Wellington Regional Council

Wellington Transport Strategy Model: Peer Review

Final Report

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December 2003

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Job title	Wellington Transport Strategy Model: Peer Review	Job number	82324
Document title	Final Report	File reference	
Document ref			

Revision	Date				
		Filename	final sign off report.doc		
Draft 1	18/08/03	Description	First draft		
			Prepared by	Checked by	Approved by
		Name	Peter Dunn	Bruce Johnson	Bruce Johnson
		Signature			
Issue 1	20/11/03	Filename	base model review report.doc		
		Description	Issued to WRC as draft		
			Prepared by	Checked by	Approved by
		Name	Peter Dunn	Bruce Johnson	Bruce Johnson
		Signature			
Issue 2	23/12/03	Filename	base model review report_final.doc		
		Description	Final		
			Prepared by	Checked by	Approved by
		Name	Peter Dunn	Bruce Johnson	Bruce Johnson
		Signature			
		Filename			
		Description			
			Prepared by	Checked by	Approved by
		Name			
		Signature			

Issue Document Verification with Document ✓

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1. EXECUTIVE SUMMARY

1.1 Background

Arup has been appointed by Wellington Regional Council to peer review the development of the Wellington Transport Strategy Model (WTSM). The development of the model is being undertaken by Beca Carter Hollings & Ferner (Beca) and Sinclair Knight Merz (SKM) for Wellington Regional Council. In addition to Arup's in-house modelling expertise, John Fearon, an international multi-modal model specialist based in the UK, was included in its review team.

1.2 Review Objectives

The objectives of this commission were to:

- peer review the new transportation model in a timely and cost effective manner
- ensure the satisfactory conclusion to the model construction process
- sign off on behalf of the Council (and Transfund New Zealand) the full model and development documentation with respect to the modelling
- test the final model to ensure a robust structure and results are available.

1.3 Background

WTSM was originally developed in the TRACKS software to a 1988 base. Booz Allen and Hamilton (BAH) updated WTSM between 1997 and 1999 based on 1988 household surveys and transferred the model to EMME/2 software. This redevelopment of the model is documented in the Wellington Transport Strategy Model Documentation, BAH, July 2001.

Beca and SKM were appointed by WRC to redevelop the model in 2001. The key objective of the model redevelopment was to recalibrate the model (WTSM) based on new data. The functional design report documents the key issues that were to be considered in the redevelopment of WTSM. This forms the context for the project and the review.

1.4 Review Approach

The following sections summarise our review of the model development and calibration of the sub-models. Our review consisted of the following approach:

- Review of the preliminary studies report that documented key model development issues raised during the technical specification and functional design of the model. The Beca/SKM team had opportunity to consider and respond to those comments
- Presentation of model development progress by Beca/SKM and discussion of key issues raised by our review with Beca/SKM
- Arup review of the sub model calibration reports produced by Beca/SKM
- Response from Beca/SKM team on sub-model calibration reviews
- Detailed model testing of base model handed over by Beca/SKM. A report was produced outlining findings
- Response from Beca/SKM team on model testing report
- Discussion of key outstanding issues of our review with Beca/SKM at a meeting.

1.5 Transfund Guidelines

Transfund's Project Evaluation Manual (PEM) provides transport model validation guidelines and clearly distinguishes two levels of the modelling process:

- Strategic demand models such as WTSM which incorporate the traditional 4 stage process
- The project model, specific to the project being evaluated, which is generally an assignment model, perhaps traversed from a sub-regional model.

The project model specification and validation guidelines are presented in Worksheet A3.11(a) and A3.11(b) respectively. These guidelines are relevant to the detailed traffic assignment models that are required for project models. It is therefore not appropriate to apply these guidelines for strategic models such as WTSM.

