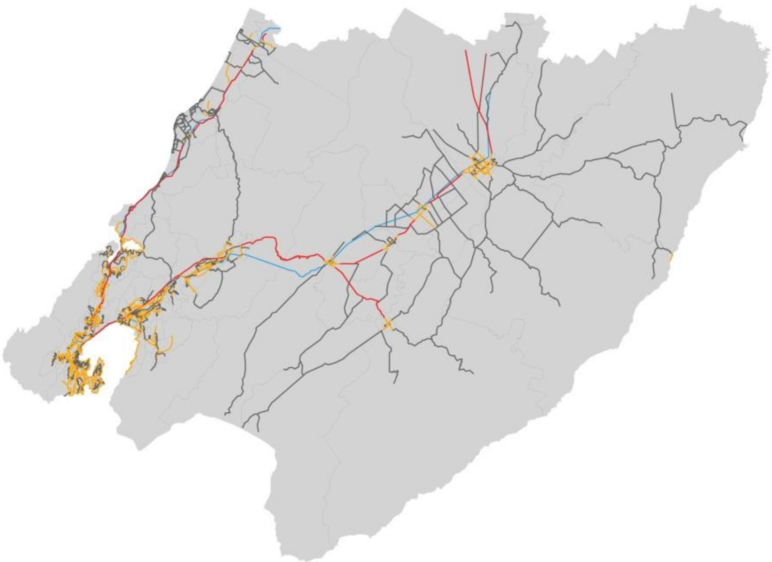
OPUS INTERNATIONAL CONSULTANTS AND ARUP

WELLINGTON TRANSPORT MODELS

Contract No C3079



TN6: WPTM Specification

Date: December 2012

ARUP OPUS

Wellington Transport Models

TN6: WPTM Specification

prepared for

Greater Wellington Regional Council

Prepared By

Dan Jones (Arup)

Reviewed By

Bruce Johnson (Arup)

Opus International Consultants Limited
Wellington Office
Level 9, Majestic Centre, 100 Willis Street
PO Box 12003, Wellington 6144
New Zealand
Ph: +64 4 471 7000

Arup
Level 17, 1 Nicholson Street
Melbourne VIC 3000
Australia
Ph: +61 3 9668 5500

Date:	December 2012
Reference:	g:\localauthorities\wrc\proj\5-c2050.00 - c3079 wtsm wptm\600 deliverables\630 final tech notes\tn6 wptm specification final.docx
Status:	Final
Revision:	1

Document History and Status

Issue	Rev	Issued To	Qty	Date	Reviewed	Approved
Draft	1	Nick Sargent - GW		3/11/2011	Bruce Johnson	Bruce Johnson
Final	-	David Dunlop - Opus		24/02/2012	Dan Jones	Dan Jones
Final	1	Nick Sargent - GW	1 Hard & 1 CD	06/12/2012	Dan Jones	Dan Jones

This report takes into account the particular instructions and requirements of our client. It is not intended for and should not be relied upon by any third party and no responsibility is undertaken to any third party.

John Bolland: ______________________________
(Peer Reviewer)

Nick Sargent: ______________________________
(GWRC)

Contents

1 Introduction

Opus International Consultants Limited (Opus) and Arup Australia (Arup) were commissioned by Greater Wellington Regional Council (GWRC) to rebase the existing 2006 Wellington Transport Strategy Model (WTSM) to a new base year of 2011. Opus updated the WTSM while Arup developed a Wellington Public Transport Model (WPTM) based on figures from WTSM and detailed public transport surveys. The whole process of model updates and development is complex and involves several steps which have each been individually reported in a series of technical notes.

This note outlines the proposed design of the WPTM. Each element of this model is discussed in this document. The purpose of this note is to give users an understanding of WPTM by detailing how it operates.

1.1 Overview of WPTM

Key features of the proposed structure and operation of the Wellington Public Transport Model (WPTM) are described in this section.

- The model time periods will be 0700-0900 (AM peak) and 2 hour average of 0900-1500 (IP);
- Base public transport demand matrices will be developed from observed data sources: rail on-board surveys, rail boarding and alighting counts, bus on-board surveys, and bus ticket sales data;
- Total observed public transport (PT) travel between zones will be established by adding the observed bus and rail demand (and ferry and cable car if available);
- The role of WPTM is to divide out the total observed demand among the available PT modes, routes, stops and network access options;
- The validity of the model will be judged by assessing how well WPTM replicates the split of base demand between bus and rail modes, routes and stations;
- The demand will be **segmented** by trip purpose, car availability status and age (child/adult). This will enable differing public transport choice behaviours and values to be represented. For example, a person with no car available cannot choose park and ride. Six segments are proposed;
- Growth in public transport demand, as population and employment grows and as the transport system changes, will be determined by linkages to the regional 4-stage model, Wellington Transport Strategy Model (WTSM);
- Demand growth rates will be extracted from WTSM and applied to the observed PT demand in WPTM by multiplication (demand factoring) or by addition. Greenfield development zones are a special case, for which a different approach is proposed;
- The access choice decision for rail – whether to walk to the station or to take the car (Park and Ride (P&R) or Kiss and Ride (K&R)) – will be determined using a logit choice model. We propose to operate this choice model in 'absolute' formulation. This means that the observed shares are used only to calibrate the model: in application mode, the choice model predicts the shares. This allows for us to forecast in completely new markets as well as forecasting changes in existing markets;
- For those who choose P&R or K&R, there will be a second layer of choice to divide demand between the best three access stations. The car-access PT trips are then assigned via the nominated station. For the calibration of the base model, P&R and K&R will only be possible via rail as the first boarding. After alighting from rail, they are free to continue their journey by any mode (or on foot);

- In application of the model, new ‘formal’ P&R sites served by bus or new modes such as light rail can also be modelled;
- For those who choose walk-access to PT, the stop or station chosen, and the mode and route boarded will be determined through assignment;
- Mode-specific preferences for bus and rail (and future modes Bus Rapid Transit (BRT) and Light Rail Transit (LRT)) will be represented through differential boarding times and / or in-vehicle time weights, coded on the EMME network. These will be informed by practice elsewhere and refined through calibration;
- The mode-specific preferences will give WPTM sensitivity to quality differentials between rail, light rail, BRT and bus, including capability to estimate benefits of upgrading from bus to light rail for example; and
- The car times and distances required to calculate utilities for P&R and K&R will be obtained from the corresponding WTSM run; public transport times and costs will be calculated within WPTM.

2 Model Structure

2.1 Introduction

The proposed model structure and linkage with WTSM is shown in Figure 2-1.

