MORNING PEAK PERIOD TRAVEL CHARACTERISTICS OF A RESIDENTIAL SUBURB IN CAPE TOWN DURING A SCHOOL AND HOLIDAY PERIOD: WHAT LESSONS CAN WE LEARN?

L. F. L. HERMANT and PROF. C. BESTER*

Jeffares & Green (Pty) Ltd, P.O. Box 38561, Pinelands, Cape Town, 7430
*University of Stellenbosch, Private Bag X1, Matieland, 7602

ABSTRACT

It is argued that an understanding of variability is central to the modelling of travel behaviour and the assessment of policy impacts and is not the peripheral issue that it has often been considered. Previous studies have shown that behaviours which make up the daily travel pattern can be highly repetitious in nature but that observing an individual's behaviour on a single day might not be representative of their routine travel and that this behaviour varies across demographic segments and driver gender.

This paper examines day-to-day travel behaviour variability of a residential area, Summer Greens, located in Cape Town using a travel numberplate dataset collected in November/December 2006.

The results showed a considerable difference in school and holiday traffic volumes as expected, but that despite this, certain identical travel behaviour patterns is observed during both these periods. It was found that the peak hour for both school and holiday periods occurred during the same time period and greater traffic volume variability was found to occur on Fridays during the holiday period than in the school period. Traffic volumes across all weeks appeared to decrease from Monday to Wednesday and "bounce back" on Thursday and Friday.

It was found that motorists exhibited more departure time freedom during the holiday period with average holiday departure times much later than during the school period. Departure times were also observed to gradually become later from Monday to Friday during both the school and holiday periods with Thursday and Friday departure times significantly different to the other weekdays. The proportion of unique vehicles observed was found to increase with time of day and the resulting impact of this on the effectiveness of Variable Message Signage (VMS) and Travel Demand Measures (TDM) applications is also discussed.

1. INTRODUCTION

When one considers the congested citybound highways occurring each morning in various cities around South Africa, it almost seems unreasonable to expect that motorists would be willing to endure such conditions on a daily basis. Certainly the peak hour volumes do not differ significantly on a day to day basis and hence the reason why transportation planners assume that travel patterns are stable i.e. have no variability, particularly when operating under capacity conditions. As a result, travel demand models are estimated on personal travel survey datasets that are collected over a one-day travel period only.

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

There is however an understanding amongst transport planners that Mondays and Fridays are non-typical days, but are classified as such purely on the basis of volume difference when compared to the other days of the working week.

Recent research conducted both locally and internationally indicates that these traffic streams, whilst stable at an aggregate macro (volume) level, change on a daily basis at a micro (or individual) level. This is because travel that is undertaken by an individual may be necessary to fulfil many activities (eg. personal business, shopping, social visits, medical/dental, etc.) that are not necessarily done on a daily basis. This variability in the traffic stream at the individual level has been referred to as "churn" (i.e. continuous change) in research by Del Mistro and Behrens in 2006 and has significant implications for the effectiveness of Travel Demand Management (TDM) policy as these policies are targeted at individual motorists rather than aggregated individuals.

The survey reported in this paper provides an alternative five-week data source, which contributes towards the understanding of travel behaviour at the origin end of a trip.

2. STUDY AREA SELECTION AND METHODOLOGY

2.1 Study Area

The residential suburb of Summer Greens located to the north east of Cape Town was identified as ideally suited for this project (refer to Figure 1 for a location and study area). The suburb is bordered by the N7 freeway to the east, the N1 freeway to the south, the Chempet/Atlantis railway line to the west and Bosmansdam Road to the North.

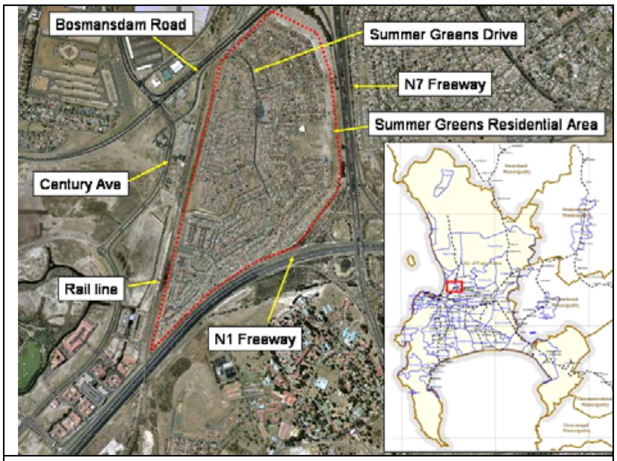

Figure 1 Summer Greens Study Area

The suburb is isolated with only one access road servicing the area, which connects directly to Century Avenue with a "Left-in" only connection from Bosmansdam Rd.

