INTERNATIONAL EXPERIENCE WITH ROAD AND CONGESTION PRICING AND OPTIONS FOR JOHANNESBURG

T. M. Ueckermann and C. Venter*

Transportation Group, ARCUS GIBB (Pty) Ltd., P. O. Box 2700, Rivonia, 2128
*Department of Civil and Biosystems Engineering, University of Pretoria, Pretoria, 0002

ABSTRACT

Road and congestion pricing refers to a range of transportation mechanisms designed to curb excessive vehicle use. These mechanisms include area licensing, road tolling and others. The main objective of the study was to identify road and congestion pricing options that would be viable and appropriate for implementation in the Johannesburg metropolitan area, based on an analysis of factors such as congestion reduction potential and associated environmental benefits, public and socio-political acceptance, equity concerns, institutional arrangements and technological requirements. The study is based on an extensive literature review on road and congestion pricing and research into the experience with existing and proposed road and congestion pricing schemes internationally. The study finds that two possible scheme scenarios could be envisaged for Johannesburg – corridor systems and cordon-based area (or zone) systems – but that many political, transport, and socio-economic questions remain that would have to be addressed before a viable scheme could be developed.

1. INTRODUCTION

Countries and cities around the world are struggling with ever increasing road congestion. Demand is exceeding available supply whilst finances are not generally available for additional infrastructure. Environmental concerns are also increasingly influencing the decision to build further road infrastructure. South African road users in the major metropolitan cities, such as Johannesburg, are also increasingly exposed to sporadic and recurring road congestion. The growth of congestion in metropolitan road networks and the consequent constraints imposed on mobility and on the economy have made it vital to manage and utilise the existing infrastructure more efficiently.

Advances in technology for electronic tolling and the recognition that the expansion of road network capacity becomes increasingly expensive and controversial have renewed the interest in road pricing. Furthermore, the successful implementation of congestion charging in central London and elsewhere, has shown that direct user charging can deliver the desired benefits of reducing congestion and increasing mode shift, whilst overcoming political and social-economic concerns. In response many cities worldwide have been investigating congestion pricing as a way to curb excessive vehicle use and reduce the negative impacts of congestion. Road and congestion pricing is implemented through a range of mechanisms including area licensing, road tolling and others.

Proceedings of the 27th Southern African Transport Conference (SATC 2008) 7 - 11 July 2008
ISBN Number: 978-1-920017-34-7 Pretoria, South Africa
Produced by: Document Transformation Technologies cc Conference organised by: Conference Planners

Road pricing has two distinct objectives (Wikipedia, 2008): revenue generation, usually for road infrastructure financing, and congestion pricing for demand management purposes. Toll roads are the typical example of revenue generation. Charges for using high-occupancy toll (HOT) lanes or urban tolls for entering a restricted area of a city are typical examples of using road pricing for congestion management purposes.

Many of the costs of driving are not born by drivers, but by society as a whole – and their payment is not linked to driving, but is hidden or 'externalised' in other costs. Road pricing aims to internalise these costs, requiring the user to pay for the full costs of their driving. Apart from construction and maintenance costs, which are paid for out of municipal and provincial taxes, these costs can include the associated higher environmental clean-up and public health costs, or lower economic output. For each trip the overall road user charge should include components for external congestion costs imposed on others as well as costs imposed on the providing authority (Lewis, 1994). These costs are shown in **Figure 1** along with the direct road user costs.