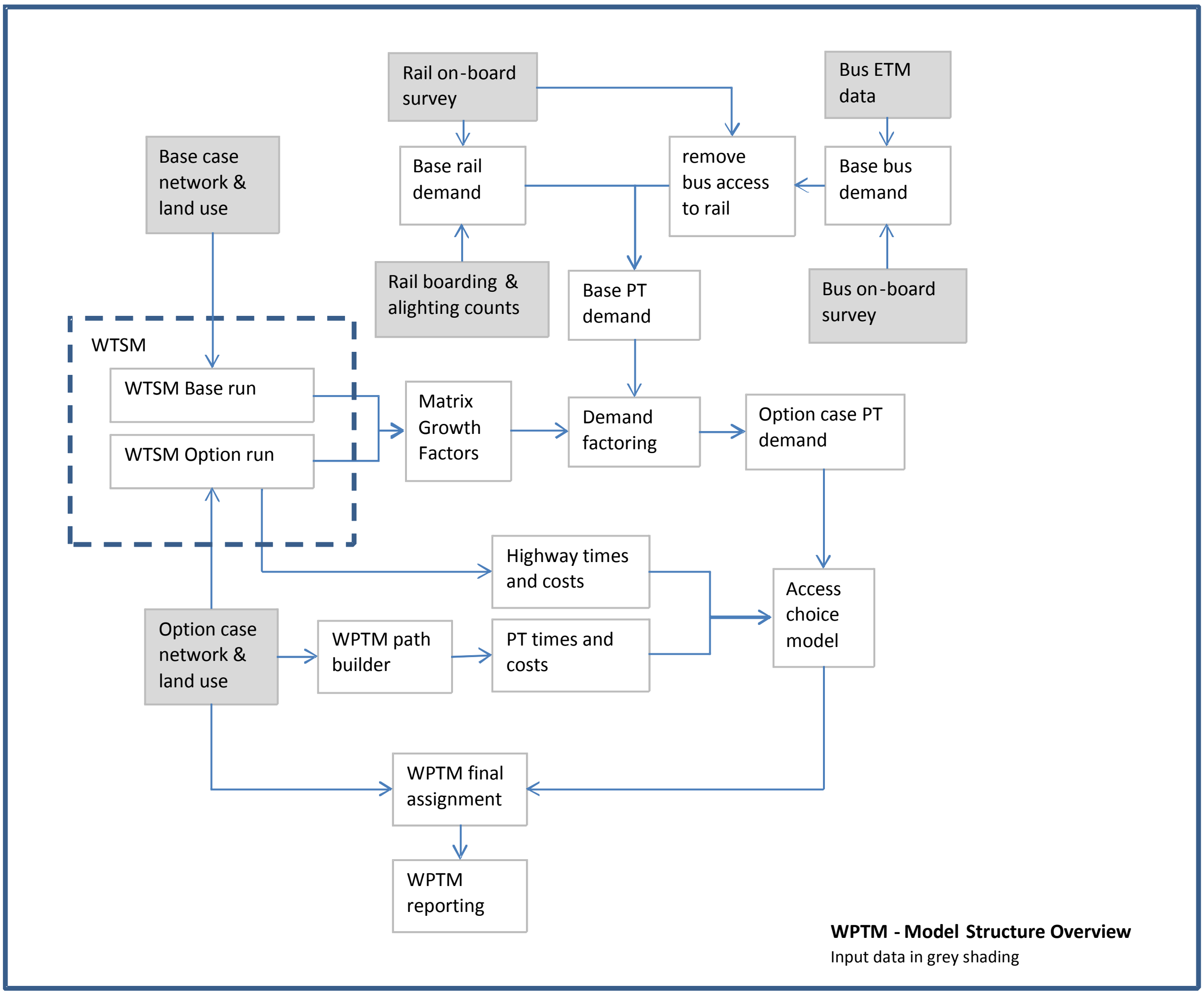


Figure 2-1: WPTM Proposed Model Structure

The details, and an explanation of how this structure was chosen, are described in this technical note. In summary, WPTM comprises:

- A database of base public transport (PT) demand built up from observed data;
- Links with WTSM to allow for growth factor expansion of observed PT demand in future years and option cases;
- An access choice model to divide PT demand between walk-in, P&R and K&R and – for car access choices – the access location; and
- An assignment model for the calculation of times and costs and to determine modes, routes and stops used.

2.2 Time Periods

The AM peak time period for WTSM and WPTM will be 0700-0900, allowing for consistent times, costs and growth rates to be transferred between WTSM and WPTM.

In the Inter peak (IP) period, WPTM will differ slightly from WTSM. The WTSM IP period is a 2 hour average from 0900-1600. For WPTM, the preference is for the IP period to end an hour earlier, at 1500, Between 1500 and 1600, the mix of trip purposes changes significantly as school and commuter trips start to ramp up, which, if it were included, would detract from WPTM (in its representation of a typical IP hour).

AM peak: 0700 - 0900

Inter peak: Average 2 hours in period 0900 – 1500

Trips will be allocated to a time period based on the boarding time (first boarding, where this can be discerned from the bus Electronic Ticketing Machine (ETM) data).

Further details on the choice of IP time period are provided in file note: “WPTM inter-peak time period” dated 18 January 2012.

2.3 Access to Public Transport

A key requirement for WPTM is modelling of access choices to PT, and in particular to rail, including “Park and Ride” (as driver or passenger) or “Kiss and Ride” (as drop offs).

In WTSM, access choice (of sorts) is undertaken as part of the assignment. Rail can be accessed from zones via regular centroid connectors or, in some cases, via “P-connectors”. The regular connectors give access via the street network for walking and bus access to rail stations. The P-connectors provide direct access between zones and rail stations, and are representative of car and other motorised mode access.

The process of choosing an approach for WPTM is discussed in Section 2.4.

2.4 Model Structure Options

For WPTM, a decision had to be made on the role for the assignment model (EMME) and the role for choice modelling techniques such as logit. Options considered are summarised in Table 2-1.

Table 2-1: Options Considered

Option	Access mode choice		Access location choice		PT mode / route choice	
	first boarding	‘main’ mode boarding	car	not car	‘main’ mode	route(s)
1	Assignment (via P-connector for car or regular connector for walk)				Assignment	
2	-	Rail/bus (logit)	Best station	Assignment	Logit	Assignment
3	-	Rail/ bus (logit)	Multiple stations (logit)	Assignment	Logit	Assignment
4	Logit	-	Multiple stations (logit)	Assignment	Assignment	Assignment

Option 1 is the WTSM approach of using assignment to divide demand between walk access via regular centroid connectors, and motorised access, including P&R, via so-called P-connectors. During the WTSM update peer review in 2008, we found this approach had a tendency to an all-or-nothing result: where a P-connector option is provided, 100% of trips use it, which limits the ability of WTSM to assess feeder bus, P&R, station catchments etc.

