VOLUNTARY TRANSPORT DEMAND MANAGEMENT: ROUTE CHOICE STUDY IN PORT ELIZABETH

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ABSTRACT

Transportation Demand Management (TDM, also called Mobility Management) is a general term for strategies that result in more efficient use of transportation resources. Voluntary TDM measures, such as the introduction of flexi time, ride sharing etc, if implemented and followed, should spread peak traffic over a longer period and improve the levels of service and reduce the negative impact of private vehicle travel on the environment. This paper analyses the potential benefits of the introduction of Voluntary TDM measures on a specific commuter route (Cape Road) in Port Elizabeth. The potential benefits were analysed in terms of time savings, cost savings, energy efficiency effects and a reduction in CO_2 emissions. Microscopic modelling of specific work journeys on this route was carried out, comparing peak travel with off peak travel.

1 INTRODUCTION AND BACKGROUND

The national climate change response green paper of South Africa (Government Gazette, 2010) states that the transport sector is the fastest growing source of greenhouse gas emissions, as well as being the second most significant source of these emissions. The transport sector also accounts for more than a quarter of energy demand, of which the overwhelming percentage is attributed to land transport. The challenge in South Africa is to balance the economic and social drive to improve people's lives on the one hand, but also to provide a more efficient and sustainable transport system on the other. Due to various socio-political reasons as well as certain planning trends, South Africa's land use and spatial development in previous years led to our society becoming too reliant on private vehicle travel. The government aims for a modal shift from private to public transport and there has been plenty of money spent on this in the past couple of decades, especially to make the choice attractive and affordable.

This paper examines what potential benefits there are in implementing voluntary travel demand management measures, as a forerunner to the more expensive interventions, such as highway capacity upgrades or public transport system improvements. It looks at the potential positive impacts on the environment if people choose to voluntarily change

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their travel patterns to be more sustainable. It also analyses what personal benefits individuals may be able to attain by travelling more sustainably, as well as looking at what follow up measures are required to secure the long-term benefits of voluntary TDM measures.

2 PROBLEM DESCRIPTION

The Nelson Mandela Bay Metropolitan Municipality (NMBM) has started with the planning and implementation of an Integrated Public Transport System (IPTS), which will include a bus rapid transit (BRT) system (See Figure 1). The IPTS coverage of the city was planned based on person trips per day, which were calculated from a home interview travel survey carried out for the first NMBM Integrated Transport Plan (ITP), in 2004. According to this travel survey there are 1.4 million person trips per day in the NMBM. The modal split is 33% walking; 26% public transport and 41% private transport. The first phases of the new bus system will focus on and cater for the person trips with the highest likelihood of becoming passenger trips in the proposed IPTS. The previously disadvantaged areas of PE will be served first as the majority of the pedestrian trips are within these areas and the existing public transport trips consists mainly of captive minibus taxi and bus users. People from these areas are deemed to be more likely to start using the new system. The economic upliftment of people, usually, coincides with the increase in motor vehicle purchases, therefore the plan is to provide a world class public transport system to dissuade people from choosing private vehicle travel.

