1. PURPOSE

The purpose of this note is to document the procedure followed to calculate mode choice parameters and check the validation of the mode choice sub model.

2. INTRODUCTION

In the mode choice phase of the analysis the aim is to calculate how many people, travelling between particular origin and destination would use each of the available modes. The most common form of discrete choice model applied to mode choice is multinomial logit model. This model is derived by assuming that people have a choice between a number of discrete alternatives or modes, e.g. Car versus bus versus train. The characteristics (times, costs etc.) of each alternative determine the satisfaction that people get from each mode. The logit model predicts the probability that an individual will choose a particular alternative (mode m). The logit function used took the form:

$$\rho_m = \frac{\exp(-\lambda u_m + \beta)}{\sum_{k=1}^{n} \exp(-\lambda u_k + \beta)}$$

Where:

ρ_m	=	probability of choosing mode m
$-u_m$	=	utility of mode m (based on cost)
λ, β	=	logit model coefficients
n	=	the set of available modes

The model incorporate four modes:

- Car driver
- Car passenger
- Bus passenger
- Active (Walking/cycling modes combined)

The utility[1] function $-u_m$ incorporates variety of variables that influence mode choice and is usually formulated as a linear function of variables reflecting the attributes of the modes (e.g. Time, parking cost, fare cost, transfer cost etc). As the utility of a particular mode improves, reflecting for example, a reduction in travel time, the model will predict an increase in the probability that a person trip will be made by using that mode.

If the probability of choosing mode m is ρ_m and the total number of people travelling between an origin and a destination is T_{ij} the number predicted to use mode m will be:

$$T_{ij}^m = \rho_m * T_{ij}$$

where the value for T_{ij} is obtained from the trip distribution model.

[1] Or more correctly the 'disutility' function

The weighting of the generalised cost components are usually calibrated from stated preference survey data. Such data was not available in this project and the weightings were be taken from generally accepted practice and are detailed below.

Calibration of λ and β will be undertaken by matching the proportionate mode split measured from the HIS data. The nested logit model can be schematically represented as shown in the Figure 1 below.

This structure was followed for Home to work and Home to education, with all of the other purposes combined

