent users and tourists;
- Users should be able to pay either pre or post journey; and
- The system should be able to protect users' privacy, while at the same time allow users to access their accounts.

Vickrey (1992) further developed principles for an efficient charging system. These, *inter alia*, include:

- Road based public transport and emergency services vehicles should be exempt of the charge;
- Taxis should be provided with a mechanism to enable them to pass the cost of the charge onto passengers;
- Restricting on-street parking during periods, through either increased charges or restrictions, when it affects the movement of traffic, or banning it altogether; and
- Imposing special rates for delivery vehicles, possibly through an on-board meter, which would reflect the affect that they have on traffic during the peak and off-peak periods.

Although the criteria developed by the Smeed report may seem straight forward and relatively easy to achieve, they are not (Vickrey 1992, and May 1992). Hong Kong, for example, could not meet the privacy requirement, while Singapore initially could not meet the balance between the charge rate and the marginal social cost (Phang and Toh, 1997). Vickrey (1992) admits that politics is a challenge when it comes to introducing a charge for something that was not charged for before and that the public do not expect to pay for. Although politics and social equity do not form part of this particular study, it is still worth mentioning as these two factors are the most influential to the successful implementation of a congestion charge. In the case of Edinburgh, which proposed the introduction of a congestion charge, the scheme was deferred as a result of opposition received during public consultation. Strong political backing led to the successful implementation of congestion charging in Singapore and London.

Gómez-Ibáñez and Small (1994), IHT (1997) and the United Kingdom Department for Transport (2005) identified various types of congestion charging, namely:

- Parking charges: This is considered to be the simplest form of congestion charging, whereby the cost of parking as well as the time it takes to find a parking space, discourages drivers from entering a congested urban area. It is considered (Gómez-Ibáñez and Small 1994) as the most ineffective form of congestion charging. There are two reasons for this. The first is that even though it may be difficult to find on-street parking, privately owned parking garages will cater for the demand. While the relevant authorities can reduce the approval of new parking garages, it has no control on the parking rate charged. This is the case for Cape Town, where an increasing number of buildings, or parts thereof, are being converted into private parking garages. The second reason for parking being an ineffective congestion charging option is that it does not reduce the volume of through traffic in an area.

- Point charging: This is considered to be more effective than parking charges as vehicles travelling through, but not destined for, the congested area are charged. It is theoretically similar to a toll road. Where it differs is that it is located at a point in a congested area and the price charged is higher than that of a toll and could be varied based on the time of day.

- Cordon charging: This is a variation or adaptation of point pricing. It is when a boundary is established around a congestion area and there are charge areas at all entries or exits. The basis of the charge rate may vary, from being a differential rate on entry to being a flat daily rate. Drivers can be charged for every entry, for entering daily, or during a defined period.

- Zone Charging: It is similar to cordon charging in that there is a boundary, and drivers are charged for entering the zone as well as charged for travelling within the zone. This charge could either be a flat daily rate or could vary dependent on the time of day, with cheaper rates for travelling in the Interpeak period. Where there are more than one zone, drivers can then be charged for driving from one zone into another and this charge could be a different rate.

- Charge based on distance travelled: Is more sophisticated than point, cordon or zone charging. As the name suggests, it is based on the distance travelled. Gómez-Ibáñez and Small (1994) report that this type of charging can be considered the evolutionary product of cordon charging. In its truest form, drivers would be charged based on the distance travelled. This could result in drivers undertaking shorter trip lengths so that they would only have to pay the minimum cost.

- Charge based on time travelled: This charge, as the name implies, is whereby drivers/companies are charged by the time they spend travelling in the designated congested area. This type of charge is one that is more reflective of the traffic conditions. It could however; lead to drivers deliberately increasing travel speeds to reduce time spent travelling. This could lead to unsafe traffic conditions

- Time and distance based charge: Also known as "congestion-specific pricing" (Gómez-Ibáñez and Small, 1994:8). Distance and time charging refers to a cost being incurred by the driver based on the distance travelled as well as the time of day. This means that the charge could varying based on time of day travelled as well as travelling conditions.

- Congestion metering: Drivers are charged based on their contribution to congestion within the designated area. This would vary on the time of day and traffic conditions in the area. This could be devolved down to a single road where a charge could be applied.

The types of congestion charging are predominantly based on what the charge rate is derived from. Technology plays a large role in the type of charge which is implemented, as the more sophisticated the technology, the more complex the type of congestion charge can be.

In a study for the World Bank, Hau (1992) suggests the following guidelines to developing cities considering congestion charging, namely:

- Consideration for a more labour-intensive option rather than a high technological one given high unemployment which could outweigh the cost implications;

- Consideration for cordon pricing with labour intensive enforcement;

- Varying charging rates in peak and off-peak periods;
- Viability of electronic road pricing where economies are set to grow and the cities are being rapidly urbanised; and
- Funding for the sole purpose of improving transport in the city.

Cordon pricing would be a good starting point for developing cities, though arguably, the use of labour intensive methods for enforcement would be debatable. Camera technology might be a much more viable option in terms of accuracy and the ability to circumvent the system would be much harder than if labour intensive methods were to be used. Another consideration is that labour intensive methods would require more infrastructure, in the form of booths, resulting in increased delay to vehicles.

2.3.1 Technology

One of the decisions in determining the most appropriate technology is whether the technology will be part of only the enforcement system or the charging and enforcement system. Charging technology relates to the mechanisms available to drivers/companies that would be used in the payment of the charge. The enforcement technology relates to the technology used for vehicle detection and checking if the relevant payment was made. It can also initiate the penalty process (TfL, 2005).

The requirements to be met when assessing technologies are the same as the general congestion charging requirements, as well as the following (Foo, 2000 and MVA, 1995):

- It should be reliable and have the ability to operate accurately in various traffic conditions;
- It should be able to operate in any environmental scenario which might arise;
- It should be able to process any charge exemptions;
- It should operate as a fair system;
- It should have the ability to, as accurately as possible, identify any violators;
- It should have the ability to protect the privacy of users; and
- In the case of some cities, visual intrusion should be kept to a minimum.

Irrespective of whether the technology is only to be used for enforcement or in combination with charging as well, the equipment required is as follows:

- On-vehicle equipment (not essential);
- Roadside equipment; and
- Central computer.

Several technologies exist, namely:

- Automatic Number Plate Recognition;
- Tag and beacon;
- Global Positioning Systems; and
- Digital Mobile Phone Technology.

2.3.1.1 Automatic Number Plate Recognition (ANPR)

ANPR is primarily used in the enforcement component of the congestion charging system, although it does have the flexibility of being used as the primary charging system. It makes use of on-site cameras (fixed or mobile) to capture images of the number plates of passing vehicles. These moving images are then sent to a central computer system, where the ANPR systems identify the number plate. The licence plate number is then matched to registered vehicles to ensure if the charge has been paid, if not, the violation penalty process then commences. This system is currently used in the London. The ANPR system is best suited for point charging and cordon charging, as the system checks for violations based on a given area.

Additional technology trials were undertaken by TfL (London Congestion Charging Technology Trials, Stage 1 Report, Jan. 2005) to assess improvements of the system in recent years. The latest version of ANPR can process input from two cameras without comprising the accuracy of the system. The trials also found that if ANPR was used for roadside processing, there would be no difference in performance. Furthermore, there would be a benefit in the reduction of operational costs as the volume of data being sent to the central computer for checking and processing would be reduced. The materials which make up the number plate can affect the quality of the camera image taken. However, this is not considered to be a high risk in Cape Town as the City currently undertakes camera enforcement and the specifications for number plates are legislated.

The roadside equipment for ANPR is pole mounted cameras with the number dependent of the number of lanes and type of charging imposed to photographically capture passing vehicles, with the back office identifying offending vehicles. These are not as visually intrusive as other systems such as the tag and beacon system. A secondary ANPR system could also be introduced to improve accuracy without requiring additional mounting poles as the poles of the primary cameras can be used. The primary cameras would read the front number plate and would face oncoming traffic, while the secondary cameras would read the rear number plate once the vehicle passed.

The detection rate of the latest trials by TfL in 2005, was in excess of 90% for a single vehicle pass. The current ANPR system used in London has a single pass detection rate of 70% to 80%. A study undertaken in a number of European cities, between 2000 and 2003, found that the mixed use of front and rear facing cameras further reduced the rate of non-detection (Transport Initiatives Group, Pricing Road use for Greater Responsibility, Efficiency and Sustainability in cities (PRoGRESS), July 2004). In terms of privacy and confidentially, the system would only retain the images for evidentiary purposes of violators and the rest would be discarded. The PRoGRESS project concluded that this technology was reasonably affordable to operate, but with possibly high capital costs. It was the ideal for cordon charging and as an enforcement component of the tag and beacon system. Mobile units could also be introduced to do spot checks to ensure that the charge has been paid.

The requirement of limited visual intrusion is relevant to Cape Town because of the historic and geographical character of the city centre and the attraction for tourists. There is also a lack of roadside space for the installation of large infrastructure for the introduction of a congestion charging system such as gantries. Cameras for the ANPR system could be mounted on existing street furniture to be less intrusive.

2.3.1.2 Tag and Beacon

A tag and beacon system can be a charging system as well as form part of the enforcement system. This system makes use of Dedicated Short Range Communication (DRSC), which uses microwave technology. The system works as follows: vehicles are fitted with a tag (this could be read only, read-write or smart card) which contains information such as a prepaid amount or registration/billing information. The vehicle then passes the charge boundary or point and the tag is read by a roadside beacon. Depending on the type of tag, the beacon could either check the validity of the tag and the value on it (in the case of a prepaid system) or read a billing address (in the case of a post travel system). Once again, depending on the type of tag (read only, write-read or smart card), the cost of the charge can either be deducted on-vehicle or by roadside equipment. This system gives the flexibility of variable charging, but is more favourably suited for cordon charging (PRoGRESS, 2004).

The enforcement component for this system would be ANPR mounted cameras, to capture passing vehicles on multi-lane roads. This was the case for Singaporean Electronic Road Pricing (ERP) scheme. It could be argued that use could be made of bridges and existing overhead signs. However, this would depend on the geographical structure of the city as well as the presence of such infrastructure in the charging area. This system can overcome the privacy and confidentially requirement if the deduction of the charge took place at the roadside, either on or off the vehicle and only violating vehicle information was sent onto the central computer, which would be a secure system.

When trialled by TfL, in 2005, the tag and beacon system reported a 99.55% detection rate. Singapore's ERP reported an error rate of 0.07% after the first three months of implementation (Foo, 2000). In 2006, TfL undertook further trials to test whether this system was a feasible option for implementation in London. Those trials reported a 99.6% detection rate. As part of the trials, some system design issues were also investigated. These included battery drain, front and rear spatial matching and on-board charging, but to name a few. The PRoGRESS trials also identified front and rear cameras as an option that should be further investigated. The results of the design issue testing were:

- Level of battery drain was predominantly as a result of parking, but could be reduced by specifying the sleep mode function to suppliers;
- Front and rear spatial matching could be achieved but the distance between the two poles would need to be optimised to take account of site geometry and varying vehicle lengths; and
- Low interference between the DSRC tags and other devices;
- Use of more than one supplier and service provider as interoperability between systems was demonstrated.

Both studies reported that metallised windscreens affected the ability and effectiveness of the tag and beacon to communicate with one another.

This method of charging and enforcement is expensive because of its sophistication. It would require all vehicles to have an on-board unit (OBU) fitted and this could be costly. A decision would need to be made about how visiting vehicles would be accommodated.

Although this system is a possibility for Cape Town, it is a very expensive system as it has high capital start up costs. The only possible way that the City could consider this, is if they went into a public private partnership (PPP). Another concern for Cape Town is that this system could be visually intrusive dependant on the type of congestion charge and the location of beacons on the multi-lane roads within Cape Town, which currently did not have gantry signs that could be used.

2.3.1.3 Global Positioning Systems (GPS)

The theory behind this system is that vehicles would be fitted with a GPS device and on entering the charge zone or passing the charge point, they would register through satellite technology. This technology is ideal for the more complex distance based charge. During both the TfL Stage 2 trials (TfL, 2006) and the PRoGRESS project (2004), it was found that this technology did not currently offer a sufficient level of accuracy. The following observations were made during both trials:

- The accuracy of locating vehicles was affected by the shadowing of tall buildings, parking garages and tunnels (known as 'canyoning'), which affects the reception between the satellite and the OBU's signal;
- Some vehicle operations were affected by the equipment more than others. This was predominantly as a result of where the GPS equipment was fitted on the vehicle; and
- No on-board processing capability, other than a journey recording function. Any additional functions would result in increased costs and cause practical problems, such as updating pricing lists.

Studies undertaken to date all indicate that, while this technology is definitely one for consideration, more research and trialling needs to take place to resolve the current performance of the system.

A major issue with a GPS system is that the more satellites that can be accessed, the more accurate the location of the vehicle can be determined. In urban areas, which have tall buildings such as is the case in Cape Town, this approach will be problematic as the signal could be reflected and distorted.