This means that all residents leaving the area are forced to use Summer Greens Drive, providing the ideal opportunity to study commuter patterns for all outbound vehicles during the morning peak period.

2.2 Methodology

Traffic vehicular data was obtained by observing vehicle numberplates over a period of five weeks from 13 November 2006 to 15 December 2006 weekdays between 06:00 and 10:00. Only the front numberplates of vehicles exiting the study area was observed with an intention to obtain a 100% capture rate.

In order to eliminate the likelihood of "spurious" matches that accompany the reading of partial plates it was decided to observe and record the full numberplate including all number prefix lettering and special custom numberplates by means of a voice recorder.

3. DATA ANALYSIS

3.1 Data Refinement and Characteristics

A data refinement process followed where unusable data was removed. A proportion of vehicles were observed without a front numberplate and so could not be used in the analysis process. It was originally thought to identify such vehicles by car model, type and colour, but variations and omissions of any of these three criteria made data matching difficult. A total of 808 vehicle trips (or 1.8%) of the total sample were trips made with vehicles without front numberplates and were removed. A further six vehicles had duplicate plates. The refinement process removed a total of 2.6% of the original data leaving 97.4% of useable data.

A total of 44 743 vehicle number plates (or trips) was observed for the duration of the five week survey period. Figure 2 shows a graphical representation of the total observed trips per 4-hour day. Yellow bars represent "sun" days, blue bars represent "rain" days and grey bars represent "overcast" days, providing a record of prevailing weather conditions experienced on the day. The graph shows slightly higher volumes on Mondays and Fridays and shows associated weather conditions which did not seem to adversely affect the volume pattern significantly. Interestingly, rain days did not affect the volume pattern in the Summer Greens survey in any way and according to the graph, appears to have somewhat reduced volumes on these days.

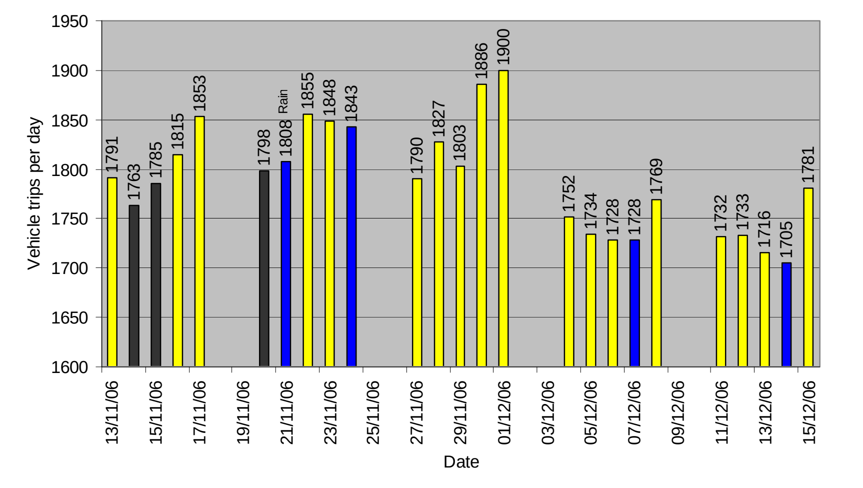

Figure 2 Total trips per day and daily weather pattern

3.2 School versus Holiday Traffic Patterns

From Figure 2, the decrease in the 4-hour trip volumes is easily identifiable with an average drop of 80 vehicles or 4.5% between the school and holiday traffic volumes. Figure 3 graphically shows the average Day of the week trip volume over the 5-week survey period.

Except for the second week of the survey, there is a tendency for volumes to drop from Monday to Wednesday and "bounce back" over Thursday and Friday which supports similar findings by Zhou and Golledge (2000).

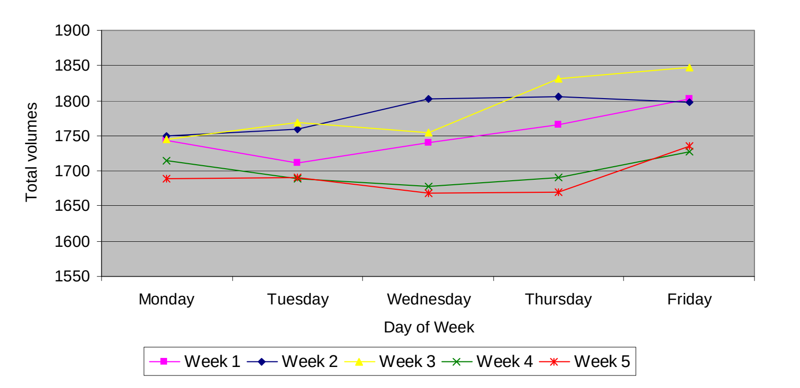

Figure 3 Average Day of the week trip volume variation across weeks

The average difference between the observed school and holiday peak hour volume is 136 vehicles representing a 17% drop in peak hour volume with the school period having a smaller standard deviation when compared to the 4-hour analysis.

