Zenith Model of Victoria

Technical Note 6
Period Allocation Model and Vehicle Occupancy Model

Zenith Version: 2.0.0

VEITCH LISTER CONSULTING PTY LTD

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Contents

1 Introduction

1.1 Background

The Zenith travel model of Victoria is one of a family of models developed by Veitch Lister Consulting (VLC) for transport planning in Australian cities and regions.

This document is one in a series of technical notes that collectively describe the Zenith Model of Victoria.

1.2 Related Documents

This technical note is the sixth of eleven. The other technical notes are:

- Working Paper 1: Model Validation Framework and Data Sources
- Working Paper 2: Review of VISTA07
- Working Paper 3: Home Based Trip Production Model
- Working Paper 4: Non-Home Based Trip Production Model
- Working Paper 5: Household Segmentation & Travel Market Segmentation Models
- Working Paper 6: Period Allocation and Vehicle Occupancy Models
- Working Paper 7: Mode Choice Model
- Working Paper 8: Destination Choice and Trip Attraction Model
- Working Paper 9: Overall Model Validation
- Working Paper 10: Backcasting and Sensitivity Testing
- Working Paper 11: Reference Case Model Assumptions

1.3 Scope of this Document

This document focusses on two key model components: the period allocation model, and the vehicle occupancy model.

The *Period Allocation Model* assigns person trips output by the *Destination Choice Model* to specific periods of the day. It is implemented in the Zenith model prior to running of the *Mode Choice Model.*

The *Vehicle Occupancy Model* is run after the *Mode Choice Model* and converts person trips made by car into car driver and car passenger trips.

Section 2 of this Working Paper describes the broad framework (or dimensions) of the Zenith model within which the *Period Allocation Model* and the *Vehicle Occupancy Model* have been developed. This includes the trip purpose breakdowns used by the Zenith model, and the periods of each weekday that are modelled.

Section 3 describes the structure of the *Period Allocation Model* and details the model calibration parameters that have been derived from VISTA07.

Section 4 provides equivalent information for the *Vehicle Occupancy Model.*

1.4 Data Sources for Model Calibration

The primary source of period allocation and vehicle occupancy data was the Victorian Integrated Survey of Travel and Activity 2007 (VISTA07). Version 1.3 of the VISTA07 was made available to VLC. This survey was used to estimate model parameters for both models.

The VISTA07 sample comprises 43,822 people, from 17,715 households. In total there are 128,744 reported trips between May 2007 and June 2008, which is considered to be a very healthy sample for the calibration of a strategic travel model.

Not all of the survey responses are usable for our purposes. Travel made by residents living outside of the Zenith model area (specifically, in Shepparton and the Latrobe Valley), and travel made on weekends, during school vacation periods and on public holidays have not formed part of the estimation sample. That leaves a sample of 7,228 households (42% of the total sample); still a very healthy sample.

2 Modelling Framework

This section of the Working Paper briefly describes the structural elements of the Zenith model relevant to the development of both the *Period Allocation Model* and *Vehicle Occupancy Model.* It details the trip purpose categories and weekday time periods adopted by the Zenith model, as well as the travel market segmentation used by the model in relation to the level of car availability of households making trips.

2.1 Trip Purposes

The Zenith model includes trip purposes relating to:

- Travel made by people residing in the modelled area
- Travel made by overseas visitors, Australian visitors and people living in regions contiguous to the modelled area
- Commercial vehicles (freight)

This Working Note only concerns itself only with the first item above - i.e. *travel made by residents* - as this is the travel market surveyed as part of VISTA07.

The journey purposes of travel made by residents within the modelled area are broken down by the Zenith model, as follows:

Home Based

- Home based work (white collar) (HWW)
- Home based work (blue collar) (HWB)
- Home based education (primary) (HPR)
- Home based education (secondary) (HSE)
- Home based education (tertiary) (HTE)
- Home based shopping / personal business (HBS)
- Home based recreation / social (HBR)
- Home based serve passenger / other (HBO)

Non-home based

- Work based work (WBW)
- Work based shopping (WBS)
- Work based other (WBO)
- Shopping based shopping (SBS)
- Shopping based other (SBO)
- Other non-home based (ONHB)

2.2 Modelled Weekday Time Periods

The Zenith model predicts travel made on an average weekday during school term time, and excluding public holidays. Within the day travel is separately forecast for the following four periods of the day.

- Morning peak - 7:00 am to 9:00 am
- Evening peak - 4:00 pm to 6:00 pm
- Inter-peak - 9:00 am to 4:00 pm
- Off-peak - 6:00 pm to 7:00 am

2.3 Travel Market Segmentation with Respect to Household Car Ownership

The *Trip Production Module* of the *Trip Generation Model* outputs person trips by journey purpose for each travel zone, based on the number of households in each zone and their profile of household attributes (number of white collar workers, blue collar workers, number of dependants and their age profile and household car ownership).

