Waikato Regional Transport Model

Professional Services Contract

WRTM-01

Final Model Specification Report

Update 2

November 2009

GABITES PORTER

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27 November 2009

Latitude Planning
5 Hillary Street
HAMILTON

Attn: James Bevan

Dear James

WRTM-01 WAIKATO REGIONAL TRANSPORT MODEL– MODEL SPECIFICATION REPORT UPDATE 1

We have enclosed the second update of the Model Specification Report for the Waikato Regional Transport Model. As anticipated when it was released in January 2008, a revised report was needed as a result of the model build process. This will finalise the three step model methodology, and largely finalises the four step model.

Further minor revision may be necessary once the four step model is fully validated.

Yours sincerely

GABITES PORTER CONSULTANTS	**TRAFFIC DESIGN GROUP**
Grant Smith	Tony Penny
MANAGING DIRECTOR	**MANAGING DIRECTOR**

TRAFFIC DESIGN GROUP
Traffic Design Group Limited
127 Armagh St PO Box 13835 Christchurch
Phone +64 3 379 2404 Fax +64 3 379 3406

GABITES PORTER
Gabites Porter Consultants Ltd
Level 1, Lumley Centre, 138 Victoria St
PO Box 25 103 Christchurch
Phone +64 3 366 9871 Fax +64 3 366 9870

Waikato Regional Transportation Model

QUALITY ASSURANCE STATEMENT

Prepared by:

Grant Smith
Managing Director, GPC

Reviewed by:

Julie Ballantyne
Associate, TDG

Approved for Issue by:

Tony Penny
Managing Director, TDG

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1. THE WAIKATO MODEL BUILDING PROJECT

1.1 Objectives

The basic requirement of the project is to build a new Waikato Regional Model and update the existing Hamilton City model so that they are available to evaluate projects, policies and plans to meet the objectives of the LTMA and the NZTS. These objectives include assisting economic development, assisting safety and personal security, improving access and mobility, protecting and promoting public health, and ensuring environmental sustainability.

Accordingly, in addition to forecasting travel demands based on changes in land use, household structures and car ownership for planning future transport infrastructure and services, the model will be developed to enable roading and public transport proposals to be analysed, and changes in transport policies, including travel demand management measures, to be evaluated.

A further key requirement of the project is to develop an integrated forecasting tool that is wholly owned and controlled by the clients.

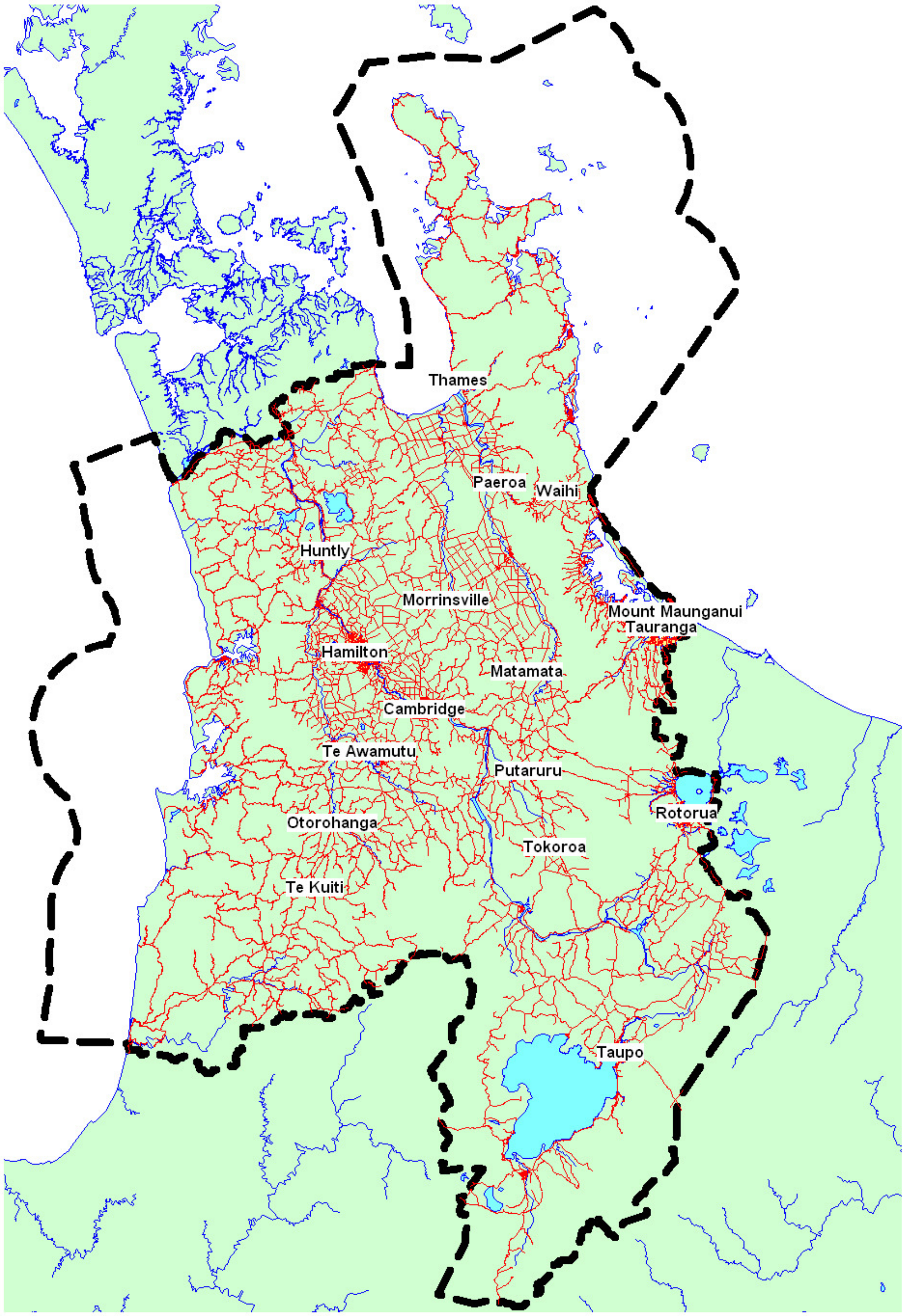
The need for high quality observed travel data is paramount for confidence in the model and its ability to accurately forecast future travel patterns. The data to be collected in this study is detailed in the survey specification report.

1.2 Model Areas

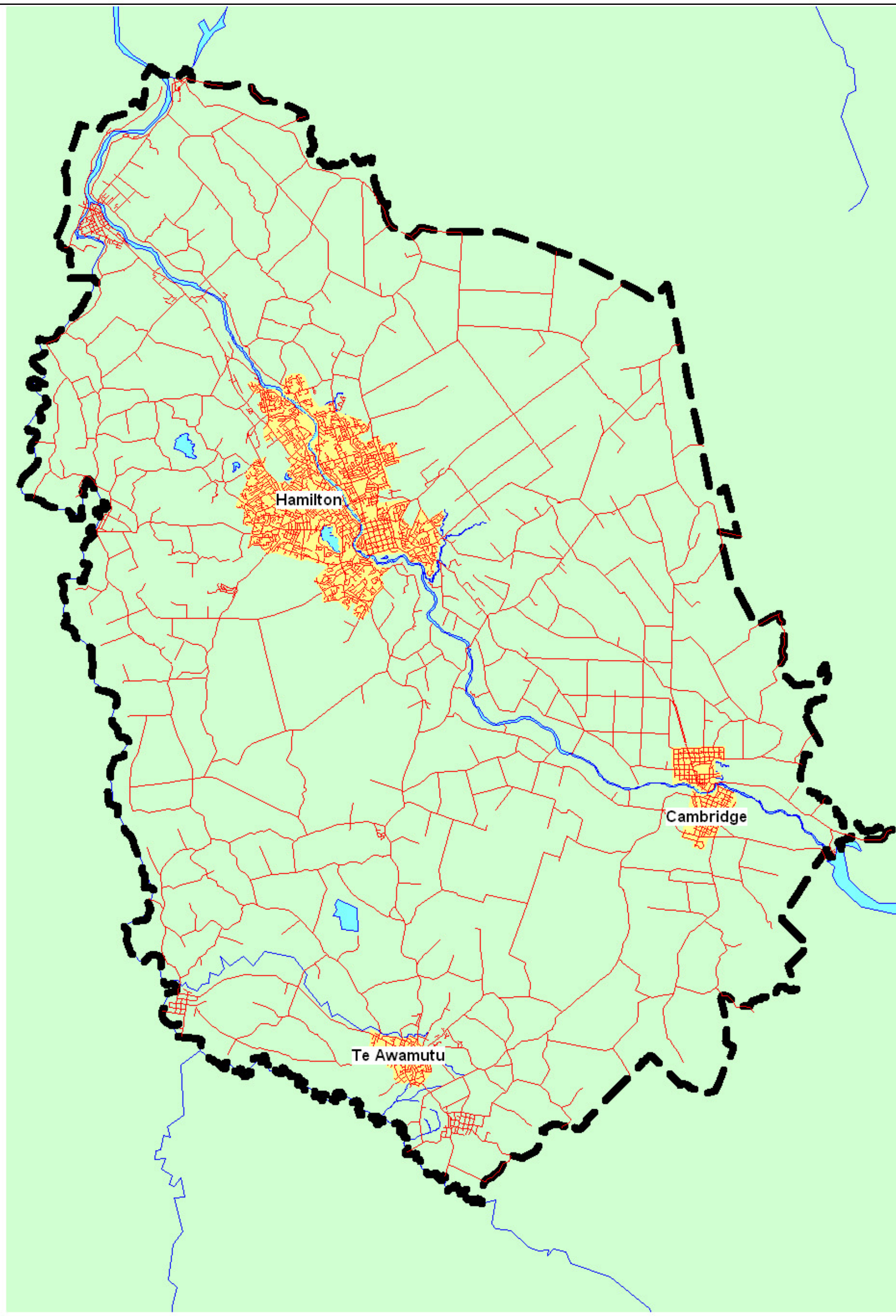
The geographic area covered by the model is shown on **Figure 1**, and extends from the Bombay Hills in the north, to Taupo in the south, and includes Rotorua and Tauranga to the east. While Rotorua, Tauranga and Taupo are included, the detail within these areas is expected to be quite coarse, and will provide the 'boundary conditions' to feed the existing models of the these three urban areas.