We concluded that the P-connector approach is reasonable for generating zone to zone times and costs for a demand model (e.g to determine trip distribution and mode share), but is not useful for final assignment.

Option 2 is the method used in the earlier version of WPTM, developed in-house by Greater Wellington Regional Council (GWRC). The P-connector approach is replaced by a two-layer logit choice model: access mode at the upper level and PT sub-mode at the lower level. We would agree that logit is a suitable approach for access choice, which tends to be determined as much by non-modelled personal circumstances as by modelled travel times and costs. In the original WPTM design, it appears that only one access station could be selected for each origin-destination pair, which means that the model would struggle to predict the division of demand between competing P&R sites.

Regarding PT sub-mode choice, the use of a logit function to split demand between rail and bus gives more analyst control over the bus vs. rail choice than would be the case with assignment, which may be useful in corridors where bus and rail are in competition such as Johnsonville. Overall though, our experience is that a logit approach to sub-mode is most successful where mode choices are quite ‘distinct’ e.g. airport fast rail vs. metro vs. bus. It is less appropriate in a multi-modal setting where networks and fares are integrated, and where one mode is designed to feed another, not to compete. Wellington is moving towards this type of integrated system. Use of logit in this setting can lead to overemphasis on the mode per-se, and loss of focus on the more important question of actual performance.

A downside of the logit approach to sub-mode choice is one mode needs to be somewhat arbitrarily defined as the primary or ‘main’ mode (in the case of the initial WPTM, this was considered to be rail). This more-or-less arbitrary designation has implications for the results, and may predispose the model to support rail projects over bus. Another, well documented, difficulty arises when a new mode is added that did not exist in the base calibration, such as LRT or BRT. Is it to be treated as a bus, a train or something entirely new? If the latter, a more complex model structure is required, and calculation of user benefit becomes more complicated.

Option 3 is an improvement of Option 2 through the addition of multiple station choice to the access model. This allows for passengers accessing by car to choose between driving to a local station with a stopping service or driving to a more distant station with an express service, for example. This would be useful in the Wellington context.

In **Option 4**, the station choice model of Option 3 is adopted but the sub-mode choice functions are undertaken by the assignment software. This overcomes the problems with logit articulated above for Option 2. The downside of Option 4 is that there is less analyst control over the bus vs. rail split, which may be seen as a good thing or a bad thing, but certainly makes assignment model calibration more challenging.

With sub-mode choice being the role of the assignment model in Option 4, the definition of a ‘main’ mode is no longer required, and the access choice model may be simplified.

2.5 Selected Structure

Option 4 was selected as the preferred method for WPTM. It is simple and takes advantage of the relative strengths of the two approaches – an assignment model to allocate demand to modes and routes, and logit models for access choice that is unsuited to assignment (access choices being influenced by non-modelled personal circumstances as much as the travel times and costs).

Mode-specific preferences of bus, rail and other modes will be captured in the assignment model through use of variable weights applied to in-vehicle time, boarding or wait time.

A question remains as to which access choices are modelled. This is considered next.

2.6 Access Choices

Table 2-2 shows the access choices reported from the 2011 on-board bus and rail surveys.

Table 2-2: Access Modes to PT

	Train		Bus	
Access	AM	IP	AM	IP
Walk / cycle	44%	59%	85%	94%
Bus	6%	13%	3%	2%
Train	1%	1%	4%	2%
Car driver (PR)	26%	12%	3%	1%
Car passenger	24%	15%	5%	2%

Source: On-board bus and initial rail surveys, 2011. Excludes missing data.

Car access to bus is very limited: only 3% (AM) and 1% (IP) of bus passengers are park and riders, and no more than 5% are car passengers. This is perhaps unsurprising given that there is no dedicated bus P&R in the Wellington region, though some low level P&R and K&R occurs at major interchanges such as Johnsonville.

The picture is very different for rail, particularly in the AM peak when half of all passengers access rail by car (more or less evenly split between drivers and passengers).

Given the low level of car access to bus, our proposal is to calibrate the access model for access to rail, and to apply the base model to rail and ferry (Days Bay). For option testing, car access will also be modelled to any new dedicated P&R, whatever mode serves it.

The interchangers, such as bus to train and train to bus, will be dealt with at assignment level, as described in the previous section. The access choice model deals only with how to get from the trip origin (e.g. the home) to the place where the first public transport service is boarded. Hence a [home]-walk-bus-rail-walk-[workplace] journey is treated as “walk access to bus” in the WPTM access model, not as “bus access to rail”. It is the role of the WPTM assignment to determine what transit legs follow this (bus-rail vs. bus-all-the-way etc.).

The only access option to bus (other than at dedicated bus P&R sites in option testing) will be walk. The survey data is too sparse to calibrate car access to bus, and allowing car access to bus would present severe problems of EMME licence size because an extra (dummy) zone is needed for each parking / drop-off site, of which there are potentially very many for bus. The proposed access choices are summarised in Table 2-3.

Table 2-3: Available Access Modes

	Access Mode		
1st boarding	Walk or cycle	Park & Ride	Kiss & Ride
Bus	Yes	No	No
Cable car	Yes	No	No
Train	Yes	Yes (stations with parking provision)	Yes
Ferry	Yes	Yes (Days Bay)	Yes (Days Bay)

For some segments there may be insufficient data to model K&R and P&R separately; in these cases all car access will be combined.

A question remains as to whether the car access mode is best split into P&R vs. K&R or car driver vs. car passenger. The difference lies in treatment of the car passengers. This issue will be resolved during model calibration.

2.7 Model Segmentation

The main reasons for segmenting demand are to ensure that:

- WPTM demand growth is linked to the correct WTSM demand drivers e.g. growth in employment drives growth in commuting and business-related travel; and growth in enrolments drives growth in travel to school; and
- The choices offered are realistic e.g. only those with access to a car have the option to choose Park and Ride.

Other advantages of greater segmentation:

- To allow for differences in perception of travel cost e.g. fares are a greater influence on choice for leisure travellers than business travellers (different values of time); and
- More useful reporting e.g. separation of adult and child travel.

But, there are also potential disadvantages of greater segmentation:

- Added model complexity; and
- Insufficient base data to support the segmentation.

We have examined the bus and initial rail surveys and the bus ETM ticket data with regard to trip purpose, car availability and age. Based on this, we propose 6 demand segments, as shown in Table 2-4.