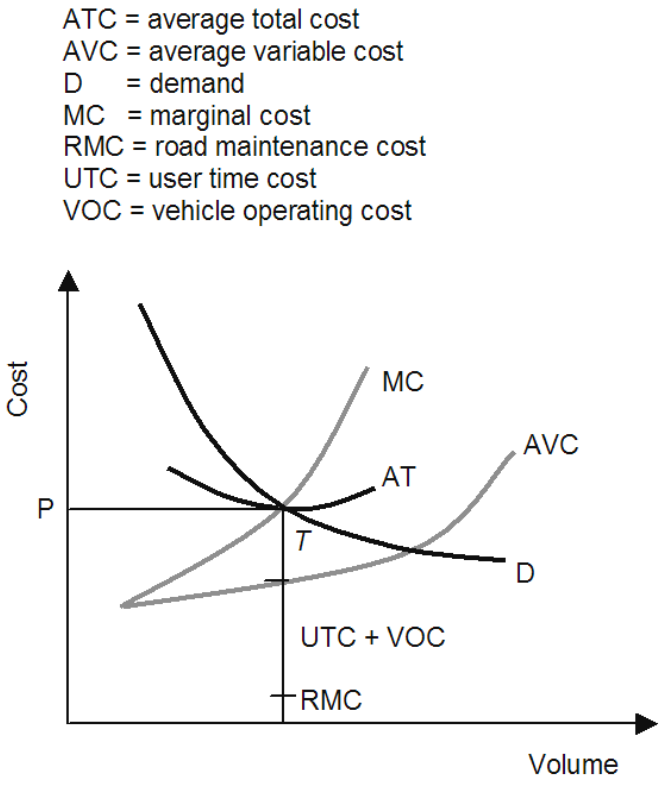


Figure 1 Congestion toll

(Source: Lewis, 1994)

2. OBJECTIVES OF THE STUDY

The main objective of the study was to identify road and congestion pricing options that would be viable and appropriate for implementation in the Johannesburg metropolitan area, based on an assessment of factors such as congestion reduction potential and associated environmental benefits, public and socio-political acceptance, equity concerns, institutional arrangements and technological requirements.

The study is based on an extensive literature review on road and congestion pricing and research into the experience with existing and proposed road and congestion pricing schemes. The study report further covers the history of road pricing, its principles and objectives, its general benefits and disadvantages as well as alternative measures.

The case studies selected covered road pricing applications that involve facility, cordon and area pricing projects in the United States, Europe, Asia and elsewhere. The location of the road and congestion pricing case studies reviewed are as indicated in **Figure 2**.