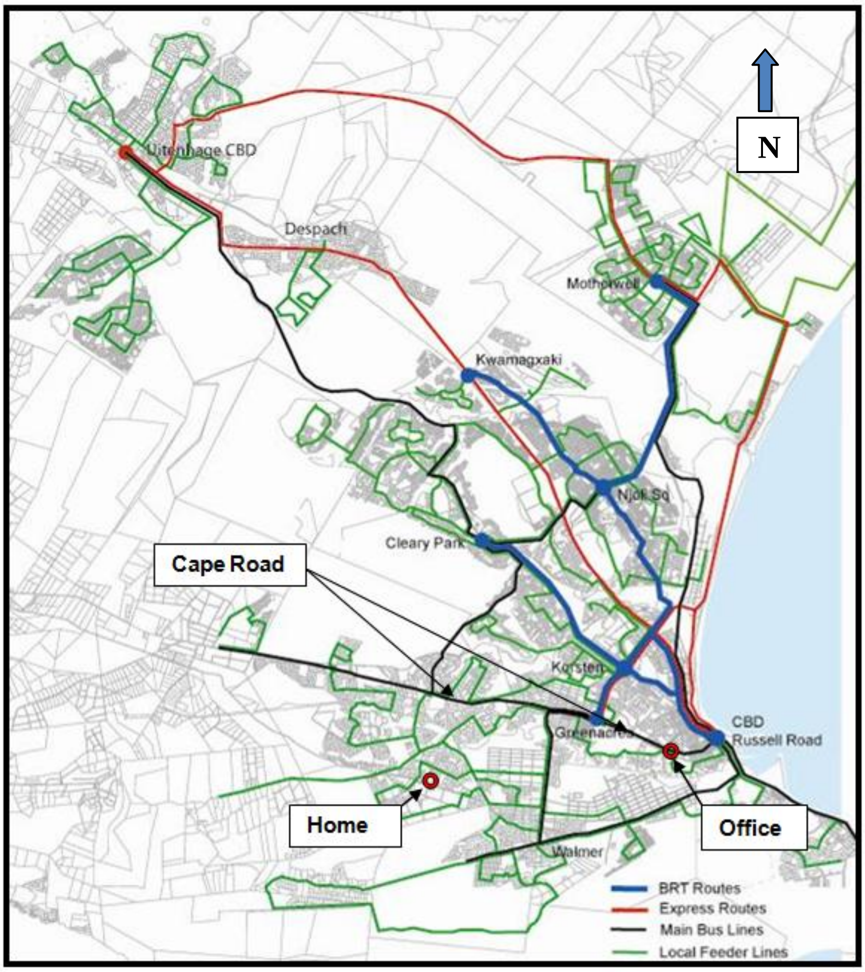

Figure 1: Integrated Bus Route Network (Source: NMBM CITP, 2011 (amended))

The first benefits of the IPTS system, to the traditionally more wealthy western suburbs, will be a bus service which will be running in mixed traffic down Cape Road. This is planned to happen within the next 5 years. The upgrade of Cape Road to include segregated lanes for the BRT will only happen in the long term, probably 10 - 15 years from now. With private vehicle-use dominating the routes to the western suburbs it is unlikely that a new bus service, running in mixed traffic, will attract people out of their cars. The western suburbs of Port Elizabeth, and specifically the suburb of Lorraine, have changed appreciably in terms of size and in terms of the amount of vehicle trips it generates, over the last 20 years. Although Lorraine is served by public transport, the majority of people from this area rely on private vehicle travel.

One of the major routes from Lorraine to the city, follows Cape Road which has become one of the busiest roads within the Nelson Mandela Metropolitan area and is not only an important arterial, which links the western part of PE with the rest of the city, but also an important mixed-use corridor. Until the dedicated, segregated infrastructure for BRT buses is implemented and a good quality transport alternative is available, another strategy is necessary to address the private vehicle dominated transport system to and from this part of the city. Transport planning interventions are required to alleviate these problems prior to the IPTS getting to the western suburbs.

3 ANALYSIS OF PEAK VS OFF PEAK TRIPS

3.1 Methodology

The route which was analysed, starts in the suburb of Lorraine, and then continues along the Cape Road corridor towards Central. It is approximately 12km long. Micro-simulation was carried out on one person's journeys to his work in order to determine what possible benefit there is in travelling during the off-peak period, as opposed to the peak period. Measurements were taken on every day of the week for both the peak, as well as the off-peak periods. The person had to work a normal 8 hour day, with a 1 hour lunch break, which determined the time at which he could leave in the afternoon. The Cape Road route option was used for all the measurements. The results were analysed with the aid of a micro simulation computer programme called SIDRA TRIP in order to determine what the difference would be between two scenarios. The results that were compared were time, fuel consumption and CO_2 emissions. Only the trips to work and back home were measured.

3.2 Commuting time savings

The trip times to work for two scenarios were measured, namely the combined morning and (corresponding) afternoon trip times for the peak and off peak. These peak and off peak trip times are illustrated by the blue and red bars respectively, in Figure 2. Similar measurements were also taken for the peak period, AM and PM combination during the October school holidays (indicated by the green bars in Figure 2).