The *Travel Market Segmentation Model* then splits these trips into trips made by households that do not have access to a motor vehicle, those that have 1 car, 2 cars and 3+ cars. This is performed separately for each journey purpose. This trip purpose/car availability segmentation of the travel market is maintained through both of the key Zenith modules - *Trip Distribution* and *Mode Choice*.

The fact that Zenith splits the travel market by both trip purpose and household car availability enables the development of a more sophisticated and robust *Vehicle Occupancy Model*, as it is clearly evident from VISTA07 that whether people choose to travel in a car as a driver or passenger is highly sensitive to both the journey purpose of the trip being undertaken, and the car availability of the household in which the person making the trip resides.

This will be more apparent from the data presented in Section 4 of this Working Note.

3 The Period Allocation Model

The aim of the *Period Allocation Model* is to take account of differences in trip making behaviour by trip purpose and time of day to enable distribution of trips to appropriate travel periods of a typical weekday during school term time. The model has been recalibrated using the Victorian Integrated Survey of Travel and Activity results for 2007 and 2008 (VISTA07).

The *Period Allocation Model* is applied immediately after the *Destination Choice Model* and before the *Modal Choice Model*.

3.1 The Concept of "Outward" and "Inward" Travel

Once execution of the *Trip Generation* and *Destination Choice* models is complete, each and every trip will have both an origin and destination defined.

The role of the *Period Allocation* model is to allocate each trip to a period (ie. AM peak, Inter Peak, etc).

Unlike many standard four step models, Zenith explicitly links both directions of a return trip when calculating destination and mode choices. For this to be possible, each return trip must be allocated both an "outward" and "inward" time – in other words, the time at which the outward leg is made, and the time at which the inward (or return) leg is made.

The definition of "outward" and "inward" trips is hierarchical. The basic rules are as follows:

1. All home-based trips, irrespective of trip purpose, are "outward" if the origin of the trip is the home. If the home is the destination of a trip then it is an "inward" trip.
2. For non-home-based travel all trips that have work as the origin are regarded as "outward", and all trips with work as the destination as "inward", with the exception of work-based-work trips where all trips are split 50/50 between "inward" and "outward".
3. For non-home-based travel all trips that have shopping (other than where work is the other end of the trip) are regarded at "outward", and all trips with shopping as the destination as "inward", with the exception of shopping-based-shopping trips where all trips are split 50/50 between "inward" and "outward".
4. Other non-home-based trips are split 50/50 between "inward" and "outward" travel.

Given the above rules, here are a couple of examples:

- I travel to work in the morning (the outward leg), and return home in the evening (inward leg).
- I travel from work to the local shops to buy lunch (outward leg), and then return to work (inward leg).

3.2 How Travel Reported in VISTA07 is Allocated to Time Periods

Each trip recorded in the VISTA07 survey was designated a trip purpose according to the activities being undertaken at the origin and destination of the trip. Based on the reported start time and end time of each trip, they were then allocated to the hour of the day within which the trip was undertaken. However, if a trip spanned across more than one hour then it was proportionally

allocated across the hours of the day within which the travel occurred. For example, a trip from home to secondary school (HSE), which departs at 7:30 am and arrives at 8:30 am will result in 0.5 of an "outward" trip being recorded for both the 7:00 am travel hour (7:00 am -7:59 am) and the 8:00 am travel hour (8:00 am-8:59 am).

All weekday trips during school term time that were recorded in VISTA07 were aggregated by trip purpose, outward travel hour, and inward travel hour, and expressed as a percentage of the total number of daily trips for that trip purpose.

3.3 Period Allocation Analysis using VISTA07

Analysis of VISTA07 reveals the percentage of travel for each trip purpose, direction (outward or inward), and hour of the day on a typical weekday during school term time.

3.3.1 Outward trips

Figure 1 shows the distribution of home-based and non-home based outward travel across the day. During the early part of the day (i.e. prior to 10:00 am) home-based trips are dominant. This is to be expected as most travel as this time is originating from the home.

As the day progresses the non-home based component of outward travel increases. From midday through to the end of the evening peak (at 6:00 pm) non-home-based travel constitutes the majority of outbound travel.