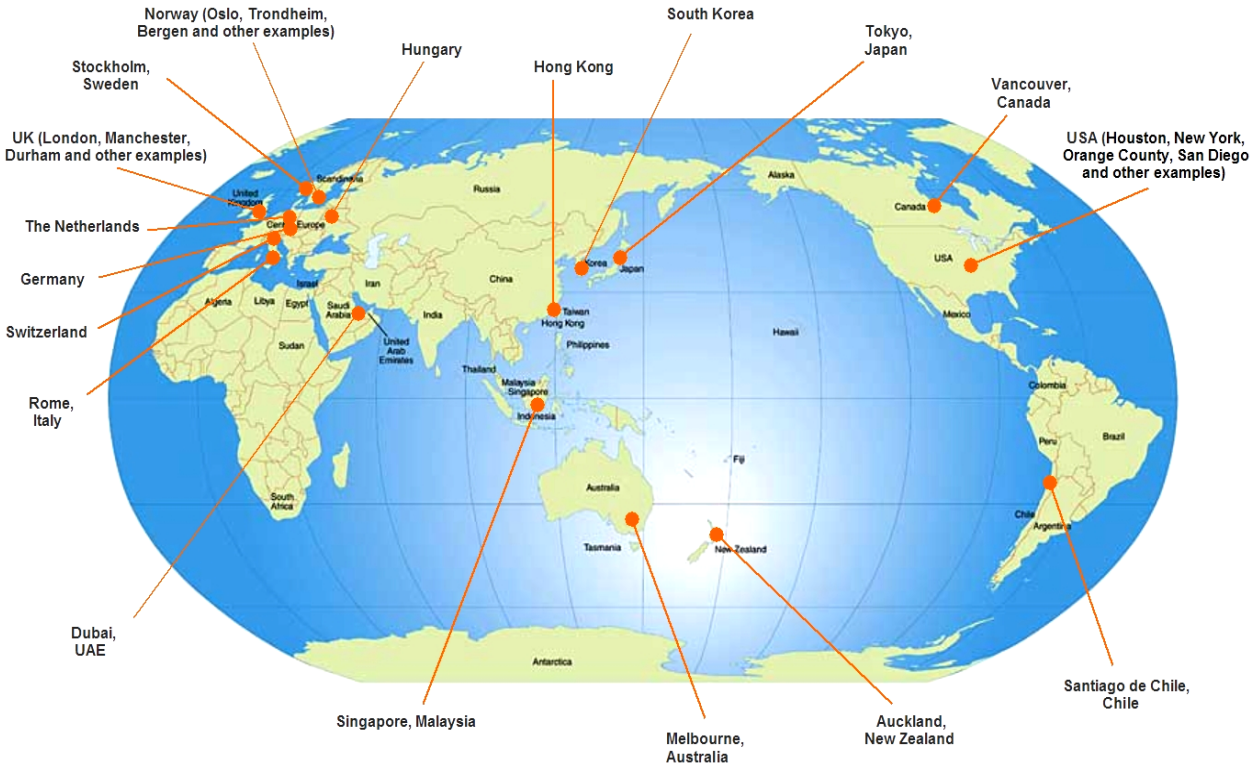


Figure 2 Location of road and congestion pricing case studies

The aim of the case studies was to help in identifying obstacles, limitations, failures and successes with their implementation from an international perspective. Within the context of the study, the aim was to address three principal questions:

- First, where in the world have road and congestion pricing been proposed, planned or implemented?
- Second, how have these projects and proposals been developed in terms of technical design, institutional issues and socio-political considerations?
- Third, what are the current status of these projects and proposals and what factors have aided or impeded their implementation?

The overall aim of the study was to identify a feasible congestion pricing option(s) for Johannesburg based on the theory and requirements for road congestion pricing as well as on the international experience to date. While the broad contextual realities of Johannesburg informed the analysis, a detailed technical analysis or modelling effort was not undertaken. The emphasis was on obtaining a first-cut assessment of local implementability, to be followed by more detailed studies at a later stage.

3. WHERE IN THE WORLD HAVE ROAD AND CONGESTION PRICING BEEN PROPOSED, PLANNED OR IMPLEMENTED?

Congestion charging has come to the fore to such an extent that it is now proposed, planned or implemented globally. In response to increasing road congestion and its negative environmental effects coupled with new or additional infrastructure finances constraints, many pricing experiments and projects have been implemented in various forms and in several countries, in particular in Asia, Europe and the United States over the past decade or so.

Much of the experience has been more successful than anticipated, with fewer adverse impacts and greater public acceptance.

4. ROAD PRICING SCHEME STAGES (TYPES)

Road pricing developments can be categorised in four distinct stages and according to a number of different principles (Eggers *et al*, 2003):

Stage 1: The corridor approach
A charged length of road that provides a means of transport from one location to another, such as a traditional toll road, a bridge crossing or a tunnel. The main objective is normally to collect revenue to pay for the road or facility.

Stage 2: The scheme area
Charging for driving in an area (also referred to as a zone, ring or toll cordon) with a closely integrated road system. This is typically applied to urban congestion charging schemes i.e. London and Stockholm. The main objectives are to improve traffic conditions and to generate revenues.

Stage 3: National and transnational systems
The charged area extends nationwide or even across countries, rather than an individual