Table 2-4: Proposed Model Segments

No.	Segment name	Age	Car?	Access choices [1] AM	Access choices [1] IP	Linked WTSM segments[2]
1	**Work** *(commuting and business)*	Adult	Yes	w,p,k	w,p,k	HBWcompetition PT+ HBWchoice PT [3]
2			No	w,k	w,k	HBWcaptive PT [3]
3	**Education** *(tertiary education)*	Adult	Yes	w,p,k	w,p,k	HBEcompetition PT + HBEchoice PT [4]
4			No	w,k	w,k	HBEcaptive PT [4]
5	**Other** *(shop, social, sport, recreation, personal business, other)*	Adult	All	w,c	w,c	HBSh PT + HBO PT+ NHBO PT
6	**Child travel** [5]	Child	All	w [6]	w [6]	HBE PT [7]

Notes
1: Access choices: w = walk or bus access; p = P&R; k = K&R c= combined P&R and K&R where data is sparse.
2: Abbreviations: HBW = home based work, HBE = home based education, EB = employers business, HBSh = home based shopping, HBO = home based other, NHBO = non-home based other
3: Business trips are not permitted to use PT in WTSM (therefore, no demand factor for business is available)
4: Tertiary education sites only
5. Travelling on public services only (not school bus services)
6. No information on use of child K&R is available: only the walk option will be allowed
7. Primary and secondary schools only

The reasoning behind the proposed segmentation is as follows:

- Home-based work is the dominant purpose in the AM peak (over 60% of trips) and requires separate treatment to ensure growth in demand is linked to jobs. There are few PT trips for the purpose of employers' business (3%) which makes it difficult to justify a separate segment, and furthermore there is no EB demand for public transport in WTSM to link to. Therefore we propose aggregating EB and HBW to create a single **Work** purpose segment (AM 67%, IP 25%).

- Travel to/from educational establishments by adults makes up 12% of demand in the AM peak and 22% in the Inter peak. This is predominantly university and tertiary students. **Education** purposes will be a demand segment to allow for linkage to growth in tertiary educational enrolments in WTSM.

- All other adult travel will be grouped into an **Other** purposes segment. This makes up just 5% of the market in the AM peak but 40% in the IP.

- We have no information from the on-board surveys relating to child (or school) travel because patrons appearing to be under 16 years old were not interviewed. The bus ETM data indicates around 20% of AM bus trips and 16% of IP bus trips are made on child tickets. However, little is currently known of child travel on rail[1]. Weekday child travel is predominantly to/from school – the time of issue for child bus tickets strongly

[1] Monthly rail ticket sales data is the only source

supports this. A **Child travel** purpose segment is proposed, to include all trips made on public services using child tickets. Our current estimate is that child travel makes up around 16% of PT demand in the AM peak and 13% in the IP. This segment will be linked to the HBE purpose in WTSM.

- Work and education-related travel will be further divided by **car availability**. For the PT access choice, car-available individuals only may choose Park and Ride. The changes in CA and NCA proportions in future years will be determined through linkage to the WTSM car ownership model. Segmentation by car availability may not be required for 'other' purposes or for child trips due to zero or low numbers of P&R in these categories.

Figure 2-2 shows the current public transport market in Wellington, broken down by the six proposed model segments.

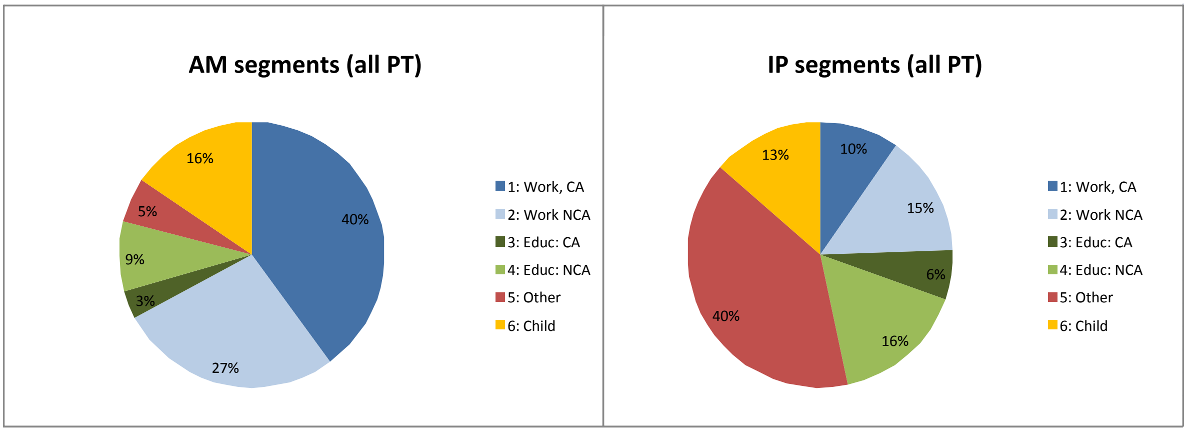


Figure 2-2: Demand Segments

Source: Expanded bus and rail on-board survey data; bus ETM data

The sample sizes are not sufficient to establish segmentation proportions by zone, therefore techniques using land use data will be used to estimate the zonal purpose splits (e.g. a zone containing a school will attract AM peak child travel). These techniques are documented in TN7.

2.8 Software

We propose to implement the model in EMME version 3.4.1 using macros. The option of developing the model using the 'modeller' application framework[2] rather than macros is under discussion.

2.9 WPTM Capabilities and Limitations

The capabilities of WPTM include:

- Matrices developed from observed demand at origin to destination level offering a high degree of confidence in their accuracy;

[2] http://www.inro.ca/en/products/emme/modeller_beta.php

- Linkage with WTSM for variable demand modelling capability in trip generation, attraction, distribution and mode split;
- Segmentation of demand for accurate behavioural modelling and disaggregated reporting e.g. for benefit calculation;
- Significant improvement in the modelling of the access choices to rail, including P&R;
- Sensitive to quality differences between alternative public transport systems: rail, bus, BRT and LRT;
- Detailed assignment network with coding of individual bus stops; and
- Sufficiently detailed and accurate in both supply and demand for calculation of public transport user benefits at the advanced stages of project development.

However, WPTM will not address the following issues:

- Capacity constraint and crowding on public transport services;
- Reliability of public transport services (though this is represented indirectly through mode-specific weightings on in-vehicle time and/or boarding time);
- Capacity constraint at P&R sites, though the fact that large sites attract more users than small sites will be reflected in the model formulation; and
- The EMME software has limited ability to represent fare systems, which will limit the types of fare analysis that can be undertaken.

3 Access model

3.1 Access model structure

A nested logit model is proposed to implement the access choice model. The structure is shown in Figure 3-1.