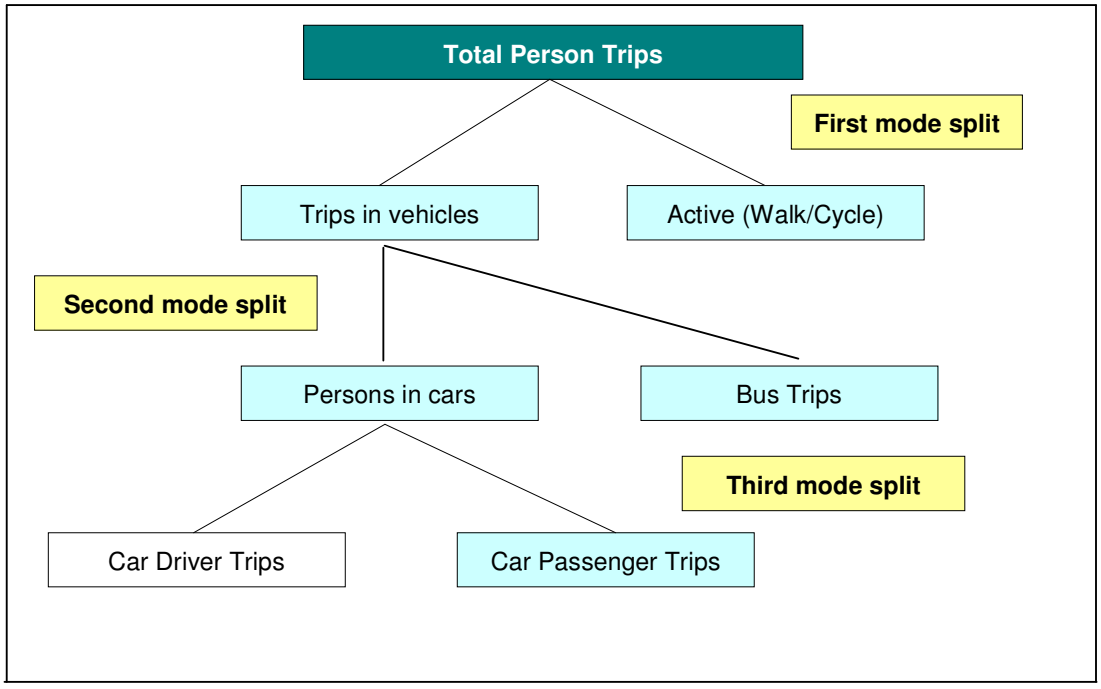

Figure 1

Structure of the Nested Logit Mode Choice Model

3. GENERALISED COST WEIGHTING VALUES

The components that make up the generalised cost and in turn the utility of travel are

- Walk time from origin to bus stop and from stop to destination
- Wait time at the stop or for a transfer
- Fare paid
- Travel time
- Transfer penalty

Of these, the only cash item is the fare paid – all the others are expressed in minutes times a weighting factor to convert then into cents, relative to the fare which (by definition) has a weighting of 1.0.

The values used are shown in **Table 1**.

Generalised Cost Components			Table 1
	Value		***Comment***
Component	***Am Peak***	***Inter Peak***	
Car in vehicle time	32.96 c/min	38.71 c/min	In car cost from TN15 Table 5
Car distance	17.00 c/km	17.00 c/km	In car cost from TN15 Table 1
PT Ride Cost	17.41 c/min	15.92 c/min	As per TN15 with no "Work travel" costs in formulation
Walk cost	34.82 c/min	31.84 c/min	Twice the ride cost
Wait Cost	34.82 c/min	31.84 c/min	Twice the ride cost
Transfer penalty	69.64 cents	63.68 cents	4 min penalty

The derivation of the car time and distance values have been set out in Technical Note 15 – The Four Step Distribution Model. The PT ride cost per minute has been establishing using the same methodology as that outlined, however all trip purposes other than Home Based Work assume "Non-work" trip costs from Table 1 with no "Work Travel" costs included in the formulation.

According to PT literature, walk and wait costs are typically twice the ride costs with a transfer penalty being in the order of a five minute penalty. For the WRTM four step validation process, this has been reduced to four minutes to get a closer fit against the number of public transport patrons transferring between services (as recorded in the Bus Intercept Survey).

4. LOGIT PARAMETER CALIBRATION AND VALIDATION

As noted above, there are two coefficients for each mode taken into the logit model, namely λ and β. In combination with the utility function for each mode, these determine the mode split. The β coefficient is often called the mode specific constant and should be as small as possible.

An initial estimate of the λ values was made using target mode split values and setting the β values at zero, and adjusting the λ values to achieve the target mode split. These were than further adjusted manually together with the B for the dominant mode in each split until the target mode split was achieved.

The modelled trip purposes have been grouped together prior to the model split as presented in **Table 2** (AM peak) and **Table 3** (Interpeak) based on those purposes which have a similar mode share. Based on the analysis an appropriate grouping of trip purposes for the two periods ended up being different. The primary intention of aggregated the purposes in the mode split component of the model was to produce a more compact model without compromising quality

The aggregate groupings are as follows:

In the AM Peak – Home Based Work; Home Based Education; and All Other Purposes.

In the Interpeak – Home Based Work; All Other Home Based Purposes and Non Home Based.

Home Based Education was not isolated in the interpeak (11am – 1pm) as there were few trips in this purpose and they were dominated by primary and secondary school trips as in the morning peak. Whilst the NHB purpose is a significant chunk of trips in the morning peak period, the mode split for this purpose was not substantially different to the non work or education "home based other" purposes. For this reason they have been aggregated together.

Table 2 summarises the logit model coefficients for each of the purposes in the morning peak period, and **Table 3** those for the Interpeak periods, including the surveyed (target) and modelled mode splits.