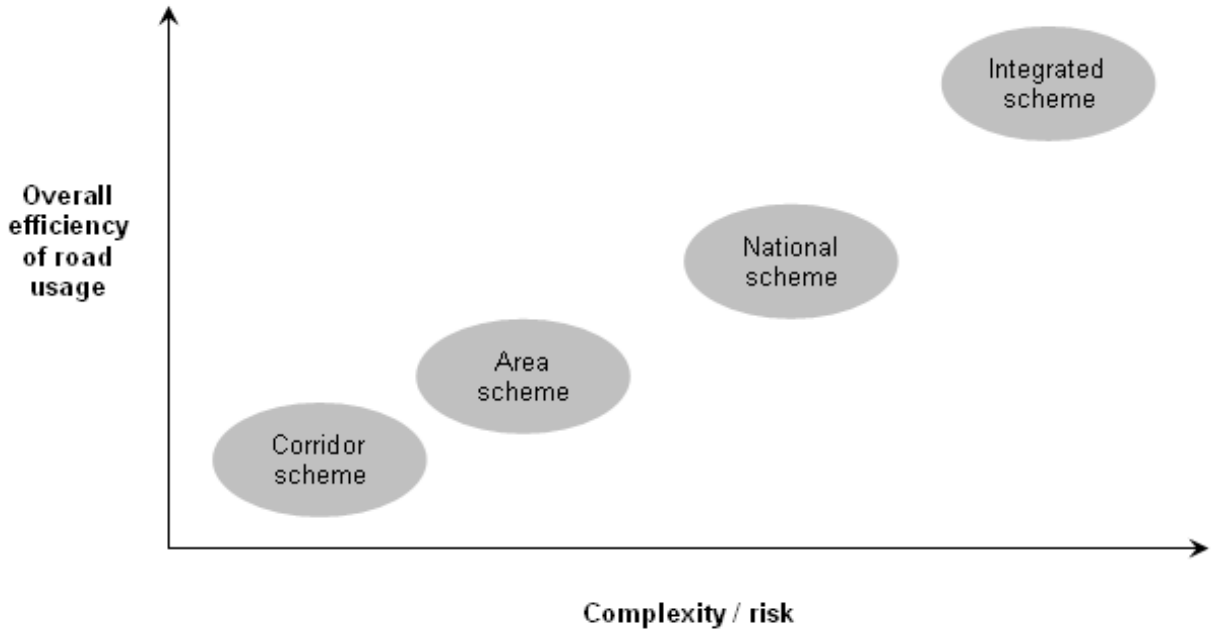
zone(s). The objectives are to regulate the overall distance driven within the network and to institute a more advanced charging structure than with traditional vehicle and fuel taxes. Examples include the HGV charging schemes in existence or proposed across Europe.

Stage 4: Integrated national system
A future vision in which road users make informed choices at every step of the journey across transport modes on a national basis. The charges normally permit incentives for a traveller to make the most of efficient transport choices.

The four stages of road user pricing development are illustrated in **Figure 3**.

At a high level, the stages illustrate the trade-off between the increasing overall efficiency of road usage and the increasing complexity and associated risks, i.e. a simple development will lead to some efficiency gains but with minimum complexity and risk, whist a fully integrated national system are intended to offer maximum efficiency gains but with an associated increase in complexity and risk.

Figure 3 The four stages of road user pricing *(Source: Eggers et al, 2003)*



5. HOW HAVE THE PROJECTS AND PROPOSALS BEEN DEVELOPED IN TERMS OF TECHNICAL DESIGN, INSTITUTIONAL ISSUES, POLITICAL AND OTHER CONSIDERATIONS?

The answer lies mostly in the local context of each case study. From the case studies reviewed it is generally clear that congestion played a major role in the decision to choose for some form of congestion pricing. The general lack of funding from conventional sources for road infrastructure and maintenance also emerges as a strong reason for opting for road pricing. The secondary reasons generally include the need for increased public transport (transit) investment and environmental improvements.

Once road pricing was identified as the way forward to address the underlying problem(s), aspects such as political, financial and institutional considerations influenced the eventual charging system specification in terms of measurement and detection, monitoring and enforcement and so forth.

It is however evident from the case studies that no one case study followed a universal route towards implementation largely due to the varying local conditions and objectives, whilst each scheme had to satisfy the public and road users of its specific benefits, implementation costs and/or deliverables.

Road pricing has gained significant acceptance where it has been implemented to date based on the general ‘commitment’ that the capital raised by the charges/taxes collected are ploughed back into roads and public transport.

The project experience to date indicates that both road and non-road users have experienced visible and tangible benefits as a result of congestion pricing in the form of reduced delays and congestion (in terms of vehicle journey times), new and/or improved road and public transport infrastructure and improved public transport services.