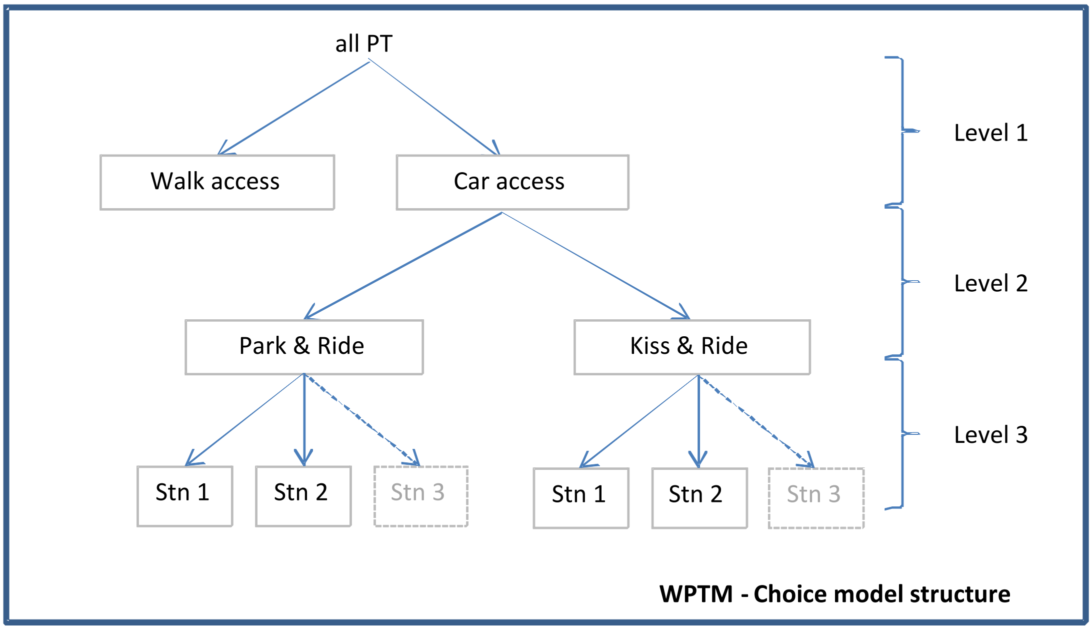


Figure 3-1: WPTM Proposed Access Choice Model Structure

At Level 1 of the model, total PT demand is allocated to walk access or car access. The car access opportunities are only to rail stations and dedicated P&R sites for other PT modes.

At Level 2, car access is divided into P&R and K&R. P&R includes drivers and passengers of cars that park. K&R includes those who are dropped off (no parking).

At Level 3, P&R and K&R users are allocated to one of three access stations. The original intention was to input a list of *candidate stations* as a user-input for each zone to ensure that station catchments are realistic. However, the initial indications are that this will not be required (the model can select the set).

For the Queensgate area, as an example, the model might select Melling, Western Hutt, Epuni, Waterloo, and Woburn; the model will then select the best three (which may differ between options) and apportion demand to them in proportion to the relative utilities. If there is no parking provision – in this example, Western Hutt has none – then no P&R demand will be forecast.

We will constrain the origins and destination to ensure realism in behaviour. If, for example, there is no evidence from the surveys of car access from the eastern suburbs of Wellington, then choice sets for these areas will exclude car access as an option. In future year application, this constraint can be removed if a P&R site is opened in a new area.

The walk access trip matrix (produced at Level 1) is allocated to bus, rail and other PT modes and routes by the assignment model. This matrix will include everyone who walks or cycles to their first boarding. Examples include people who:

- Walk to bus stop, take bus to a location close to the destination, walk to destination;
- Walk to rail station, take train to a location close to destination, walk to destination; and
- Walk to bus stop, take bus to rail station, take train to location close to destination, walk to destination.

The P&R and K&R trip matrices produced at Level 3 are assigned with the origin location fixed to the access station selected by the choice model. The assignment model determines the routes to reach the destination. Examples include people who:

- Take train to Wellington Station, walk to destination; and
- Take train to Wellington Station, take a bus to a location close to the destination, walk to the destination.

3.2 Utilities

Each choice requires a ‘utility’ as input. The proposed utility functions will be as described in the following tables.

Table 3-1: Choice Model Utilities

Utility	Leg	Calculation
Level 3		
P&R	O to Stn1	$U_{p1c} = \lambda_3 * \beta_{ca} * (IVT_{car} + (0.5*ParkCost+VoC) / (VoT*Occ))$
	Stn1 to D	$U_{p1p} = \lambda_3 * (\alpha_{1,m}.IVT_m + \alpha_2.wait + \alpha_3.walk + \alpha_{4,m}.boardings_m + fare/VoT)$
	O to D	$U_{p1} = U_{p1c} + U_{p1p}$
P&R Stn2 & Stn3	U_{p2} and U_{p3} (formulation as above)	
K&R Stn1 (best)	O to Stn1	$U_{k1c} = \lambda_3 * \beta_{ca} * (IVT_{car} + VoC / (VoT*Occ))$
	Stn1 to D	$U_{k1p} = \lambda_3 * (\alpha_{1,m}.IVT_m + \alpha_2.wait + \alpha_3.walk + \alpha_{4,m}.boardings_m + fare/VoT)$
	O to D	$U_{k1c} + U_{k1p}$
K&R Stn2 & Stn3	U_{k2} and U_{k3} (formulation as above)	
Level 2		
P&R	$U_p = \lambda_2/\lambda_3 * \ln(\exp(U_{p1}) + \exp(U_{p2}) + \exp(U_{p3}))$	
K&R	$U_k = \lambda_2/\lambda_3 * \ln(\exp(U_{k1}) + \exp(U_{k2}) + \exp(U_{k3})) + ASC_k$	
Level 1		
Car access	$U_c = \lambda_1/\lambda_2 * \ln(\exp(U_p) + \exp(U_k)) + ASC_c$	
Walk access	$U_w = \lambda_1 * (\alpha_{1,m}.IVT_m + \alpha_2.wait + \alpha_3.walk + \alpha_{4,m}.boardings_m + fare/VoT)$	

Table 3-2: Choice Model Parameters

	Description	Source
λ_1	Scaling parameter for Level 1	See notes below
λ_2	Scaling parameter for Level 2	
λ_3	Scaling parameter for Level 3	
β_{ca}	Car access coefficient	Other models + calibration
$\alpha_{1,m}$	IVT coefficient; m={bus, rail, lrt, brt…}	WTSM / WPTM + calibration
VoT	Value of time	WTSM + calibration
Occ	Car occupancy	WTSM + survey data
α_2	Wait time weight	WTSM / WPTM + calibration
α_3	Walk time weight	WTSM / WPTM + calibration
$\alpha_{4,m}$	Boarding penalty; m={bus, rail, lrt, brt…}	WTSM / WPTM + calibration
ASC_k	Alternative specific constant for K&R	Calibration
ASC_c	Alternative specific constant for car access	Calibration

Table 3-3: Choice Model Variables

	Description	Source
IVT_{car}	Car time from origin to station	WTSM skim
ParkCost	Parking cost at P&R site (currently free)	GWRC
VoC	Vehicle operating cost from origin to access station	WTSM
Fare	PT fare from access station to destination	WPTM skim
IVT_m	IVT by mode; m={bus, rail, lrt, brt…}	WPTM skim
Wait	Waiting time	WPTM skim
Walk	Walking time	WPTM skim
$Boardings_m$	Number of Boardings by mode; m={bus, rail, lrt, brt…}	WPTM skim

3.3 Network Skims

Assembly of the utilities requires 'skim' times and costs from WPTM and WTSM. The utilities for the car access options are created by combining origin zone to station zone car costs (from WTSM) with station zone to destination zone PT costs from WPTM.