Worksheet A3.11(c) outlines strategic model checks for application of a strategic model including whether a peer review had been undertaken. No validation or calibration guidance is provided in the PEM for strategic models. We know of no absolute measures or thresholds that are used internationally to demonstrate that a strategic transport model is calibrated or validated. Calibration and validation guidelines for strategic models are also relatively rare internationally. This is because the requirements vary from model to model based on the objectives and transport and planning environment. Some documents that we are aware of are:

- Guidance on the methodology for multi-modal studies (Vol 2) DETR 2001
- Major Scheme Appraisal in Local Transport Plans, Part 3: Detailed Guidance on Forecasting Models for Major Public Transport Schemes, Department for Transport, UK, 2002
- Model Validation and Reasonableness Checking Manual, Federal Highway Administration February 1997.

Generally these documents provide comprehensive guidelines for the development of four-stage models including calibration and validation checks. We have used the principles espoused in these documents where appropriate, as a basis for this peer review.

Based on our review we believe that the model is suitable to be used as a strategic model to test transport policies in the Wellington region and as a basis to build project models notwithstanding the limitations discussed in Section 12.3 of this report.

1.6 Sub Models

1.6.1 Productions

Whilst the production model is very disaggregate, the final models were shown to be satisfactorily calibrated.

1.6.2 Attractions

The attraction models are typically more difficult to calibrate than production models, as more data is available at the production end of the trip. The larger differences in the attraction models generally related to low trip generating sectors. The attraction model was satisfactorily calibrated, with balancing factors for attractions no greater than 6%.

1.6.3 Car Ownership

The effort put into the car ownership model was driven by the current high ownership and the expectation that this will not change greatly in the following years. This influenced the approach adopted, as it was perceived that whilst a car ownership model was required in some cases an enhancement to other sub models was a higher priority. Therefore in some cases simplifications were made.

The car ownership model was shown to reproduce the census figures and for short term forecasting the cross-sectional model and time series models produce similar results. If the model is to be used beyond 2021 and significant changes to the transport or land use environment the car ownership model should be reviewed.

1.6.4 Distribution and Mode Split

Significant effort has gone into developing the most appropriate distribution and mode split model for each purpose. Various alternative models were tested and an appropriate distribution and mode split structure has been applied. There are some variations from sector to sector, which is common to all strategic models, but the significant differences are mostly explainable.

1.6.5 Assignment

The validation has been reviewed and we found that WTSM has been validated to an acceptable level for a strategic model. The public transport assignment validation is not as strong as the traffic assignment validation (note: this is typical for strategic models) and there are some weaknesses in key areas for buses. However these generally relate to the coarseness of the model and the lack of bus survey data. The collection of bus travel data should further improve this validation. The model's limitations are discussed in Section 12.3.

1.7 WTSM Use and Application

Based on our assessment of the base model we conclude that WTSM is an appropriate tool to:

- assess transport strategies and policies in the Wellington region.
- assess the strategic impacts of major road and public transport projects
- assess the impacts of land use strategies on the transport environment
- as a basis to develop sub-regional traffic models with more detailed zone and network structure. The sub-regional models may employ more detailed representation of congestion and model junction delay in detail
- as a basis to develop project models for detailed assessment of road projects

The following comments should not be read as negative commentary of the model, which in our opinion is well calibrated and is fit for the purposes outlined above. As with all models, the modeller needs to be aware of limitations of WTSM in potential applications, including:

- Ultimately the model is reliant on the quality of the demographic forecasts fed into it
- Some enhancement may be necessary to assess corridor studies, if a high level of detail is required
- Johnsonville Corridor with the imbalance in the assigned split between rail and bus. A fix will be provided by Beca/SKM as an alternative to the base model
- Care will need to be taken in using the model to assess public transport projects in the sector to the south and east of Wellington CBD. The model demonstrated a significant discrepancy against the bus boarding counts (refer Table 3.5 of the validation report). This was shown to relate to very short distance trips that could not be accurately represented at the coarser zonal and network detail and the removal of primary school trips from the demand matrix. Further data collection – such as on-board bus surveys may be required to

refine the model in this area should detailed analysis of public transport projects be required in this area