> During the validation process, the coarse zoning of these urban areas caused problems with the large zones concentrating traffic onto small parts of the network. This affected both the assignment and the distribution of trips, and accordingly more detail was added. Other smaller towns such as Tokoroa, Putaruru and Matamata also had more detail included.

The area covered by the more detailed modelling of Hamilton is shown on **Figure 2**, and includes Ngaruawahia, Taupiri, Cambridge, and Te Awamutu (and Kihikihi).



Waikato Regional Transportation Model	Waikato Regional Model Boundary	Figure 1
Gabites Porter Consultants Traffic Design Group		



Waikato Regional Transportation Model	Hamilton Model Boundary	Figure 2
Gabites Porter Consultants Traffic Design Group		

2. REQUIREMENTS OF THE RFT FOR THIS REPORT

The Request for Tender specifies that the Model Design and Specification report includes

> *Prepare a Model Design and Specification Report describing the proposed form of the model, proposals for model development, data collection and analysis, validation and interface requirements and demonstrating the ability of the model to forecast changes in demands and patterns.*

The report builds on the methodology as included in the Tender, and as modified by the discussion and agreements during the negotiation period prior to acceptance of the contract. The note represents the approach proposed given the present understanding of the Waikato Region and Hamilton in particular, but aspects may need modification once new surveyed data becomes available.

The data collection and analysis components are covered separately in the survey specification report. Also, at this stage in the project, it is difficult to 'demonstrate' the way in which the future model will operate, but that will be covered in Stage VI of the project.

3. GENERAL MODEL FORM

3.1 Model Structure

The general method described in the RFT comprises a hierarchical approach to modelling with a region wide strategic demand model which contains the Hamilton, Rotorua, Taupo and Tauranga[1] areas at a coarse level, so that there is consistent precision over the whole region. The greater Hamilton area will also be modelled as a sub-area with very much greater detail, including public transport, Travel demand management (TDM) and the option of a parking model. The existing models of Rotorua, Taupo, and Tauranga would remain unchanged, except that flows by trip purpose at the boundaries would interface with the higher level regional model.

It is important to appreciate that the output of this study will be a single modelling tool consisting of integrated models of the Region and Hamilton City, but with the urban areas being modelled at two different levels of detail. The time periods, road network, land use activity would be common to both levels, and the interface between them seamless.

The higher level model will be a vehicle driver model only, (a three step model) while the Hamilton model will include public transport (a four step model). Both will be built using generalised cost so that TDM initiatives (such as tolling) can be tested.

The approach to the model is to keep it as simple as possible. In terms of the Hamilton model, the general methodology that has been included to date in the Hamilton City model will be retained. There will be much more detail included as the Hamilton model had its origins in the first transportation study of 1968 and successive reviews and upgrades have generally built on the pre-existing model of the time. This project will enable the model to be built from scratch for the first time in almost forty years.

The conceptual approach to the model change radically once the HIS data became available, and there was little significant difference between trips rates within the Hamilton model area and the wider region. As a result, there was no need to continue with a separate, more detailed model of Hamilton to be windowed from the full regional model. Instead the necessary detail was included within Hamilton, meaning only one model is required. The model will still provide boundary conditions for the detailed 'stand alone' models of Tauranga, Rotorua and Taupo, all of which have very detailed internal zone structures.

3.2 High Level Model

The RFT suggests that the regional model should have fixed matrices with growth factors based on landuse change for forecasting. The implication in the RFT, and the Scoping report is that the matrices would be built up from roadside interview surveys, and the unobserved cells filled by a synthetic model, perhaps assisted by matrix estimation. The

[1] These are referred to as the 'Urban Models'

difficulty with matrix estimation is that segmentation by trip purpose is lost, and this is an important part of the boundary conditions needed for the urban models

A fully synthetic[2] three step model will be built from a home interview survey which covers the whole region. This will have less reliance on the roadside interview surveys than envisaged by the RFT as the survey budget will only enable some12 sites to be surveyed, but the roadside surveys will be necessary to provide factors to correct for under reporting in the Home Interview. They will also provide a check on intra regional patterns and to provide detail of freight movements.

The aim will be to develop three time periods for an average weekday, with the morning and evening peak generated as two hour periods (0700-0900 and 1600-1800), and the interpeak as a seven hour period (0900-1600). These period assignments are necessary to provide the external trips segmented by purpose on the boundaries of the Urban Models. Although the results of these assignments would be available, generally 24 hour flows and network performance measures would be reported as these are more readily understood in the strategic regional context.

There are two alternative methods for producing an all day assignment from period based generation and distribution. The first and preferred method in this case is to use a process of factoring the period matrices from traffic counts to establish an all day trip matrix which will be assigned to the network. Detailed intersection modelling would not be included. Factoring the matrices means that any difference in period factors over the region can be accommodated using a standard Furness procedure.

The second method is to build up the all day assignment by factoring the period assignments but this would need to rely on a single factor covering the whole region for each time period, and this is unlikely to be appropriate. Nevertheless, both methods will be trialled.

If the data proves inadequate to develop a regional model as three time periods from the home interview survey, then one of the available fallback technologies is to develop all day (24hour) generation and distribution models, and factor these to the three periods prior to assignment to provide the interface with the Urban models.

If the home interview data proves insufficient to develop household category generation models, then the roadside interviews will be analysed using partial matrix theory supplemented by matrix estimation to develop regression based trip end models and distribution functions at the 24 hour level, with these factored to the three periods prior to assignment to get the inputs for the Urban Models.

> The model approach meant that there are period models over the whole region, validate to two-hour flows and travel times. The periods are 0700-0900, 1100-1300 and 1600-1800. A 24 hour network assignment has been built up from the period loaded networks.

[2] Synthetic means that the trip matrices are developed from models, rather than surveys, and forecast using landuse rather than growth factors.

The general form of the Regional model is shown on **Figure 3**. This is the process applied to each time period, and **Figure 4** shows the way in which the 24 hour model is built up from the periods.

3.3 The Hamilton Sub-Model

For the Hamilton model, separate peak and inter-peak models will be developed for an average weekday. The additional cost of collecting data on weekend travel patterns will be incorporated into the HIS survey if budget is available, so that weekend models could be developed at a later stage.

The Hamilton model will be calibrated as an "absolute" model with travel patterns fully synthesized based on a series of functions and area/mode specific constants, calibrated to the observed travel patterns. The alternative of an incremental-type (pivot-point) approach is not appropriate given the sparse PT trip matrix that presents issues for single-mode cells as they are insensitive to new services, or new development areas that are not present in the base matrix.

The existing Hamilton model is a conventional four step model with a nested logit post distribution mode split. This form will be used for the am and interpeak unless a compelling reason for change emerges once the data is analysed. The evening peak model will be a three step (Vehicle Driver) model. It may be noted that this approach requires trip generation to be at the period level rather than the periods being factored from 24 hours generation because the Am and interpeak periods are generating Person trips while the evening peak is generating vehicle driver trips only.

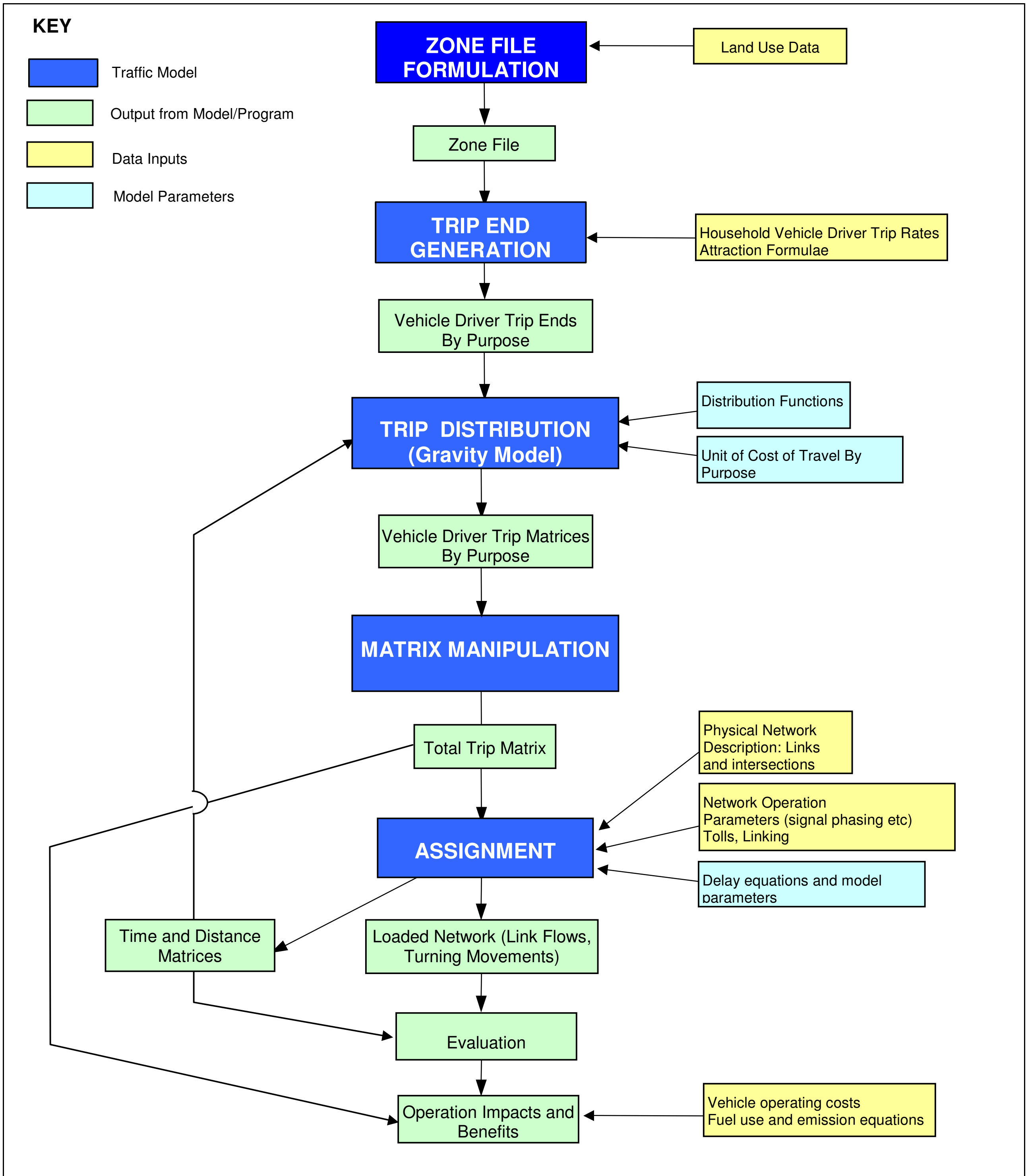
The HIS will give only a small sample size (1.0% to 1.5%) of all households, and a robust validation will need additional data from highway screenline intercept (OD) surveys at the external cordon and across key internal screenlines.