Table 3-4: Network Skims

Choice	WTSM	WPTM
P&R and K&R via Stn N	Car IVT and operating costs from origin to Stn N	PT IVT, wait, walk, boarding times and fare from Stn N to destination
Walk	n/a	PT IVT, wait, walk, boarding times and fare from origin to destination

The P-connectors, which are coded in the common WTSM / WPTM network, have no role and are inactivated for WPTM.

3.4 Calibration approach

The choice models will be calibrated to replicate observed access behaviour. The general principle will be to assert the α and β model parameters based on WTSM and other local and international guidelines[3]. Regarding the scaling parameters, our proposal is that:

- λ_1 will be a multiple (1.5 – 2) of the mode choice spread parameter[4];
- λ_2 will be a multiple (1.5 – 2) of λ_1; and
- λ_3 will be a multiple (1.5 – 2) of λ_2.

The scaling parameters control the model sensitivity. There is lowest sensitivity at Level 1 and greatest sensitivity at Level 3. What this means, as an example, is if we add a P&R site, the strongest response is demand switching from the other P&R sites, followed by demand switching from K&R, and the least strong response is switching from walk access.

The multipliers shown in red are termed structural ratios and we anticipate that values in the ranges 1.5 to 2 will work based on our experience elsewhere. For example, with a typical mode choice model scaling parameter of -0.03 and structural ratios set to 1.75, the values of λ_1, λ_2 and λ_3 would be -0.05, -0.09 and -0.16 respectively. These will be amended during calibration.

The α terms control the relative weighting of components of the public transport time in the public transport generalised cost. These are inherited from the assignment model. They will be set initially at WTSM and previous WPTM values, and revised during calibration of the assignment model. The β term controls the weighting of car access time relative to public transport time in the overall generalised cost. This will be based on evidence from other models such as the Sydney strategic travel model, and adjusted during calibration.

The alternative specific constants will be calibrated to obtain access mode shares that agree with observed data from the bus and rail surveys and other counts. We anticipate that an additional term adding extra utility at large sites will be required to model the preference for Waterloo Station say which has 619 spaces over Epuni Station which has 31 spaces.

Access choice model calibration and validation will be covered in TN19.

---

[3] As a general principle, the order of importance and relevance for parameters is [1] calibration, [2] WTSM and previous WPTM, [3] NZ guidance (EEM), [4] International guidance (e.g. Webtag; ATC Guidelines), [5] experience elsewhere.

[4] From WTSM or other source

4 Assignment Model

4.1 Public Transport Route Choice

The generalised costs for input to the access choice model will be extracted by running the EMME public transport assignment module. After access choice, the demand will be assigned to the PT network. There are some new options in the EMME PT assignment in respect of:

- How walkers choose which outgoing link to take when leaving a node: all-or-nothing was the old EMME method; there is now an option to split demand between all outgoing links (a function of expected cost); and
- How demand is divided between alternative routes in the set of 'attractive' routes: in proportion to frequency was the old EMME method, there is now an option to split demand as a function of generalised cost.

During model calibration, the most appropriate assignment method will be determined.

4.2 Assignment Parameters

Assignment parameters will be drawn initially from WTSM and the initial version of WPTM and then adjusted during calibration to obtain a good model fit. We propose to use either in-vehicle time or boarding time or both, by mode. Initially the mode-specific weights will be set to 1 and a pure assignment undertaken. The process of model calibration will involve adjustment of those weights to obtain a reasonable division of demand, for example, between bus and rail modes. This will focus on movements where bus and rail are currently in competition: along the Johnsonville Line and between parts of Lower Hutt, Petone and Wellington.

The need for WPTM to be in line with general good practice dictates that weights must lie within a certain range and that the weight applied to a lowest quality, least reliable mode should be greater than the weight applied to a higher quality, reliable mode. Elsewhere, almost without exception, where time is weighted, the higher weight has been applied to bus and the lower weight to rail. However, this is a calibration exercise.

For new modes, we will propose mode-specific weights based on the 'where in the spectrum' of quality the new mode lies relative to the existing modes. There is also quite considerable international literature to inform this. The sensitivity to new mode constants and weights will be tested prior to finalising the model.

Final assignment parameters will be benchmarked and sense-checked against models elsewhere, and NZ and international guidelines.

4.3 Network

WPTM and WTSM have a common network, and the same network used for the WTSM run is passed on to WPTM. Some network elements are used in WPTM but not WTSM. These are coded into the common network and 'activated' only for the WPTM run. Similarly, there are network elements needed for WTSM that are inactive in the WPTM run (P-connectors are an example).

Full details regarding the network are given in TN1.

4.4 Transit Time Functions

The running times between stations and any dwell times for rail, cable car and ferry will be taken directly from current timetables. For bus there are two options:

- Extract running times between timing points from timetables in the base year. For future years or option cases, the ratio of link times from the highway model (option / base) can be transferred to bus running times, with special treatment for bus lanes; or
- Calibrate transit time functions for bus that relate bus running time to highway link times and possibly other network attributes.

Particular attention will be paid to representing the slow progress of buses through the CBD at peak times and through other congestion hotspots in base and future options.

Feedback from WPTM stakeholders obtained indicates a general preference for linkage with the WTSM speeds through suitable functions, and this is our preferred approach. Full details are provided in the memorandum “Bus Transit Times Analysis”.

4.5 Fares and Values of Time

Fares will be represented on the network through a combination of a boarding charge and a fare-zone boundary crossing charge, combined with values of time to convert fare paid to equivalent minutes. Economic Evaluation Manual (EEM) values of time are likely to understate perceived values by a considerable amount, resulting in unrealistic apportionment of demand; therefore the values of time applied to fares in the assignment model will be treated as calibration parameters.

The EMME software is rather restricted in its ability to model anything other than the simplest fare systems; therefore it is inevitable that some degree of approximation will be required in representing fares. The key aim is to represent the *differences* between fares on competing modes and service. The zonal fare structure and reasonably standardised bus and rail fares mean that competition is not generally on price, with the exception of the premium-priced Airport Flyer bus.