- The model is limited, as are other strategic models, in demonstrating the impacts of roading and public transport policy on slow mode demand. This is due to the necessary simplification of the structure of the model which aggregates slow modes with either car or public transport for mode split and applies proportions against a trip distance profile following mode split to derive slow mode demand. As the majority of slow mode trips are short distance trips and for short distance choice trips a significant penalty is required for car trips to switch to public transport, the impact on slow modes is not considered to be significant
- Whilst the model can test the broad road pricing policy impacts on travel in the Wellington region, it is not of sufficient detail for analysis required to support procurement of a tolling project
- Whilst the model includes representation of junction delay on approaches, it is necessarily approximate for a strategic model given the coarse network and zoning. Therefore the model is not sufficiently detailed to assess local road projects, such as junction improvements etc
- If forecasting is undertaken beyond 2031 the car ownership model should be checked as there is no saturation value in the time series model
- The model may have some limitations in forecasting impacts of significantly changed transport or land use conditions, eg. response to intensification in the inner city and very significant improvements to the public transport which may influence car ownership
- Modellers should be aware of the correction factor applied to Sector 41 if the model is used to assess future development in Petone. In this respect the model response should be checked
- For forecast years external growth factors should be reviewed if external demographics are available
- Because the observed mode splits are close to 1 forecasting of mode shift where significant improvements to public transport that service HBSh may be an issue
- Particularly with long term forecasting, the signalised intersections with fixed capacity (i.e. green times are fixed) should be reviewed to ensure they are responding to changed travel patterns.

2. INTRODUCTION

2.1 Background

Arup has been appointed by Wellington Regional Council to peer review the development of the Wellington Transport Strategy Model (WTSM). The development of the model is being undertaken by Beca Carter Hollings & Ferner (Beca) and Sinclair Knight Merz (SKM) for Wellington Regional Council. In addition to Arup's in-house modelling expertise, John Fearon, an international multi-modal model specialist based in the UK, was included in its review team.

2.2 Review Objectives

The objectives of this commission were to:

- peer review the new transportation model in a timely and cost effective manner
- ensure the satisfactory conclusion to the model construction process
- sign off on behalf of the Council (and Transfund New Zealand) the full model and development documentation with respect to the modelling
- test the final model to ensure a robust structure and results are available.

2.3 Outputs

The outputs were as follows:

- Stage 1, review preliminary reports and advise the Council with regard to the reliability of the processes used
- Stage 2, review the model once the calibration process is complete and report on the model structure, robustness and validity of the processes utilised within the software
- Stage 3, test model sensitivity and response with a view to future use of the model and future year forecasting and option testing
- Stage 4, the Consultant will produce a report summarising the whole peer review process and signing off on the model.

A series of progress reports have been prepared by Arup, these include:

- Preliminary Studies Review: A review of a report that addressed 17 key issues raised in the Technical Specification and Function Design of WTSM
- Calibration Review: A review of the sub model calibrations. The sub-models were reviewed as they were calibrated
- Model Testing Report: A review of the validation and detailed model testing undertaken by Arup.

2.4 This report

This report provides a summary of the peer review of the Wellington Transport Strategy Model:

- Section 2 provides background of the model development and the review approach
- Sections 3 to 10 summarises our review of the sub-models
- Section 11 outlines our review of the validation and describes our model testing
- Section 12 outlines our conclusions.

3. MODEL DEVELOPMENT

3.1 Background

WTSM was originally developed in the TRACKS software to a 1988 base. Booz Allen and Hamilton (BAH) updated WTSM between 1997 and 1999 based on 1988 household surveys and transferred the model to EMME/2 software. This redevelopment of the model is documented in the Wellington Transport Strategy Model Documentation, BAH, July 2001.