2.3.1.4 Digital Mobile Phone Technology (DMPT)

This system is similar to that of the GPS system. However, instead of using satellites, it makes use of cellular phones and the network base stations. Besides the privacy concerns that this system has, it also cannot accurately locate the vehicle in which the phone is. This is because of the way it currently operates. A cellular network is divided into an area of cells, each of which has radio coverage to a base station. When calls are made, the call does not necessarily go through the base station closest to it if the network is saturated, but could be diverted to one which has capacity. This possible diversion makes location determination difficult. Another difficulty lies in the delay in transmission. Consequently, when the signal bounces back, the vehicle might have moved sufficiently to avoid the charge.

As this technology needs to be refined, matured and further tested, it is not currently a feasible application for Cape Town.

Table 1 below summarises the various types of technologies and which type of congestion charge is most suited for it.

Table 1 – Congestion Charge Type - Technology Matrix

Congestion Charge Type	**ANPR**	**Tag & Beacon**	**GPS**	**DMPT**
Point Charging	✓	✓	✓	✓
Cordon Charging	✓	✓	✓	✓
Zone Charging	✓	✓	✓	✓
Charging based on travel distance			✓	✓
Charging based on travel time			✓	✓
Charging based on travel distance and time			✓	✓
Congestion metering	✓	✓	✓	✓

2.4 Examples of congestion charging approaches

There are many cities which have implemented congestion charging such as, for example, Singapore and London which had as their primary reason for implementing a congestion charge reducing congestion by reducing volume.

2.4.1 Singapore

Singapore's congestion charging scheme was introduced in 1975 as an Area Licensing Scheme (ALS). The Singaporean government realised that they would need to develop a policy to manage the growth of traffic and car ownership that would not negatively affect the economic growth of the city-state. Due to the rapid economic growth experienced in the 1970's, travel speeds into the central business district (CBD) had decreased to 19km/hr during the morning (AM) and evening (PM) peak periods.

The Singaporean authorities considered four pricing schemes for implementation (Gómez-Ibáñez and Small, 1994). These were:

- Congestion charge using electronic vehicle detection;
- Road tolls;
- Increased parking charges in the downtown area; and
- Area Licensing Scheme.

These options were evaluated against the following criteria:

- Accessibility and mobility was to be maintained by improving mass transit as these two were vital to the economic vitality of the city;
- Control of local congestion would apply when needed, thereby acknowledging the benefits of private vehicles;
- It had to be easily enforceable and administered; and
- It should not require a subsidy from the authorities.

The first three of the four schemes were discounted. Electronic vehicle detection was discounted due to cost and reliability at the time. Road tolls would take up too much space and toll collection would cause delays. Increasing parking fees, although more favourable than the previous two, was discounted as well because it couldn't discourage through traffic and chauffeur-driven cars. The authorities decided to implement the ALS. It was a paper based system covering 6.1km^2. The system was enforced manually, with enforcement officers stationed at 22 entry points. Drivers would purchase a license and display it on the windscreen for inspection when passing the inspection booths.

It was initially only for the AM peak period between 07h30 and 09h30, Monday to Saturday. Initial traffic reductions were forecasted to be 25-30%, but a reported 44% was achieved (Phang and Toh, 2004).

In the ALS's initial implementation, the following conditions applied:

- All automobiles carrying three people or less and later revised to include taxis (three weeks later);
- Public transit vehicles were exempt;
- Carpools or taxis with more than four people were exempt; and
- Trucks and motorcycles were exempt.

To complement the ALS, the authorities encouraged car pooling by providing the incentive that vehicles with four or more passengers would be exempt from the charge. It also promoted 'park 'n ride', whereby parking areas were provided on the fringes of the zone, for a small fee and people were shuttled into the restricted zone. The City of Cape Town also mentions a 'park 'n ride' as one of its possible TDM measures.

As mentioned above, the initial result of the ALS was a 44% reduction in the volume of traffic entering the zone in the restricted time periods. It also resulted in a change in travel patterns. Three new patterns emerged:

- A shift of travel to just before and after the charging hours. This resulted in an increase in volumes during these periods;

- The diversion of traffic onto alternative routes to avoid the charge. This would be limited in the case of Cape Town due to the geographical layout of the city; and
- The authorities had hoped that as there was a reduction in inbound traffic in the AM peak, there would be a reversal of the pattern in the outbound PM peak traffic. This did not happen, because there was no charge during this period, so motorists did not have to change their behaviour and same amount of traffic had entered the City, just over a longer AM period.

The introduction of the ALS also resulted in the under utilisation of major roads into the CBD as well as the relocation of congestion by time and location. Drivers tended to enter the CBD just before the charge time would come into effect, and also tended to divert onto lower, more local roads to avoid the charge. Some commuters had higher travel costs because they staggered their working hours and trips, by travelling longer distances to avoid the charge. There was an increase in trips by vehicles that were exempt from the charge such as taxis.

To counter the effects of the increase in volumes before and after the charging period, the length of the period was increased on 1 August 1975 to end at 10h15. This reduced the volumes of traffic between 09h30 – 10h15. On 31 December 1975 the cost was increased from S$3 to S$4 and again on 1 March 1980 to S$5. In the years that followed, the authorities adapted the charge in various ways in order to address the issues/concerns that the initial ALS raised/caused. On 1 June 1989, a PM charge was introduced between 16h30 and 19h30, Monday to Fridays. The time was later shortened to end at 18h30. The cost of the charge was reduced back to S$3, but most exemptions were removed. Only scheduled buses, police, military and emergency vehicles were still exempt.

In January 1994, a whole day ALS was introduced as a means of "smoothing the peaks and troughs" (Phang and Toh, 2004:18). The new hours included a Saturday and were: Monday to Friday, 07h30 – 18h30 and Saturday, 07h30am to 15h00 (the Saturday time period was later shortened to end at 14h00). People could now buy a licence for the whole day, or for half a day at a reduced rate. This resulted in a smoother distribution of traffic as was hoped for by the authorities.

In June 1995 the government introduced a weekday Road Pricing Scheme (RPS) on the East Coast Parkway between 07h30 and 08h30, drivers, except those exempt as in the ALS, purchased a licence to use the highway. This reduced traffic and increased travel speeds on the highway.

Luk (1999) reported that the short term demand elasticities for the charge ranged between -0.19 and -0.58, with mean elasticity of -0.34. This finding suggested that car travel was less sensitive to cost, as might be the case in Cape Town. Further, Litman (2008) attributed this lack of sensitivity to cost to the possibility that high and middle income earners were more likely to be car owners, judging from the high car taxes in Singapore. Another factor to consider was the good public transport system in Singapore. Arguably, the elasticities in Singapore are reflective of those for Cape Town given that high and middle income earners were more likely to own cars and therefore were less sensitive to the cost of travel by this mode.

2.4.1.1 Successes and Shortcomings of the ALS/RPS

According to Phang and Toh (2004), the ALS and RPS was successful because it managed to curb congestion and led to a modal shift in favour of public transport. They do, however, report that the charge rate was about the optimal rate, which led to the 44% peak period reduction and under-utilisation of roads. They also reported on the findings of studies by other researchers, which supported their work. These included:

- A shift in congestion to before and after the restricted hours as well as the shift of traffic to other roads. (as reported by Toh (1977) and Wilson (1988));
- The impact on commuters who changed their travel time to avoid paying the charge (Hendersen, 1988); and

- The increase in bus patronage resulted in an increase in bus passengers travel time and this resulted in a decrease in overall welfare (Wilson, 1988).

According to Phang and Toh (2004), Li (1999) had a contradictory view to all findings of their previous study. He did a study which showed that drivers didn't think the S$3 was high. He used values that applied to drivers and not the general application. He also use the "*average wage rate for car owners, which is higher than the average national wage rate, and the study was done with data collected in 1990, fully fifteen years after the ALS and the S$3 fee were implemented.*" (Phang and Toh,2004:20).

In May 1991, a weekend car scheme was introduced to encourage people to use their cars outside the congestion charge hours of operation. Motorists were given the following incentives:

- *"70% discount on the annual road tax and rebates on the registration fee and import duty…"(*Phang and Toh,2004:20)

The above applied if vehicles were registered as weekend vehicles. This resulted in households owning more than one car or a luxury car benefiting most from this scheme. This was regarded by the less wealthy as unfair. The authorities then revised the scheme in October 1999 and called it the off-peak car scheme (OPCS) whereby all vehicles got a "*flat S$800 discount on the annual road tax, amongst other things"* (Phang and Toh, 2004:21)

2.4.1.2 ERP

Because the manual ALS/RPS system became unmanageable, the authorities decided to switch to an Electronic Road Pricing system. Hong Kong has proposed a similar scheme, but it did not proceed because it could not adequately address the privacy requirement. The Singaporean government overcame this by introducing a CashCard system, whereby only violations would be passed onto a secure central computer system. They achieved a smooth transition between April and September 1998 at a cost of S$200 million.

The Singapore ERP is such an extensive scale, it is the first of its kind in the world. Other cities in Canada, Norway and United States of America had introduced ERP, but they differed from Singapore in the following ways:

- Smaller in terms of scale;
- Not a direct debit system; and
- Primarily for revenue generation of road construction projects and not for traffic congestion reduction.

One of the major decisions taken when deciding on ERP was that vehicles would be fitted, with the OBUs free of charge for a certain period of time.

2.4.1.2 Operational and technical features of ERP

One of the key operational requirements of the ERP gantry system used, was that it had to be able to process transactions with vehicles travelling at speeds in excess of 120km/hr across multiple lanes.

The system works as follows:

"Each gantry has a set of two antennae, two cameras and two optical detectors per lane. Upon detection of an incoming vehicle and within a fraction of a second, the ERP system communicates with the in-vehicle unit (IU), identifies the type of vehicle, deducts charges, and if a violation is detected, captures the image of the vehicle and its licence plate. Information about errors and violations is sent by a ground-level control box called the 'outstation controller' via telephone cables to a central computer system located at LTA's control centre. The central computer churns out reports of offences and system errors and mails these reports to the vehicle owners." (Foo 2000:36)

The OBU is attached to the vehicles windscreen, in the case of motorcycles the speedometers, and is powered by the vehicles battery. It has a LCD screen, which shows the balance of the CashCard or if there is a problem with either the card or the unit. The CashCard is issued by Network for Electronic Transfer (NETS), which is a consortium of local banks. The cards can be purchased at banks, post offices and petrol stations. It can be topped up at automatic teller machines as well.

2.4.1.3 The structure of ERP charges

It is based on Passenger Car Units (PCUs). It was originally planned that the ERP charge for taxis would be phased in because it was recognised as a form of public transport. The charge to goods vehicles was also supposed to be phased in so that businesses could get accustomed to the system. Only passenger cars paid the full charge.

When it was first implemented, there was a low system error rate of 0.07%. The main errors were faulty IUs and CashCards as well as gantry communication. Although the ERP only collected S$6.6 million in its first month, which was lower than that collected under the ALS, it was considered successful. This is because it was never about revenue regeneration, but traffic congestion reduction.

In September 1998, it was found that the ERP reduced traffic volume by 24% and speeds increased to 45km/hr within the Restricted Zone. The reduction meant that there was a modal shift to public transport and that other motorists switched routes. It also meant that there was an under-utilisation of roads. The number of taxis entering the CBD reduced because, whereas before they paid a flat rate, they were now charged per entry. This meant that people wanting a taxi from the CBD had to wait longer as taxis only entered when they had passengers. There was an increase in the number of taxis and good vehicles on the expressways increased.

In response to the changes in traffic conditions, the LTA did the following:

- the charge for taxis and good vehicles on expressways were increased;
- there was a reduction in charge on under-utilised in the RZ; and
- for time periods and roads where traffic speeds exceeded the acceptable range, the charged was reduced, and vice versa.

The Singaporean congestion charge illustrates that the introduction of the charge does not need to be sophisticated in terms of technology. It is something that needs to evolve with time to cater for the ever changing traffic patterns that are experienced. The following lessons can be learnt from the Singapore experience in relation to application in Cape Town:

- An expensive and sophisticated technology system in not a necessity for the introduction of a congestion charge;
- An all day charge does not need to be applied from the onset, a phased approach can be used;
- It is possible to come close to optimal charging with the technology available today;
- Capetonians would need a paradigm shift in terms of obeying the charging and not trying to circumvent the system; and
- Strong, committed political backing is essential.

2.4.2. London

Transport for London (TfL) introduced a zone congestion charging scheme in Central London in February 2003. The idea of introducing a congestion charge to London was not a new one, with studies being undertaken by the Department of Transport in 1995 and 1999 (MVA Report Vol 1: London Congestion Charging Research Programme Final Report, HMSO, London, 1995 and Review of Charging Options for London (ROCOL): A Technical Assessment, HMSO, London, 1999).