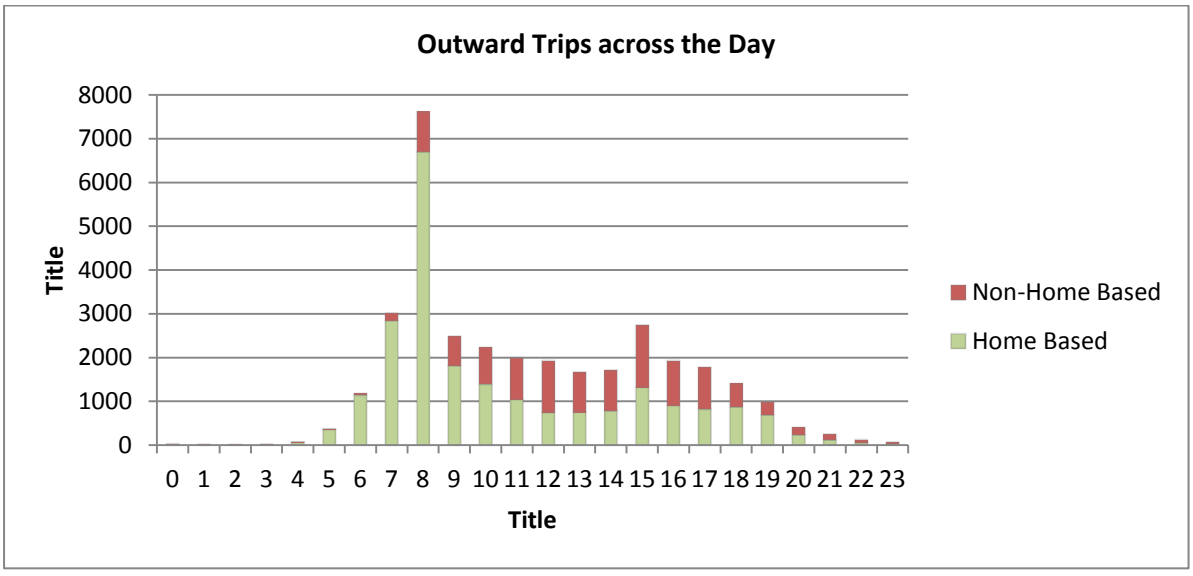

Figure 1: Plot of outward trips across the day

Figure 2 shows the trip purpose profile of outward home-based travel across the day.

Interestingly, this diagram shows that the amount of outbound home-based travel occurring on the transport network between 8:00 am and 9:00 am is more than double that in any other hour of the day. During this hour the largest trip purpose category is HBO (people serving the needs of their passenger - mainly dropping children at school and the car access leg of kiss-and-ride public

transport trips), followed by HWW (white collar work trips), HPR (primary school students) and HSE (secondary school students).

During the middle of the day, and in the evening, shopping (HBS) and recreational trips (HBR) comprise the majority of outbound home-based travel.

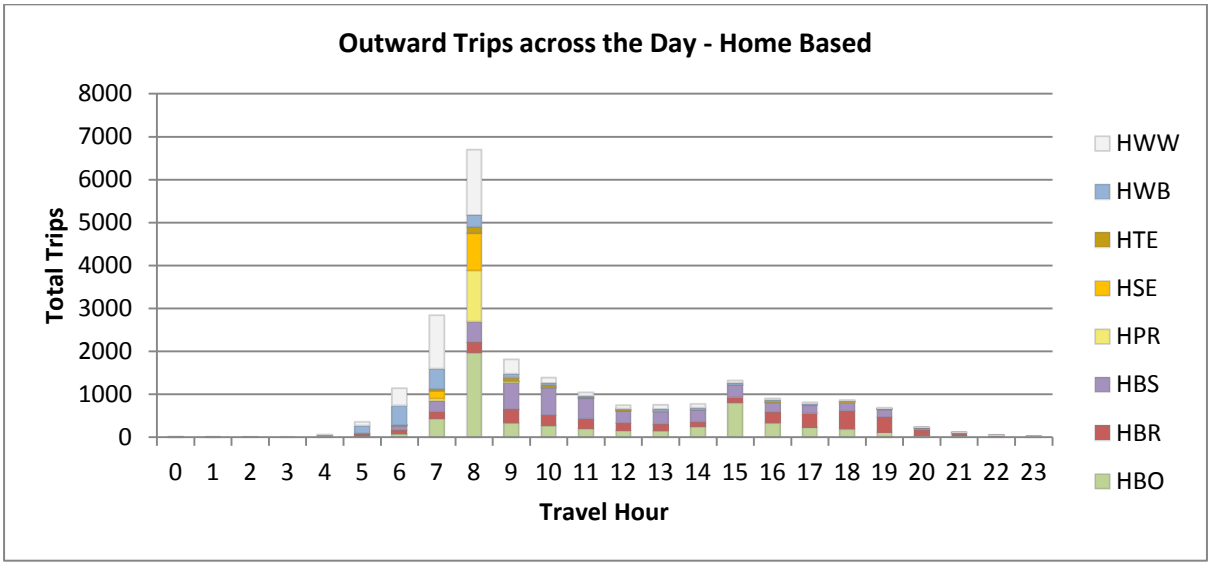

Figure 2: Plot of outward trips across the day – Home Based

Figure 3 shows the profile of outbound non-home-based travel across the day.