3.3 The Cross-over Point

Figure 4 shows the average 15-min volumes for the school and holiday periods plotted on a time series graph.

Both school and holiday periods share the same peak hour viz. 06:45 to 07:45. In order to compare the school versus holiday traffic volumes, the volumes have been aggregated weekly. There is a noticeable difference in volumes before the 07:30 to 07:45 time period in the order of 50 vehicles per 15-min period. Also noticeable in the figure, is that the holiday average 15-min period volumes are in fact higher than the school period by 12.5% to 24% for the period from 08:00 to 09:15.

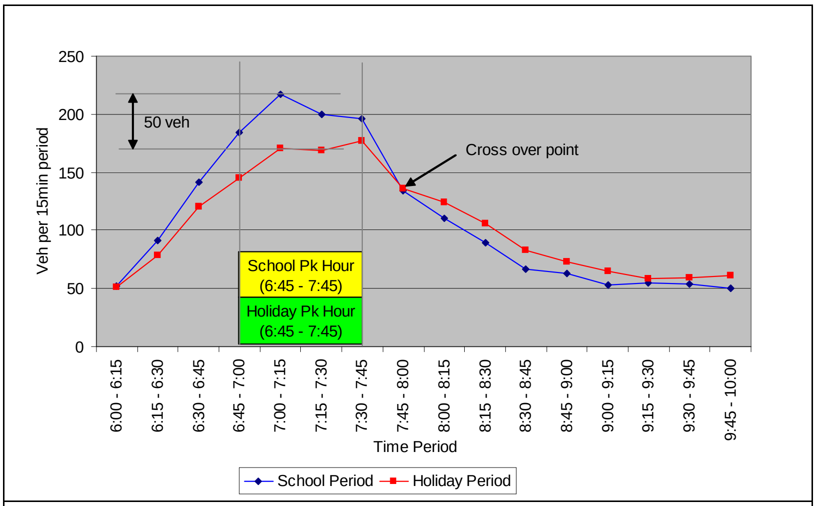

Figure 4 Time series plot in average 15-min time intervals

The point at which this starts to occur has been termed the "cross over" point and typically occurs during the 07:45 to 08:00 time interval. The higher holiday volumes after the "cross over" point is explained by the fact that working parents are no longer required to drop scholars off at school before 08:00 am and appear to have a more unrestricted departure time. This freedom is aided by the overall 4.5% lower volumes experienced during the holiday period, which allows workers to leave home later but yet reach their destinations at the same time as in the school period.

3.4 Frequency of Appearance

The frequency of appearance per week is defined as the *number of days in the week* a particular vehicle appears (excluding the total number of appearances or multiple observations of that same vehicle per day). The average weekly frequency of appearance is shown in Figure 5.

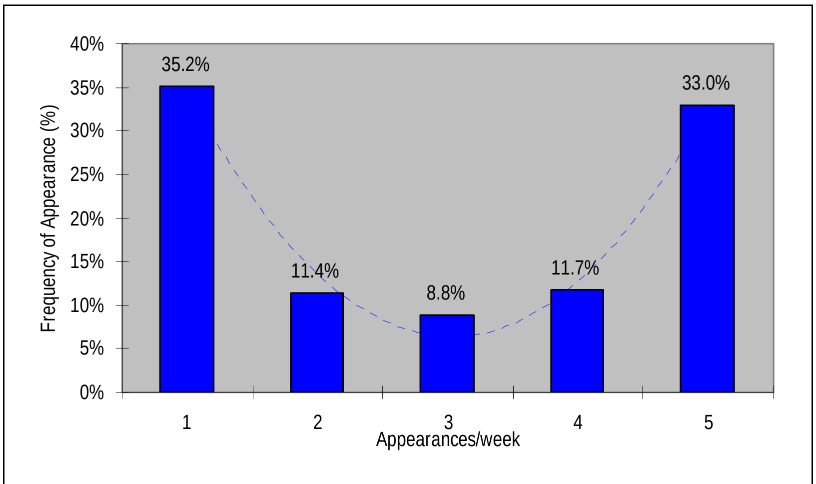

Figure 5 Average Weekly Percentage Frequency of Appearance

The Summer Greens data displays an almost similar "1 day per week" appearance percentage as the "5 day per week" appearance value resulting in a "U"- shaped data curve over the five week survey period.

3.5 Number of Trips with respect to Frequency of Appearance

The frequency of appearance per week was defined in the previous section as the number of days a particular vehicle appears over one week but did not take into account the total number of appearances (or trips) per day. Figure 6 shows the percentage of trips made with respect to the vehicle appearance frequency per week. The Summer Greens data shows a high proportion of trips in the "5 day per week" category (indicating multiple daily trips).