Beca and SKM were appointed by WRC to redevelop the model in 2001. The key objective of the model redevelopment was to recalibrate the model (WTSM) based on new data. The functional design report documents the key issues that were to be considered in the redevelopment of WTSM. This forms the context for the project and the review.

3.2 Data Sources

The key data sources for WTSM were as follows:

- Home Interview Surveys (HIS), which included a sample of 2538 households undertaken between September 2001 and February 2002
- Rail Interview Surveys and counts in March 2002
- Bus ticketing information
- 2001 census data from Statistics New Zealand
- Various traffic counts and travel time surveys.

3.3 Software

WTSM is mostly implemented in the EMME/2 software. EMME/2 is developed, distributed and maintained by INRO Consultants from Montreal, Canada. EMME/2 has a significant share of the modelling market with over 2000 licences worldwide. Arup and others have used EMME/2 for similar projects internationally.

3.4 Review Approach

The following sections summarise our review of the model development and calibration of the sub-models. Our review consisted of the following approach:

- Review of the preliminary studies report that documented key model development issues raised during the technical specification and functional design of the model. The Beca/SKM team had opportunity to consider and respond to those comments
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- Discussion of key outstanding issues of our review with Beca/SKM at a meeting.

3.5 Documents Reviewed

Much documentation was received during the study. The reports reviewed by Arup are as follows:

- Preliminary Studies Report Final: Beca/SKM 21 August 2002
- WTSM Trip End Report Draft 1 February 2003
- WTSM Car Ownership Report Draft 6 March 2003
- WTSM Distribution and Mode Choice Report Draft 5 May 2003.
- WTSM Validation Report Draft, 22 May 2003.

A full list of reports provided for the review is appended.

Further, Arup were provided with the 'draft' base model on 13 June 2003 for detailed review and sensitivity testing.

Our review of the key issues from these reports follows in Sections 3 to 11. Our sub headings generally follow those used in the Beca/SKM reports.

4. TRIP PRODUCTIONS

4.1 Introduction

In this section the key outcomes of our review of the Trip Production model development and calibration are discussed.

The trip purposes modelled are:

- Home Based Work (HBW)
- Home Based Education (HBEd)
- Home Based Shopping (HBSh)
- Home Based Other (HBO)
- Non-Home Based Other (NHBO)
- Business Trips (BU) – both home and non-home based.

This is considered a reasonable disaggregation.

4.2 Production Model Statistical Approach

The approach to statistical testing is appropriate.

4.3 Home Based Work Productions

The employee segmentation in WTSM is very disaggregated. The full time and part time trip rates are shown to be significantly different. This segmentation is reasonable given the split between full and part time workers is provided in the forecast planning data.

Past experience of models in Australasia suggests that there may have been some value in the segmentation of blue and white-collar workers for distribution. However this would have provided yet further segmentation with reduced sample size and if implemented would have required aggregation of other segments.

In comparison to trip rates applied internationally the WTSM trip rate differences seem plausible. In Melbourne the HBW trip rates were around 1.3 for Blue Collar, in the UK National Trip End Model NTEM rates can be as high as 1.5, which compares to an average of around 1.4 in Wellington for all HBW trips.

The r-squared value is relatively low for the chosen model at 0.422, which can be expected given more variance for a person based compared to a household based model.

4.4 Home Based Education Productions

Overall the approach to the Home Based Education production model is reasonable. The r-squared value is higher than for HBW.

4.5 Home Based Shopping Productions

In the development of the Home Based Shopping model it was surprising that vehicle ownership and household location had no effect on shopping trip rates. However we consider the model reasonable with non-full time workers making twice the amount of trips as full time workers.

4.6 Home Based Other Productions

The final Home Based Other production model appears to be reasonable.

4.7 Non-Home Based Other Productions

The final model appears to be reasonable. Given that NHBO are often under-reported in the household interview surveys, it was encouraging that no correction was required during validation.