The two major outward non-home-based trip purpose categories are WBS (work based shopping) and SBS (shopping based shopping). WBS demand is at its most intense during the lunchtime period and evening peak. SBS demand is spread more evenly across the day.

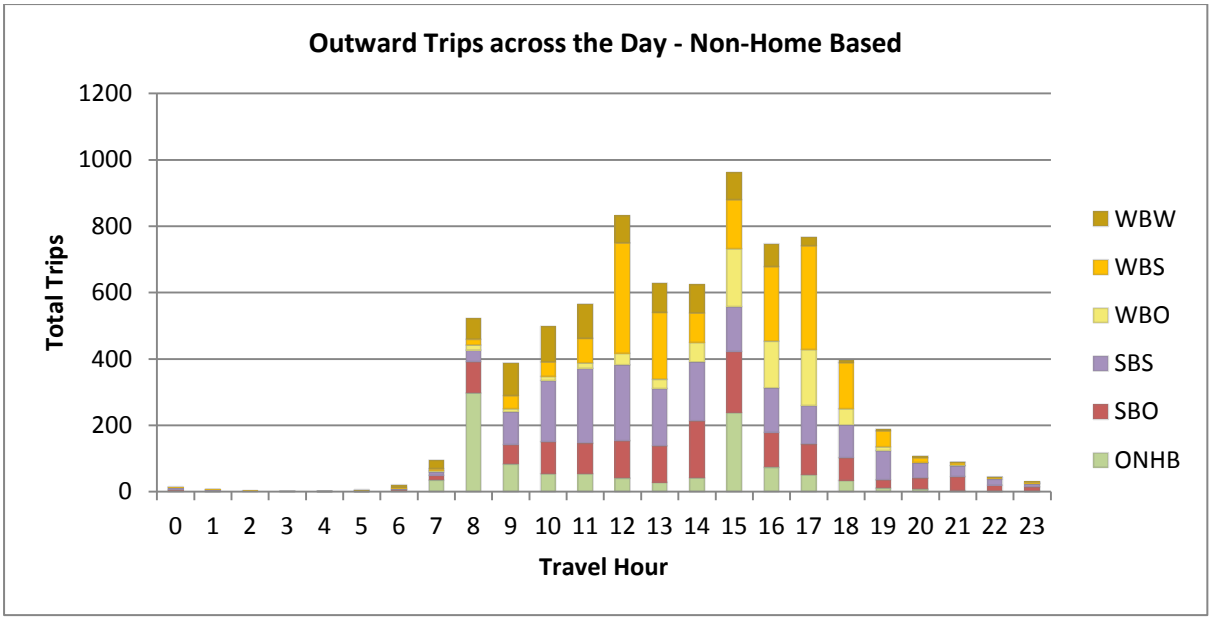

Figure 3: Plot of outward trips across the day – Non-Home Based

3.3.2 Inward trips

The profile of inward travel demand across the day is presented in Figure 4.

The majority of inward home-based travel occurs after 3:00 pm, while inward non-home based travel occurs almost exclusively in the morning and early afternoon.