The authors of the MVA report found the following road transport trends in London at the time of the study, namely:

- A general increase in car trips;

- An increase in the use of vans for goods traffic at the expense of lorries;
- A capacity operation of roads during peak periods;
- A flattening of the peak periods, with commuters choosing to travel at different times of the day; and
- A decrease in road travel speeds.

The later ROCOL study also reported similar road transport challenges for London, illustrating that not much had changed during the period between 1995 and 1999. The ROCOL report reported the following average travel speeds, namely:

- 16km/hr on a typical working day in Central London;
- Inner London experienced average speeds of 19km/hr in the AM and PM and 24km/hr in the Interpeak; and
- 27km/hr, 27km/hr and 30km/hr in the AM, Interpeak and PM respectively in Outer London.

TfL reported that in the period preceding the introduction of the congestion charge in 2003, travel speeds in Central London were 13km/hr, similar to what it was 100 hundred years ago (TfL website).

Clearly there was a problem of congestion which was considered so serious that its reduction was listed as one of the key priorities of the Mayor's Transport Strategy for London (Mayor's Transport Strategy, Greater London Authority, 2001).

Consequently, congestion charging was considered feasible for the following reasons:

- It could be considered as the most effective tool in reducing traffic levels in comparison to other TDM measures; and
- The revenue generated could be used to fund improvements to London's public transport system.

One of the driving factors when considering the type of congestion charging was the timeframe in which it would need to be implemented and the enforcement technology which would be used.

The MVA study considered the following types of congestion charging:

- Congestion metering: Rejected because of technology doubts. Although considered by the study team as the most accurate, it raised more questions than answered. Example, who was liable for payment when drivers were delayed because of roadworks. Drivers wouldn't know what the charge was until after the journey was undertaken.

- Time-based charging: Drivers would be charged for time travelled in the area. Although it is a good idea, it suffers from the same disadvantages as the congestion metering option. It was therefore rejected.

- Distance based: Charging is based on the distance travelled in the area. Although less effective than time-based charging, the driver is able to predict the cost before travel, as drivers should be able to obtain the distance, and the probability of speeding could be reduced (unlike time-based).

- Area Licensing (Zone charging): Is a simplified area-based charge levied for using the road network in a charge area within a charge period. Zone charging does not depend on the amount of travel.

The MVA study summarised that the most feasible types of congestion charging applicable to London, given the constraints, were Zone Charging and Distance Based Charging.

On the 17th February 2003, London introduced its zone based congestion charge. A £5 (R70) daily flat rate was payable on the day of travel with the charge zone operational between 07h00 and 18h30 and was enforced using ANPR technology. In 2005 the charge rate increased to £8 (R112) and the hours of operation were extended to 19h00. The congestion area can be seen in Figure 1. While residents within the charging area were eligible to a 90% discount on the charge, the following user groups were exempt from the charge:

- Disabled car users;
- Buses;
- Licensed taxis; and
- Motorcyclists.

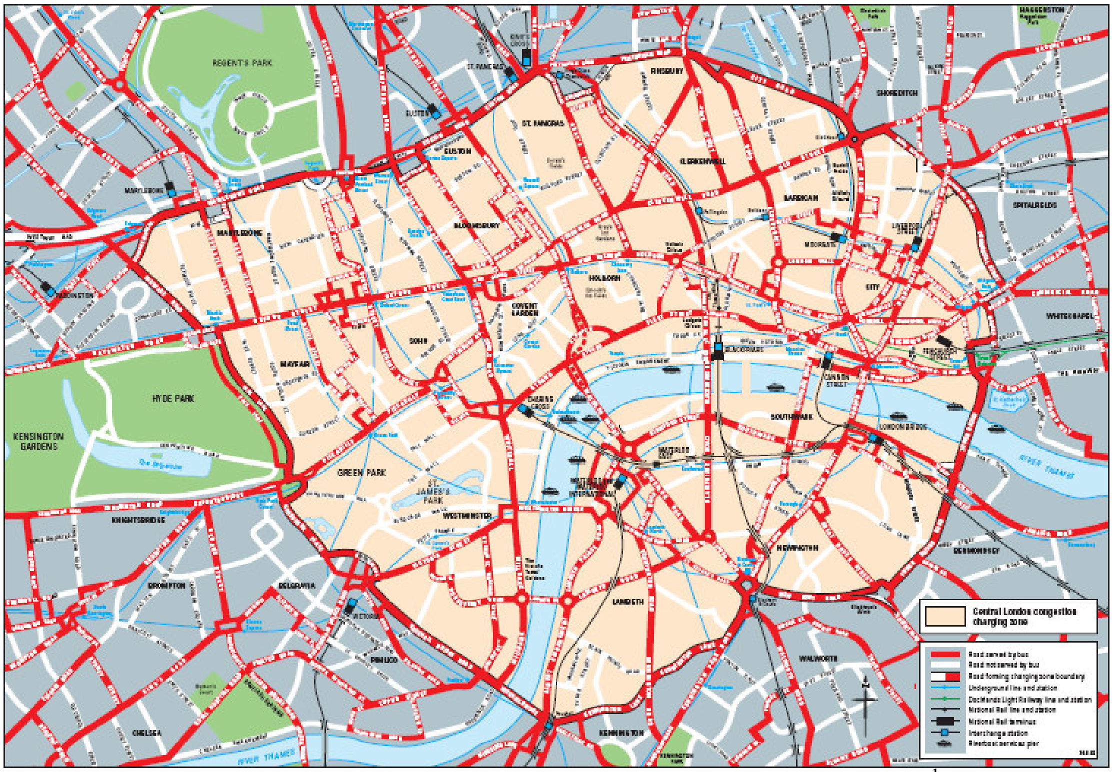

Figure 1 – Original Congestion Charging Zone in Central London[1]

The payment of the charge could be done at approved news agents, online and by text messaging. Motorists have to pay the charge within 24 hours of entering the zone but at a charge of £10 (ZAR140), the £2 increase could be considered a late payment penalty. Should the charge not be paid, a penalty charge notice (PCN) will be issued the following 24hours for £120 (ZAR1,680) within 28 days. A 50% discount applies should the charge be paid within 14 days.

Within the first year, there was a reported 30% reduction in congestion, as was the expectation of TfL (Congestion Charging Central London Impact Monitoring 2nd Annual Report. Transport for London. 2004). Other impacts reported by TfL included:

- There was a 20% reduction in congestion on the radial routes approaching the charging zone;
- The time spent by motorists queuing was reduced by one third; and
- There was reported journey time saving of approximately 14% on cross London journeys.

[1] Source: http://www.tfl.gov.uk/assets/downloads/cc_proposed_boundary_map.pdf

The reported traffic reduction in 2006 was 21%, which is lower than 2005, but still within TfL's 2002 congestion charge impacts forecast (TfL Central London Congestion Charging Impacts Monitoring Fifth Annual Report, Transport for London, July 2007). TfL have now noted that it has and will continue to become increasing difficult to make a direct comparison between 2002 baseline forecasts and existing and future ones. This is due to the reallocation of road space to alternative modes of transport, eg; buses, cycling and walking. There has also been an increase in road works in Central London, resulting in road closures and diversions during the latter part of 2006 and is set to continue.

A summary of the key findings of the fifth monitoring report in 2006 include, *inter alia*;

- There was still a reduction in congestion of between 20% and 30% against the 2002 baseline;
- There was an average reduction in delay of 30%; and
- There was a significant reduction in decongestion.

According to Litman, (2006), the charging system in not considered to be optimal as it is based on a flat daily rate and not on the distance travelled. He also concludes that it does not reflect the daily fluctuations in traffic and congestion levels in the capital. Although true, it should be remembered this particular type of charge was chosen for its potential ease of understanding and implementation.

Santos and Shaffer (2004) reported that London experienced higher short term transport elasticities of between -1.3 and -2.1. They attributed this situation to the good public transport provision, which is widely available and widely used. In countries where the provision of public transport is poor, one would expect lower elasticities.

The early success of the congestion charge led to the then mayor of London, Ken Livingstone, requesting TfL to investigate expansion opportunities for the zone. (Report to the Mayor: Proposed Western Extension of the Central Charging Scheme, September 2005). The decision of expand to the west was based on the following (TfL, 2005: 1):

- It experienced high levels of congestion throughout the day;
- The existing technological infrastructure could be used to manage and enforce the charge;
- There was sufficient alternative modes of transport; and
- There were viable alternative routes for motorists wishing to avoid the charge to use.

In February 2007, the charging zone was extended to include a western zone as illustrated in Figure 2. TfL have reported that in its initial three month period, post implementation, there has been an approximate reduction of 10% to 15% in traffic volumes entering the extension zone. Although there has been an increase in traffic volumes on the periphery (5%), this has reportedly not adversely affected traffic operation.

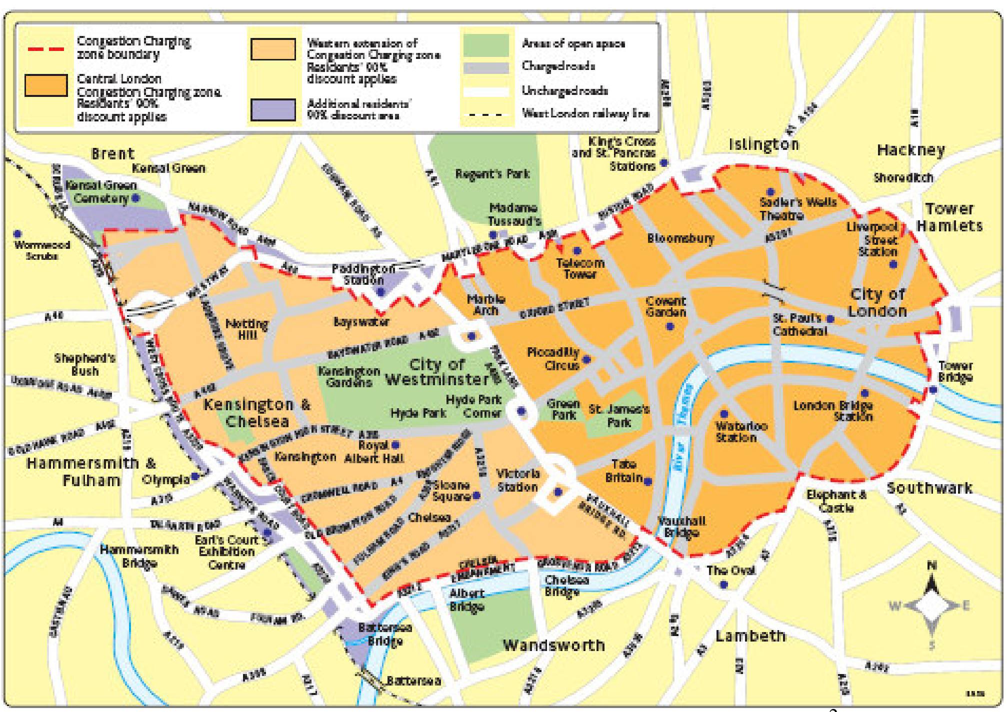

Figure 2 – Present day congestion charging zone[2]

[2] Source: http://www.london.gov.uk/mayor/congest/docs/zone-map-102006.pdf

The congestion charging scheme led, by consequence of traffic volume reduction, to a reduction in vehicle emissions. As a result, the then mayor of London and TfL decided to introduce an emission congestion charge variable to the type of vehicle entering the zone. This is meant to encourage people to purchase vehicles with lower carbon dioxide (CO2) emissions. Low emission vehicles are entitled to a 100% discount from the charge, while the vehicles emitting higher levels of CO2 will have to pay up to £25 (ZAR350). The then mayor announced that this amendment is to be introduced from the 27th October 2008.

It could be argued that this latest amendment to the congestion charge will result in London having more of a road pricing scheme than a congestion charge. By not charging low emission vehicles, there could be an increase in these types of vehicles entering the zone. This will result in an increase in traffic volumes and congestion. It is thought that for a charge to be successful, the sole purpose needs to be to reduce and stabilise traffic volumes and congestion, as is the case in Singapore. The fact that there reductions in emissions and that there are funds generated for the use of transport improvements is secondary to the primary objective of a congestion charge.

Although the political implications of congestion charging are outside the scope of this project, the outcome of the May 2008 London mayoral elections have been included for completeness and also to illustrate how sensitive such a scheme is to politics. In May 2008, London elected a new mayor, Boris Johnson. In his campaign, and subsequently his transport priorities, he has promised the following:

- The scrapping of the emission congestion charge amendment as it would only increase congestion;

- Reconsultation on the western extension zone, introduced in 2005, and if found to be unfavourable by the public and stakeholders, could result in the scrapping of the western extension zone; and
- The introduction of an account system, whereby motorists will not be fined if they do not pay on the day.

TfL have succeeded in introducing a system that has led to the successful reduction in traffic since its inception in 2003. It illustrates that, as in the case of Singapore, the charging system does not need to be complex. It can be introduced as a reasonably simple system, but should have the ability to evolve to meet the ever changing traffic conditions. TfL are investigating the tag and beacon system as the next step in the evolution of congestion charging in London.