The typical characteristics from the road and congestion case study assessments are summarised in **Table 1**.

Table 1 Typical road and congestion pricing scheme characteristics

Typical road and congestion pricing scheme characteristics	
Description of scheme	Congestion charging zone, toll-ring, electronic road pricing (ERP), electronic toll collection (ETC), toll road.
Type of scheme	Cordon (area or zone) and linear systems (toll roads) as in Melbourne.
Start/Opening date	The Singapore area-licensing scheme (ALS) opened in 1975. Most modern applications have however only been implemented in the last two decades or so driven by advances in telematics and technology and widespread interest and acceptance of road pricing as part of travel demand management (TDM).
Original reasons for scheme	To reduce congestion and/or to raise capital for road/transport improvements (additional capacity) and in some instances to reduce emissions and hence air quality
Other reasons for scheme	Funding Public transport improvements, promoting public transport use, reducing pollution (vehicle emissions i.e. CO_2)
Scheme area/size	Cordon/zone based systems vary in size from selected city/town areas (i.e. London, Stockholm etc.) to larger metropolitan areas (i.e. Tokyo) to countrywide freeway implementation (i.e. Japan and Hungary). Linear systems typically constitute a toll road, which vary from a few to 100's of kilometres.
No. of vehicles charged/tolled per weekday	Varies according to type of scheme and/or scheme area as well as charging regime.
Charging regime	Mostly uniform with different charges for different categories of vehicles but increasingly converted to variable/dynamic charges
Charging period(s)	Mostly weekdays during the a.m. and p.m. peak period or daylight hours. Most linear systems tend to charge 24 hours, 7 days a week.
Price/Fee/Charge (2005)	Varies depending on charging regime. Trucks are generally charged higher fees. London has the highest fee at £8 (approx. R115).
Measurement (Detection)	ETC with in-vehicle (or on-board) units with antennae and vehicle detectors mounted on gantries and/or by means of automatic numberplate recognition
Detection (Enforcement)	Enforcement are typically by means of CCTV and automatic numberplate recognition
Payment	Payment is generally by pre-paid smartcards which can be topped up with debit/credit cards online, by SMS or at selected outlets
Concessions (Discounts, Exemptions etc.)	Varies, although public vehicles such as buses and those of emergency services are typically exempt. Discounts are often given for low emission or 'clean' energy vehicles.
Penalty	Varies from about R350 upwards to R1150 (London). Penalties are normally linked to payment deadlines and discounts may be offered for prompt payment.
Annual operating costs	Varies depending on scheme type and size. From about R20 million for small towns (Kristiansand, Norway) upwards to approx. R500 million in London. New York proposes an operating cost of approx. R1,7 billion.
Annual revenues	From about R400 million (in Singapore) upwards to approx. R1,5 billion (in London). The New York scheme proposes revenues of approx. R4,4 billion in its first year.
% (Operating cost / Revenue)	Varies depending on scheme type and size and pricing technology/systems. From as low as 5% up to approx. 35% (in London). Both Singapore and Stockholm has a cost of approx. 21%.

Typical road and congestion pricing scheme characteristics	
Conditions before scheme	Congested central city or urban/radial routes (i.e. motorways)
Benefits	Reduced congestion (improved travel speeds and journey times), and improved public transport ridership levels. New road infrastructure (i.e. bypasses) and or public transport services and/or facilities are implemented from the revenues.
Disadvantages	Perceived business losses in some instances (i.e. London). Toll diversion problems were experienced in Hungary.
Strengths	Once the benefits of the scheme realizes the political and public responses are generally positive (more so than before scheme implementation)
Weaknesses	Implementation, technology and operational costs tend to be on the high side. In some cases the scheme type and/or charging regime may not result in significant travel behavioural changes (i.e. Oslo and Singapore).
City area (km^2)	Varies from small to medium towns as the case with the toll-rings in Norway (i.e. Trondheim with an area of approx. 71 km^2) to larger urban conurbations as the case with Melbourne (approx. 8 831 km^2)
City population	Varies from small to medium towns (<100 000 pop.) to larger cities (<1 million) to urban conurbations with populations in excess of 10 million (i.e. greater New York has a pop. of approx. 18,8 million)
Public transport system	The larger 'global' cities tend to have a well-developed suburban commuter rail network with mass metro rail systems and/or light rail systems coupled with conventional bus services. The smaller towns/cities tend to have bus services with some rail services.