It is intended that the PT operational model will be developed from the home interview survey, with under reporting factors derived from the bus intercept surveys and other patronage data such as that derived from the automatic ticketing system. The PT model will have the same zoning system and network as the vehicle model and the system already in place in Hamilton will be reviewed and adapted as necessary.

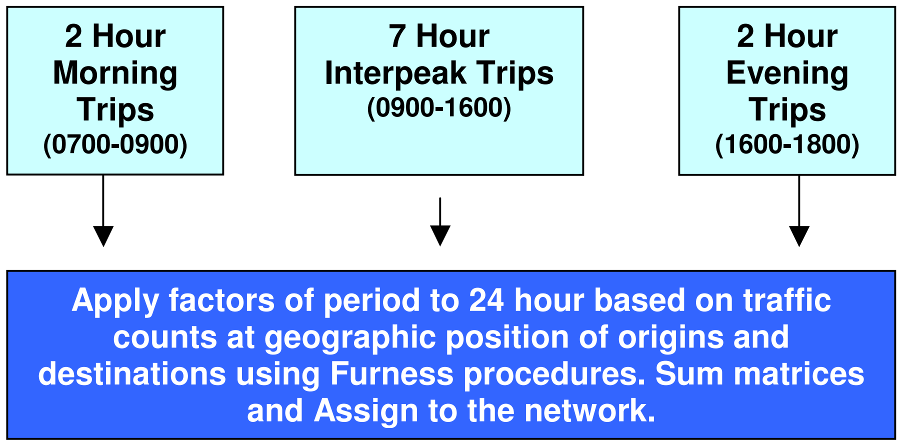
However, it is possible that the Home Interview data will be too sparse to allow this approach to be taken, and the model may need to be built from the Bus intercept survey. The appropriate method will be determined once data is available.

The general form of the four step model for the morning and interpeak periods is shown on **Figure 5**, while **Figure 3** is applicable to the evening peak.

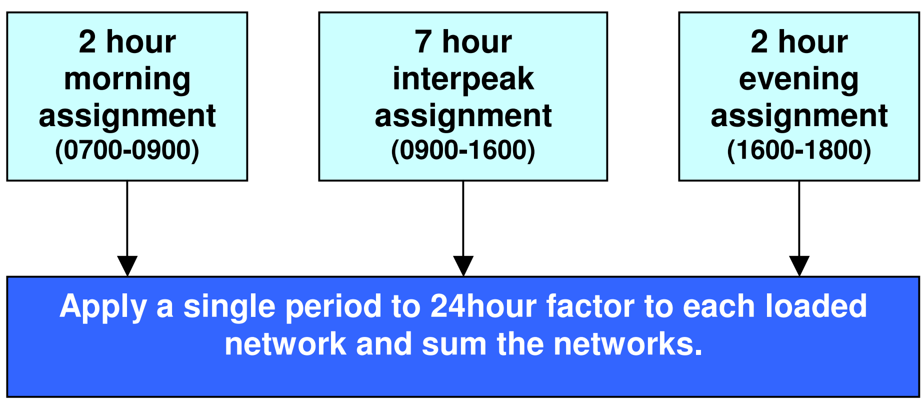
As with the three step model, the four step model has covered the whole region, meaning that all four modes are available over the whole region. As noted earlier, the trip rates are the same between Hamilton and the wider region. Where public transport services are not provided, trips are carried by other modes.



Waikato Regional Transportation Model Gabites Porter Consultants Traffic Design Group	**Vehicle Driver Model Components (Regional and Hamilton PM Peak models)**	**Figure 3**

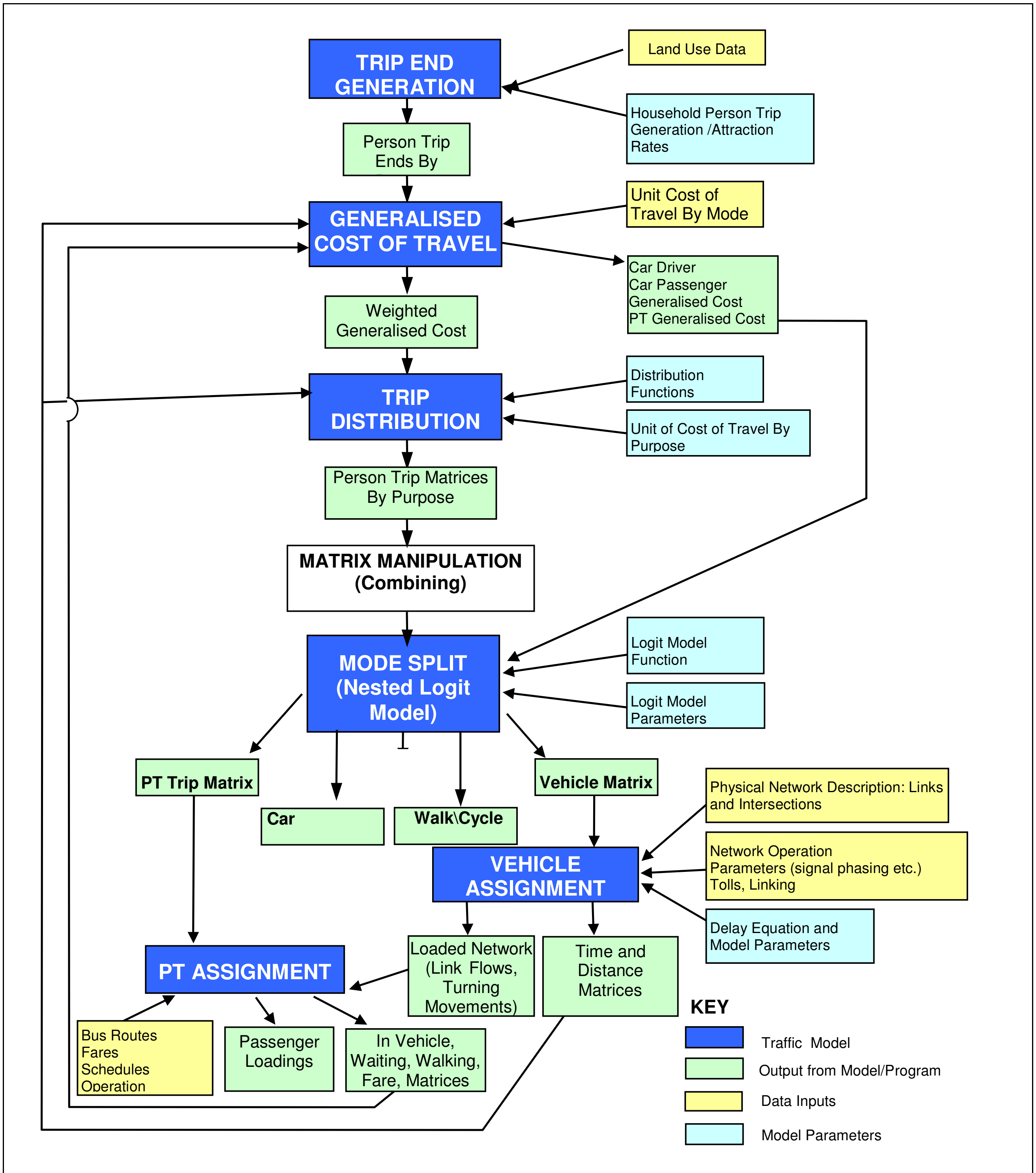


Option One – Full all day assignment



Option Two – Factor and sum loaded networks

Waikato Regional Transportation Model	**All Day Flows from Period Models**	**Figure 4**
Gabites Porter Consultants Traffic Design Group		



Waikato Regional Transportation Model Gabites Porter Consultants Traffic Design Group	**Model Components for Hamilton Sub-Area (Morning Peak and Interpeak)**	**Figure 5**

4. SPECIFIC MODEL COMPONENTS

Each of the components of the three and four step models are described in the following sections.

4.1 Time periods

The models will have common time periods of 0700-0900, 0900-1600, and 1600-1800 for generation, distribution and mode split where applicable. While period assignments will be available for all models, the primary reporting of the regional model will be as all day (24hour volumes). The Hamilton model trip matrices will be converted into peak and average interpeak hours prior to assignment. Accordingly, network validation will be at the 24 hour level for the regional model, and at the one hour level for the Hamilton model.

The period matrices will, of course be available for full period assignments should that be required for any specific project.

Network validation has been at the two hour period level of 0700-0900, 1100-1300 and 1600-1800. Hourly assignments have not been undertaken.

4.2 Base Year

The base year of the model will be 2006, consistent with the input land use data from the 2006 Census.