The boarding and fare-zone boundary crossing charges will be informed by the ticket types from the ETM data and Metlink fare tables.

4.6 Special Zones

At the airport, PT demand can be taken from the WTSM airport passenger model (being developed as part of this commission) and will not be input to access choice modelling.

4.7 Assignment Calibration and Validation

Assignment calibration and validation for WPTM will be covered in TN19.

5 Demand

5.1 Overview

A key feature of WPTM is that demand matrices are developed from observed data, rather than being synthesised by the model. This ensures that demand is as accurate as it reasonably can be (modelling errors being minimised), and making WPTM particularly well suited for application to corridor projects such as the PT Spine, operational studies such as bus reorganisation, and projects in the later stages of design.

The input demand to WPTM is total base year observed PT demand. This is built from observed data sources, by mode, and summed for input to WPTM. It is the role of WPTM to divide out the total PT demand among the modes and to attempt to replicate the shares implicit in the individual mode observed matrices. The main PT modes are bus and rail, and there are minor contributions from ferry and cable car that are relevant to only a small number of origin-destination pairs.

5.2 Observed Rail Demand

There are two datasets from which rail demand information is available for WPTM:

- On-board rail surveys (trip purpose, time, access mode, egress mode, ticket type, age, sex, car availability); and
- Boarding and alighting counts at rail stations.

The proposed approach to create rail trip matrices is summarised below and illustrated in Figure **5-1**.

- The train boarding and alighting counts are cleaned to ensure all data passes quality and logic tests;
- A station to station matrix is built up from the rail survey data;
- Zero cells in the station-to-station matrix are seeded with a small value;
- The station-to-station matrix is controlled to the boarding and alighting counts by furnessing;
- Furnessing factors are appended to the survey records;
- Origin to destination matrices are built from WTSM zone to WTSM zone, by purpose and access mode; and
- Land use data is used to recode the demand by WTSM zone to the smaller WPTM zones.

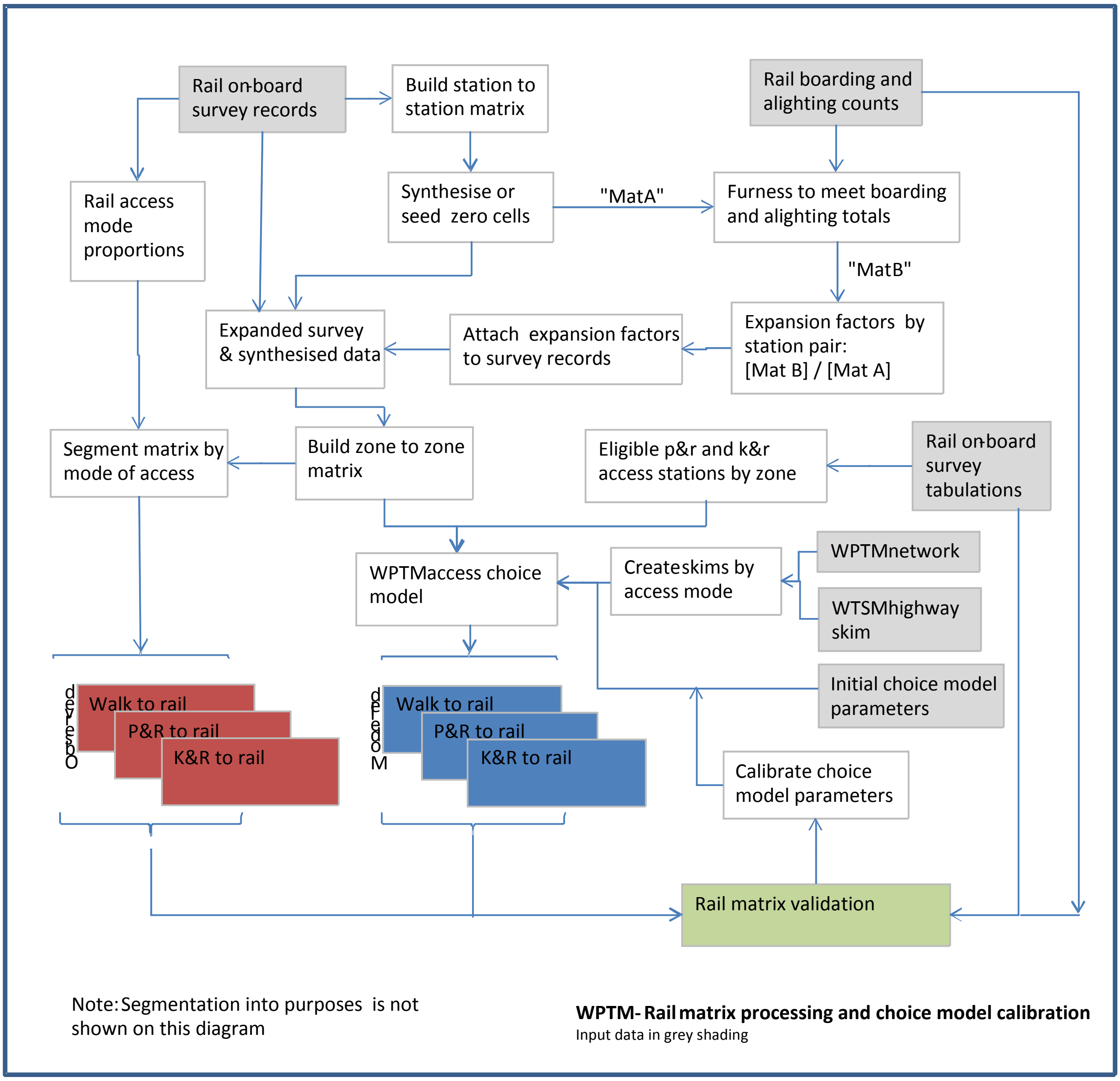


Figure 5-1: Proposed Approach to Creating Rail Trip Matrices in WPTM

Full details of rail matrix creation will be provided in TN7 and matrix calibration and validation will be covered in TN19.

5.3 Observed Bus Demand

There are two datasets from which bus demand information can be extracted for WPTM:

- On-board bus survey (trip purpose, time, access mode, egress mode, ticket type, age, sex, car availability); and
- ETM data (board stop, alight stop, time, ticket type).

The proposed approach to create bus trip matrices is summarised in Figure 5-2.