2.4.3 Durham

In Durham in the United Kingdom, a congestion charge was introduced in 2001 along Durham Road to reduce traffic congestion, pollution and improve air quality. Drivers paid a charge of £2 (R28) on exiting Durham Road. The charge was enforced through a collapsible bollard, which was linked to a payment machine (Durham County Council, 2008). This city made use of a simple form of congestion metering, which to date had proven to be effective and demonstrated that charging could be done at a road level. However, it raised raise the question of its applicability on a wider road network.

2.5 Chapter Summary

Global studies as well as the case studies presented in this chapter illustrate that the principles of congestion charging can successfully lead to a reduction in traffic volumes and congestion. They suggest that the systems do not, out of necessity, need to be complex nor the optimal type of congestion charge.

CHAPTER 3
RESEARCH METHODOLOGY

3.1 Introduction

This study aims to explore the feasibility of introducing a congestion charge for Cape Town's Central Business District (CBD) as a Travel Demand Management (TDM) tool. The study objectives to be achieved are:

- The level of traffic reduction that can theoretically be achieved;
- The type and extent of congestion charge that would be suitable for Cape Town; and
- The congestion charging technological systems that can be practically implemented in Cape Town.

The guiding questions to meet the above objectives were:

- What is the level of trip reduction that can be achieved?
- What are the infrastructure implications of the various types of congestion charging systems that are available?
- What is the 'best fit' charging system for Cape Town, given its geographical layout? and
- What the charge price could be?

These questions together with the review of relevant literature provided the basis for the research design and methodology.

The literature review illustrated current understanding of what, *inter alia*, is understood by congestion charging, what technologies were available as well as the experience of selected cities who had implemented them.

According to Mouton (2001) and Hofstee (2006) a literature review is conducted for the following reasons, namely:

- To ascertain what the current thinking/theorising on the subject is;
- To determine if there is already a theoretical basis for the study; and
- To determine if previous studies of this nature have yielded similar results.

3.2 Research Design

A research design is understood to be the approach taken to test the hypothesis of the study (Hofstee 2006). This study was based on a combination of qualitative and quantitative methods. It is qualitative in that a current body of knowledge which exists relating to similar schemes which are already in existence and can be transposed. It is also quantitative in nature in that it tests what the potential reduction in traffic would be, based on secondary traffic data, and obtained from the City.

3.2.1 Qualitative Research

A component of this study is qualitative in nature. Qualitative research seeks to find the reasons behind the facts and is suitable for this study as it determines why specific types of congestion charging have been introduced and why others have been discounted. It also provides further explanation of the results from the quantitative research.

The use of case studies has received mixed reception among the research community. Some researchers are of the opinion that it should only be used for an exploratory basis (Soy, 1997). Myers (2000) argues that case studies are ideal for, not only supplementing quantitative data, but also for insight into small sample studies. According to Mouton (2001), case studies are used to answer research questions which are both descriptive and exploratory. Case studies are useful when specific, detailed information is required when testing a hypothesis (Hofstee, 2006).

One of the limitations of the use of case studies is that they are not considered to be generalised enough. However, arguably, case studies in this instance offered a sufficiently generalized view to be used as a basis for testing the hypothesis. A large body of knowledge already exists on the case studies chosen for this research since extensive research had been done into the various aspects and impacts of congestion charging on the selected cities.

3.2.2 Quantitative Research

Quantitative research aims to meet the study objectives through the use of predominantly numerical analysis. The statistical analysis of data relating to the movement of commuters and data analysis using Origin-Destination (OD) data held by the City of Cape Town in the form of household travel surveys as well as data from Statistics South Africa. This secondary data, provided a practical interpretation of the data in the Cape Town EMME/2 strategic transport model, which is used in the development of transport policy for the city.

3.3 Research Methodology

The OD car commuter trip matrix from the 2007 Cape Town EMME/2 scenario was converted to car trips by applying vehicle occupancies supplied by the City. These volumes were then factored up to 2008 forecasted volumes by applying the City's forecasted traffic growth of 2.5% per annum. The data was used in the calculation of the percentage trips to the CBD and other zones to gain an understanding of travel patterns for Cape Town as well as confirm that the CBD was most popular destination in the AM Peak.

To determine the potential traffic reduction that could be produced by the charge, transportation elasticities were used. Similar studies for Mexico City and Metropolitan Manila, undertaken to initially test the reduction in traffic made use of transportation elasticities and is considered feasible for application in this research. The elasticities used were based on afterstudies conducted on cities where congestion charging and tolling already existed. The range used was similar to those of Singapore, where data was collected from their scheme. The range reflects the level of car ownership predominantly by middle and high income earners as well as the poor public transport provision in the case of Cape Town. The alternative, which was to test the potential reduction using a strategic modelling package, such as EMME/2 or SATURN as was the case for London. This was discounted owing to the lack of access to an EMME/2 package. It would also require a large amount of man hours to test a scheme of this nature.

A similar study undertaken by Mahendra (2002) stated that low income driver trips were more elastic than that of high income earners. As a result, a range of elasticities between -0.1 and -0.5 were applied. This range differs slightly from the elasticities collated by the Victoria Transport Institute (Litman 2008), which ranged between -0.21 and -0.83. The difference can be attributed to Litman's elasticities being based on cities where road pricing, in one form or other, have been operational for a period of time. Higher elasticities were observed where there were uncongested parallel roads available, which is not the case in Cape Town. Also, according to Roth and Villioria (2001), if the public transport system was readily available, then the travel demand elasticity could approach -1.0, which is the case in London. However, a more representative range was applied to Cape Town.

The types of congestion charging were investigated to determine the most applicable to Cape Town. This was based on international case studies as well as literature reviewed as part of this research.

Exemptions were also identified, as the case studies revealed that there would need to be a compromise as it was not practical to apply a blanket charge. The exemptions were based on the City's aspirations to promote a modal shift. It is envisaged that if public transport were not exempt, the cost of the charge would be passed onto passenger, which could be deemed as unfair. Emergency vehicles were also included as the City recognises that it provides an essential service.

In order to implement a charging system, a defined charge area needed to be identified. The area needed to be easily recognisable by drivers, acceptable to stakeholders and easy to implement. It should also, where possible, provide a bypass route for through traffic.

Once the charge area was identified, the control of the area, in terms of monitoring and enforcement was investigated. This included an investigation into the various charging and enforcement technologies available. There were a number of technology trials undertaken between 2003 and 2006 and these trials were considered sufficient to assess the type of technology would be appropriate for Cape Town, without having to undertaken the testing of the systems, which would be time consuming and expensive

In order to determine the potential traffic reduction, Use was made of a 43 x 1 OD matrix, based on trips to the CBD. The weighted average travel costs were calculated as follows:

P = (d x c) + p ……………………………………………………………………*Equation 3.1*

Where: P = weighted average travel cost

d = weighted average round trip distance to CBD

c = vehicle operating cost

d = daily parking cost

c = (petrol cost x petrol factor) + service costs + tyre costs

In the calculation of ‘c’, data released by the South African Automobiles Association was used. For the petrol cost, the June 2008 rate for 95 unleaded LRP for coastal areas was used and is based on a 1500 – 1800 vehicle engine capacity. The researcher used this rate as a conservative estimate as it is the highest petrol rate for any grade. The parking cost was based on R900 per month in 2008, as listed in current commercial property listings in the CBD.

The average weighted travel cost was then used in the travel demand elasticity formula used in this study to calculate the potential reduction in traffic. The formula used for transportation elasticity in this study is:

$$\eta = \frac{[Q2 - Q1)(P1 + P2)]}{[(P1 - P2)(Q1 + Q2)]} \qquad \text{.....} \textit{Equation 3.2}$$

Where, η = demand elasticity

Q1 = Traffic volumes before

Q2 = Traffic volumes after

P1 = Travel cost before

P2 = Travel cost after

3.4 Chapter Summary

This chapter discussed the methodology which was used in this research and the reasoning behind the choice of approach used. A combination of a qualitative and quantitative mechanisms were utilised as it was considered the best approach in testing the hypotheses of this research. Although there are other methods of testing the hypothesis, those presented in this chapter are considered to be the best options available at this time of this research. To test traffic reduction in a strategic modelling package would not only be time consuming, but expensive as well. This applies to the consideration of the type of technology as well.

CHAPTER 4
ANALYSIS OF DATA AND FINDINGS

4.1 Introduction

For the purpose of this research, use was made of the Cape Town EMME/2 model data for 2007. The data comprise a 39 x 39 Origin-Destination matrix. This matrix was adapted to allow for a 39 x 1 matrix of trips from all zones to the city centre to be used. This particular matrix is shown in Table 2 together with the total number of trips to the city and the percentage of trips to the city relative to other zones.

Table 2 – Transport zones and trips to city CBD

Zone No.	Zone	Car Commuter trips to Cape Town CBD from transport zones[3]	Percentage of Car Commuter trips to Cape Town CBD from transport zones	Percentage of Car Commuter trips to destination zones
1	Cape Town Central	847	1.48%	14.39%
2	Woodstock/Salt River	842	1.47%	4.40%
3	Table Valley	2091	3.66%	0.84%
4	Sea Point	2312	4.05%	1.57%
5	Milnerton	1858	3.24%	3.82%
6	Pinelands	1388	2.43%	4.88%
7	Groote Schuur	1871	3.27%	4.19%
8	Camps Bay	643	1.13%	0.38%
9	Table View	3300	5.77%	2.17%
10	Monte Vista	3295	5.77%	1.21%
11	Goodwood/Parow	3242	5.67%	5.63%
12	Epping/Langa/Bonteheuwel	219	0.38%	2.93%
13	Cape Flats	1120	1.96%	0.87%
14	Athlone	2172	3.80%	1.00%
15	Claremont	3223	5.64%	4.12%
16	Constantia	507	0.89%	0.66%
17	Hout Bay	497	0.87%	0.79%
18	Swartland	2327	4.07%	1.11%
19	Durbanville	3564	6.24%	4.87%
20	Bellville	1789	3.13%	7.07%
21	Elsiesriver	759	1.33%	1.42%
22	Heideveld	727	1.27%	0.63%
23	Strandfontein/Phillippi	514	0.90%	0.33%
24	Grassy Park	2197	3.85%	1.56%
25	Muizenburg	758	1.33%	0.45%

[3] Refer to Appendix A for vehicle trip calculations

Zone No.	Zone	Car Commuter trips to Cape Town CBD from transport zones[3]	Percentage of Car Commuter trips to Cape Town CBD from transport zones	Percentage of Car Commuter trips to destination zones
26	Retreat/Tokai	2520	4.41%	2.52%
27	Brackenfell/Kraaifontein	1641	2.87%	2.01%
28	Kuilsrivier	1131	1.98%	1.21%
29	Airport	701	1.23%	1.45%
30	Mitchell's Plain	2939	5.14%	1.54%
31	Fish Hoek	1218	2.13%	2.01%
32	Blue Downs	792	1.39%	1.24%
33	Macassar	75	0.13%	0.27%
34	Khayelitsha	916	1.60%	0.52%
35	Helderberg	1345	2.35%	5.31%
36	Nyanga	627	1.10%	0.40%
37	Atlantis	327	0.57%	1.22%
38	Stellenbosch	167	0.29%	3.07%
39	Paarl	684	1.20%	5.93%

Table 2 indicates that the highest percentage of commuter trips is to the Cape Town CBD, followed by the Table View and Monte Vista zones. A number of businesses have head offices in these areas and the car commuter trip distribution was therefore not consequently surprising.

4.2 Type of congestion charge

The determination of the most applicable type of congestion charge for Cape Town was based on the following factors:

- Ease of understanding for drivers and visitors;
- Ease of implementation;
- Payment system;
- Enforcement; and
- Aesthetics.

A number of types of congestion charging can be discounted at an early stage for implementation in Cape Town. This is due to the complexity of the charge in terms of those factors and comparative cost of other types of charging.

The types discounted for the purposes of this particular study are:

- Distance-based charging;
- Time-based charging; and
- Congestion specific/congestion metering.

An increased parking charge was also discounted as it would not address through traffic. Rather a cordon and zone-based charge was focused on, given that they appeared, prima facie, to be the most feasible for Cape Town. Both charges possess the ability to capture through traffic and the flexibility to be implemented with relative ease and moderate capital investment, dependent on the payment and enforcement technology used. The flexibility of varying the pricing rates throughout the day was another consideration. If the charge were zone based, drivers travelling within the defined zone, during the charge period, would need to be captured. This would require additional enforcement cameras, located throughout the CBD and would, not only be expensive, but could in some locations be visually intrusive. As a result, the charge should be cordon-based as the area is not extensive and cameras could be located at entry points. Although it would result initially in an extension of the peak period, it would encourage the use of alternative non-motorised transport modes for short trips within the CBD during the day.

A simple, cordon based charge could arguably be introduced relatively easily, as was the case in London. The system could also be adapted later if the City chose to introduce a more sophisticated charging system, such as distance-based charging. At the same time, it has the flexibility of also being expanded to other areas and possible commercial nodes, which experienced unacceptable levels of congestion. The system is also easy for visitors to understand as the charge rate can be set and known ahead of time. For these reasons, a cordon congestion charge is considered to be most appropriate for Cape Town and further investigated.