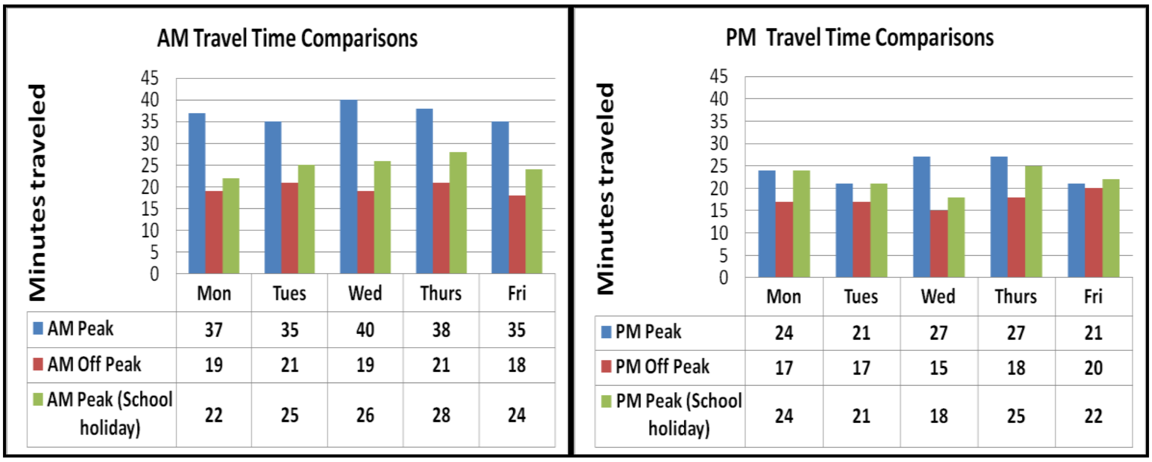

Figure 2: Travel time comparisons

The total amount of time saved per week by travelling to work in the off-peak is 120 minutes. The split of this off peak time saving is, 87 minutes in the AM and 33 minutes in the PM. If it is assumed that the average person will work 48 weeks in a year then the time savings is 5760 minutes or 96 hours in a year, per person.

The results of the surveys show a significant difference in time saved between AM and PM when travelling off peak as apposed to during peak. This can possibly be attributed to the starting times of schools. This point is accentuated by the travel times during peak times in the October school holidays. The AM peak travel times during the school holidays are much lower than the normal AM peak times and only slightly lower when comparing the two PM peak scenarios (see Figure 2 for comparisons).

3.3 Fuel consumption

The SIDRA TRIP modelling software, Akcelik (2009), uses the following model equation to calculate the fuel consumption of a standard sedan as a value per unit time:

$$\mathbf{f_t} = \{\alpha + \beta_1 R_T v + [\beta_2 M_v a^2 v/1000]_{a>0} \qquad \text{for } R_T>0$$

$$= \alpha \qquad \text{for } R_T \leq 0$$

where

f_t = instantaneous fuel consumption rate (mL/s)

R_T = total tractive force (kN) required to drive the vehicle

M_v = vehicle mass (kg) including occupants and any other load

a = instantaneous acceleration rate (m/s^2), negative for deceleration

α = constant idle fuel consumption rate ((mL/s)

β_1 = the efficiency parameter, which relates fuel consumed to the energy provided by the engine

β_2 = the efficiency parameter, which relates fuel during positive acceleration to the product of inertia energy and acceleration

The fuel consumption when travelling in the peak was 12.79 litres in the week. The consumption was 10.09 litres during the off peak week (see Figure 3). That is a reduction of 2.7 litres per week by travelling outside the peak hour.