4.3 Zone Systems

Precision levels

A report prepared for Auckland City Council in 1994 defined three levels of precision for models arising from the way in which intersections were treated during assignment. These were

- *Level 1 – The traditional level of precision whereby network supply functions occur on the links or partly on the links and at the intersection as a whole*
- *Level 2 – Intersection delays are calculated on each approach to the intersection*
- *Level 3 – When delays occurring on the network are calculated lane by lane on the links and according to each turn at the intersections.*

It went on to say

> *The principles of consistency and uniformity in model formation require the general level of activity in terms of the number of trips generated an attracted at each traffic zone to be similar and at a precision level consistent with the remainder of the model.*

and

> *It is necessary that both the present and any future set of traffic zones contain the same level of activity according to the precision levels detailed below*
>
> - *Level 1 – 1000 equivalent households*
> - *Level 2 – 400 equivalent households*
> - *Level 3 – 250 equivalent households.*

Zone Definitions

The Waikato model will be built to level 2 for the Regional model and finer than level 3 for the Hamilton sub model.

At this stage it is envisaged there will be around 300 to 400 zones in the Regional model, built up from aggregations of census mesh blocks, and about the same number within the Hamilton sub model. The precise boundaries will be built up during the system build stage of the project.

> There are currently 698 zones in the model with 484 in the Hamilton urban model and the balance in the rest of the region.

4.4 Road Network Coding

The road network will be built up from GIS centreline data supplied through Terralink, which will then be consistent with the Environment Waikato GIS system. The Terralink data includes 14 road types, as shown in the table below.

Terralink Road type definitions			Table 1
1	Motorway	8	Minor Urban
2	Arterial Urban	9	Minor Rural
3	Arterial Rural	10	Acess Urban
4	Major Urban	11	Acess Rural
5	Major Rural	12	Vehicle Track
6	Medium Urban	13	Footpath
7	Medium Rural	14	Foot Track

The Regional parts of the model will include all roads from Motorway to Medium Rural, while the Hamilton model area will also include the minor category and footpaths.

4.5 Trip End Generation – Category Derivation

Conventional practice in New Zealand is the use of a households category model for trip generation, usually as a cross classification of the number of people with car ownership. The more recent models (outside of Wellington, Auckland, Christchurch and Tauranga) have had 5 persons categories (1,2,3,4,5+) against 4 car ownership (0,1,2,3+) giving 20 categories in all. The three step models have category trip rates calibrated for vehicle driver trips, and the four step model total person trips by all modes.

While this model form has performed well and has been relatively easy to calibrate, and to use in forecasting mode, it does not necessarily reflect the aging population, and changing social structure that has occurred and is continuing to do so. Subject to confirmation from the Home Interview survey, a third cross classification will be introduced to better reflect the household life cycle. These might include Households with

NO CHILDREN
Two adults at least one working
Two adults neither working
One adult Working
One adult not working
Three of more adults

CHILDREN
One adult older children
One adult younger children
One adult younger and older children
More than one adult with older children
More than one adult with younger children
More than one adult with younger and older children

These will be confirmed from analysis of the 2006 census data prior to the household Interview survey being undertaken. This would potentially require 120 categories[3] but will be confirmed during data analysis. However, the full three way cross tabulation will not be needed, for example the single adult household with no children is confined to one person per household category, and one car availability category.

[3] Ten household in each category would mean 1200 Households being surveyed or potentially twice that if there needs to be an urban/rural split.

In the event, this classification did not work, and a slightly different approach was taken as shown below

One Adult working
One adult not working
2 Adults working
2 adults not working
Two adults one working
3+ adults
Two Persons
Three Persons
Four Persons
Five or more persons

It may also be the case that the rural households will behave differently from those in Hamilton, and a different category model calibrated for the wider area as opposed to Hamilton. However, not all categories will necessarily be represented in both areas which will also mean that the sample size can be reduced.

The actual categories will be able to be confirmed following analysis of the census data, and from trip rates once the home interview data is available.

The assumption inherent in this model is that the three variables (persons/household cars/household and household life cycle) are not highly cross-correlated. This will need to be checked once the data is available. The second reason for adopting these variables was the need to have categories that can be readily forecast, of which persons and cars are reasonably straightforward. The life cycle may not be as easy but will be trended forward from past census observations.

The number of households in each of the categories for a zone depend on the average persons per household and cars per household giving a combined probability, $\rho_{i,j}$, where i and j are category model variables. Thus for any life cycle category k

$$\rho_{I,j,k} = \rho_{I,k} \times C_{j,k}$$

$$\text{e.g.} \quad \rho_{1,\,3+,1} = \rho_{1,1} \times C_{3+,1}$$

where

$\rho_{1,\,3+,1,1}$ = proportion of households in the category with 1 person, and 3+ cars in life cycle category 1

$\rho_{1,1}$ = proportion of households with one occupant in life cycle category 1

$C_{3+,1}$ = proportion of households with 3+ cars in life cycle category 1

The probability curves (that is the proportion of households in each category given a zonal average) will be calibrated from the 2006 Census data, as will the average number of vehicles and persons per household in each life cycle category. During forecasting, the future zonal averages of persons per household and vehicles per household will be determined from official and regional growth forecasts, and a vehicle ownership model which will be updated from recent work in Wellington.

4.6 Trip End Generation - Trip Rates Per Household By Purpose

The private trips will be further dis-aggregated into trip purposes, an example of which is shown in Table 1.

The final purpose composition will be dependent on the data, but will be the same for both the Regional model and the Hamilton sub-area.

Possible Trip Purposes	Table 2
Trips purpose	**Trip direction**
HBW = Home Based Work	HTW = Home to Work
	WTH = Work to Home
HBB = Home Based Business	HTB = Home to Business
	BTH = Business to Home
HBO = Home Based Other	HTO = Home to Other
	OTH = Other to Home
HBEd = Home Based Education	HTE = Home to Education
	ETH = Education to Home
NHB = Non Home Based (possibly split into work and non work)	

Experience has shown that where possible 'from home' and 'to home' trips should be modelled independently in order to preserve the directionality of the trips. This is particularly important in the interpeak period where these purposes are of similar order and in the evening peak that is more diverse than the morning peak.

Four other purposes were added,
Home to Shopping and Shopping to home
Home to Social/recreation and Social/Recreation to home

The category model used for private trip generation will be based on the home interview survey. The household category trip rates will be derived by dividing the total number of surveyed person or vehicle driver trips by the number of households in each respective category (c) for each purpose in all zones.

i.e:

$$Rate_C = \frac{\Sigma T_C}{\Sigma HH_C}$$

Total person or vehicle driver trip productions by purpose in each zone or aggregates of zones will be generated using $Rate_c$ multiplied by the number of households in each zone or aggregates of zones in each category.

Total study area Productions for both 'home to' and 'to home' trip ends generated using the category model will be, (with the exception of non home based trips) distributed to each zone according to the proportion of total households that occur in each zone.

Zonal trip attractions by purpose will be derived using multiple linear regression against landuse activity supplied by the Department of Statistics using the Anzsic groupings and school/tertiary rolls as the independent variables.

For home based trips, the zonal attractions will be scaled so the total attractions equal total productions. For non home based trips, the attractions will be scaled so that the sum equals the sum of the productions, and then productions for each zone will be set equal to attractions.

4.7 Special Generators

In some models it is necessary for land uses such as the airport, Universities ,and hospitals to be treated separately from the generality of the rest of the model. Wherever possible, this should be avoided, and the need for special generators will be determined during model validation.

No special generators have been used.

4.8 Trip Distribution (Private Purposes)

The trip distribution phase will use the trip ends described above, and form trip matrices by purpose using a conventional gravity model. In line with common New Zealand practice, the model form (at least initially) will be

$$T_{ij} = O_i.K_i\, D_j.L_j\, f(c_{ij})$$

subject to the double constraints of

$$K_i = \frac{O_i}{\Sigma_j T_{ij}}$$

$$L_j = \frac{D_j}{\Sigma_i T_{ij}}$$

Where:

T_{ij} = Trips between zones i and j

O_i = Origins at zone i

D_j = Destinations at zone j

$f(c_{ij})$ = Some function of the travel cost between zones i and j

$K_i\ L_j$ = Balancing factors

The balancing factors will be successively applied until there is convergence where that is defined as being no difference between iterations to five decimal places.

The existing models are all doubly constrained and unless a good reason emerges to change, then that process will be continued. The alternative is to keep work and education trips and non home based trips doubly constrained but all other purposes singly constrained.

External trips were singly constrained, but all other purposes were doubly constrained.

It should be noted that the 'to home' purposes are generated at the household end, and productions and attractions will be reversed to become origins and destinations prior to distribution. For all other purposes, origins are the same as productions and destinations are the same as attractions.

The Distribution Function

The trip distribution function will be based on generalised cost, and is likely to take the shape of a negative exponential, as is commonly used in New Zealand and Australian models. It may be expressed as

$$f(c_{ij}) = e^{-\alpha c_{ij}}$$

Where:

$f(c_{ij})$ = function of cost of travel between zones i and j

c_{ij} = cost of travel between zone i and zone j, and is a weighted function of travel time, travel distance, parking costs, and tolls, and public transport walk, wait ride transfer and fare costs.

α = exponent

Experience has shown that the distribution function values used (α) tend to be very similar for urban areas throughout New Zealand, and indeed transport well between countries. However, it is likely that the Regional model values may be different, and will, initially at least, be calibrated separately. The alpha values will be calibrated separately for each purpose.

If that formulation does not calibrate satisfactorily, other mathematical forms will be explored.

4.9 Mode Split

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 to be used in the Hamilton sub-area model will be:

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

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 will incorporate four modes:

- Car driver
- Car passenger
- Bus passenger
- Walking/cycling modes combined

The utility[4] 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:

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

[4] Or more correctly the 'disutility' function

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

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

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 below.[5]

This structure will be followed for each of the private purposes. The final Bus passenger trip matrix is derived by adding bus passenger trips from the first (car is available) and the third (car is not available) mode split phases. Similarly Car passenger trips are obtained by adding Car Passenger matrices from the second (car is available) and the third (car is not available) mode split.