Source: Ueckermann T.M., 2008

Some characteristics from a selected number of the case studies assessed are summarised in **Table 2**. The characteristics listed include a description (name) of the scheme; type of scheme; scheme area, size or length; original reasons for scheme; other reasons for scheme as well as a summary of the scheme benefits/results.

Table 2 Sample characteristics from selected case studies

Scheme	London, UK	Melbourne, Australia	Santiago de Chile	Singapore	Stockholm, Sweden	Trondheim, Norway
Description of scheme	Central London Congestion charging Scheme (CLCCS)	'CityLink' Toll Road	Santiago ETC Network	The 1975 Area Licensing Scheme (ALS) was supplemented by a Road Pricing Scheme (RPS) in 1995 and replaced by Electronic Road Pricing (ERP) in 1998.	Road (congestion) pricing scheme	Trondheim toll ring scheme
Type of scheme	Stage 2: Cordon	Stage 1: Facility	Stage 1: Facility	Stage 2: Cordon	Stage 2: Cordon	Stage 2: Cordon
Scheme area, size or length	22 km^2 (original scheme: area inside Inner Ring Road)	A 22 km long toll road linking three of Melbourne's freeways	A network of urban toll roads	ERP Cordon	18 two-way toll stations on the boundary of the inner city enclosing an area of approx. 48 km^2 [1]	22 toll stations (in an area of approx. 24 km^2) [2]
Original reasons for scheme	Congestion, improve journey time reliability, public transport improvements	New infrastructure to create additional capacity and to deal with congestion.	Reducing air pollution	Traffic management (control of congestion and journey times).	The objectives were to reduce traffic volumes (improve traffic flow) and improve public transport services. [1]	To raise capital for new road infrastructure and transport improvements. [2]
Other reasons for scheme	Reduced emissions	Environmental benefits	To provide new infrastructure to alleviate congestion and improve journey times	Promotion of public transport and car-pooling.	Reduce emissions (improve urban environment) [1]	Public transport and environmental improvements [1]
Benefits and results	37% increase in vehicle speeds; 16% reduction in vehicles; Congestion reduced by 40% during charging hours; Improved bus reliability, and reduced bus operating costs [2].	The project has significantly reduced congestion in north and west Melbourne, which in turn reduced pollution and led to safer conditions on the local streets.	Reduced air pollution; reduced accidents at intersections.	The ERP system further reduced traffic by 10-15% compared to the earlier ALS/RPS system; traffic speeds increased by 22% [1]	Public transport improvements inc. 200 new buses operating 16 services. Traffic reduced by 22% across the boundary but less within the boundary [1]	10% reduction in traffic during toll hours and 8% outside toll hours (iv). Overall reduction of 4% in traffic flows; weekday bus travel incr. by 7% [2]
References	*1. Buchanan, 2007* *2. Eggers et al, 2003*	*1. Transurban, 2007*	*1. CfIT, 2006*	*1. Buchanan, 2007*	*1. Buchanan, 2007*	*1. Buchanan, 2007* *2. May and Sumalee, 2005*

6. IS ROAD PRICING A VIABLE AND APPROPRIATE OPTION FOR JOHANNESBURG?

The question of 'whether road congestion pricing is a viable and/or appropriate option for implementation in Johannesburg?' was assessed based on the factors and measurement criteria listed in **Table 3** and on the individual case study characteristics and experiences.