4.8 Business Trip Productions

The final business trip production model appears to be reasonable.

4.9 Summary

Whilst the production model is very disaggregate, the final models were shown to be satisfactorily calibrated.

5. TRIP ATTRACTIONS

5.1 Data Analysis File and Sector System

5.1.1 Survey Data

The use of roadside interview surveys increases the accuracy of the estimation of internal trip attractions from external productions as shown by the higher sample rates from the roadside survey compared to the household survey.

5.1.2 Sectors

Compared to Trip Production models there is generally less data (quality and quantity) to derive the trip attraction models. Trip attraction models generally need to be developed at aggregate levels using regression techniques. Aggregating zones to create a smaller number of sectors with a statistically significant sample to assess variation of trip attraction rates is appropriate. Importantly major generators such as shopping centres have been isolated. Generally other zones include a sample of around 30 to 90 trips from the household survey.

5.1.3 Attraction Model Statistical Approach

We concur with the comment regarding negative co-efficients and their potential to result in negative values. We are therefore satisfied with the statistical approach.

5.2 Home Based Work Attractions

In general the model fit seems reasonable for a trip attraction model. However, the model appears to under-predict for observed values of less than 2000, which may be due to origin forcing. As these sectors contain relatively small numbers of trips, this is not considered to have a significant impact on the model results.

5.3 Home Based Education Attractions

Overall the Home Based Education model fit is reasonable.

5.4 Home Based Shopping Attractions

There have been many studies around the world that have investigated trip attraction rates and its dependencies. The evidence often relates trip attraction to retail floor area and catchment population, but the relationships are rarely simple given a range of accessibility factors, parking provision etc. Here retail employment is essentially a surrogate for retail floor space and the treatment of shopping centres separately has enabled a reasonably statistically significant model. The definition of shopping centres was somewhat arbitrary and based on zones generating a high number of trips and those identified on the map. However more detailed information, such as a database of retail floor area or employment, was not available to establish a more rigorous relationship.

The model over-predicts observed trips to a sector of less than 2000 trips and under-predicts sectors with observed trips between 2000 and 4000 trips, possibly suggesting a non linear relationship. Perhaps further enhancement of the model could address this trend if the model is required to assess shopping trips in detail in the future. However, the model is considered acceptable given the above trend is for sectors with lower demand and the three identified outliers have been appropriately treated.

5.5 Home Based Other Attractions

Overall the model seems to have a good fit, however we note a general tendency to overestimate trips in sectors observed to generate between 1000 and 5000 trips and then to underestimate for larger attractors.

5.6 Non Home Based Other Attractions

A negative coefficient has been applied to the Petone sector which is essentially a correction indicating lower than average trip attraction rates for the sector. Applying correction factors to outliers are not uncommon in such models. Some care may be required if development is forecast in this sector in the future.

The model fit is considered reasonable with a tendency to over-predict for observed trips less than 5000.

5.7 Business Attractions

The model fit is considered acceptable with a slight bias to over-predict at less than 1000 observed trips per sector and over-predict 6000 observed trips per sector.

5.8 Overall

The attraction models are typically more difficult to calibrate than production models as more data is available at the production end of the trip. The larger differences in the attraction models generally related to low trip generating sectors. The attraction model was satisfactorily calibrated, with balancing factors for attractions no greater than 6%.

6. FAMILY STRUCTURE

6.1 Model Structure

The model estimates the full cross-classification by zone, by 7 person types and 15 household categories.

6.2 Family Structure Model

Realistically the size of the household survey limits the level of accuracy in the household/person cross-classification in any model, however the available data provides the best estimate available.

Acceptance of the forecasting problem identified on page 3 of the Family Structure report appears appropriate in light of the complexity of the alternative and the likely sampling errors in the cross-classification.