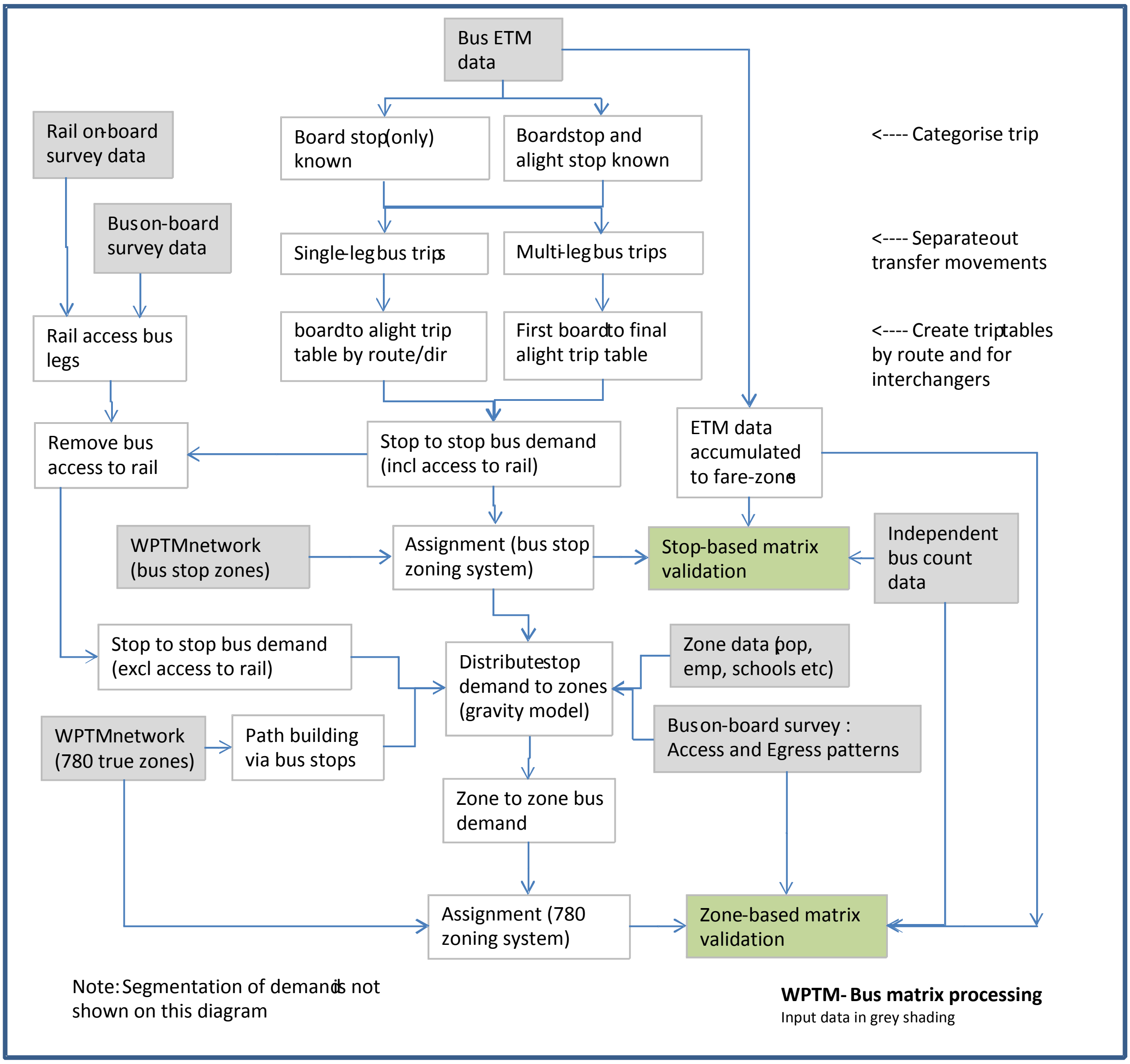


Figure 5-2: Proposed Approach to Creating Bus Trip Matrices in WPTM

- Raw ETM data is cleaned to ensure all records pass quality and logic tests;
- For records where the alighting stop is missing, determine the alighting stop based on patterns from other records in the database;
- For transfer trips, delete individual legs and replace with a single trip from initial board stop to final alight stop;
- Apportion the ETM records into four segments: adult work, adult education, adult other, child – the proportions varying by period and land use in bus stop vicinity;
- Build stop-to-stop matrices for each route / segment / period and validate;
- Recode the trip matrices from stops to true zones by application of a gravity model; and
- Assign and validate.

5.4 Observed Ferry and Cable Car Demand

Ferry and cable car demand affect a small number of movements. A manual process was used to allocate the demand to a range of zones. Details are provided in TN7.

5.5 Total Public Transport Demand

The total public transport demand matrices require a few additional factors to be considered:

- The bus legs of bus rail trips are deleted from the bus matrix (these movements already being present in the rail matrix);
- Rail matrices are divided into car available and no-car-available, based on information from the rail survey data;
- The bus, rail, cable car and ferry matrices are added, for each segment; and
- The observed total PT matrices by purpose and car availability are input to WPTM.

6 Forecasting

6.1 Overview

Before WPTM is run in forecast mode, a forecast scenario is run in WTSM to create the option / base demand factors. These will be applied for each scenario to the WPTM observed matrices to uplift demand. By this linkage, WPTM inherits the variable demand modelling capability of WTSM in respect of generation, attraction, distribution and mode split.

For future years, and / or scenarios with changes to the transport networks, the base public transport matrices will be adjusted (incremented) by linkage to growth factors from WTSM.

This will be achieved as follows:

- Extract matrices of public transport demand, by segment, for WTSM base and option cases (225 zones);
- Recode to 780 zones (and, possibly, adjust distribution if development is unevenly distributed) and calculate option / base PT demand ratios (or differences) at a cell-by-cell level; and
- Apply the ratios (or differences) to the WPTM base PT matrices, by segment.

For options where new (greenfield) development is tested, the process described above may not be appropriate. In such cases, WTSM demand will be used directly in WPTM to replace the observed demand, similar to the approach followed in the Sydney Strategic Transport Model[5].

The interface between WPTM and WTSM will be described in detail in TN21.

[5] Pivot-point procedures in practical travel demand forecasting, Andrew Daly, James Fox, Jan Gerrit Tuinenga

7 Reporting

7.1 Overview

A selection of standard outputs and indicators will be automatically created during model runs.

7.2 Standard Outputs

A final definition of these outputs will be determined with input from stakeholders. It is likely to include the following items for each time period:

- Total PT demand, by sector;
- Boardings, by PT route;
- Peak loading, by PT route;
- Passenger kilometres, by PT route;
- PT sub-mode shares;
- Peak ratios of seated and standing passengers to capacity, by route;
- System wide revenue;
- Access mode shares by station;
- Screenline volumes by mode; and
- Boardings and alightings at rail stations.

7.3 Graphical Outputs

A selection of standard plots will be produced. These will be provided to GWRC in the form of EMME graphical worksheets for the client to use and adapt to requirements.