Table 3 Key congestion pricing evaluation factors and measurement criteria

Factor	Measure	Description
Type of project	Cordon, area (zone), corridor (toll roads) or other scheme	The choice of scheme type(s) is determined based on considerations such as the layout of the road network, the extent and location of congestion and the implementation in combination with other TDM measures. Aspects such as traffic diversion and land-use impacts are important considerations.
Congestion reduction potential	Reduced delays and journey times (users)	The scheme type selected must be able to attain the desired benefits in terms of reduced congestion, more consistent journey times, public transport improvements and so forth.
Institutional issues	Co-ordination between different authorities i.e. metropolitan, provincial and national	The scheme must be agreeable to all the relevant authorities with suitable legislation, responsibilities, financial criteria, operating and co-ordinated processes in place. Funding distribution mechanisms and enforcement are key issues to be agreed.
Acceptance and support	Acceptance from a socio-political, business (retail) and road freight industry point of view	Public acceptance must be sought well in advance of the process by means of media campaigns and consultations. Road-user and government organisations must be consulted. Information must be readily available before and after scheme opening.
Charge levels	Affordability in terms of equity concerns and general impact on the economy	The main objective is to introduce as equitable scheme as possible by taking a practical and accommodating approach in its implementation. It should be possible to set variable charges for different roads, vehicle classes and times which should be clearly outlined to road users.
Equipment and technology	The technology must be 'simple' to implement, and affordable and sustainable in the long-run	The overall 'tolling' system must have a good track record in terms of user-friendliness, reliability, accuracy etc. Privacy measures must also be in place to gain the trust of the road user. The scheme should offer convenient payment methods.
Investment focus areas	Investment areas may include the facility only (i.e. toll road), roads and transport, environmental and other improvements	The results from the scheme, project funding, revenue and operating costs must be readily available to all stakeholders including members of the general public i.e. by means of a website etc.
Environmental considerations	Mitigation against unwanted effects i.e. noxious emissions and noise.	Particular areas or zones may also require special treatment in terms of TDM controls.

Source: Ueckermann T.M., 2008

The findings from the assessment indicated that *inter alia*:

a) Two possible scheme scenarios can be envisaged for Johannesburg – corridor systems and cordon-based area (or zone or area) systems - possibly in combination with each other. In summary, it is however clear that a solution is required for Johannesburg that considers both the need for revenue generation for various transport improvements as well as for roadway decongestion purposes. Satellite schemes based on area licensing or small cordon zones covering busy central business districts (CBDs) such as Sandton also present opportunities for further investigation.

b) It is further clear that road pricing could be made more effective in combination with a range of other complementary travel demand management (TDM) or Managed Lanes measures such as public transport priorities. The concept is however equally applicable to other roadways and can therefore also be implemented as part of a comprehensive cordon or area traffic management scheme.

c) A highly co-ordinated strategy is required across all three spheres of government that have road competencies in Gauteng Province, such that a restraint placed on the roads in one sphere does not simply cause a move of congestion to another sphere.

d) From the legislation review it is evident that the functional competencies of all three spheres of government - national, provincial and local - are fairly clearly defined in terms of the types of road over which they have jurisdiction, as well as under what circumstances they may impose charges, and more specifically, road user charges.

e) Whereas one of the basic ideas behind the road/congestion pricing concept entails earmarking of the revenue generated for road or related projects (i.e. public transport), evidence from the case studies suggests that the treatment of the road/congestion pricing charges as either a toll or a tax is often one of the key issues to resolve politically as well as legally. High-level interaction would be required with national, provincial and metropolitan treasury departments in convincing them that the congestion pricing tolls are indeed (road) user charges and not taxes.

f) It is further clear that road/congestion pricing must be supported by a comprehensive package of transport policies targeting aspects such as the impact on the environment, economic growth and accessibility.

g) An effective public transport system is essential for offering a viable alternative to private vehicle use as well as for absorbing those drivers ‘tolled-off.’ As the extent of the public transport system that is required in Johannesburg to form an effective alternative to private car use will take years to implement, it can be argued that congestion pricing in central areas (i.e. Johannesburg CBD) will not be viable for at least the next five to ten years based on public transport considerations alone.