6.3 Calibration and Validation of the Models

There do not appear to be significant differences in the distribution at 15 sector level given the smaller HIS samples at this level. We note that Sector 3 is an outlier, but has a small number of trips.

Overall the calibration of the models is shown to be to be good.

7. EXTERNAL AND AIRPORT TRIPS

7.1 External Trips

7.1.1 Treatment of External Trips and Counts

All external trips were cordon loaded. It is usually better practice to have an external network on zones, which allows for the estimation of external costs and allows changes in external demographics to influence the external trip generations. However in the case of Wellington, particularly given the extent of the model coverage, the external cordon was not considered to be a significant issue and therefore the cordon loaded approach is acceptable.

7.1.2 External Trip Growth

The model assumes that external trip productions and attractions will grow at the same rate as those in the study area. This is a simplistic approach and does not reflect trends for increasing trip lengths over time and any changes in demographics in the external area relative to the internal area.

Ideally it would be better to have an external zoning system and if full planning data is available there the internal models could be used to forecast growth in productions and attractions. However it is understood that the data requirements and the wide coverage of WTSM made this enhancement a low priority. It is suggested that external demographics could be used to influence the growth factors when developing forecast demand matrices.

7.1.3 Airport Trips

The airport model estimates air passenger vehicle trips based on airport passenger numbers and access data. Trip rates are calculated based on rates per passenger number. Actual trip generation is calculated from a more detailed model that splits trips between the various available modes. Given the lack of available landside data some values have been estimated based on judgement.

Growth is predicted from air passenger numbers and time period factors are applied based on arrival and departure schedule information supplied by Wellington International Airport Limited (WIAL).

The airport trip model is necessarily simplistic, but more detailed than some comparable models in Australasia. Given it has been checked against available data and the strategic nature of the model it is an acceptable approach.

8. CAR OWNERSHIP

8.1 Model Form

The model is in 3 parts:

a) A 0, 1 or 2+ cars choice model developed from the HIS with probabilities of ownership based on household type and income. The 0, 1+ choice is made first and then the 1, 2+ choice;

b) Zone specific factors are used to adjust (a) to fit zonal car ownership observed in the Census; and

c) Growth is controlled for the study area as a whole to match forecasts from a time series model.

This is essentially the standard UK approach and has been for over 30 years.

8.2 Data Collection and Processing

8.2.1 Household Survey Data

The household sample was 2538 of which only 1593 had sufficient income data to facilitate use in the car ownership model development. Of these 1108 owned a car and could be included in the 1/2+ model development.

The HIS specifies numbers of cars available to the household including company cars.

The household sample is sufficient for car ownership model development providing that there is not too much disaggregation by household type. The rule of thumb is generally a minimum of 1000 households.

8.2.2 Time Series Data

The time series data covers GDP, real car price and national car ownership and population levels between 1970 and 2001. It was necessary to estimate data for some of these variables for some years.

Time series models have the limitation that they do not cover the real drivers of car ownership which are disposable income, which is not necessarily exactly correlated within GDP, and numbers of the population in the age range eligible to drive, which can vary considerably, eg. due to the baby boom or immigration. Another issue relates to the real car price index as in times of recession there is a tendency to trade down market in terms of car value and in times of boom to trade up market.

However the application of a time series model is a common application in such models to correct the cross-sectional model. Recognising such limitations we recommend that longer-term forecasts should be reviewed. This can be undertaken by comparing the cross-sectional model results to the time series model results.

8.2.3 Census Data for Model Fitting

Car ownership data was derived from the 2001 census by zone, by household category, by car ownership (0, 1 or 2+).

8.3 Household Car Ownership Model Calibration

8.3.1 Introduction

The car ownership models are of the logit form. There are separate models for each household type and different saturation levels and income functions by household type.

8.3.2 Calibration Process

The maximum log-likelihood models were developed using a non-linear optimiser.