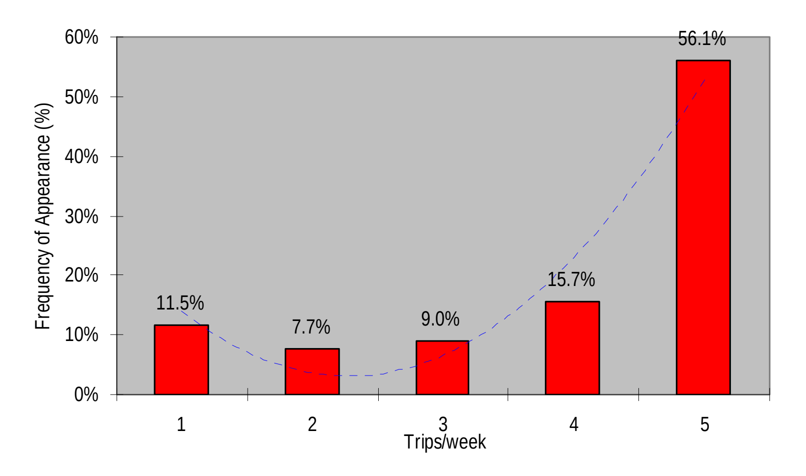

Figure 6 : Plot of Average Percentage of trips w.r.t. Frequency of Appearances per week

3.6 First Departure Time

A comparison of mean departure times of first time vehicle observations was conducted. Due to the close proximity of the survey station to the residential area, the observed departure times can be considered to be within five minutes of true origin departure times. For the purposes of this analysis, the first time of departure is taken to equal the recorded vehicle observation time.

Figures 7 and 8 shows a plot of mean observed departure times reported across "days" of the week and reported across "weeks" respectively. Times observed have been converted to a "seconds" clock starting at 0 seconds at 0:00 (midnight) and ending at 86 400 seconds at 24:00 (midnight).

The average departure time during the school period increases from Monday to Friday from 07:32 to 07:36, an increase of four minutes.

The same pattern occurs during the holiday period, but less significant ie. from 07:41 to 07:43, a difference of only two minutes.

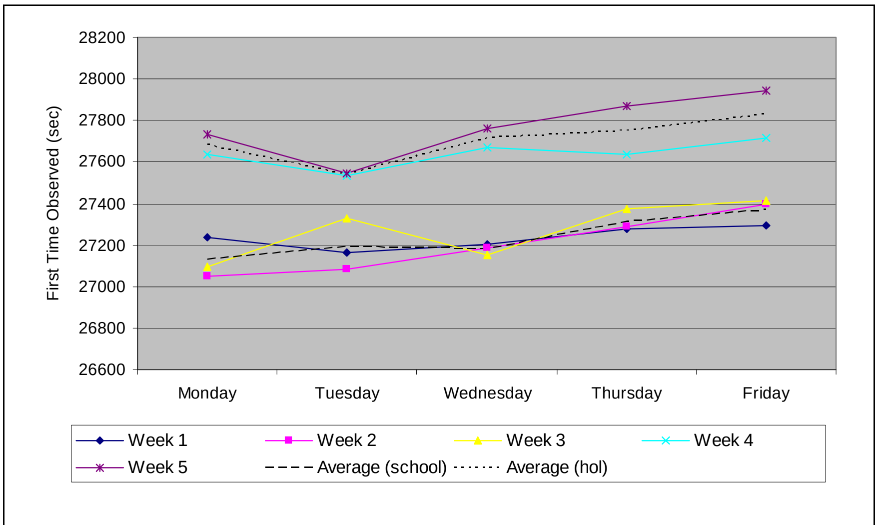

Figure 7 Mean Observed Departure Time across Days

From Figure 8, there is a significant difference of average departure times between the school period and the holiday period with an average difference of 7 minutes and 49 seconds with much later departures occurring during the holiday period.