4.2.1 Exemptions and Discounts

As with all cities that have introduced congestion charging, there were certain types of drivers or vehicles which were either exempted from the charge or qualified for a discounted rate. For Cape Town, it is recommended that no discounts are applied, as the cordon area is small and the Cape Town Public Transport Interchange is located within it. However, it is recommended that the following vehicles should be exempted from the charge, namely:

- Buses;
- Minibus taxis;
- Metered taxis; and
- Emergency services.

This list is short in comparison to other cities across the world. The implication of these exemptions would be to reinforce public transport as a viable alternative to the use of motor cars, while at the same time encouraging its use. Once exemptions are extended to other road user groups, usually with the aim of gaining public acceptability, the effectiveness of the scheme could be called into question.

4.3 Charge area

The geographical nature of the City, especially the CBD, needs to be taken into account when considering the charge area. A bypass route, which is direct and easy to access, needs to be provided as an alternative to through traffic, with the charge zone illustrated in Figure 1 below. For the purpose of this study, the bypass route is proposed as follows, shown anticlockwise:

- N2;
- Buitengraght Street;
- Buitensingel;
- Orange Street;
- Annandale Road;
- Mill Street;

- De Villiers Road;
- Tennant Street; and
- Oswald Pirow Street.

Figure 1 – Proposed congestion charge zone for Cape Town[4]

[4] Source: Map Studio

4.4 Technology

When considering the type of technology which could be used, the following factors need to be understood:

Accuracy;
Relative capital and operational costs; and
Potential illegal behaviour.

As argued earlier, GPS technology is not currently considered to be advanced enough for implementation at this stage and would be costly. It is also thought to be excessive where either cordon or zone-based charging take place (PRoGRESS, 2004). It is however worthwhile monitoring global trials and research in its development for future consideration.

The use of a tag and beacon system may also be considered as a viable option for Cape Town. It does however have a capital cost implication, which makes it more expensive than the ANPR system. It would require the installation of an OBU into vehicles as well as read or read/write tag, which is costly, especially if it is to be subsidised by the City. There is also the strong possibility that, because drivers not only need to pay the congestion charge, but also contribute financially to the OBU, it will not be a popular choice. As the OBU as well as the tag has a financial value attached to it, it will make it attractive to theft, which needs to be considered. A further complication would be how to accommodate visitors to Cape Town. This consideration could be difficult if the rest of the country did not have a charging system. One possible solution would be the use of portable OBUs that could be made available for hire. However, this intervention could further increase the cost. Roadside equipment would need to include an on-site system, which would be able to read the tag as well as an ANPR system to complement the tag and beacon as an enforcement system. Although successfully trialled and implemented in a number of European cities, it raises challenges for Cape Town in terms of cost as well as potential theft and the accommodation of visitors to the city. As a result, it is not considered a feasible option for Cape Town at the present time and more research into resolving these challenges would need to be done.

It is recommended that a tag and beacon system be considered by the City as a later stage, should the City aspire to a distance-based congestion charging system.

Therefore, it is recommended for the implementation of a congestion charge, that a payment system similar to the one currently operating in London would be most feasible. The payment of the congestion charge for vehicles entering charge area could be done telephonically, online or at approved retailers, local shops and post offices. Sign posts, televisions advertisements, outdoor advertising, *inter alia*, could advise visitors to the city about the congestion charge.

4.5 Enforcement

The enforcement of the charge would be by means of an ANPR system. This technology is currently being used as the enforcement system for the N2's bus and minibus taxi (BMT) lanes. A traffic regulation was provided for the enforcement of the BMT lanes and the City are looking to extend the use of the ANPR system on other bus lanes across the city. The regulation could either be extended or a new one provided to permit the enforcement of a congestion charge. Primary enforcement cameras would be placed inside the cordon boundary at intersections, with supplementary enforcement cameras placed at strategic points within the charge zone. The supplementary cameras would be located in such a way so as to capture any vehicles which might have been able to avoid the primary ones or have entered the zone prior to the charge time. Potential camera locations are illustrated in Figure 2 below.

Figure 2 – Proposed primary and supplementary enforcement camera locations

The recent trials undertaken by TfL in 2005 show that ANPR technology has sufficient levels of accuracy in terms of matching vehicle number plates captured on camera to those registered in the system (approximately 99%). There could initially be a high level of non-matches as a result of drivers not being registered and, incorrect details provided at the time of paying the charge or illegal vehicles entering the charge zone. In this study, illegal vehicles are those that do not have a license disk on display or whose vehicle licenses has expired.

In the case of illegal vehicles being captured on camera, this information could be passed onto the traffic department or relevant authority to follow up on. The ANPR system would identify persistent offenders and their most frequented route, which the relevant authority could then target.

As in the case of London, the visual impact of roadside equipment needs to be considered, and, where possible, minimised. To this end, use could be made of existing road infrastructure. This might require service agreements with utility companies. Figures 3 to 5 illustrate the potential visual impact the positioning of the ANPR cameras could have. Figures 3 and 4 illustrate the primary cameras, along with potential roadmarkings and signage, while Figure 5 illustrates the supplementary cameras for additional enforcement.

Figure 3 – Potential roadmarkings and signage along Heerengraght, facing Adderley Street[5]

Figure 3 illustrates how the primary cameras could be located underneath the bridge deck, making use of existing infrastructure. It also illustrates the type of information sign and roadmarkings which could be used to inform drivers that they were entering the charge area.

[5] Photos taken by Raymond van Demiel

Figure 4 – Potential camera location at the intersection of Herzog Boulevard and Oswald Pirow Street

Figure 4 illustrates the use of poles in the mounting of both the primary (located on the right far side) and the supplementary (located on the right near side of the figure) cameras and how they could be accommodated on existing traffic islands. Consequently, new poles need not necessarily be erected.

Figure 5 – Potential supplementary camera location along Strand Street, facing the intersection with Adderly Street

Figure 5 illustrates the potential position of supplementary cameras, on an existing traffic island. This location is based on Figure 2 to ensure that if vehicles bypassed the primary cameras, they would be captured on the supplementary ones.

Arguably, the visual impact on the City's streetscape would be minimal given that the primary cameras could be located at the intersections on the boundary and the supplementary ones could be kept to a minimum and at locations where they would be the least intrusive.

4.6 Traffic Reduction

The cost of car travel in Cape Town is based on the weighted average trip length and cost. The average weighted trip cost, including parking is R85.60. Table 3 reports on the cost of travel per transport zone. When compared to the average cost of a round trip bus journey of approximately R27.04, travel by car is 237% more. However, this reality has not affected the number of commuters travelling by car and confirms the City's view that cost of travel does not affect mode choice (MA,1998). This could be due to a perceived access, quality and availability of public transport, income levels and land use patterns, as identified in the MA. In terms of income, it could be argued that commuters have a historical acceptance of high private vehicle travel costs. They do not possibly associate the time and cost of travel to the personal time cost.

Table 3 – Calculation of average travel costs

Fuel Factor				9.22
Fuel Cost (cents/litre)				9.85
Maintenance (cents/kilometre [c/km])				16.71
Tyres (c/km)				11.26
Fuel Factor				9.22
Zone No	Zone Name	No. of trips	Round trip length (km)	Travel Cost
1	Cape Town Central	868	2.23	R 2.65[6]
2	Woodstock/Salt Rover	863	6.42	R 7.63
3	Table Valley	2144	4.89	R 5.81
4	Sea Point	2370	5.46	R 6.48
5	Milnerton	1899	19.14	R 22.74
6	Pinelands	1423	16.66	R 19.80
7	Groote Schuur	1918	13.19	R 15.67
8	Camps Bay	659	11.43	R 13.58
9	Table View	3382	32.71	R 38.87
10	Monte Vista	3378	28.96	R 34.40
11	Goodwood/Parow	3323	29.34	R 34.86
12	Epping/Langa/Bonteheuwel	224	23.41	R 27.82
13	Cape Flats	1148	24.00	R 28.52
14	Athlone	2227	20.51	R 24.37
15	Claremont	3303	20.93	R 24.86
16	Constantia	519	24.69	R 29.33
17	Hout Bay	510	28.29	R 33.61
18	Swartland	2385	56.79	R 67.47
19	Durbanville	3653	44.81	R 53.24
20	Bellville	1834	42.66	R 50.69
21	Elsiesriver	778	31.95	R 37.96
22	Heideveld	745	28.54	R 33.91
23	Strandfontein/Phillippi	527	38.50	R 45.75
24	Grassy Park	2252	31.43	R 37.34
25	Muizenburg	777	40.57	R 48.21
26	Retreat/Tokai	2583	32.38	R 38.47
27	Brackenfell/Kraaifontein	1682	56.59	R 67.24

[6] Refer to Appendix B for example of calculation

28	Kuilsrivier	1159	50.97	R 60.56
29	Airport	719	39.93	R 47.44
30	Mitchell's Plain	3013	46.62	R 55.39
31	Fish Hoek	1249	51.45	R 61.14
32	Blue Downs	811	55.42	R 65.85
33	Macassar	76	71.25	R 84.66
34	Khayelitsha	939	55.81	R 66.31
35	Helderberg	1379	92.35	R 109.73
36	Nyanga	643	36.63	R 43.52
37	Atlantis	335	70.41	R 83.66
38	Stellenbosch	171	100.00	R 118.82
39	Paarl	701	121.36	R 144.20
WEIGHTED AVERAGE TRAVEL COST				R40.60
Parking (per day)				R45.00
TOTAL WEIGHTED AVERAGE TRAVEL COSTS				R85.60

Table 4 shows the potential reduction in traffic into the CBD if a congestion charge was introduced and was based on the number of trips, average travel costs and the congestion charge. It reflects various charge rates so as to compare the level of traffic reduction, which could be achieved, based on cost and transportation elasticities.

Table 4 – Percentage traffic reduction

Elasticity	R15[7]	R20	R25	R30	R50	R90
-0.5	7.74%	9.94%	11.98%	13.88%	20.31%	29.39%
-0.45	7.00%	8.99%	10.85%	12.58%	18.47%	26.85%
-0.4	6.24%	8.03%	9.70%	11.26%	16.58%	24.23%
-0.35	5.48%	7.06%	8.54%	9.92%	14.66%	21.52%
-0.3	4.72%	6.09%	7.36%	8.56%	12.70%	18.74%
-0.25	3.95%	5.10%	6.17%	7.19%	10.70%	15.86%
-0.2	3.17%	4.10%	4.97%	5.79%	8.65%	12.89%
-0.15	2.39%	3.09%	3.75%	4.38%	6.56%	9.83%
-.01	1.60%	2.07%	2.52%	2.94%	4.42%	6.66%
Average Reduction	4.70%	6.05%	7.32%	8.50%	12.56%	18.44%

Table 4 indicates that the potential average traffic reduction could be between 4% and 18%, dependent on the charge rate. As the City does not seem to have a target for traffic

[7] Refer to Appendix C for calculation example

reduction, the results from Table 4 illustrate that for a level of traffic reduction to be comparatible with that of London and Singapore, where initial traffic reductions were forecasted between 25% and 30%, the congestion charge rate would need to be at least R90. The levels of reduction illustrated in Table 4 could reduce traffic back to 2005/06 traffic volumes into the CBD.

The City's Draft TDM strategy discusses congestion charging as a TDM measure and highlights that before it can be introduced, ITS should first be further developed. This would provide drivers with travel information, which would allow them to make en-route decisions regarding their trip.

Where the Draft TDM strategy discusses implementation challenges of a congestion charge, it focussed on the technology, the location of payment stations and the opposition of user groups. It is interesting to note that the potential socio-economic impact on middle and low income drivers has not been mentioned, even though it is highlighted in literature reviewed to be a fundamental challenge which needs to be addressed. This is definitely a challenge for Cape Town, as is the current state of the public transport system which is viewed in a negative light. Even though the City is undertaking a BRT initiative, which could mitigate against the socio-economic impact, it might not be considered a attractive alternative for high income drivers. High income drivers make up 59% of traffic volume entering the CBD.

The results of the traffic reduction illustrate that a level of reduction can be achieved through congestion charging. Even with this potential reduction, there are, what can be considered fundamental challenges that need to be addressed before it can be introduced. The first being an upgrade of the city's pubic transport system, which even though the City is improving it through the BRT initiative, it might not necessarily be considered attractive enough to encourage high income drivers to switch modes. However, the City's Draft TDM strategy also seeks to promote the use of high occupancy vehicles, which some might consider more attractive modal choice and as an alternative to paying a congestion charge.

4.7 Chapter Summary

A cordon based congestion charge is evidently the most feasible option for Cape Town. The charge could operate similarly to that of London, where a cost is incurred by the driver for entering within the cordon. Payments could be made through various streams, such as online, through approved retailers and telephonically.