Logit Model calibration and Validation – AM Peak						Table 2
Morning Peak Home Based Work						
Mode	**λ**	**β**	**Target%**	**Model Trips**	**Model%**	**Difference**
In vehicle	0.010	0.001	93.3%	84425	93.3%	0.0
Active	1.135	0	6.7%	6103	6.7%	0.0
In Car	0.100	0.001	98.2%	82915	98.2%	0.0
Bus Passenger	0.205	0	1.8%	1511	1.8%	0.0
Car Driver	0.001	0.001	92.8%	76774	92.6%	-0.2
Car Passenger	2.470	0	7.2%	6142	7.4%	+0.2
Morning Peak Home Based Education						
Mode	**λ**	**β**	**Target%**	**Model Trips**	**Model%**	**Difference**
In vehicle	0.052	0.001	57.9%	45629	57.9%	0.0
Active	0.083	0	42.1%	33191	42.1%	0.0
In Car	0.230	0.001	95.6%	43676	95.7%	+0.1
Bus Passenger	0.130	0	4.4%	1953	4.3%	-0.1
Car Driver	1.790	0.001	12.8%	5540	12.7%	-0.1
Car Passenger	0.003	0	87.2%	38137	87.3%	+0.1
Morning Peak Home all other purposes						
Mode	**λ**	**β**	**Target%**	**Model Trips**	**Model%**	**Difference**
In vehicle	0.010	0.001	92.7%	185383	92.8%	+0.1
Active	1.820	0	7.3%	14334	7.2%	-0.1
In Car	0.100	0.001	99.4%	184185	99.4%	0.0
Bus Passenger	0.320	0	0.6%	1199	0.6%	0.0
Car Driver	0.110	0.001	68.4%	125710	68.3%	-0.1
Car Passenger	0.575	0	31.6%	58477	31.7%	+0.1

Logit Model calibration and Validation – Inter Peak						Table 3
Inter Peak Home Based Work						
Mode	***λ***	***β***	***Target%***	***Model Trips***	***Model%***	***Difference***
In vehicle	0.001	0.001	92.9%	30002	92.8%	+0.1
Active	1.130	0	7.1%	2316	7.2%	-0.1
In Car	0.400	0.001	99.0%	29697	99.0%	0.0
Bus Passenger	0.320	0	1.0%	306	1.0%	0.0
Car Driver	0.001	0.001	95.0%	28172	94.9%	-0.1
Car Passenger	3.700	0	5.0%	1525	5.1%	+0.1
Inter Peak Home Based All Other						
Mode	***λ***	***β***	***Target%***	***Model Trips***	***Model%***	***Difference***
In vehicle	0.005	0.001	89.3%	107524	89.2%	-0.1
Active	0.950	0	10.7%	12979	10.8%	+0.1
In Car	0.310	0.001	98.7%	106093	98.7%	0.0
Bus Passenger	0.290	0	1.3%	1432	1.3%	0.0
Car Driver	0.525	0.001	68.5%	72710	68.5%	0.0
Car Passenger	1.225	0	31.5%	33384	31.5%	0.0
Inter Peak Non Home Based						
Mode	***λ***	***β***	***Target%***	***Model Trips***	***Model%***	***Difference***
In vehicle	0.005	0.001	86.4%	119164	86.5%	+0.1
Active	0.710	0	13.6%	18581	13.5%	-0.1
In Car	0.310	0.001	99.7%	118731	99.6	-0.1
Bus Passenger	0.480	0	0.3%	434	0.4	+0.1
Car Driver	0.530	0.001	76.5%	90817	76.5%	0.0
Car Passenger	1.165	0	23.5%	27915	23.5%	0.0

The Model Specification Report contained the following criteria for Mode Split

Mode Split
Model Output: Proportion by mode
Check: That the observed mode split is matched by the model
Criteria: All modes within ± 2% over the model area.

The morning peak and interpeak mode splits are both well within these criteria, not only by mode but by purpose as well.