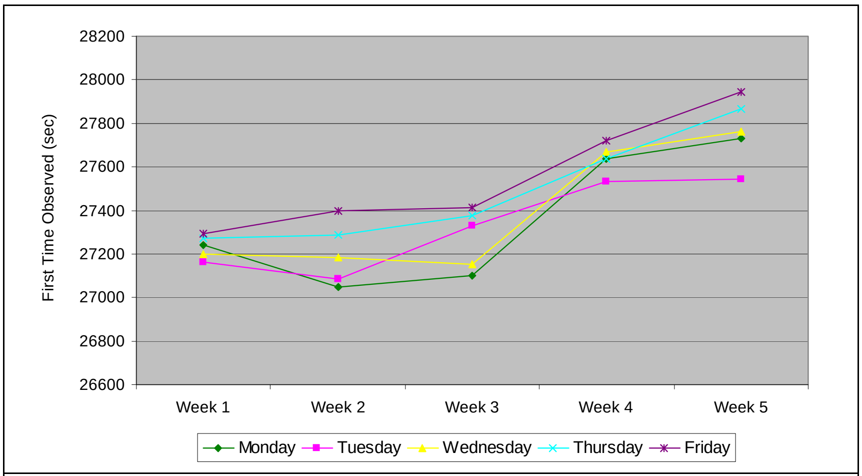

Figure 8 : Mean Observed Departure Time across Weeks

An ANOVA analysis conducted revealed that departure times on Fridays are different to all other days of the week, except for Thursday, which means that <u>both</u> Thursdays and Fridays exhibit significantly different trip departure times than the other remaining weekdays (excluding weekends). This is consistent with the findings by Pendyala (2003) who found that <u>both</u> Thursdays and Fridays are different in trip making characteristics than other weekdays and with Zhou and Golledge (2000) who found that Fridays are different from other days of the week with respect to trip making behaviour.

<u>3.7 Returning Vehicle Departure Times</u>

A time distribution analysis was conducted on the time difference of all “following day repeat” vehicles. This was calculated using the time difference between the first appearance (or occurrence) of both the initial and following day trip.

A histogram showing the distribution of time difference of following day repeat vehicles is plotted in Figure 9.

A UK study by Cherret and McDonald (2002) revealed that between 61.9% to 67.6% of all returning vehicles appeared within five minutes of each other. From the Summer Greens data, only 34.8% of returning vehicles appeared within five minutes of each other over the entire five week period. However, this value rises to 54% when the time period window is extended to ten minutes.

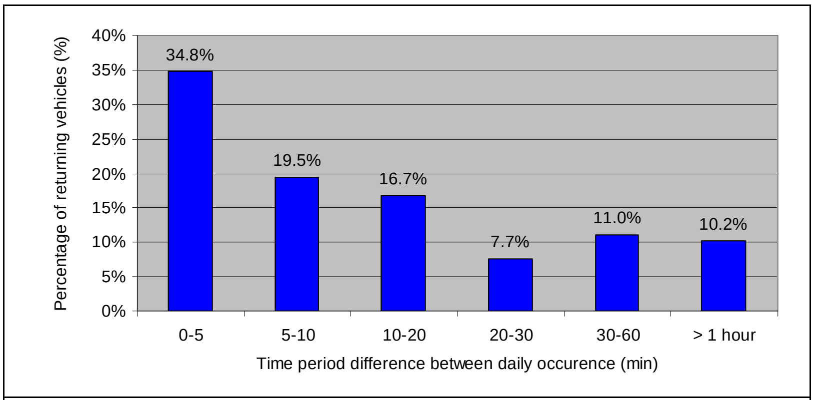

Figure 9 Time Difference Distribution of following day repeat vehicles

An ANOVA analysis revealed that there are no significant differences between the proportions of vehicles reappearing within the specified time bands for all days of the week, except between Thursday and Friday as expected, indicating that on Fridays, motorists tend to display greater departure time variability, irrespective of whether it is a school or holiday period.

3.8 Unique Vehicles

This section provides a detail of the breakdown in time periods of all "unique" vehicles observed. "Non-unique" vehicles are defined as vehicles observed on more than one day. Theoretically, the Summer Greens survey data should constitute only a small proportion of unique vehicles unless residents only use their car once in five weeks. Figure 10 shows a summary of the percentage unique vehicles for each of the three Summer Greens Scenarios (viz, overall data (all vehicles), school data (cars only) and holiday data (cars only) over the full time duration of the survey.

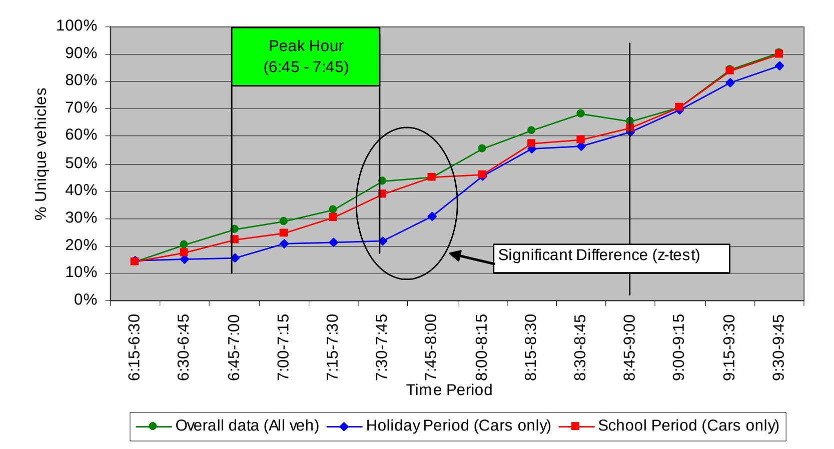

Figure 10 Summary plot of Unique vehicle proportions (School and Holiday periods)

The figure shows that vehicles appearing on more than one day formed 75% of the total traffic before 07:00 am. In the peak hour, vehicles appearing more than one day reduces from 75% to 55% over the one hour period. After the peak hour, the vehicles appearing more than once, reduces even further from 55% to 10%.