h) Incentives such as discounts for shared car use such as car clubs, carpools and the like offer alternatives to the private car, which could lead the way for the implementation of high-occupancy toll (HOT) lanes.

i) The road pricing or congestion pricing charge or toll levels are also dependent on whether the scheme's objective is to reduce congestion or to raise capital or a combination thereof and on a number of other factors, including the costs of the revenue collection and enforcement. To this end, Johannesburg would be likely to opt for tried and tested methods of ETC from a reliability and maintenance point of view, rather than to trial new and possibly costly technologies.

j) Road pricing or congestion pricing can be applied to stimulate the supply of new road space, or for rationing the demand placed on existing road infrastructure. The case studies however suggest that conventional road space development priorities should generally be focussed on:

- Reducing congestion and improving vehicle travel times;
- Environmental improvements, and
- Accommodating traffic growth by improved travel demand management measures.

7. CONCLUSIONS

The following presents some of the main conclusions from the study:

a) It is evident that road pricing, with the good of generating revenue for infrastructure investment, and road congestion pricing, with the good of reducing congestion, can be considered as viable measures to maintain a reasonable level of service by making travellers more informed about their travel decisions and the effects of their travel on others and the environment. Whilst it is not possible to completely eliminate congestion, road congestion pricing coupled with improved traffic management measures is a practical means of controlling demand.

b) The assessment of the case studies suggest that two possible scheme scenarios can be envisaged for Johannesburg – corridor systems and cordon-based area (or zone) systems - possibly in combination with each other. It is however clear that a solution is required for Johannesburg that considers both the need for revenue raising for various transport improvements as well as for roadway decongestion purposes.

c) An effective public transport system is essential for offering a viable alternative to private vehicle use as well as for absorbing those drivers 'tolled-off.' The extent and quality of the public transport system in Johannesburg on the other hand can be described as being in its 'infancy'. As the extent of the public transport system that is required to form an effective alternative to private car use will take years to implement, it can therefore be argued that congestion pricing in central areas (i.e. Johannesburg CBD) will not be viable for at least the next five to ten years based on public transport considerations alone.

d) If congestion pricing is to be implemented in Johannesburg the charging levels are likely to be set such that they accommodate equity concerns. However, too low charges may not bring about the intended benefits such as reduced congestion and improved journey times. Conversely, too high charges may toll-off too many drivers

thereby increasing congestion on 'non-tolled' routes, whilst also affecting revenue as well as potentially increasing road accident risks (due to higher speeds).

e) It is evident that even a combination of road pricing and travel demand management measures will not stop roads from being congested in future. With increasing traffic, more and more vehicles will put additional pressure on the available infrastructure even if new roads are build or capacity added to existing roads by the construction of additional lanes. Also, increased use of public transport will also result in increased congestion on these modes. It is therefore envisaged that road space will, in future, be increasingly dedicated for exclusive use by specific road users such as, for instance, buses and coaches or heavy goods vehicles.

f) It is further clear that road/congestion pricing must be supported by a comprehensive package of transport policies targeting aspects such as the impact on the environment, economic growth and accessibility.

8. RECOMMENDATIONS

Road pricing has considerable merits as both a congestion management and as a revenue-raising tool. It is however also evident that cordon or area (zone) based congestion pricing can only be implemented in the longer-term in central areas based on public transport (as a viable alternative) and equity considerations whereas corridor-based pricing (toll roads) can be implemented in the short-term.

In the interim it is therefore recommended that a range of travel demand management (TDM) measures be considered for implementation in urban areas as well as along activity and freeway corridors, such as high-occupancy vehicle (HOV) lanes, as a means of providing incentives for reduced reliance on the private car. As the tolled freeway network in Gauteng expands, it becomes feasible to charge differential tolls depending on vehicle occupancy and network congestion levels. Such incremental approaches may start to lay the groundwork for more extensive congestion charging in future, and serve as a much-needed test bed for behavioural and economic impacts.

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