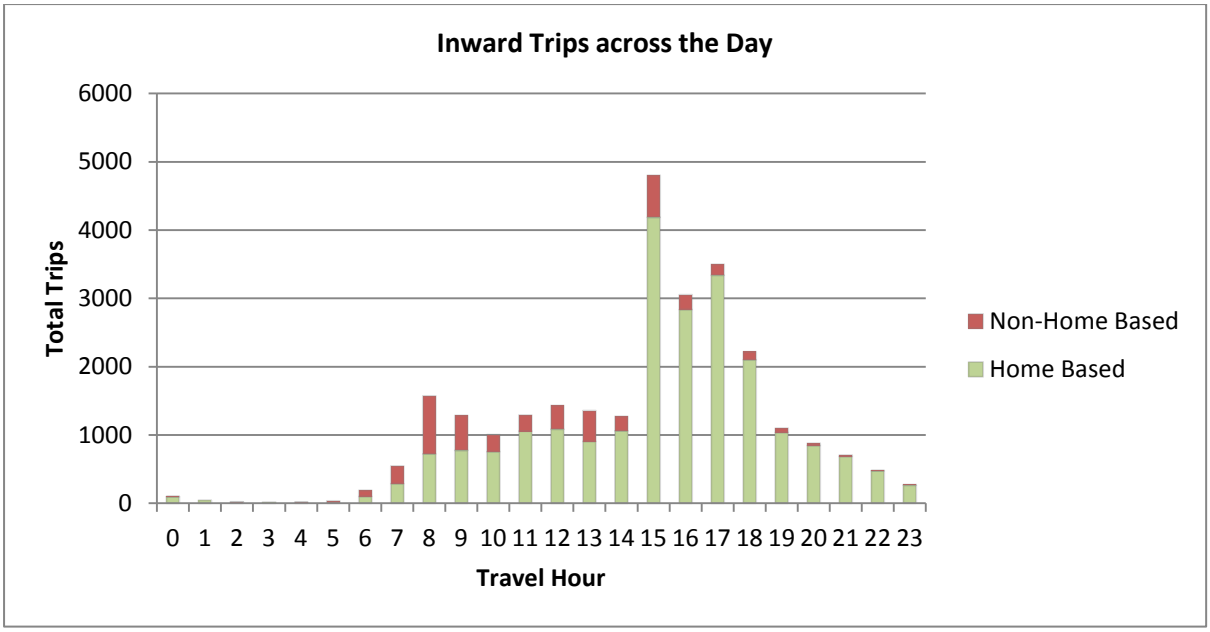

Figure 4: Plot of inward trips across the day

Figure 5 presents the trip purpose profile of inward home-based travel across the day.

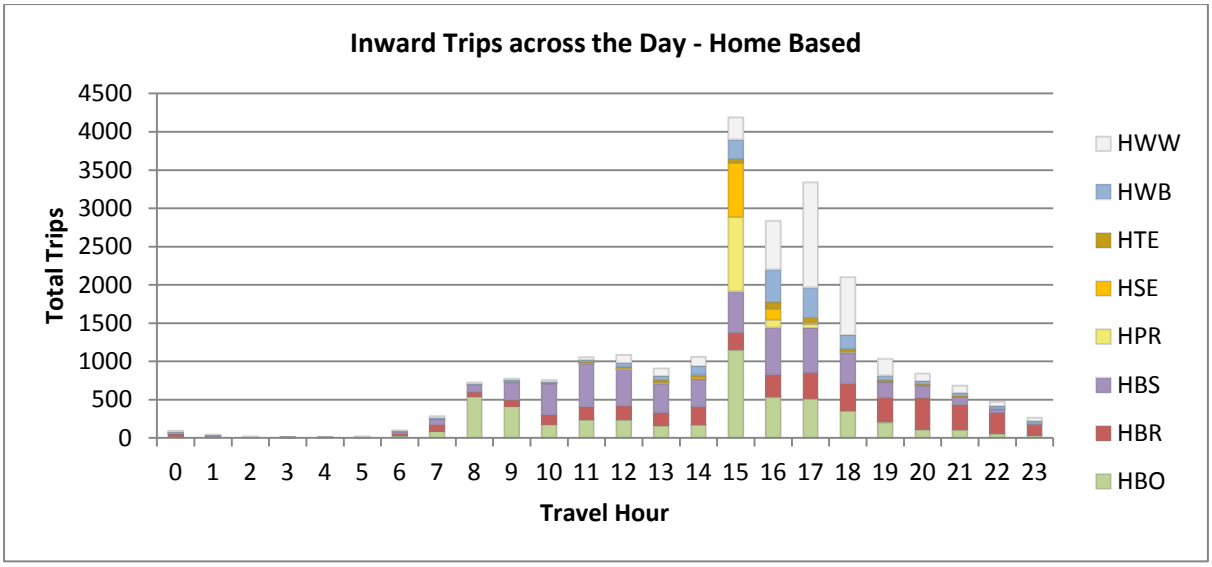

Figure 5: Plot of inward trips across the day - Home Based

As expected, shopping (HBS), recreation (HBR) and serve passenger/other (ONHB) travel occurs across a broad spectrum of the day, while inward work and education travel is mainly confined to the latter half of the afternoon.

Figure 6 shows the profile on non-home-based inward travel demand across the day.