Over an average 4-hour survey day, it is observed that there are fewer unique vehicles during the holiday period than the school period perhaps as a result of a lowered business and commercial activity.

The application of VMS (or RDS) data would optimally be displayed (or broadcasted) before 07:45 when at least 75% of the vehicles are returning vehicles. After 08:15, less than 40% of vehicles are returning vehicles and based on the previous argument, the impact of VMS and RDS would diminish after this time.

3.9 Action Space

The concept of using "Action Space" plots to represent travel behaviour data was used effectively by Schönfelder (2001) and shows the most important statistics and a comparative assessment of the extent of dispersion. The box, of which the red line shows the median, is limited by the first and the third quartile of the distribution. Figure 11 shows the extent of the dispersion of action spaces for the Summer Greens dataset over the full duration of the

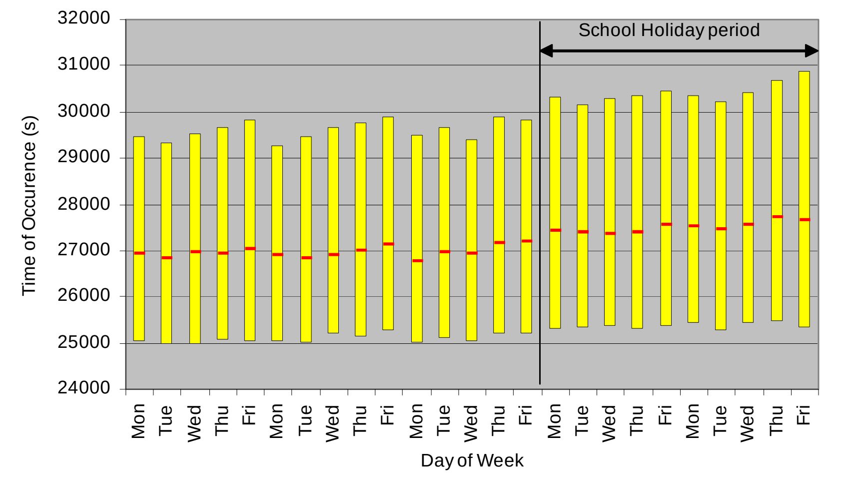

Figure 11 Plot of Vehicle Time occurrence "Action Space"

survey. In the figure, time has been converted to a 24-hour second clock.

From the figure, it can be observed that the median times during both the school and holiday periods are uniform, with the school period median time averaging at 7:29, which is lower than the holiday period median, averaging at 7:38, a difference of approximately nine minutes.

In order to view the bandwidth action space differences more clearly, the 25th to 75th percentile bandwidth values are plotted on a common zero axis and is shown in Figure 12 below. For ease of reference, all Friday bandwidths are indicated in blue.

From Figure 12, the bandwidth observations on Fridays confirm the findings of Schönfelder (2001), who found that there was more extensive use of time area space on Fridays.

Interestingly, although there are greater traffic volumes recorded during the school period, the area time spread for this period is far less than the holiday period across all days of the week. The holiday period is visibly less time constrained with larger area spaces.

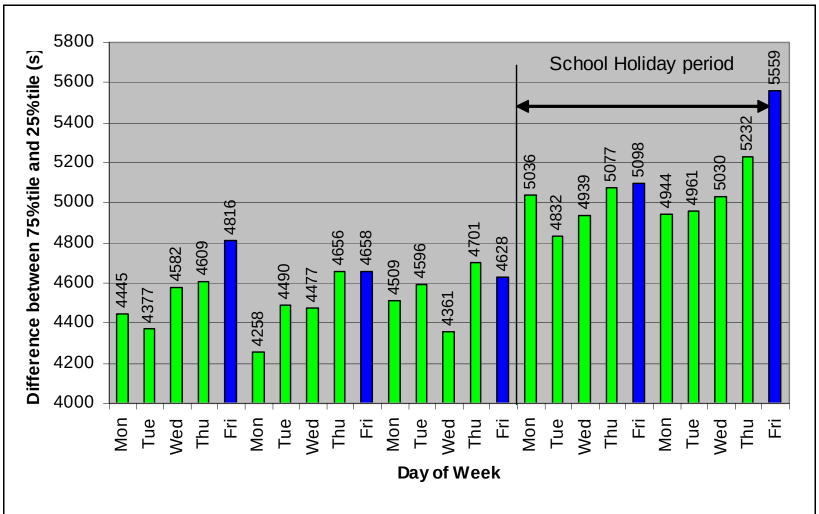

Figure 12 : Plot of 25th to 75th Percentile Bandwidth

It should also be noted that the first Monday of the holiday period experiences almost the same area space as Friday of that week. Greater use of cars on Friday outside peak times may account for the greater variation in time area spaces.