Cape Town is already making use of ANPR technology for the enforcement of the BMT lanes on the N2 and this system is flexible enough to extend to include a congestion charge. It also has the opportunity to target persist offenders, whose vehicles are illegally on the roads, through cooperation with the traffic department.

Although the calculation of the potential reduction in traffic was only for the AM peak period, it does illustrate a potential reduction in traffic, though only back to 2005/06 levels. To achieve such reductions, the charge would need to be more than 100% more than the travel cost calculated in this research. This then identifies challenges, which the City would need to overcome for a congestion charge to be truly feasible for the CBD. These challenges include addressing the socio-economic impact the charge would have on middle and low income drivers and the current public transport system, which is perceived negatively and not as a viable alternative to high income drivers. This is an area which requires further research.

CHAPTER 5
CONCLUSION

The aim of this research was to test the following hypotheses, namely:

H1: Congestion charging will reduce the number of vehicles daily entering and passing through the CBD;

H2: Of the available TDM strategies, congestion charging is technically appropriate for Cape Town; and

H3: Not all congestion charging technological systems can be implemented in Cape Town.

The primary objective of this research was to determine whether the introduction of a congestion charge was technically feasible for Cape Town as an effective TDM measure for reducing the traffic volumes into the CBD with emphasis on:

- The level of traffic reduction which could theoretically be achieved;
- The type and extent of congestion charge that would be suitable for Cape Town; and
- The congestion charging technological systems that could practically be implemented in Cape Town.

The determination of the type and extent of the congestion charge for Cape Town comprised of researching the types of charges currently being utilised worldwide as well as those which were under development. The type of congestion charge was typically closely linked to the technologies available and required for charging and enforcement.

It was found that the more sophisticated types of charging, such as time and distance based or congestion metering, were not suitable for implementation in Cape Town at this stage. This conclusion was arrived due to the sophisticated technology required, which in the case of GPS, was not mature, and the high implementation costs.

Charging types considered to be appropriate were the cordon charge or the zone charge. However, a zone charge was later discounted as a type for initial implementation due to the small charge area selected. As a result, a simple cordon charge was, arguably, the most feasible type of congestion charge. The manual payment of the charge could be through a call centre, online or approved retailers, making it easy for residents and visitors alike to understand. Enforcement would be by using ANPR technology, which was already being used by the City to enforce the BMT lanes.

A congestion area was identified based on the need to provide an area which was easily identifiable. Another determining factor was the need for a bypass route in close proximity to the cordon and which could accommodate through traffic without penalty and without the need for upgrading to accommodate additional traffic volumes. This should not be a problem given that an existing bypass route exists. For this particular study public transport and emergency vehicles were exempted from the congestion charge. Public transport vehicles were exempted as they could conceivably pass on the cost of the charge to the passengers and this would not encourage a modal shift. Further emergency vehicles were exempted as they formed part of essential services.

The introduction of an AM Peak cordon based charge of R50 could potentially reduce traffic volumes into the CBD on average by 12.56%. The reduction is based on travel demand elasticities of between -0.1 and -0.5. The potential reduction is within the reported range for road pricing of 10% to 20% for affected travel as identified by Litman (2008). The results showed that even though there would resultantly be a decrease in traffic volumes, drivers would be less likely to change modes due only to an increase in travel costs. This finding is reinforced by the results of increasing the charge to R90, as it could potentially only reduce trips by at least 6.6%. An introduction of such high charge would give rise to socio-economic challenges, which the City would need to first address, along with a currently poorly perceived public transport system.

This study sought only to test the technical feasibility of a congestion charge initiative. The results of the analysis of the available data considering all other impacting factors suggest that the introduction of an AM Peak congestion charge for a defined cordon around the CBD would result in a reduction of traffic volumes, but it would require the City to address two fundamental challenges, namely the current public transport system and the socio-economic impact on middle and low income drivers. The most feasible technology to use at this point in time would be the ANPR system. The tag and beacon system, on the other hand, has too many challenges that would need to be addressed first. A simple cordon based AM peak charge, using ANPR technology for enforcement and with manual payments, similar to London, would be a feasible TDM measure for Cape Town to consider, provided the City addresses, *inter alia*, the challenges mentioned above.

5.1 Hypotheses testing

The hypotheses were tested as follows:

Hypothesis 1

This study hypothesised that a congestion charge would reduce the number of vehicles entering and passing through the Central Business District (CBD). The results indicated that a reduction could be achieved, but that there are fundamental challenges that the City would need to first address.

The hypothesis that congestion charging will reduce the number of vehicles daily entering and passing through the CBD cannot be rejected.

Hypothesis 2

The study hypothesised that of the available Travel Demand Management strategies congestion charging is technically appropriate for Cape Town. The results indicate that it is technically appropriate as a simple cordon based congestion charge can be introduced as there is natural geographical bypass route around the CBD. The payment system, which could be used, would be similar to London and would not require any roadside equipment. A simple cordon charge would also be easy for residents and visitors alike to understand.

The hypothesis that of the available Travel Demand Management strategies congestion charging is technically appropriate for Cape Town cannot be rejected.

Hypothesis 3

The study also hypothesised that not all congestion charging technological systems can be implemented in Cape Town. The results indicated that of the technologies currently available, the GPS technology could be discounted as it still required testing and the tag and beacon system would be expensive and visually intrusive. Both of these technologies had challenges to overcome before they could be considered for introduction in Cape Town. However, the ANPR technology is already in operation in the city and could be expanded to include the enforcement of a congestion charge.

The hypothesis that not all congestion charging technological systems can be implemented in Cape Town cannot be rejected.

5.2 Areas for further research

This study has identified the followings areas for further research, which could be undertaken to gain an understanding of the wider impacts of a congestion charge for the CBD:

- A cordon congestion charge should be tested in the City's strategic EMME/2 model to ascertain the wider impact on the surrounding road network and also to gage more comprehensively which areas would yield the larger reduction in traffic;

- The areas identified in the EMME/2 testing could be used to further explore the social and economic impact and identify what mitigation measures would be required;

- Determining the cost incurred in terms of man hours lost due to travelling in congested conditions and what the potential savings could be, could result in more support for a charging scheme;

- A state of preference survey should also be undertaken to gauge and understand public opinion of such an initiative; and

- Research into the political aspirations for the introduction of a congestion charge needs to be undertaken, as political support has been shown to be vital in other countries.

APPENDIX A
CAR COMMUTER ORIGIN-DESTINATION TRIP INFORMATION

Table 5 – Origin of commuter trips from Transport zones to macro zone 1[8] destination

Origin Zone	To Zone 1	Origin Zone	To Zone 1	Origin Zone	To Zone 1	Origin Zone	To Zone 1	Origin Zone	To Zone 1	Origin Zone	To Zone 1	Origin Zone	To Zone 1	Origin Zone	To Zone 1	Origin Zone	To Zone 1
101	0	708	0	1202	0	1825	0	2209	81.07	2723	96.78	3116	205.2	3519	28.05	3902	50.15
102	0	709	0	1203	28.61	1826	104.5	2210	284	2724	109.3	3117	15.23	3520	0	3903	0
103	0	710	182.1	1204	48.86	1827	361.5	2301	0	2725	2.06	3118	83.65	3521	11.6	3904	71.44
104	0	711	83.38	1205	80.85	1828	49.87	2302	305.3	2726	104.9	3119	21.93	3522	8.62	3905	124.5
105	0	712	139.4	1206	129.4	1901	161.2	2303	283.4	2727	0	3120	0	3523	27.08	3906	0
106	0	713	215.4	1207	95.32	1902	224.8	2304	0	2728	162	3121	42.67	3524	46.32	3907	442.7
107	0	714	124.3	1208	65.78	1903	201.9	2305	2.49	2729	0	3122	87.96	3525	53.77	3908	43.01
108	230	715	178.8	1209	0	1904	125	2306	0	2730	0	3123	7.54	3526	13.91	3909	260.2
109	296.2	716	76.77	1210	0	1905	39.98	2307	0	2731	0	3124	25.22	3527	30.25	3910	121.1
110	0	717	161.4	1211	0	1906	197.6	2308	24.57	2801	148.1	3201	0	3528	32.1	3911	0
111	377.6	718	242.6	1301	129	1907	110.4	2309	23.15	2802	144	3202	62.07	3529	59.81	3912	54.32
112	120.8	719	45.89	1302	127.5	1908	42.5	2310	11.28	2803	89	3203	27.53	3530	18.67	3913	0
113	0	801	178.1	1303	179.2	1909	47.41	2311	0	2804	102.9	3204	134.9	3531	81.58		
114	0	802	131.2	1304	144.7	1910	48.08	2312	68.88	2805	126	3205	113.7	3532	144.9		
115	0	803	97.25	1305	219.2	1911	42.68	2313	0	2806	3.79	3206	57.33	3533	218.7		
116	0	804	88.66	1306	143.3	1912	35.04	2314	0	2807	0	3207	54.46	3534	6.54		
117	0	805	57.89	1307	60.71	1913	30.21	2315	0	2808	22.91	3208	136	3535	0		
118	0[9]	806	116.5	1308	71.25	1914	53.79	2401	35.93	2809	65.2	3209	60.89	3536	0		
201	0	901	218	1309	71.36	1915	1.87	2402	125.6	2810	15.5	3210	101.4	3537	0		
202	112.8	902	394.1	1310	103.3	1916	52.59	2403	306	2811	20.08	3211	75.38	3538	0		
203	328.4	903	76.49	1311	164.3	1917	162.1	2404	33.24	2812	4.87	3212	47.36	3539	43.69		
204	420.8	904	99.77	1312	155.8	1918	36.05	2405	170.8	2813	53.69	3213	68.72	3540	46.88		
205	89.91	905	389.3	1313	62.83	1919	36.12	2406	309.8	2814	57.22	3214	0	3541	66.18		
206	49.05	906	267.7	1314	0	1920	211.5	2407	354.1	2815	45.96	3215	0	3542	0		
207	72.99	907	532.3	1315	0	1921	91.28	2408	106.1	2816	36.29	3216	35.41	3543	162.7		
208	0	908	133.8	1316	135.4	1922	130.4	2409	55.92	2817	192.8	3217	0	3544	0.93		
209	0	909	0	1317	0	1923	48.38	2410	257	2818	26.93	3218	45.44	3545	18.08		
210	0	910	0	1401	71.86	1924	88.02	2411	35.99	2819	367.7	3219	0	3546	0		
211	0	911	0	1402	64.56	1925	52.28	2412	211.5	2820	28.66	3220	19.63	3547	1.55		
301	598.9	912	0	1403	49.44	1926	148.1	2413	148	2821	73.26	3221	0	3548	8.62		
302	505.2	913	19.56	1404	354.9	1927	203.5	2414	103.8	2822	0	3222	9.31	3549	0		
303	412.8	914	0	1405	141	1928	188.8	2415	180.2	2823	0	3223	70.35	3550	19.11		
304	412.8	915	0	1406	318.8	1929	83.24	2416	99.41	2824	0	3224	23.47	3551	63.13		
305	313	916	0	1407	0	1930	132.9	2417	109	2825	5.74	3225	30.37	3552	102.9		

[8] As provided by the City of Cape Town, and extracted from 2007 EMME/2 Origin-Destination Matrix

[9] Sum of commuter trips from transport zones 101 to 118 used in example of commuter trip to vehicle trip conversion