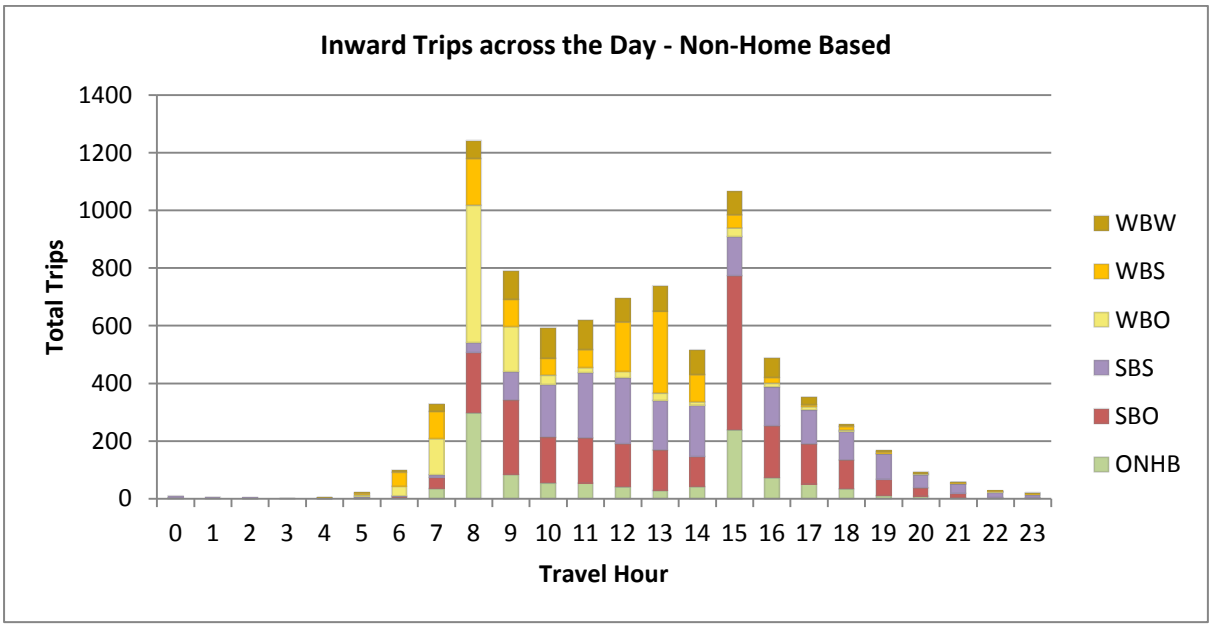

Figure 6: Plot of inward trips across the day – Non-Home Based

As for outward travel, WBS and SBS are the largest non-home-based travel category for inward travel. Work-based-other inward trips (WBO) are confined to the early morning.

3.4 Period Allocation Factors

The Zenith model links the outward and inward legs of journeys when making decisions about destination and mode. This process explicitly recognises real world constraints; for example, it is usually not possible to take public transport to work, and then drive home.

To accommodate this, period allocation factors must be defined for each combination of outward and return time.

Table 1 through Table 17 list the period factors included in the model for each trip purpose. In the case of Home Based Work (both blue and white collar), the factors are separately defined for three "areas":

- Non CBD
- CBD Core
- CBD Non Core

As can be seen in Table 1 through Table 3, the period allocation factors for Home Based Work (White Collar) vary significantly between the three areas. In particular, the proportion of travel which occurs in the AM Peak (Outward) -> PM Peak (Return) is much higher for the CBD Core (0.5336 versus 0.4146). This has a large impact on the amount of peak travel to/from the CBD (ie. the CBD rail cordon).

A similar effect can be observed for Home Based Work (Bluc Collar) in Table 4 through Table 6.

HWW	AM Peak	Inter Peak	PM Peak	Off Peak	Total
AM Peak	0	0.0865	0.4146	0.1153	0.6164
Inter Peak	0	0.0482	0.0802	0.1047	0.2331
PM Peak	0	0	0	0.026	0.026
Off Peak	0	0.0528	0.0386	0.0331	0.1245
Total	0	0.1875	0.5334	0.2791	1

Table 1 - Period Allocation Factors - Home Based Work (White Collar) – Non CBD

HWW	AM Peak	Inter Peak	PM Peak	Off Peak	Total
AM Peak	0	0.0351	0.5336	0.1558	0.7245
Inter Peak	0	0.0229	0.0968	0.1137	0.2334
PM Peak	0	0	0	0	0
Off Peak	0	0	0	0.0421	0.0421
Total	0	0.058	0.6304	0.3116	1

Table 2 - Period Allocation Factors - Home Based Work (White Collar) - CBD Core

HWW	AM Peak	Inter Peak	PM Peak	Off Peak	Total
AM Peak	0	0.0226	0.3568	0.2121	0.5915
Inter Peak	0	0	0.1243	0.189	0.3133
PM Peak	0	0	0	0	0
Off Peak	0	0.0242	0.024	0.047	0.0952
Total	0	0.0468	0.5051	0.4481	1

Table 3 - Period Allocation Factors - Home Based Work (White Collar) - CBD Non-Core

HWB	AM Peak	Inter Peak	PM Peak	Off Peak	Total
AM Peak	0	0.0776	0.2508	0.0417	0.3701
Inter Peak	0	0.0519	0.0401	0.0914	0.1834
PM Peak	0	0	0	0.0399	0.0399
Off Peak	0	0.1783	0.1714	0.0568	0.4065
Total	0	0.3078	0.4623	0.2298	0.9999