ANOVA tests revealed a significant difference between the school period versus holiday period bandwidths as expected with no significant differences in daily bandwidths within these periods. The test on the median values confirmed the median differences between school and holiday periods but with an unexpected significant median difference calculated between week 4 and 5 as well.

This final result again confirms the time flexibility available to motorists during the first week of the holiday period and the results show even more flexibility in the second week of the holiday period.

3.10 Relationship between Departure time and Observation Frequency

The purpose of identifying the relationship between departure times and weekly trip frequencies is to provide some understanding for congestion pricing strategies. A raw plot showing the average “first time of occurrence” for each of the 5309 vehicles, over the five week survey period is shown in Figure 13. The data is arranged along the x-axis according to the total no of occurrences and shows a converging data relationship with the time of first occurrence.

Figure 14 shows the action space bandwidth (ie 25th to 75th %tile values) of the "first times of occurrence" associated with each vehicle identified within the survey time period 05:45 to 10:00.

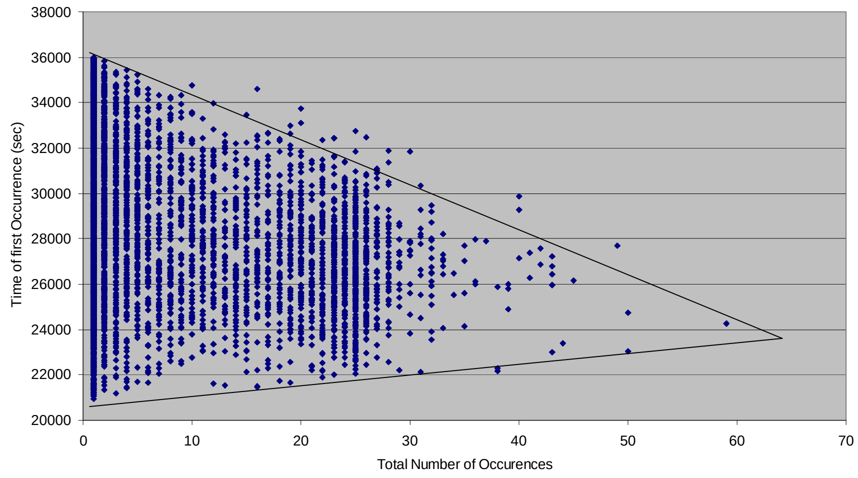

Figure 13 Plot of average "first time of occurrence"

The figure shows that there is a gradually decreasing tendency of the median "first occurrence observation" times (red tick) relative to "no. of occurrences" and that there is some "instability" after a total occurrence of around 34 observations per vehicle for the entire survey period.

The area of instability is attributable to private car business activity conducted after the peak period rather than commuting activity.

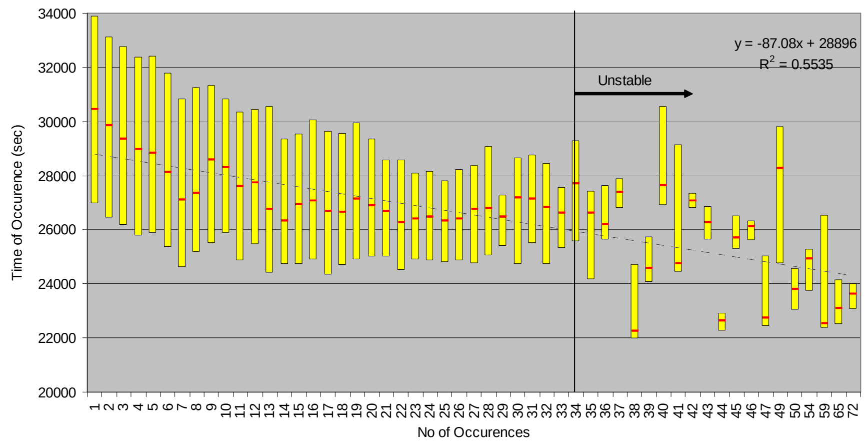

Figure 14 Average "first time of occurrence" Action Space Plot

4. APPLICATION OF DATA TO DETERMINE TDM EFFECTIVENESS

The impact of congestion pricing on this community requires an assumption to be made with regard to the willingness of these users to commit to such a TDM measure.

For the purposes of this exercise, the assumption regarding the percentage willingness of users to commit to a TDM measure is shown in Figure 15 and is dependant, on a sliding scale, on the number of vehicle occurrences per week. It is assumed that the more often a motorist undergoes a trip, the more likely that this motorist will adjust to a desirable TDM behaviour than the once-off motorist who will find it unnecessary to do this adjustment.