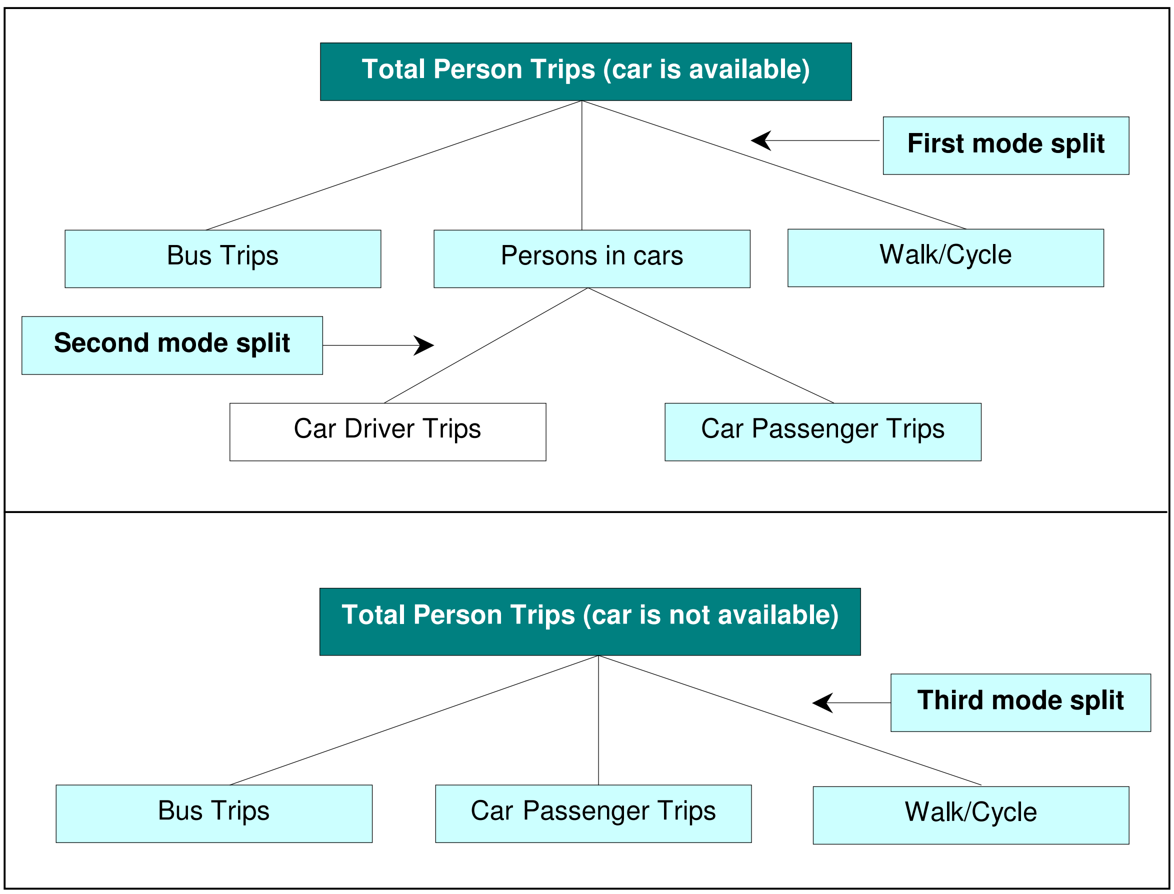


Figure 4

Structure of the Nested Logit Mode Choice Model

[5] Note that car available and no car available are not nested.

Households with and without car available will be assumed from the category model definitions, and will be developed separately during all three stages of generation, distribution and mode split. The costs that are fed back into distribution will be the weighted generalised cost for those households, depending on the number of trips in each mode.

Recent work in Dunedin has suggested that a series of binary mode choices are easier to control than the three way choice shown in Figure 4. Also the distinction between households with no car as opposed to having a car available has also been dropped. Accordingly the structure used is

Split One – **All person** trips into Active modes (walking/cycling) vs Other
Split Two – **Other trips** into Public Transport vs Vehicle occupants
Split Three – **Vehicle occupants** into car driver vs car passenger

Home based work and home based Education were kept separate with all other purposes aggregated prior to the mode split step.

4.10 Trip Assignment

Assignment Techniques

There are several techniques available for assignment, including *inter alia* all or nothing, equilibrium, incremental, and stochastic.

Equilibrium assignment requires that the delay function is a monotonically increasing function of flow on the link. While intersection delays can be included as part of the delay function, that can only occur if the intersection delays are also a function of the approach volumes. As soon as conflicting movements are brought into play, the mathematics of the equilibrium assignment are violated, and there is no unique solution. Practical tests using equilibrium assignment with full intersection modelling have proved this to be the case.

In this application (and in particular with the Hamilton sub model) intersections will be explicitly modelled during the assignment process, where the delay is a function of the approach flow and the conflicting flows. This is true also of signals as the cycle time and phase splits are internally calculated, rather than being user defined. An assignment technique which has a unique solution needs to be used. An incremental assignment is the only available technique.

There is a potential problem that may arise as a result of the size of the study area in the regional model. Vehicles on the edge of the model will not be able to complete their journey within the time period. The assumption behind a conventional assignment is that the number of trips in the system at the start of the period is the same as that at the end, and therefore the issue of completion does not arise. That may be the case in Waikato, or it may not and it will not become clear until the network validation stage.

> The mean trip lengths for all purposes as reported in Technical Note 11 are in the 10 to 15 minute range, which means that there are few trips (if any) longer than the model periods. The validation against traffic counts for both light and heavy vehicles is good, and there was no need to go to the complexity of a dynamic assignment.

If the assumption does not hold, then a dynamic assignment technique will be adopted. This technique only allows vehicles to travel through the network for the length of the period being modelled.

Costs of Travel

When undertaking transportation analyses it is important to make the distinction between the travel costs seen by the driver, (commonly termed perceived or behavioural costs), and the true cost of a trip from the viewpoint of the country as a whole.

Behavioural costs give the best empirical fit to the observed behaviour of travellers. They represent the cost or price that travellers perceive they are paying in terms of time, distance, comfort and convenience. For example, it can be argued that most car drivers, when deciding whether or not to make a trip by car, consider as their mileage costs only the cost of the fuel that they buy. The value of time that people place on travel depends on the type of journey undertaken, so that behavioural time costs for journeys to work, journeys during working hours and shopping trips are different.

Resource costs are defined as the whole of resources consumed per unit of travel to the nation as a whole. For example, resource cost per km does not include fuel tax, as this is purely an internal or "paper" transfer, but does include allowances for oil, maintenance and other operating costs [true]. The discrepancy between behavioural and resource costs has been termed "driver misperception," that is the hidden costs that play little or no part in a driver's trip making decisions.

The perceived costs to be used in the model will initially be based on the costs included in the EEM at 2006 prices. They will be derived separately for each purpose as required by the distribution models, but a weighted average will be used for assignment.

Loading Profile

The trip matrices that result from the Generation, distribution and mode split phases will then be assigned to the road network using an incremental time dependent assignment procedure with multiple iterations and a loading profile such as that shown in Error! Reference source not found..

In this procedure, traffic is loaded in time slices onto the network at flow rates that approximate the traffic flow profile over the time period being modelled. Interzonal time and distance and toll matrices are extracted (or skimmed) during the assignment process. These are weighted sums corresponding to the skim points on the loading profile and are fed back into the distribution and mode split phases.

The assignment procedure is explained in the TRACKS user manual. To summarise, in each iteration a proportion of the matrix is loaded according to the loading profile which is derived from traffic counts over the period. As a consequence the profiles for each period are different. Where there are a number of iterations before a skim (i.e. iterations 1 through 7 in the AM Peak period) the process is effectively an incremental assignment for that proportion (81%) of traffic, but with the start times and delays as calculated at the end of the previous skimmed iteration. Times and distances are accumulated at the skim point. If iterations are successively skimmed, then the assignment is an 'all or nothing' assignment for the proportion being loaded e.g. iteration 10 with 6% being loaded.

The profile can be altered for future runs, but it must be kept constant for all assignments (do min and options) in any given year.

Morning Peak Period Assignment Parameters				Table 3	
Assignment Increment	% Trip Matrix Loaded	% of Peak Hourly Flow Rate	Steady State Time (Minutes)	Perceived Assignment Costs	
1	11.6	-	-		
2	11.6	-	-	23.44	20.51
3	11.6	-	-	c/min	c/km
4	11.6	-	-		
5	11.6	-	-		
6	11.6	-	-		
7	11.4	81	30		
8	6.5	-	-		
9	6.5	94	15		
10	6.0	100	15		

Network Links

Travel Journey times will be established by a combination of link times and delays at intersections. The simplest form of calculating journey times in the 1960's and 70's was where all delay (link and intersection) was attributed to a link. Volume/delay relationships were derived for various types of road. Selection of the appropriate curve was made on the basis of a number of variables that physically describe the road.

Results from more recent surveys have allowed 'link only' delays to be empirically separated from intersection delays. The volume delay relationships used in this study will be for delays on links only and were based on those analytically derived by Akcelik:(1991) using a time dependent Davidson model. As a result, these curves give 'link only' delays, allowing intersection delays to be separately calculated. The J_A parameter, or friction factor, in Akcelik's equation for travel time was set for each link type so that Vcapacity/Vfree flow = 0.5. This is consistent with standard traffic theory and Fisk's behavioural model and matches data surveyed in Wellington. As a result these curves give 'link only' times, allowing intersection delays to be separately calculated. Each link in the network is given a volume delay curve depending of the speed limit, function and characteristic of the road the link represents. A steady state period of one hour was used.