Origin Zone	To Zone 1	Origin Zone	To Zone 1	Origin Zone	To Zone 1	Origin Zone	To Zone 1	Origin Zone	To Zone 1	Origin Zone	To Zone 1	Origin Zone	To Zone 1	Origin Zone	To Zone 1	Origin Zone	To Zone 1
401	509.1	917	0	1408	256.4	1931	47.08	2418	290.2	2826	13.21	3226	50.42	3553	21.5		
402	524.2	918	209.7	1409	523	1932	10.58	2419	154	2901	0	3227	51.36	3554	23.56		
403	464.2	919	0	1410	7.44	1933	124.5	2420	16.13	2902	47.1	3228	0	3555	33.27		
404	378.4	920	0	1411	532.6	1934	103.1	2501	59.19	2903	0	3229	18.35	3556	0		
405	213.8	921	0	1412	151.9	1935	77.57	2502	59.34	2904	67.19	3230	5.65	3557	0		
406	274.8	922	0	1413	346.3	1936	145.2	2503	134.4	2905	86.21	3231	0	3558	0		
407	145.7	923	0	1501	340	1937	147	2504	57.52	2906	123.5	3232	14.79	3559	0		
408	9.01	924	0	1502	289.8	1938	167.9	2505	33.21	2907	242.8	3233	36.56	3560	0		
409	0	925	0	1503	52.56	1939	0	2506	0	2908	94.35	3234	63.59	3561	0		
501	143.7	926	0	1504	299.2	1940	0	2507	129	2909	69.99	3235	41.98	3562	0		
502	168	927	0	1505	387.4	1941	0	2508	125.7	2910	27.72	3236	78.54	3563	0		
503	126.6	928	0	1506	351.3	1942	0	2509	0	2911	44.36	3237	0	3564	0		
504	0	929	0	1507	285.9	2001	14.15	2510	226.1	2912	0	3238	0	3565	0		
505	0	930	0	1508	48.03	2002	62.81	2511	154.4	2913	68.77	3239	0	3566	0		
506	0	931	144.4	1509	252.9	2003	45.78	2512	0	2914	110	3240	0	3567	0		
507	570.5	932	207.9	1510	388.4	2004	41.04	2513	0	2915	0	3241	0	3568	0		
508	0	933	76.77	1511	0	2005	0	2514	13.64	2916	0	3242	0	3601	126.7		
509	278.3	934	251.4	1512	0	2006	197.9	2601	72.92	2917	0	3301	61.6	3602	157		
510	118.8	935	95.67	1513	65.57	2007	119.4	2602	0	2918	0	3302	20.63	3603	77.8		
511	0	936	187.9	1514	90.71	2008	0	2603	190.8	2919	0	3303	0	3604	52.38		
512	0	937	232.2	1515	786.2	2009	209.6	2604	192.5	2920	0	3304	0	3605	8.24		
513	281.1	938	263.9	1601	50.79	2010	84.78	2605	138.5	2921	105.7	3305	0	3606	108.3		
514	176.4	1001	494.9	1602	42.93	2011	436.6	2606	295.9	2922	63.72	3306	54.4	3607	25.13		
515	160.7	1002	323	1603	45.95	2012	113.7	2607	113.8	2923	106	3307	3.55	3608	107.6		
516	138.6	1003	702	1604	21.11	2013	0	2608	80.8	3001	144.7	3308	41.13	3609	28.53		
517	0	1004	304.9	1605	11.8	2014	0	2609	0	3002	518.9	3309	0	3610	0		
518	32.41	1005	222.3	1606	12.53	2015	0	2610	177.4	3003	258.6	3401	61.05	3611	35.13		
519	71.38	1006	171.6	1607	50.65	2016	49.99	2611	230.5	3004	0	3402	127.2	3612	38.27		
520	0	1007	0	1608	29.71	2017	33.71	2612	0	3005	232.4	3403	63.97	3613	23.33		
521	0	1008	261	1609	179.8	2018	106.3	2613	84.53	3006	149.5	3404	97.41	3614	54.63		
522	0	1009	0	1610	68.04	2019	6.74	2614	64.13	3007	119	3405	199.4	3615	53.25		
523	0	1010	0	1611	15.42	2020	0	2615	47.92	3008	198.7	3406	141.5	3616	26.9		
524	0	1011	0	1612	0	2021	168.4	2616	52.59	3009	107.2	3407	0	3617	41.01		
525	0	1012	370.7	1701	11.36	2022	89.8	2617	17.22	3010	147.5	3408	37.2	3618	34.19		
601	86.83	1013	549.7	1702	191.5	2023	222.3	2618	120.1	3011	199	3409	134.2	3619	18.59		
602	139.6	1014	184.7	1703	15.89	2024	103.4	2619	293.2	3012	199.8	3410	106.6	3620	0		
603	165.3	1015	129.5	1704	70	2025	43.08	2620	155.4	3013	301.2	3411	80.49	3621	12.38		
604	200.4	1016	0	1705	8.84	2026	0	2621	194	3014	198.2	3412	31.09	3622	37.11		
605	0	1017	38.24	1706	46.44	2027	62.62	2622	24.16	3015	282.1	3413	55.93	3623	3.1		
606	0	1101	213	1707	0	2028	89.66	2623	14.85	3016	0	3414	94.26	3624	28.43		
607	0	1102	24.39	1708	46.17	2029	0	2624	75.44	3017	74.54	3415	71.02	3701	0		

Origin Zone	To Zone 1	Origin Zone	To Zone 1	Origin Zone	To Zone 1	Origin Zone	To Zone 1	Origin Zone	To Zone 1	Origin Zone	To Zone 1	Origin Zone	To Zone 1	Origin Zone	To Zone 1	Origin Zone	To Zone 1
608	30.55	1103	0	1709	48.12	2030	0	2625	173.1	3018	56.79	3416	46.22	3702	48.18		
609	95.97	1104	191.2	1710	24.03	2031	0	2626	102.2	3019	49.55	3417	37	3703	0		
610	54.01	1105	0	1711	87.32	2101	0	2627	173.7	3020	170.5	3418	5.55	3704	32.4		
611	279.4	1106	0	1712	31.21	2102	40.93	2628	25.85	3021	123.8	3419	0	3705	15.54		
612	127.5	1107	210.4	1801	338.8	2103	58.64	2629	5.82	3022	122	3420	0	3706	17.78		
613	0	1108	0	1802	46.31	2104	253.3	2630	47.29	3023	60.8	3421	31.5	3707	16.63		
614	0	1109	81.36	1803	114.7	2105	43.41	2701	11.55	3024	56.86	3422	49.32	3708	34.76		
615	0	1110	259.7	1804	101.6	2106	95.29	2702	141.5	3025	187.5	3423	0.5	3709	56.67		
616	0	1111	195.5	1805	216	2107	56.65	2703	138.2	3026	187.2	3424	0	3710	0		
617	0	1112	96.51	1806	230.5	2108	83.59	2704	59.33	3027	249.7	3425	0	3711	79.8		
618	0	1113	187.4	1807	186.3	2109	181.1	2705	198.9	3028	147	3501	33	3712	43.24		
619	0	1114	27.05	1808	7.41	2110	115.2	2706	0	3029	152.7	3502	28.37	3713	0		
620	89.57	1115	470.9	1809	199.2	2111	125.9	2707	173	3030	58.04	3503	123.2	3714	0		
621	89.22	1116	430.7	1810	41.25	2112	53.33	2708	71.46	3101	117.2	3504	67.55	3715	21.57		
622	103.1	1117	407.7	1811	197	2113	0	2709	19.41	3102	104	3505	0	3716	0		
623	0	1118	34.51	1812	69.78	2114	9.82	2710	215.9	3103	29.8	3506	64.17	3717	66.87		
624	0	1119	350.9	1813	162.8	2115	50.97	2711	231.9	3104	59.32	3507	12.45	3718	5.21		
625	12.92	1120	87.45	1814	69.76	2116	39.08	2712	0	3105	180.2	3508	10.8	3801	0		
626	0	1121	195.7	1815	55.64	2117	69.29	2713	106.9	3106	96.02	3509	26.45	3802	30.69		
627	35.11	1122	85.35	1816	26.01	2118	106.7	2714	78.19	3107	147.9	3510	0	3803	0		
628	196.1	1123	61.52	1817	76.87	2201	91.54	2715	2.01	3108	124.4	3511	70.91	3804	52.38		
701	0	1124	99.86	1818	50.34	2202	49.52	2716	10.12	3109	21.18	3512	10.69	3805	81.25		
702	89.32	1125	113.7	1819	0	2203	314.4	2717	1.92	3110	55.43	3513	0	3806	0		
703	102.9	1126	84.74	1820	0	2204	0	2718	83.5	3111	59.53	3514	10.22	3807	10.96		
704	60.46	1127	26.71	1821	33.64	2205	169.8	2719	79.26	3112	11.93	3515	147.3	3808	21.39		
705	113.4	1128	294	1822	26.49	2206	0	2720	76.26	3113	211.8	3516	29.34	3809	23.02		
706	121.1	1129	0	1823	0	2207	181.4	2721	92.76	3114	15.48	3517	0	3810	83.8		
707	68.05	1201	0	1824	0	2208	37.97	2722	91.56	3115	0	3518	0	3901	76.62		

Conversion of commuter trips to vehicle trips

Vehicle trips = (sum of transport zones in macro zone)/vehicle occupancy of macro zone

847 = (0+0+0+0+0+0+0+230+296.2+0+377.6+120.8+0+0+0+0+0+0)/1.21

Table 6 – Commuter trip to vehicle trip conversion

Macro Zone Origin	No. of commuter trips	Vehicle Occupancy Rate	No. of vehicle trips
1	1024.6	1.21	847
2	1073.95	1.27	842
3	2242.7	1.07	2091
4	2519.21	1.09	2312
5	2266.49	1.22	1853
6	1705.58	1.23	1388
7	2005.27	1.07	1871
8	669.6	1.04	643
9	3800.86	1.15	3300
10	3752.54	1.14	3295
11	4230.25	1.30	3242
12	448.82	2.05	219
13	1767.85	1.58	1120
14	2818.2	1.30	2172
15	3637.97	1.13	3223
16	528.73	1.04	507
17	580.88	1.17	497
18	2766.27	1.19	2327
19	3850.65	1.08	3564
20	2301.76	1.29	1789
21	1383.2	1.82	759
22	1209.7	1.66	727
23	719.07	1.40	514
24	3102.72	1.41	2197
25	992.5	1.31	758
26	3164.62	1.26	2520
27	2358.67	1.44	1641
28	1643.81	1.45	1131
29	1257.41	1.79	701
30	4753.78	1.62	2939
31	1723.59	1.41	1218
32	1534.96	1.94	792
33	181.31	2.43	75
34	1471.41	1.61	916
35	2028.45	1.51	1345
36	1098	1.75	627
37	438.65	1.34	327
38	303.49	1.82	167
39	1244.04	1.82	684

APPENDIX B
TRIP COST CALCULATION

P = (d x c) + p ....Equation 3.1

Where: P = weighted average travel cost

d = weighted average round trip distance to CBD

c = vehicle operating cost

d = daily parking cost

c = (petrol cost x petrol factor) + service costs + tyre costs

EXAMPLE:

P = (2.23 x [{9.85c x 9.22} + 16.71+11.26]

= R2.65

APPENDIX C
EXAMPLE OF ELASTICITY CALCULATION

$$\eta = \frac{[Q2 - Q1)(P1 + P2)]}{[(P1 - P2)(Q1 + Q2)]} \quad \text{..} \textit{Equation 3.2}$$

Where, η = demand elasticity

Q1 = Traffic volumes before

Q2 = Traffic volumes after

P1 = Travel cost before

P2 = Travel cost after

For application in study, formula rearrange to make Q2 the subject:

$$Q2 = \frac{P1Q1 + P2Q1 - P1Q1\eta + P2Q1\eta}{P1 + P2 + P1\,\eta - P2\,\eta}$$

EXAMPLE

$$Q2 = \frac{(R85.60 \times 58569) + (R100.60 \times 58569) - (R85.60 \times 58569 \times -0.5) + (R100.60 \times 58569 \times -0.5)}{R85.60 + R100.60 + (R85.60 \times -0.5) - (R100.60 \times -0.5)}$$

= 54033.09

Percentage reduction = [(Q1 – Q2)/Q1] x 100
= [(58569 – 54033.09)/58569] x 100
= 7.74%

Table 7 – Reduced traffic volumes based on elasticity

Elasticity/Charge	R 15.00	R 20.00	R 25.00	R 30.00	R 50.00	R 90.00
-0.5	54033.08895[10]	52746.68067	51552.73059	50441.61659	46674.1158	41353.83586
-0.45	54470.77114	53302.69795	52216.2684	51203.2117	47753.74472	42844.22117
-0.4	54911.86915	53864.2977	52887.85101	51975.52338	48855.75392	44379.73912
-0.35	55356.42311	54431.56442	53567.6256	52758.77944	49980.84656	45962.47133
-0.3	55804.4738	55004.58432	54255.74299	53553.21416	51129.75563	47594.6294
-0.25	56256.06265	55583.44537	54952.35771	54359.06859	52303.24543	49278.5653
-0.2	56711.23173	56168.23734	55657.62813	55176.59073	53502.11335	51016.78258
-0.15	57170.02378	56759.05185	56371.71659	56006.03583	54727.19165	52811.94888
-0.1	57632.48224	57355.98242	57094.7895	56847.66665	55979.34935	54666.90953

[10] Refer to above calculation

APPENDIX D
CORRESPONDENCE WITH THE CITY OF CAPE TOWN

Mohamed, Sam

From: Gershwin Fortune [Gershwin.Fortune@capetown.gov.za]
Sent: 03 May 2007 07:27
To: Mohamed, Sam
Subject: RE: HI & URGENT REQUEST

Hi Samantha

You are most welcomed to use the TDM Strategy but please note that at present it is a draft report (consultant opinion) and have not been officially adopted as a City document. Please reference accordingly. For our records we would love to have a copy of your final write-up.

Please clarify your request re: ITP studies, eg L&S?

Regards,

Gershwin

From: Mohamed, Sam [mailto:Sam.Mohamed@atkinsglobal.com]
Sent: Wednesday, May 02, 2007 2:45 PM
To: Gershwin Fortune
Subject: HI & URGENT REQUEST

Hi Gershwin

How are you? Are you ever going to get back to me about the ability to use your more recent studies? It will only be used in the academic sense for my research. I urgnetly need a response. Also, is it possible to get copies of the early ITP type studies doen by the City, eg L&S?

Please get back to me and hope you had a good long weekend.