In determining the income function, 38 households within zero income were ignored. Households are unlikely to have zero income and this illustrates the problems of determining income, eg. respondents will give erroneous results either on purpose or because they do not really know their income, or their 'income' may be derived from sources, which they do not perceive as income, eg. capital gains or social security payments. This is a general problem with such models. The approach to model fitting in this case is standard.

8.3.3 Models of the Probability of Owning at Least One Car

After testing various model forms a log function of income was chosen with the coefficient for this function varying by household type. The constant was taken as the same for all household types and the saturation level was taken as 1.0 for all household types.

The coefficients for the 2 categories of 1 adult households and 2 categories of 2 adult households are fairly similar in magnitude. Figure 3.1 of the Car Ownership Report suggests that there is little overlap between employed and non-employed household incomes and the differences where the curves overlap for the same number of household adults are likely to be caused by sampling and income estimation error. In view of the above it would have been worth considering collapsing the household types to 3, i.e. 1 adult, 2 adults, 3+ adults.

The model was developed based on household category given that forecasts are supplied at this level of detail. Whilst we have some concern about the level of disaggregation in this model, we understand that an aggregate model was considered and tested by the modelling consultant and provided little further improvement.

Referring to Figures 3.2 to 3.7 in the Car Ownership Report we question whether the models accurately reflect car ownership at lower levels of income, although the chosen model is shown to be the best of those tested. This is a critical area as the slope of the function is high and mis-estimation in this area can cause significant differences between forecasts and outturn car ownership. This is a common problem in car ownership modelling and we are not aware of a satisfactory solution.

8.3.4 Models of the Probability of Owning 2 or More Cars

A saturation level of 0.95 was used to be consistent with other studies. This is probably not unreasonable for 2 adult households as there will always be a small proportion of adults who cannot/will not drive for physical or psychological reasons. We would normally expect that for 3+ adult households a saturation level of 1.0 would probably be more appropriate. However we understand that the modelling consultant tested varying levels of saturation flows and the data did not support different saturation levels for 3+ adult households.

A linear income function model was adopted. We had some concerns at the inconsistency between using a log function for 0/1+ and a linear function for 1/2+. Its possible that this could cause problems particularly at lower income levels where the functions differ significantly. Looking through Figures 3.9 to 3.11 we did see some benefits for choosing the log function as this would give a better fit at lower income levels and would not be significantly different at higher incomes. Also it tends towards a zero probability at zero income, whereas the linear function is likely to forecast a significant probability at zero income, which is not plausible. The log likelihoods for the different models are probably not significantly different, particularly in the light of both being based on slightly different datasets. The modelling consultant has considered these issues, tested the alternative linear and log models and concluded that the linear function is the most appropriate in the context of the structure of this model. Figure 3.9 suggests that the income/car ownership data for category 3 is questionable with an apparent decline in the probability of 2+ with increasing income. This is probably due to a limited sample of the sample above $120k income band in household category 3 and is unlikely to cause significant problems assuming the segment remains small.

8.4 Implementing the Car Ownership Model: Fitting to Census Data

8.4.1 Implementation of the Car Ownership Model

It is assumed that the HIS sample for households of each type is representative for all zones. This is unlikely to be the case particularly in relation to income and family size, ie. non-adults, which tend to vary between areas.

Future income growth is applied as a single factor. This implies that the current income distribution remains constant and the same income growth for all zones. These assumptions are unlikely to be correct, but it is difficult to see how any changes in distribution could be forecast or included in the model.

8.4.2 Car Ownership Model Adjustment Factors

It is not clear how the adjustment factors were calculated, but presumably they are the values which when applied to the linear predictor replicate the observed car ownership shares for the band. This approach of effectively adjusting zonal income to achieve a fit at zonal level is widely used and unless zonal income data is available is the only tenable method of application at zonal level.