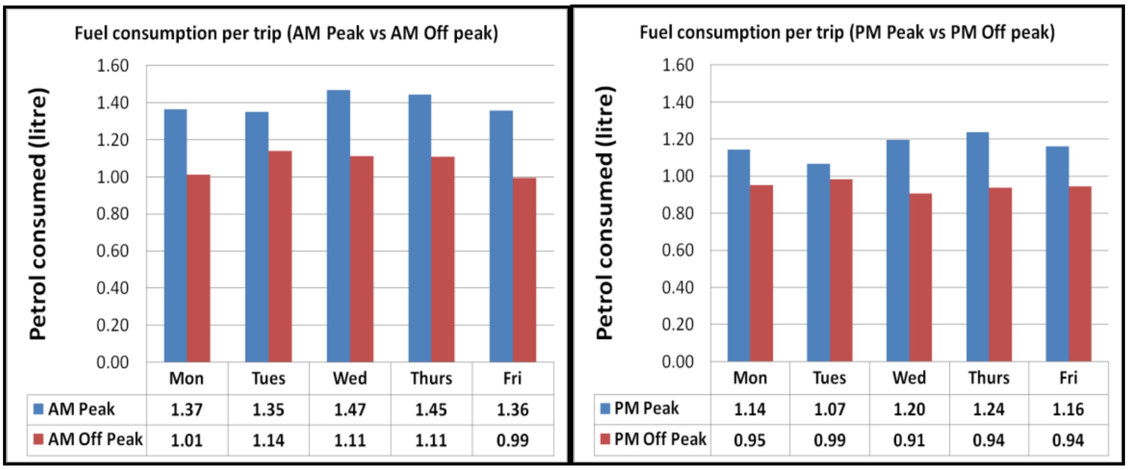

Figure 3: Fuel consumption comparisons

Assuming a working year consists of 48 weeks, this would mean a possible saving of 129.6 litres of petrol per year per vehicle.

3.4 Carbon dioxide (CO_2) emissions

The common theory is that carbon dioxide (CO_2) emissions increase as traffic congestion increases. The reason for this is that during congested traffic conditions, vehicle engines run longer and drivers are forced to decelerate and accelerate more which contributes to more CO_2 emissions. Figure 4 and 5 illustrate the reduction in decelerations and accelerations for the AM off peak, compared to the AM peak period. It also illustrates that it is possible to achieve a higher average speed and travel the same distance in about half the time during the AM off peak.