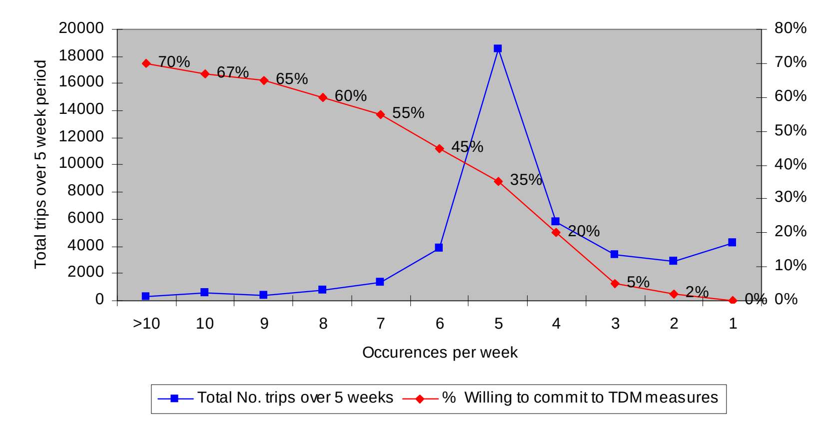

Figure 15 Assumption with respect to Willingness to Commit to TDM measures

The total number of weekly trips for both the Pre- and Post TDM scenarios is plotted in Figure 16. The figure shows that there is a substantial drop in weekly trip numbers for the "5 day per week" occurrence, despite only a 35% "willingness" assumption allocated for this group. The drop in total number of trips over the individual weeks over the 4-hour period is as follows :

Week 1 : 29.0%
Week 2 : 28.1%
Week 3 : 28.4%
Week 4 : 26.6%
Week 5 : 26.4%

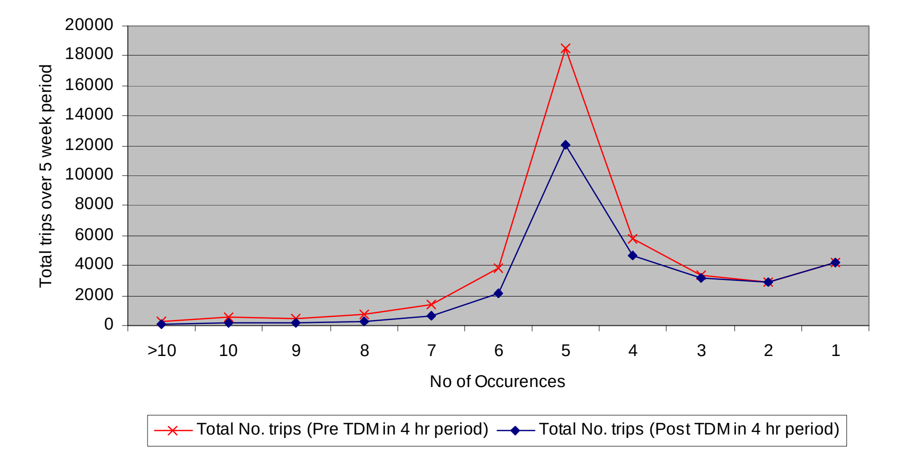

Figure 16 Total number of Pre- and Post – TDM trips for all weeks (Summer Greens)

The overall average drop in weekly trips due to the hypothetical TDM measure is 27.7% for all data within the four hour survey period. It is however argued that TDM measures would become less effective after 07:45 when a greater proportion of unique vehicles are present in the vehicle stream and so the calculated 27.7% drop in traffic should be seen as an average drop over the entire four hours.

5. REFERENCES

[1] Cherrett T. and McDonald M, 2002. "Traffic Composition during the Morning Peak Period. Implications for Urban Traffic Management Systems". Transportation Research Group, University of Southampton, Southampton, UK, July 2002

[2] Del Mistro R. and Behrens R, 2006. "Variability in traffic stream : A gateway to successful Travel Demand Management". Conference Paper : Session 1.7 Behavioural modification, University of Cape Town, August 2006

[3] Pendyala R, 2003. "Day-to-Day Variability in Travel using Lexington, KY GPS-Based Dataset" Department of Civil and Environmental Engineering, University of South Florida, 4202 East Fowler Avenue, ENB 1118, Tampa, Florida, 2003

[4] Schönfelder S, 2001. "Some notes on space, location and travel behaviour". Conference Paper presented at the 1st Swiss Transport Research Conference, Monte Verità, Ascona, March 2001

[5] Zhou J. and Golledge R, 2000. "An Analysis of Variability of Travel Behaviour within a One-Week Period based on GPS". Paper presented at the IGERT Conference, UC Davis, U.S., April 2000