Akcelik's formula is:

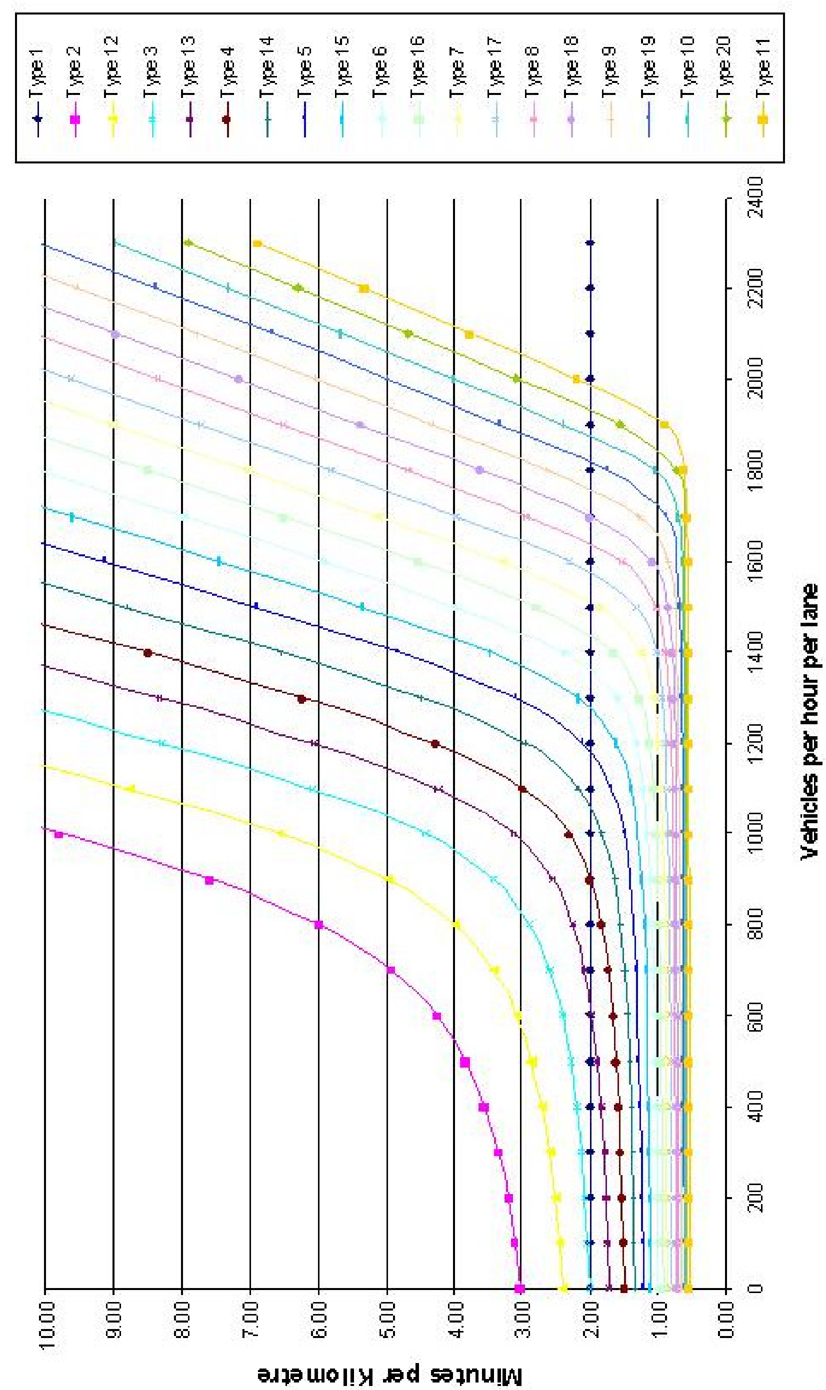
$$t = t_o \left\{ 1 + 900 r_f \left[(x - 1) + \left((x-1)^2 + (8 J_A x) / (Q t_o r_f) \right)^{1/2} \right] \right\}$$

Where:

t	=	travel time per unit distance (secs/km)
t_O	=	minimum (zero flow) travel time per unit distance (e.g., secs/km)
J_A	=	delay (side friction, level-of-service(LOS)) parameter
x	=	q/Q = degree of saturation
q	=	demand (arrival) flow rate (veh/sec)
Q	=	capacity (veh/sec) per lane
r_f	=	ratio of flow period T_f, to minimum travel time t_o

Twenty curves were developed with free flow times at 5km/hr intervals. The capacities and J_A values used for each curve are given below. Curve number 1 is a flat line for a centroid connector. Examples of the resulting volume/delay curves to be used for this study are shown in Figure 6 Each link in the network will be allocated a curve from an assessment of the free flow speed, its capacity and the environmental conditions of the link.

New future links should be coded by assessing the environment in which the link will operate, and choosing a curve with an appropriate free flow speed and capacity, given the way in which link with a similar curve operate under current traffic condition.



Waikato Regional Transportation Model	**Volume – Delay Curves**	**Figure 5**

Network Intersections

Each intersection on the road network is coded explicitly. The coding adopted in TRACKS to represent the different types of approach control is:

Type 0	-	Not controlled, has priority
Type 1	-	No controls marked, non priority
Type 2	-	Merge
Type 3	-	Roundabout
Type 4	-	Give Way, non-priority
Type 5	-	Stop, non-priority
Types 6,7	-	Signals
Types 8,9	-	Signals

a) Priority Intersections

Delays at priority intersections are calculated at the movement level. That is, left, right and through movements on all legs have delays calculated specifically.

The approach lanes at each intersection are coded as one of eight movement types as shown below. The opposing traffic flows are calculated from the intersection geometry, determined from the link coordinates.

1. Left, Through and Right
2. Left and Right
3. Left
4. Left free
5. Left and Through
6. Through
7. Through and Right
8. Right

The way each lane type was treated came from the publication titled, "Performance Analysis of Priority Intersections - A Practitioner's Guide" by Gabites Porter:(1991).

A queuing theory model is used to calculate the delays. The queuing theory formulation adopted is that described by Fisk:(1989), which uses an M/M/1 model (indicates a queuing system with negative exponential distributions for arrival headway and service times, with one service channel) and a coordinate transformation approximation to allow for over-saturated conditions.

The formulation is:

d	=	$r/\mu\ (1 - r)$	steady state conditions, r<1
		$(r - 1)\ T/2$	deterministic conditions, r>1

Where:

r = q_2 / μ

$$\mu = \frac{q_1 e^{-q_1 t}}{1 - e^{-q_1 b}}$$

T	=	duration of time period over which a steady state is assumed
q_1	=	major road flow rate
q_2	=	minor road flow rate, always defined as approach being delayed
t	=	critical gap
b	=	move-up time for minor road traffic.
μ	=	mean service rate
r	=	traffic intensity

Fisk shows that the delay equation can be written:-

$$d = \frac{-(2 + \mu t - r\mu t) + \sqrt{(2 + \mu t - r\mu t)^2 + 8r\mu t}}{4\mu} + \frac{1}{\mu}$$

when the coordinate transform is included and this formulation is used. The default critical gaps and move-up times to be used are described in **Table 4**, but may need to be changed during validation.

Intersections: Critical Gap and Move-Up Times		**Table 4**
Lane Type	**Critical Gap (sec)**	**Move-up Time (sec)**
Left turn-non-priority	5.0	3.0
Left turn-priority	5.0	3.0
Thru/Right-non-priority	5.0	3.0
Thru/Right-priority	5.0	3.0
Merge	3.0	2.0
Roundabout	4.0	3.0
Bottleneck	3.0	2.0

NB: a bottleneck is automatically recognised at a node where the number of lanes leaving the node is less than the number of lanes entering the node.

Intersections: Other Parameters	Table 4 Cont
Parameters	**Factor**
Tracking Headway	1.2 seconds
Lane Sharing Convergence Parameter	0.01000
Number of external iterations	50
Number of internal iterations (lane sharing algorithm)	200

b) Roundabouts

Delays at roundabouts are calculated using the formulae described in the SIDRA 5 User Manual.

c) Signalised Intersections

Delays at signalised intersections are calculated according to turning movements using the formulations in ARR123, including equations 6.4, 6.3 and 6.1 shown below. While ARR123 is the basis for SIDRA it does not give exactly the same results, especially for the more recent versions of SIDRA.

A general formula for the average delay per vehicle, d (in seconds) is

$$d = D/q \qquad \textbf{eqn (6.4)}$$

Where:

D = total delay (veh/hr/hr)

q = flow rate (veh/s)

$$D = \frac{qc(1-u)^2}{2(1-y)} + N_0 x \qquad \textbf{eqn (6.3)}$$

Where:

qc = average number of arrivals in vehicles/cycle
q = flow (veh/sec)
c = cycle time (sec)
u = green time ratios = g/c
y = flow ratio = q/s
s = saturation flow (veh/sec)
N_O = average overflow queue (vehicles)
x = q/Q = degree of saturation

$$N_0 = \begin{cases} \frac{QT_f}{4}\left[z + \sqrt{z^2 + \frac{12(x - x_0)}{QT_f}} \right] & \text{for } x > x_0 \\ 0 & \text{for } x \le x_0 \end{cases}$$ **eqn (6.1)**

Where:

Q	=	capacity (veh/hr)
T_f	=	flow period (hours)
z	=	x - 1
x_o	=	degree of saturation below which the average overflow queue is approximately zero = 0.67 + sg/600

Signalised intersections were modelled specifically and each required a SIDRA input data file.

d) Geometric Delays

The delays calculated above are the stopped delays for vehicles. As vehicles decelerate to stop or negotiate a corner a geometric delay is encountered. The geometric delay is calculated from the formulations in Gabites Porter:(1991).

4.11 Public Transport Assignment

The following section briefly details the development of the public transportation model. There is much technical detail included and no attempts have been made to simplify the text beyond its technical status.

The Assignment Process

The PT assignment model is analogous to the vehicle assignment and is used for assigning PT trips onto the network.