Table 4 - Period Allocation Factors - Home Based Work (Blue Collar) – Non CBD

HWB	AM Peak	Inter Peak	PM Peak	Off Peak	Total
AM Peak	0	0.0323	0.3975	0.1206	0.5504
Inter Peak	0	0.0164	0.1288	0.1273	0.2725
PM Peak	0	0	0	0	0
Off Peak	0	0.0665	0.0631	0.0476	0.1772
Total	0	0.1152	0.5894	0.2955	1.0001

Table 5 - Period Allocation Factors - Home Based Work (Blue Collar) - CBD Core

HWB	AM Peak	Inter Peak	PM Peak	Off Peak	Total
AM Peak	0	0.0597	0.3071	0.1266	0.4934
Inter Peak	0	0	0.1181	0.0838	0.2019
PM Peak	0	0	0	0	0
Off Peak	0	0.1311	0.0977	0.0759	0.3047
Total	0	0.1908	0.5229	0.2863	1

Table 6 - Period Allocation Factors - Home Based Work (Blue Collar) - CBD Non-Core

HSE	AM Peak	Inter Peak	PM Peak	Off Peak	Total
AM Peak	0	0.8962	0.0703	0	0.9665
Inter Peak	0	0.0335	0	0	0.0335
PM Peak	0	0	0	0	0
Off Peak	0	0	0	0	0
Total	0	0.9297	0.0703	0	1

Table 7 - Period Allocation Factors - Home Based Education – Secondary

HTE	AM Peak	Inter Peak	PM Peak	Off Peak	
AM Peak	0	0.1496	0.1312	0.0225	0.3033
Inter Peak	0	0.2821	0.2311	0.0951	0.6083
PM Peak	0	0	0	0.0369	0.0369
Off Peak	0	0	0	0.0514	0.0514
Total	0	0.4317	0.3623	0.2059	0.9999

Table 8 - Period Allocation Factors - Home Based Education - Tertiary

HBS	AM Peak	Inter Peak	PM Peak	Off Peak	Total
AM Peak	0.0292	0.063	0.0261	0	0.1183
Inter Peak	0	0.471	0.1092	0	0.5802
PM Peak	0	0	0.0502	0.0392	0.0894
Off Peak	0	0	0	0.2121	0.2121
Total	0.0292	0.534	0.1855	0.2513	1

Table 9 - Period Allocation Factors - Home Based Shopping

HBR	AM Peak	Inter Peak	PM Peak	Off Peak	Total
AM Peak	0.022	0.0596	0	0	0.0816
Inter Peak	0	0.2245	0.0706	0.0492	0.3443
PM Peak	0	0	0.0392	0.1209	0.1601
Off Peak	0.0051	0	0	0.4089	0.414
Total	0.0271	0.2841	0.1098	0.579	1

Table 10 - Period Allocation Factors - Home Based Recreation

HBO	AM Peak	Inter Peak	PM Peak	Off Peak	Total
AM Peak	0.1057	0.1639	0.0497	0.0224	0.3417
Inter Peak	0	0.3706	0.06	0	0.4306
PM Peak	0	0	0.0638	0.0312	0.095
Off Peak	0	0	0	0.1327	0.1327
Total	0.1057	0.5345	0.1735	0.1863	1

Table 11 - Period Allocation Factors - Home Based Other

WBW	AM Peak	Inter Peak	PM Peak	Off Peak	
AM Peak	0.0243	0.0878	0.0078	0	0.1199
Inter Peak	0	0.762	0.0288	0	0.7908
PM Peak	0	0	0.0645	0	0.0645
Off Peak	0	0	0	0.0249	0.0249
Total	0.0243	0.8498	0.1011	0.0249	1.0001

Table 12 - Period Allocation Factors - Work Based Work

WBS	AM Peak	Inter Peak	PM Peak	Off Peak	Total
AM Peak	0	0	0	0	0
Inter Peak	0.0523	0.6811	0	0	0.7334
PM Peak	0.0643	0.1085	0	0	0.1728
Off Peak	0	0.0413	0	0.0524	0.0937
Total	0.1166	0.8309	0	0.0524	0.9999

Table 13 - Period Allocation Factors - Work Based Shopping

WBO	AM Peak	Inter Peak	PM Peak	Off Peak	Total
AM Peak	0.0235	0	0	0	0.0235
Inter Peak	0.1378	0.3796	0	0.0564	0.5738
PM Peak	0.2283	0.0938	0	0.0172	0.3393
Off Peak	0.0271	0.0363	0	0	0.0634
Total	0.4167	0.5097	0	0.0736	1

Table 14 - Period Allocation Factors - Work Based Other

SBS	AM Peak	Inter Peak	PM Peak	Off Peak	Total
AM Peak	0	0.0218	0	0	0.0218
Inter Peak	0	0.5878	0.044	0.0104	0.6422
PM Peak	0	0	0.067	0.032	0.099
Off Peak	0	0	0	0.2371	0.2371
Total	0	0.6096	0.111	0.2795	1.0001