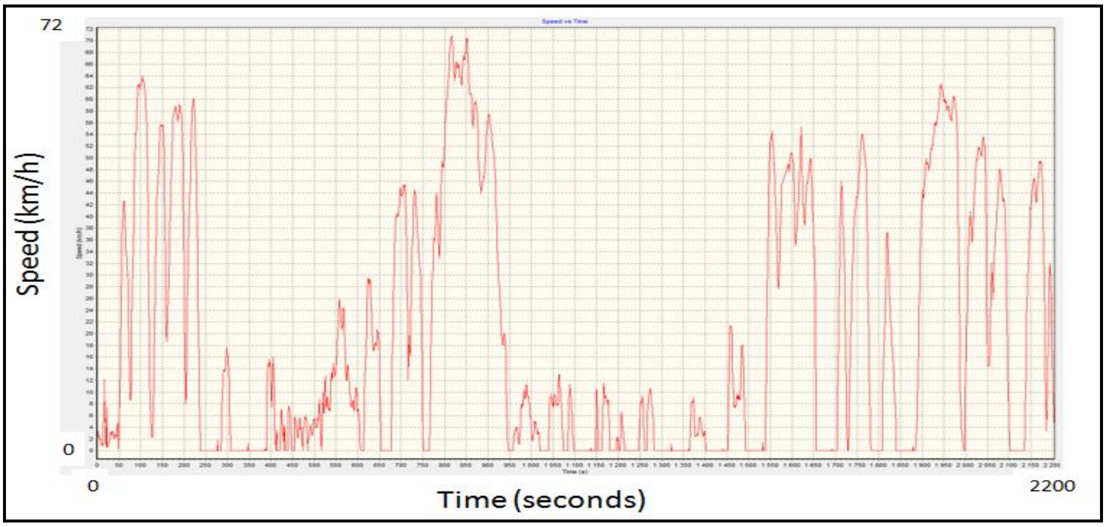

Figure 4: Speed vs Time for a typical AM Peak

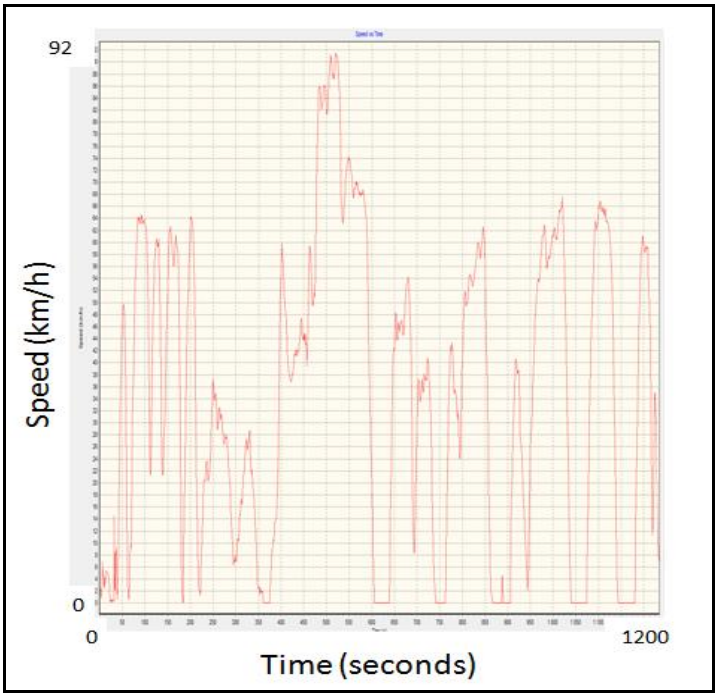

Figure 5: Speed vs Time for a typical AM Off-Peak

The SIDRA TRIP modelling software, Akcelik (2009), uses the following model equation to calculate the carbon dioxide emissions:

$$f_t\,(CO_2) = f_{CO2} * f_t(fuel)$$ where

f_t (fuel) = fuel consumption rate (mL/s)
f_{CO2} = CO_2 to fuel consumption rate (kg/L)

The effect of congestion on the volume of the CO_2 emissions can clearly be seen in the modelling results of this particular route in Port Elizabeth (see Figure 6). The amount of CO_2 emitted by an average vehicle during peak hour trips in a week is 31.98kg. Conversely the CO_2 emissions during the off peak trips in a week was 25.23kg. That is a 324kg reduction in a 48 working week year per vehicle.

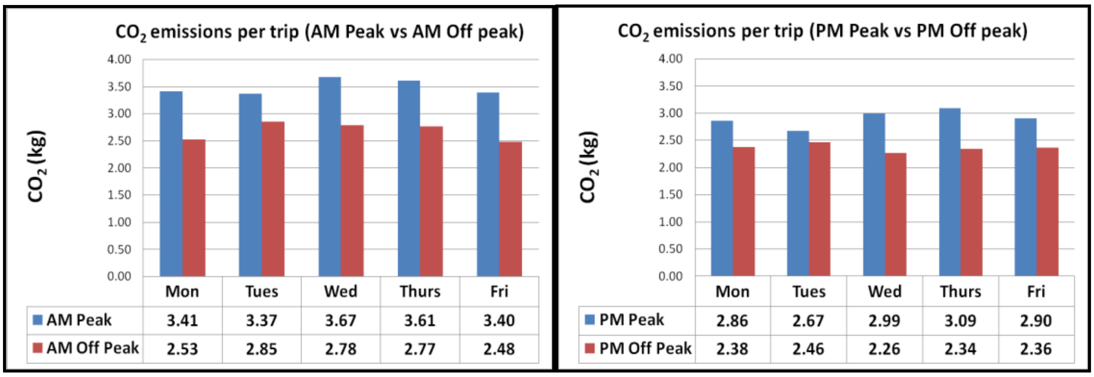

Figure 6: Carbon dioxide emissions comparisons

The reduction in CO_2 emissions during off peak travel can be attributed to the shorter travel time and higher average speeds, due to fewer forced stops as a result of congestion.

4 POTENTIAL COST SAVINGS

The cost of travel is made up of more components than simply the cost of petrol consumed; it also includes the running costs like tyre, oil, repair, maintenance and depreciation values, which the SIDRA model also includes. Indirect costs, such as travel time are also included when calculating the generalised cost of travel. In order to calculate the generalised cost of the journey to work and back, the SIDRA TRIP model requires certain information. The information required by the model was:

Table 1: Constants required by the model

Average hourly income	The average income for the suburb of Lorraine was calculated using socio-economic data from the Lorraine Local Spatial Development Framework (LSDF) 2007 and the NMBM Comprehensive Integrated Transport Plan 2011/2012. The rate which was calculated as the average hourly income was R133.00.
Price of petrol	At the time of the first measurements the price of unleaded petrol was R9.80 per litre. This value was used throughout the modelling.
Time value factor	The default time value factor of the model is set at 0.6. The implication is that the value of travel time is 60% of the value of wages. Litman (2011) states that this value is often over estimated and "lower values are found when motorists' willingness-to-pay is actually tested with congestion tolls". Therefore the value was set at 0.2 based on the relatively high average income.
Average occupancy	The average occupancy of the car was set at 1. This is to simulate the fact that the surveyor travels to work alone.