Unlike conventional vehicle assignment, PT assignment assigns the bus passenger matrix onto a fixed set of routes. Similar to vehicle assignment the decision of which route is taken is based on least cost algorithm. The main difference between the vehicle and public transport assignment is in the way the matrix is loaded. Public transport represents a dynamic assignment model where the modelled period and the matrix are divided into slices and passengers are released in intervals starting from the beginning of the modelled period. A dynamic assignment approach is necessary because of the way that buses run following a fixed timetable. The decision is made by each passenger as to which service or services will be taken, given the time that a service is available, and the time between two or more services connecting.

a) The single ride trip will occur if:

$$T^1_A > T^i_S + T_F + T_C$$

Where:

T^1_A	=	*the time at which the first available bus arrives at the bus stop A.*
T^i_S	=	*slice release time where the number of slices is i.*
T_F	=	*access and egress time by foot.*
T_C	=	*access time by car to/from the park'n'ride station*

The difference between the left and right hand side in the inequality above represents the waiting time T_W:

$$T_W = T^1_A - T^i_S + T_F + T_C$$

The waiting time has to be greater or equal to 0 and less or equal to maximum waiting time otherwise the trip can not occur.

$$T_{W(max)} \geq T_W \geq 0$$

b) The multi ride trip will occur if the single ride trip condition is satisfied for the first bus service used, and

$$T^2_B \geq T^1_B + 30sec$$

Where:

T^1_B	*is the time at which the first bus arrives at the bus stop B.*
T^2_B	*is the time at which the second bus departs at the bus stop B.*
30sec	*is the minimum time allowed for the passenger transfer.*

The difference between the first bus arrival and the second bus departure represents the waiting time:

$$T_W = T^2_B - T^1_B$$

Therefore TW and has to be greater or equal to 30 seconds and less or equal to maximum waiting time TW(max) for the trip to occur:

$$T_{W(max)} \geq T_W \geq 30sec$$

If the maximum number of transfers is 3, then another condition has to be met for the trip to occur:

$T^3{}_C > T^2{}_C + 30$, and

$T_{W(max)} \geq T_W \geq 30sec$

Where:

$T^2{}_C$	=	*the time at which the second bus arrives at the bus stop C.*
$T^3{}_C$	=	*the time at which the third bus departs at the bus stop C.*
T_W	=	$T^3{}_C - T^2{}_C$
$T_{W(max)}$	=	*the maximum waiting time.*

Further constraints are the maximum inter-zonal cost and the maximum number of transfers. They cannot exceed values specified in the parameter file.

The inter-zonal cost for PT trips is derived as the weighted sum of several components:

- wait time cost
- walking time cost at each end of the trip
- park'n'ride cost (if used)
- fare cost
- a penalty for transferring between services

All bus routes are divided into a number of fare sections and the bus fare is derived depending of which fare section crossed. In the base model, a new ticket has to be purchased if a transfer is needed.

If a car is used as part of a PT trip (for example a park'n'ride trip) then the car cost is added and it consists of:

- In vehicle time cost, and
- In vehicle distance cost
- Parking cost

Time and distance costs are derived from the loaded vehicle network. During the assignment the link time is multiplied by 1.3 to allow for the time lost at bus stops where the boarding and alighting of buses occurs. The route file defines express routes where passengers can board buses only on certain stations, and no additional allowance is made for pick up times.

Public Transport Model Outputs

The public transport assignment outputs a series of matrices representing various time and cost components, and are a weighted average of the cost of all trips between each zone pair.

- In vehicle time.
- Average walk time
- Average wait time
- Average car cost
- Average fare cost

Other matrices output by the public transport assignment are:

- Average number of fare sections crossed
- Average number of transfers.

It is also possible to establish the services used between each zone pair for each slice of loading. Also available are the origin and destination nodes for each bus service used and the park'n ride nodes if these facilities are used to complete the trip. The path file also contains information about each of the slices loaded, the release time and the cost in dollars for that trip portion. If the trip happens to be the one where passengers transferred from one bus to another, then the node at which the transfer occurs is recorded.

Passenger patronage per service with the time component included is reported in a separate file, which lists all services and the number of passengers getting on and off the buses along the route.

Similar to vehicle assignment a loaded network is produced at the end of each run, and depending on the switch used in the parameter file loaded network will contain either PT passenger numbers or the number of buses. The number of buses is a graphical check on the coding and is a direct reflection of input

5. GOODS VEHICLES

The Request for Tender requires the explicit modelling of "heavy commercial vehicles". To address this, a Commercial Vehicle Sub-Model is proposed for the WRTM, which will enable trips by medium or heavy commercial vehicles to be forecast. Medium or heavy commercial vehicles would be defined according to New Zealand Transport Agency's Economic Evaluation Manual, which are vehicles over 3.5 tonnes in gross laden weight.

Internationally, sophisticated models of freight movements are commodity-driven rather than vehicle-based, with conversion to vehicle trips carried out downstream of the trip generation and distribution stages. With commodities forming the key input to these models, development of a commodity-based commercial vehicle model is outside the resources available for the current project as forecasting commodities is a complex task. Instead, the WRTM Good Vehicle Sub-Model will be a three stage vehicle trip-based model, encompassing trip generation, distribution and assignment. Trip generation and distribution will be conducted at a daily level (24 hour) and matrices factored to peak hours for assignment.

Prior to the development of the synthetic model, a matrix of observed commercial vehicle trips is required. This matrix is the primary building block enabling the construction of the Goods Vehicle Sub-Model. The quality and quantity of the observed vehicle movements will therefore govern the complexity of the model that can be developed.

Relationships prepared for the Christchurch Commercial Vehicle Model, and potentially those developed for the Tauranga/Western BOP model will be utilised to develop the first estimate of the observed matrix for the WRTM. This will be achieved by combining the synthetic equations with input land use data from the 2006 Census on a zonal basis. This matrix will then be compared with travel patterns of medium and heavy vehicles collected through Roadside Interview Surveys and at screenline level through comparison with classified automatic traffic counts. Depending on the ability of these equations to reproduce commercial vehicle travel in the Waikato, the synthetic equations will be refitted to improve the relationships.

It is almost certain that the equations will require modification due to the different nature of the area. In this case, matrix estimation techniques would be applied to improve the observed matrix. Synthetic equations for trip generation would then be re-estimated using multiple linear regression, with Census employment data by ANZSIC category as the key explanatory variables. The gravity model would therefore also require refitting, using standard automatic calibration techniques.

Special generators for commercial vehicles will be identified and trip generation surveys planned as part of the Data Collection phase of the project. This will enable the general relationships to be fine-tuned on a generator basis.

6. CALIBRATED PARAMETERS AND DATA SOURCES

This section covers the parameters that will be calibrated during the model build, and the data sources to be used for that calibration.

Parameter:	Household car driver trip rates by category – Regional model
Data Sources:	Home Interview survey of household outside of Hamilton sub area, Census data
Process:	Accumulate car driver trips in each category and purpose and divide by the number of houses in each category. Calculate standard deviation within each category and purpose
Check:	Repeat process for trips within Hamilton sub area and use all data if they are comparable

Parameter:	Household person trip rates by category – Hamilton sub model
Data Sources:	Home Interview survey of households within Hamilton sub area, Census data
Process:	Accumulate person trips in each category and divide by the number of houses in each category. Calculate standard deviation within each category

Parameter:	Attraction equation coefficients - Regional model
Data Sources:	Home Interview survey of households over whole region, Census data
Process:	Extract trip attractions by purpose and aggregate zone from the HIS, and regress against ANZSIC major groups.
Check:	May need to be different equations within and outside the Hamilton sub-area. Combine if possible.

Parameter:	Attraction equation coefficients – Sub area model
Data Sources:	Home Interview survey of households within Hamilton, Census data
Process:	Extract trip attractions by purpose and detailed zone from the HIS, and regress against ANZSIC major groups and school/tertiary rolls.

Parameter:	Distribution functions – Regional model
Data Sources:	Home Interview survey of households over whole region, Generalised costs from road assignment
Process:	Calculate distribution function for each purpose and fit negative exponential function.
Check:	Iterative process with assignment

Parameter:	Distribution functions – Hamilton sub-area model
Data Sources:	Home Interview survey of households within Hamilton, Generalised costs from weighted road and public transport assignments
Process:	Calculate distribution function for each purpose and fit negative exponential function.
Check:	Iterative process with mode split and assignment

Parameter:	Mode split parameters – Hamilton sub-area model
Data Sources:	Home Interview survey of households within Hamilton, Generalised costs from weighted road and public transport assignments
Process:	Calibrate the mode parameters until observed mode split is matched.
Check:	Iterative process with mode split and assignment

Parameter:	Generalised cost parameters – Regional and Hamilton sub-area model
Data Sources:	From internationally accepted values
Process:	Adopt weightings from these studies

7. VALIDATION

This section covers the application of the model at the validation year (2006) the validation checks and criteria to be applied, and the data sources to be used in that validation. There may be some cases where later data (such as new turning counts) will need to be normalised to 2006.

Trip Generation

Model Output:	Trip ends by purpose – Regional and Hamilton models
Check:	That model trip ends by purpose, time period, zone and total match observed
Criteria:	Total trip ends aggregated across all zonesl within + 15% for each trip purpose within each period, $R^2 > 0.8$ at a regional zone level for well populated HIS trip purposes in each period and generally > 0.5 where possible for less populated trip purposes.

Trip Distribution

Model Output:	Convergence
Check:	That the balancing iterations in the doubly constrained gravity model do not change between iterations.
Criteria:	All within 0.1 %, and at least 95% within 5% of volumes
Model Output:	Trip lengths
Check:	That modelled mean trip time and distances match observed
Criteria:	Visual inspection of comparison, document means and standard deviations, and checkR^2 > 0.8 between modeled and observed for well populated HIS trip purposes in each period and generally > 0.5 where possible for less populated trip purposes.
Model Output:	Zone and Sector movements
Check:	That modelled mean trip patterns match observed at zone and sector level
Criteria:	Visual inspection of comparison using scatterplots, and $R^2 >$ 0.95 for each period at a TLA level.

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.

Model Output: Elasticities
Check: That the modelled response to changes is in accordance with international experience
Criteria: Fare change has an elasticity of 0.3, and frequencies 0.1

Public Transport Distribution and Assignment

Model Output: Bus numbers
Check: That the number of buses on each link matches observed. This is essentially a check on service coding
Criteria: Absolute match

Model Output: Bus journey times
Check: That the journey time for each service matches observed. In part a check on timetable coding and in part that the stopped and network travel times are correct
Criteria: Journey times within ± 5% of expected for each service

Model Output: Passenger boarding and alighting
Check: That the number of passengers on and off for each service match observed
Criteria: Most within ± 10%, R^2 >0.8, Geh < 4 on all services and < 5 on individual services.