Samantha Mohamed

Transport Planning
Atkins: Highways & Transportation

Address: Euston Tower, 286 Euston Road, London, NW1 3AT
Tel: 020 7121 2311
Fax: 020 7121 2333
E-mail: sam.mohamed@atkinsglobal.com
www.atkinsglobal.com

Mohamed, Sam

From: John Spotten [John.Spotten@capetown.gov.za]
Sent: 30 March 2007 08:50
To: Mohamed, Sam
Subject: RE: REQUEST FOR INFORMATION

Hi Samantha,

Our emme transport model is an AM peak period model(6-9am) which concentrates on the home to work and school trips at transport zone level (850 transport zones covering Cape town metro, Stellenbosch, Paarl and Wellington.

We can provide the household survey data 2004 which was a major input to updating our emme transport model in mdb format and futher analysis in xls format.

Also can provide emme transport model data in a gis format, either shape or mapinfo, of the Origin and Destination transport zone totals by mode and a spreadsheet of the OD matrices by Mode by Transport Zone, for home to work and school trip purposes, for the 2006 base year, 2011 and 2016. 2006, 2011 and 2016 modelled traffic volumes can be provided for the am peak hour to show road usage and travel patterns together with the existing traffic counts for 2006 and the emme transport road network.

A document giving the methodology and assumptions can be provided.

Let me know if this suits your requirements and I will burn a CD with all the data.

Bye for now
john

John Spotten C.Eng Pr.Eng
Head of Transport Modelling and Systems Analysis
Transport Planning
10th Floor Harbour Side
Cape Town Civic Centre
Tel +27 21 4004732
Fax +27 21 4004931
Cell +27 846678901

From: Mohamed, Sam [mailto:Sam.Mohamed@atkinsglobal.com]
Sent: 27 March 2007 01:56 PM
To: John Spotten
Subject: REQUEST FOR INFORMATION
Importance: High

Hi John

I've been referred to you by Tony Vieira. I am currently doing my MTech and my dissertation involving investigating the feasibility of a congestion charge for Cape Town. To this end, I'm trying to obtain existing and any future traffic and travel data which may be available. Is it possible to get a copy of the most recent OD survey used in the EMME2 model developed for the City as well as any traffic volumes, modal split and travel patterns for the City as well as the predicted model? Could you also please advise me of any assumptions which have been made for the predicted model. I was also wondering if you knew who I could approach to obtain a copy of the most recent household surveys undertaken for Cape Town.

Thank you very much for all your assistance.

Kind regards
Samantha Mohamed

From: Tony Vieira [mailto:Tony.vieira@capetown.gov.za]
Sent: 22 March 2007 22:24
To: Mohamed, Sam
Cc: John Spotten
Subject: RE: REQUEST FOR INFORMATION
Hi Samantha

Yes I do remember you very well. Sam the person to speak to is John Spotten. He will have the info that you require. You will see his email from the CC. above.

If you need any other info please do not hesitate to ask.
Please send my best regards to Sandra as well.

All the best

Regards

Tony Vieira
Manager: Transport Impact Assessments
Tel: 4067320 / 7108050
Fax: 4195249 / 7108039

From: Mohamed, Sam [mailto:Sam.Mohamed@atkinsglobal.com]
Sent: Tue 20-Mar-07 4:02 PM
To: Tony Vieira
Subject: REQUEST FOR INFORMATION

Hi Tony

I'm sure that you don't remember me, I worked for the City a few years back in Khayelitsha with Barrie Barnard. I currently work in London with Sandra. I am currently doing my Mtech with the Cape Peninsula University of Technology. My dissertation focuses on congestion within the City of Cape Town with the aim of exploring the feasibility congestion charging in the City. To this end I am hoping that you could assist me or point me in the right direction. Is it possible to get a copy of the most recent OD survey used in the EMME2 model developed for the City as well as any traffic volumes, modal split and travel patterns for the City? Could you maybe advise who to approach to request this kind of information?

Thanking you in advance.

Samantha Mohamed

Transport Planning
Atkins: Highways & Transportation

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BIBLIOGRAPHY

Automobile Association. 2008 AA Rates for Vehicle Operating Costs (Jun 2008). http://www.aa.co.za/Advice+and+Information/Rates/AA+Rates+for+Vehicle+Operating+Costs+%28Jun+2008%29.htm [22 June 2008]

Automobile Association. 2008. Fuel Price Fluctuations January 2008 – December 2008 http://www.aa.co.za/Advice+and+Information/Fuel+Price+Fluctuations/Fuel+Price+Fluctuations+%28Jan+2008+-+Dec+2008%29.htm [06 November 2008]

City of Cape Town. 1998. Moving Ahead Cape Metropolitan Transport Plan Part 1: Contextual Framework. Cape Town.

City of Cape Town. 2006. Influencing Travel Behaviour Towards a Travel Demand Strategy (Draft). Cape Town.

Commission for Integrated Transport. Road User Charging. http://www.cfit.gov.uk/atoz/06.htm [07 June 2007]

Constance P. 2004. Chile's toll-road revolution. IDBAMÉRICA. January 2004. http://www.iadb.org/idbamerica/index.cfm?thisid=2565 [15 July 2007]

Gomez-Ibanez JA and Small KA. 1994. NCHRP Synthesis 210 Road Pricing for Congestion Management: A Survey of International Practice. Transportation Research Board

Hau T. 1992. Congestion Charging Mechanisms for Roads An Evaluation of Current Practice. World Bank

Hofstee E. 2006. Constructing a Good Dissertation. EPE

Hook W and Ferreira E 2004. Congestion Charging: Can it Work in São Paulo? ITDP Sustainable Transport. Issue 16.

Hook. W. 2007. Email with researcher on 24 January 2007

Institute Highways & Transportation. 1997. Transport in the Urban Environment. London: Essex

Li M.Z.F. 1999. Estimating congestion toll by using traffic count data – Singapore's Area Licensing Scheme. Transportation Research E. Volume 35 (1-10)

Liebenberg and Stander. 1994. Public Transport Study for Cape Town Metropolitan Transport Area: Policies and Strategies Summary Report on Phase 2. Final Draft. Director Metropolitan Transport Planning. Cape Town

Liebenberg and Stander. 1994. Public Transport Study for Cape Town Metropolitan Transport and Strategies. Summary Report on Phase 2. Final Draft. Director Metropolitan Transport Planning. Cape Town

Litman T. 2006. London Congestion Pricing: Implications for Other Cities. Victoria Transport Policy Institute

Litman T. 2008. Transportation Elasticities. Victoria Transport Policy Institute

Litman T. 2008. Win-Win Emission Reduction Strategies. Victoria Transport Policy Institute

Luk J.Y.K. 1999. Electronic Pricing in Singapore. Road & Transport Research. Vol 8 No 4(28 – 30)

Mahendra, A. 2000. Congestion Pricing in Cities of the Developing World: Exploring Prospects in Mexico City. Published Masters thesis, Massachusetts Institute of Technology, Massachusetts

Mattsson L.G. 2003. Modelling Road Pricing in Stockholm. Royal Institute of Technology: Department of Infrastructure, Division of System Analysis and Economics

May A.D. 1992. Road Pricing: An International Perspective. Transportation Volume 19 Issue 4 (313 – 333)

Mouton J. 2001. How to succeed in your Master's and Doctoral Studies. Van Schaik Publishers

Myers M. 2000. The Qualitative Report. Volume 4, Numbers 3/4 http://www.nova.edu/ssss/QR/QR4-3/myers.html [17 January 2008]

Papacostas C.S. and Prevedouros P.D. 2001. Transportation Engineering & Planning, 3rd Edition. Prentice Hall

Phang S.Y. and Toh R.S. 1997. From manual to electronic road congestion pricing: The Singapore experience and experiment. Transportation Research Part E – Logistics and Transportation Review Volume 33 Issue 2 (97-1-6)

Phang S.Y. and Toh R.S. 2004. Road congestion pricing in Singapore: 1975 to 2003.Transportation Journal Volume 43 Issue 2 (16-25)

Roth G. and Villoria O.G. 2001. Finances of Commercialized Urban Road Network subject to Congestion Pricing. Transportation Research Board of National Academies Volume 1747/2001 (29-35)

Sampson D. 2008. Email with researcher on 22 July 2008

Santos G and Shaffer B. 2004. Preliminary Results of the London Congestion Charging Scheme. Public Works Management and Policy Volume 9 No 2 (164-181)

Seik F.T. 2000 An advanced demand management instrument in urban transport Electronic road pricing in Singapore. Cities Volume 17 No 1 (33-45). Elsevier Science Ltd

South Africa. Department of Transport. 1996. National Transport Policy. Pretoria: Government Printer

South African. Department of Transport. 2000. National Land Transport Transition Act 22. Pretoria,: Government Printer

South African Department of Transport. 2003. Technical Report The First South African National Household Travel Survey 2003. Pretoria. Government Printer

Soy, Susan K. 1997. The case study as a research method. Unpublished paper, University of Texas at Austin.

Spotten J. 2007 & 2008. Various emails with researcher between 30 March 2007 and 28 November 2008-12-06

Toh R. 1977. Road Congestion Pricing – Singapore Experience. Malayan Economic Review. Volume 22 Issue 2 (52-61)

Transport for London. 2003. Transport for London Impacts Monitoring – First Annual Report. Transport for London

Transport for London. 2005. London Congestion Charging Technology Trials Stage 1 Report, February 2005. Transport for London

Transport for London. 2006. Distance Based Charging Report on Transport for London's GPS OBU Trial October 2006. Transport for London

Transport for London. 2006. London Congestion Charging Technology Trials Stage 2 Final Report, October 2006. Transport for London

Transport for London. 2007. Central London Congestion Charging Impacts Monitoring Fourth Annual Report, June 2006. Transport for London

Transport for London. 2007. Central London Congestion Charging Impacts Monitoring Fifth Annual Report, July 2007. Transport for London

Transport Research Knowledge Centre. 2004. PROGRESS Project 2000-CM.10390 Pricing Road use for Greater Responsibility, Efficiency and Sustainability in citieS – Main Project Report version 1.0. http://www.transport-research.info/Upload/Documents/200608/20060821_163557_02363_PROGRESS%20Final%20Report.pdf [26 September 2007]

United Kingdom. Department of Transport. 1995 MVA Report Vol 1: London Congestion Charging Research Programme Final Report, HMSO, London: vernment Offices

United Kingdom. Department of Transport. 1999. Review of Charging Options for London (ROCOL) Technical Assessment. London: Government Offices

United Kingdom. Ministry of Transport. 1964. Road Pricing: The Economic and Technical Possibilities. London. Her Majesty's Stationery Office
Vickrey, W. 1992. Principles of Efficient Congestion Pricing. www.hhh.umn.edu/centers/sip/projects/compric/learn/princip.htm 13 August 2007]

Vuchic V.R. 1999. Transportation for Liveable Cities. New Brunswick, NJ. Rutgers Center for Urban Policy Development

Western Cape (South Africa). Department of Transport and Public Works. 1995. Green Paper on Western Cape Provincial Transport Policy, Cape Town: Department of Transport and Public Works, Provincial Government of the Western Cape.

Wilson P.W. 1988. Welfare Effects of Congestion Pricing in Singapore. Transportation, Volume 15 Issue 3 (191-210)

BIOGRAPHICAL SKETCH

Samantha Mohamed graduated from the Peninsula Technikon in 2002 with a Bachelor of Technology in Civil Engineering (cum laude). She has worked as a traffic engineer for the City of Cape Town before moving East London to work for the Amathole District Municipality to work as the Chief Technical Officer: Transport. Samantha currently works in London for a consulting engineering company as a Senior Consultant in the Transport Planning and Management business. She has worked on a number of transport schemes in Central London, which has sparked her interest in travel demand management and congestion charging. She works on a range of transport schemes, from junction capacity to transit schemes. Samantha is member of the Women's Transport Seminar in London and is a Construction Ambassador with the CITB construction skills. Although no longer living in Cape Town, Samantha takes a key interest in the City's transport and initiatives.

THE FEASIBILITY OF A CONGESTION CHARGE FOR CAPE TOWN CENTRAL BUSINESS DISTRICT FROM A TRAFFIC ENGINEERING PERSPECTIVE

Samantha Mohamed
+44 78 09749878
Department of Civil Engineering
Supervisory chair: Professor Theo Haupt
Degree: Master of Technology, Civil Engineering
Month and year of graduation: December 2008

The aim of this research was to determine the feasibility of congestion charging in Cape Town's central business district as a travel demand management tool. It seeks to encourage the ongoing debate of what travel demand management tools are appropriate for implementation in Cape Town. This research found that although it is feasible in reducing traffic, it does have challenges, with the City of Cape Town, hereafter the City, first need to address. This includes the perception of public transport only being for low income earners and the socio-economic impact that a congestion charge will have on middle and low income earners. It is hoped that this research will contribute to the debate and get people talking, because for a congestion to be successfully introduced, not only does the City have to address the above-mentioned challenges, it also requires political buyin.