The following formula is used by the model, Akcelik (2009), to calculate the cost of travel per trip:

$\mathbf{C_t} = k_0 * F_t \mathbf{/ 1000} - k_t * T_t \mathbf{/ 3600}$ where:

C_t = cost (R)
k_0 = vehicle operating cost factor (R/litre)
k_t = time cost factor (R/hour)
F_t = total fuel consumption (mL)
T_t = travel time (seconds)

The results of the model are set out in Table 2. The total amount saved per week by this particular individual travelling during the off peak is R137.00 which for a 48 week year constitutes a saving of R6576.00 per year.

Table 2: Comparisons of generalised costs

	Monday	Tuesday	Wednesday	Thursday	Friday	Total per week	Difference between peaks per week
AM Peak	R 56.40	R 54.90	R 60.70	R 59.00	R 55.20	R 286.20	
AM Off peak	R 38.20	R 42.80	R 41.30	R 41.70	R 37.00	R 201.00	R 85.20
PM Peak	R 44.30	R 40.90	R 46.70	R 48.20	R 45.00	R 225.10	
PM Off peak	R 35.00	R 34.90	R 33.40	R 35.00	R 35.00	R 173.30	R 51.80
							R 137.00

5 TRENDS OF TDM BEHAVIOURAL CHANGES FOR THE PORT ELIZABETH SITE

Even though the potential benefits of a successful voluntary TDM programme are clear to see from the results of the modeling, in reality, the success of such interventions isn't as obvious to predict. Each site or route is unique and there are different factors which influence the outcome of TDM programmes. It is important to know the site and prepare properly before implementing TDM measures. According to Litman (2011), *"mobility management programmes, where appropriately implemented have been successful, reducing vehicle trips by 10 – 30% and are generally cheaper than accommodating additional urban peak travel".*

5.1 Commute Trip Reduction (CTR)

Voluntary TDM measures are often implemented among other TDM measures as part of a Commute Trip Reduction (CTR) or Employee Trip Reduction Programme (ETRP). These programmes are aimed at reducing employee aggregate kilometres travelled. The CTR chapter of the Online TDM Encyclopaedia states that a comprehensive CTR programme can reduce peak-period private vehicle trips by 5 – 20% per worksite

One obstacle encountered during implementation of voluntary TDM measures is the fact that management isn't always keen on the implementation of the measures. It increases administration responsibilities because they believe they need to keep a closer eye on employees and that productivity is affected.

5.2 Commuter travel choices influenced by travel information

There have been various studies done investigating the effect of providing people with the knowledge and information to enable them to choose trip times or routes. A study in China by Jou (2001), investigating commuter departure time and route choice, showed that commuters are likely to change their departure time and / or their route if they receive relevant pre-trip travel information. This indicates that without the knowledge of the possible benefits of more efficient travel habits people may not make the change.

Individualised marketing is another method of giving people information and influencing there travel choices. According to Cairns & Sloman et al (2004) studies in Australia have tested the method of individualised marketing where whole suburbs have been targeted with information about the impact of travel trends on the environment. People from these suburbs have also been given information on alternative options to improve the sustainability of their transport choices. There was a 14% fall in car driver trips and a fall of 17% in vehicle kilometres after the first trial of this large scale marketing was completed in the suburb of South Perth in the year 2000.

5.3 Morning peak traffic reduction

Due to the fact that the congestion peak period is often worse during the morning school run, CTR programmes, which focus specifically on reducing morning peak traffic, has developed walking school bus programmes. The idea is that children who live within walking distance of their school, form groups in their neighbourhoods. These groups are then accompanied by teachers and/or parents to school in the morning. If successfully implemented it reduces the aggregate kilometres travelled and has the potential, if implemented city wide, to have an significant impact on the reduction of the morning peak volumes.