Table 15 - Period Allocation Factors - Shopping Based Shopping

SBO	AM Peak	Inter Peak	PM Peak	Off Peak	Total
AM Peak	0.0293	0.0273	0	0	0.0566
Inter Peak	0.0362	0.6288	0.0229	0	0.6879
PM Peak	0	0.0735	0.0353	0	0.1088
Off Peak	0	0.0156	0.0301	0.101	0.1467
Total	0.0655	0.7452	0.0883	0.101	1

Table 16 - Period Allocation Factors - Shopping Based Other

ONHB	AM Peak	Inter Peak	PM Peak	Off Peak	Total
AM Peak	0.0693	0.1795	0.047	0	0.2958
Inter Peak	0	0.5528	0.0449	0	0.5977
PM Peak	0	0	0.0396	0.0264	0.066
Off Peak	0	0	0	0.0405	0.0405
Total	0.0693	0.7323	0.1315	0.0669	1

Table 17 - Period Allocation Factors - Other Non-Home Based

4 The Vehicle Occupancy Model

4.1 Vehicle Occupancy Parameters

Vehicle occupancy results were calculated by investigating the driver and car passenger behaviour for each trip purpose. The vehicle occupancy parameters are the ratio of the number of people travelling by car to the number of drivers for each trip purpose. These calculations are used to convert trips made into vehicles using the road network. The results are shown below inTable 18.

Table 18: Vehicle occupancy parameters by purpose

Purpose		0 Cars	1 Car	2 Cars	3+ Cars
HWW	CBD	N/A*	1.471 (50)	1.088 (148)	1.094 (58)
	Non-CBD	2.250 (18)	1.137 (1020)	1.044 (3329)	1.037 (1866)
HWB	CBD	N/A*	1.250 (10)	1.000 (19)	1.750 (7)
	Non-CBD	2.000 (16)	1.146 (487)	1.084 (1614)	1.066 (1038)
HTE	CBD	N/A*	N/A*	1.000 (1)	1.000 (3)
	Non-CBD	2.000 (2)	1.196 (67)	1.200 (174)	1.140 (212)
HSE	CBD	N/A*	N/A*	N/A*	N/A*
	Non-CBD	N/A*	N/A*	49.444 (445)	12.400 (186)
HPR	CBD	N/A*	N/A*	N/A*	N/A*
	Non-CBD	N/A*	N/A*	N/A*	N/A*
HBS	CBD	N/A*	1.250 (10)	1.471 (25)	1.600 (8)
	Non-CBD	2.828 (82)	1.370 (2418)	1.362 (3791)	1.235 (1638)
HBR	CBD	1.000 (1)	2.100 (21)	1.889 (17)	1.250 (5)
	Non-CBD	6.000 (48)	1.522 (1420)	1.798 (3069)	1.483 (1213)
HBO	CBD	N/A*	1.333 (16)	1.308 (17)	1.800 (9)
	Non-CBD	5.667 (17)	1.406 (2226)	1.477 (5677)	1.317 (1721)
WBW	CBD	N/A*	1.286 (9)	1.071 (30)	1.083 (13)
	Non-CBD	N/A*	1.108 (206)	1.080 (716)	1.060 (526)
WBS	CBD	N/A*	1.200 (6)	1.000 (4)	1.000 (3)
	Non-CBD	1.833 (11)	1.102 (398)	1.077 (872)	1.075 (515)
WBO	CBD	1.000 (1)	1.250 (10)	1.077 (14)	1.333 (8)
	Non-CBD	1.000 (1)	1.047 (312)	1.067 (881)	1.048 (307)

Purpose		0 Cars	1 Car	2 Cars	3+ Cars
SBS	CBD	1.000 (1)	2.000 (2)	1.000 (3)	N/A*
	Non-CBD	7.333 (22)	1.363 (894)	1.403 (1361)	1.374 (558)
SBO	CBD	1.000 (1)	1.000 (4)	1.500 (6)	1.500 (6)
	Non-CBD	3.600 (18)	1.672 (744)	1.681 (1674)	1.440 (560)
ONHB	CBD	N/A*	1.000 (4)	1.500 (3)	1.200 (6)
	Non-CBD	2.500 (5)	1.830 (430)	2.168 (1097)	1.737 (304)

- N/A – Vehicle occupancy factor not applied. No vehicle driver trips detected in VISTA07
- The numbers in parentheses are the number of person trips by car recorded in VISTA07 for each cell of the table.

It is evident from Table 9 that there is considerable variation in average vehicle occupancy by journey purpose, level of household car availability and whether a trip is destined for the CBD or travelling within the suburbs.