Model Output: Screenline link passenger volumes
Check: That the number of passengers on each and all links in a screenline match observed
Criteria: That each screenline is within ± 10% of observed and most individual links are within ± 15% of observed

Model Output: Total patronage
Check: That the total demand in the trip matrix matches observed at a sector level
Criteria: R^2 > 0.6 on trip ends, R^2 > 0.5 at cell level

Note some of the PT criteria are very optimistic and will be reviewed by 4th Dec 2009.

Road Assignment

Model Output: Distribution / Assignment convergence
Check: That the distribution/ assignment iterative loop has converged
Criteria: That the difference between total vehicle minutes and vehicle kilometers between iterations is within 0.1% and that at least 95% of individual links show changes < 5%

Model Output: Journey times
Check: That the modelled journey times match observed
Criteria: Each journey within ± 10%

Model Output: Link Flows
Check: That the modelled link flows match observed for all vehicles and goods vehicles
Criteria: To meet (or better) EEM requirements (GEH and RMSE)

Model Output: Turning movements
Check: That the modelled turning movements match observed
Criteria: To meet (or better) EEM requirements

Note that no validation is to be included at a turning movement level. There are two reasons for this. Firstly, any requirement for validation at this level of detail must be considered on a project-by-project basis and as such forms part of the necessary local area validation required for any option assessment project work. Secondly, given that the base model is 2006 and that the model validation has taken place in 2009 it is difficult to reconcile the three year gap between validation year and data collection year, especially when collecting data at such a fine level of detail. On any given day traffic volumes fluctuate considerably and this has been taken into account in the traffic flow validation data collection. When traffic volumes are then broken down further to a turning movement level and then back-projected by 3 years, these factors on top of the day-to-day and seasonal fluctuations make assessing appropriate volumes for validation very difficult. On this basis turning movement validation has been deferred but will be revisited on an as required basis in the project work associated with the WRTM.

8. INTERFACES WITH OTHER MODELS

The Regional model will need to interface with the Hamilton Sub-model, and with the Tauranga, Rotorua and Taupo urban area models.

The interface with all of these will by way of a 'window' cut during the period assignments of the Regional model. However each model will have differing requirements and only the Hamilton model will be fully integrated with the Regional model.

In the regional model, the urban models will be represented by skeletal networks such that the trip distribution and assignment can be reliably modelled. This will enable useful transfer of data to the urban models in terms of future external trips, and through traffic.

Hamilton

The Hamilton sub-model will need flows at the boundary, preferably by purpose for each modelled time period. These will be incorporated into the trip end generation stage so that external trips are competing with internal trips for destinations. A through trip matrix for each period will also be prepared during the windowing process. The process will be automated so that it is 'seamless' when the models are run.

The adopted model form has made this process redundant.

Rotorua and Taupo

These models exist and have recently been updated to 2006. Boundary flows at the externals for all purposes combined can be provided, as well as a through matrix. Both these models run under TRACKS and there will be no incompatibility issues.

Tauranga

The Tauranga Model is run under the Cube Software and interface issues are unlikely to present a problem, based on TDG's knowledge of the software.

9. FORECASTING ABILITY

There are two approaches to consider when applying the model as a forecasting tool.

One approach is to apply the model on an incremental basis, in which the model is used as a tool to estimate the growth in traffic. This involves running the model for both the base year and forecast year. The changes in travel demands in terms of trip ends or matrices will then be calculated from the model outputs and applied as growth factors to more detailed base year matrices. This is considered to be more appropriate for short term forecasts.

The other approach is referred to as synthetic, in which the model produces forecasts and the outputs are used directly for planning. This is generally more appropriate for longer term forecasts involving more significant changes in land use and infrastructure, although the validation criteria are correspondingly less onerous.

The appropriate future application of the model will ultimately depend on the level of validation achieved, and it will be necessary that there is a local area validation step when using the model for detailed project analysis.

It is important that the end use of the model is kept in mind during the building, calibration and validation processes. Appendix A contains a list of the projects which the local authorities have in mind, and contains a brief comment on the way in which the model will be used for each project. Some of the projects do not have a modelling application, and these are also identified.

The models' ability to forecast will be checked and demonstrated during stage VI of the study, and in addition to the requirements of the RFT, some limited sensitivity testing of both supply and demand changes will be undertaken.

Appendix A – Possible model applications

Agency	Project	Project Description	Applicability of the model
Hamilton City Council	RAMMS	Minor work for future traffic estimates	Provides Future traffic volumes
Hamilton City Council	Ruakura	Information to test alternatives	Testing of alternative landuse and roading strategies
Hamilton City Council	Rotokauri	Major assessments of various land use/ transport network alternatives	Testing of alternative landuse and roading strategies
Hamilton City Council	Rototuna		
Hamilton City Council	Parking Model	Effects of parking policies	Not included in the model
Hamilton City Council	CBD Improvement	Testing alternatives	Testing alternative traffic management schemes
Hamilton City Council	E1	CB estimates of alternative designs	Economic and network efficiency of alternative designs.
Hamilton City Council	Peachgrove	Information to test alternatives	Economic and network efficiency of alternative designs.
Hamilton City Council	Ruakura	Information to test alternatives	Economic and network efficiency of alternative designs.
Hamilton City Council	Wairere	Review of BCRs	Economic and network efficiency of alternative designs.
Hamilton City Council	Bus Routes.	Effect of networks changes on vehicles and PT	Analysis of alternative networks and PT services
Hamilton City Council	Grey / Claudelands	Information to test alternatives	Supply Traffic flows for Sidra analysis
Hamilton City Council	Boundary Road	Ongoing BC calculations for stages and designs	Economic and network efficiency of alternative designs.

Agency	Project	Project Description	Applicability of the model
Environment Waikato	Regional Land Transport Strategy Review	A review of the policies, actions and targets of the Operative Waikato Regional Land Transport Strategy, including an analysis of strategic options, key transport projects and development of a land transport programme for the region.	Provides transport demands from which to develop future strategies
Environment Waikato	Inter Regional Transport study	A study of inter-regional transport routes between Waikato region and Auckland, Bay of plenty, and Taranaki Region. Modelling of specific traffic routes will be required.	Provides information for assessment of alternative routes and design requirements
Environment Waikato	Regional Roading Hierarchy	Development of Regional Roading Hierarchy. Modelling may be required to assist	Provides base information to develop and confirm the hierarchy
Environment Waikato	Regional Road Safety Strategy	Development of Road safety Strategy. May require modelling of specific black routes	Provides data for input into crash reduction studies
Environment Waikato	Regional stock truck effluent co-ordination	Co-coordination of stock truck effluent sites. May require some modelling	Not directly applicable.
Environment Waikato	Regional Funding plan – JOG, Regional petrol Tax	Modelling may be required to justify alternative funding sources such as regional fuel tax, tolling etc.	These TDM measures are able to be considered.
Transit/ Environment Waikato	SH 1 Expressway Strategy Study	Builds on work currently underway by Transit	Economic and network efficiency of alternative designs.
Environment Waikato/ONTRACK, Toll	Regional Rail Strategy	Required to develop a regional rail study. Modelling of traffic to Inland Port may be required.	Not directly applicable.

Agency	Project	Project Description	Applicability of the model
Environment Waikato/ Transit/ TAs	Subregional integrated transport strategies	Modelling to investigate sub-regional traffic movements	Provides transport demands from which to develop future strategies
Environment Waikato	Investigate and report on alternative transport methods such as barging and rail.	Modelling will be required to support benefits of moving trucks off the roads. Have used Auckland model previously to support Kopu barging project.	Not directly applicable, but 'what if' options may be tested.
Transit NZ	SH1 Rangiriri Bypass	Design phase of a major bypass of Rangiriri township to west of existing SH1 route. Modelling required for traffic data and economic evaluation.	Economic and network efficiency of alternative designs.
Transit NZ	SH1 Huntly Bypass	Design phase of a major bypass of Huntly township through the Taupiri Ranges. Modelling required for traffic data and economic evaluation.	Economic and network efficiency of alternative designs and interchange locations.
Transit NZ	SH1 Ngaruawahia Bypass	Design phase of a major bypass of Ngaruawahia township between Taupiri and Horotiu. Modelling required for traffic data and economic evaluation.	Economic and network efficiency of alternative designs and interchange locations.
Transit NZ	SH1 Te Rapa Bypass	Design phase of northern sector of Hamilton Western Corridor between Horotiu and Avalon Drive. Modelling required for traffic data and economic evaluation. Will need to interact with Hamilton City Transportation model.	Economic and network efficiency of alternative designs and interchange locations.

Agency	Project	Project Description	Applicability of the model
Transit NZ	SH1 Hamilton Bypass	Design phase of a major eastern bypass of Hamilton City between Ngaruawahia bypass and Tamahere. Modelling required for traffic data and economic evaluation. Will need to interact with Hamilton City Transportation model.	Economic and network efficiency of alternative designs and interchange locations.
Transit NZ	SH1/3 Hamilton Southern Links	Investigation phase of southern sector of Hamilton Western Corridor to link from Kahikatea Drive/Greenwood Street to Tamahere. Modelling required for traffic data and economic evaluation. Will need to interact with Hamilton City Transportation model.	Economic and network efficiency of alternative designs and interchange locations.
Transit NZ	SH1 Cambridge Bypass	Design phase of a major northern bypass of Cambridge township. Modelling required for traffic data and economic evaluation. Will need to interact with Cambridge Traffic Study model.	Economic and network efficiency of alternative designs and interchange locations.
Transit NZ	SH2 Kopuku Realignment	Investigation (& then subsequently Design) phase of a major upgrading of this section of SH2 west of Maramarua township. Modelling required for traffic data and economic evaluation.	Economic and network efficiency of alternative designs.
Transit NZ	SH2 Maramarua Deviation	Design phase of a major realignment to north of Maramarua township. Modelling required for traffic data and economic evaluation.	Economic and network efficiency of alternative designs.