6 FOLLOW UP MEASURES TO SECURE THE LONG-TERM BENEFITS

Even though successfully implemented voluntary TDM measures (flexi-time, ride sharing etc.) and regulatory measures (parking reductions or restrictions) should lead to a possible short term reduction in private vehicle trips; a reduction in pollution; and a reduction in congestion during peak traffic in the short term, it can also lead to an increase in aggregate traffic in the medium to long term. Litman (2011) highlights the problem of generated traffic. When additional roadway capacity is provided more vehicle trips may be generated, due to the reduced cost of travel on the route. These generated trips are made up of diverted vehicle trips as well as induced vehicle trips. An increase in the aggregate number of vehicle trips per day is likely over time if there are no follow up measures to sustain the success of the initial TDM measures.

According to Vuchic (1999), urban traffic congestion reaches a point where it maintains equilibrium and it doesn't increase at the same rate as one would expect. If it does increase people take different routes, change transport mode (if available) or ultimately change destination to avoid the congestion. He states that the only way to reduce long term congestion is to reduce the point of this equilibrium. How does the point of equilibrium get changed? The ideal way, which is the focus in South Africa, is by mass transit. According to Vuchic people will take longer to consider changing to public transport if the options are not attractive, which in South Africa means safe, comfortable, convenient and affordable. With a new bus service planned for the Cape Road corridor it would make sense that a successfully implemented (voluntary) TDM programme in terms of reducing the aggregate number of vehicle trips, kilometres and minutes in congestion, can be a valuable first step to get people out of their vehicles and into alternative, sustainable modes of transport, thus helping change the point of equilibrium.

7 CONCLUSIONS AND RECOMMENDATIONS

7.1 Conclusions

- The implementation of a TDM scheme, which focuses on voluntary measures, is a strategy which will challenge people's attitudes towards travelling more sustainably. If implemented methodically and effectively it should serve as an invaluable initial measure prior to the actual segregated BRT infrastructure being implemented on Cape Road.
- In the absence of the Cape Road BRT, the initial stages of TDM implementation should focus on affecting changes in trip timing (flexi-time), route choice and vehicle occupancy (ride-sharing) until adequate alternatives are available. Once there is a good alternative transport mode (like the BRT) in place, the focus can move to changing people's mode choice.
- Successfully implemented voluntary TDM measures should lead to a possible short term reduction in private vehicle trips; a reduction in pollution; and a reduction in congestion during peak traffic, but it can also lead to an increase in aggregate traffic in the medium to long term, if there are no follow up measures to ensure the benefits are capitalised on.

7.2 Recommendations

- A Commuter Trip Reduction strategy should be implemented targeting employers and schools in the city along the Cape Road corridor and focussing specifically on morning peak traffic reduction. The initial stages should focus on voluntary measures providing incentives for flexi-time working, as well as ride sharing, with modal shift strategies being implemented once attractive alternative modes are in place. Schools should be encouraged to start pilot *walk-to-school* programmes, which can be rolled out to other schools if successful.
- A direct individualised marketing strategy pilot should be considered for one of the various suburbs which will not be served by the first BRT routes. Residents will be encouraged to travel more sustainably through dissemination of information regarding the cost benefit of travelling off peak, the reduction in pollution if travelling off peak and the reduction in energy consumption if travelling off peak. If successful, this can be rolled out to other suburbs.
- If the initial TDM measures are successful the follow up measures, such as regulatory TDM and the good quality Bus System, should be implemented soon afterwards to ensure that the increased road capacity (especially during the peak periods) is not taken up by induced/aggregate traffic. In terms of road space management the improved flow of vehicles due to the increased road capacity would mean that <u>taking a lane</u> from mixed traffic for the BRT instead of <u>adding a lane</u> would be a valid option to investigate.
- One of the biggest transport planning challenges facing South Africa is to slow the growth of private vehicle ownership and to reduce the aggregate amount of private vehicle kilometres travelled. By doing this the twin environmental threat of pollution and energy consumption will be blunted. The ultimate goal is a modal shift from private vehicle travel to public transport, and interim measures such as TDM, which can challenge people's travel behaviour, is a good first step.

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