If the models are correct for each household category it would be expected that the census adjustment factors would average zero. However, the 0/1+ models for categories 1 and 5 appear to have highly non-symmetrical factors as does the category 5 model for 1/2+. This suggests that the HIS data for categories 1 and 5 may not be representative of the study area as a whole. These categories may well contain smaller numbers of households than some of the other categories, which may have made bias more likely. Also certain types of household which are highly active are generally difficult to contact which also may have caused bias in these groups.

Different census factors for each household category imply a different income distribution for each zone. There is no guarantee that these factors will remain constant in forecasting, but as with all such adjustment factors there is no logical way of adjusting them in forecasting.

We have highlighted limitations in the approach, but the approach is reasonable given the available data and the model objectives.

8.5 Time Series Analysis

8.5.1 Implementation

The disaggregate car ownership model is controlled to the trend model by means of an additional adjustment to the linear predictor. It is implied by the notation that a separate value is applied for each model, ie. 0/1+ and 1/2+. However, the trend model only forecasts car per person. The 0/1+ and 1/2+ models are adjusted to achieve the trend forecast of cars per person by applying the same adjustment factor for both models. This is most logical, (although not necessarily correct) approach given lack of evidence otherwise.

8.5.2 Model Form

The model predicts annual changes in cars per person based on annual changes in GDP, car price and time trends.

Whilst the general time trend factor has a saturation level, the time series model does not include a saturation level for GDP or car price terms. Ideally a saturation level should be applied as one car per person would never be achieved as children or adults with particular disabilities cannot drive and/or own a car. Experience suggests that as car ownership approaches saturation levels the rate of increase of car ownership declines.

We understand that the modelling consultant was not able to successfully calibrate a model with a saturation level. Whilst the model is satisfactory for forecasting to 2031, care will need to be taken for longer term forecasting beyond 2031.

8.5.3 Model Results

The R-squared values for both the initial model and Model 1 appear to be relatively low, caused by the smoothing of the year to year fluctuations. However referring to Figure 5.2, both models appear to be an improvement on the BAH model.

8.5.4 Predicted Growth

It is noted that car ownership levels are reaching saturation in Wellington, but no saturation term is included in the trend model. The trend model therefore continues growth from the current level of just over 0.5 cars per person to nearly 0.7 cars per person by 2031. It is stated by the modelling consultant that the cross sectional model, which does include a saturation value produces similar results to 2021. In longer term forecasting care will need to be taken that car ownership levels are not reached that are not plausible in the context of the age structure and proportion of adults who would be unable to drive, e.g. those with disabilities, which preclude driving.

8.6 Overall

It is understood that the effort put into the car ownership model was driven by the current high ownership and the expectation that this will not change greatly in the following years. This influenced the approach adopted, as it was perceived that whilst a car ownership model was required in some cases an enhancement to other sub models was a higher priority. Therefore in some cases simplifications were made.

The car ownership model was shown to reproduce the census figures and for short term forecasting the cross-sectional model and time series models produce similar results. If the model is to be used beyond 2021 the car ownership model should be reviewed.

One further comment on the general application of the car ownership model. Following reasonably standard practice it has been formulated to be a function of household structure and income. The zonal adjustment factor process provides for other potential existing locational attributes that may influence car ownership. In this respect it means that insofar as accessibility to public transport may influence car ownership decisions this cannot be reflected in the forecasting model – for example introduction of a new rail line will not lead to change in long-term car ownership levels. Evidence from Australian cities shows that car ownership levels are highly correlated to proximity to rail lines. Whether such a trend exists in Wellington would require further investigation.

9. MODE SPLIT AND DISTRIBUTION

9.1 Introduction

The distribution and mode split (DMS) models are calibrated in 24-hour production and attraction format for HBW, HBed, HBSh, HBO, NHBO and EB.

9.2 Preliminaries

9.2.1 Trip Matrices

This section describes the car availability segments – captive, competition and choice, noting that competition and choice are combined for purposes other than HBW. The car availability segmentation is important in the structure of the demand forecasting models, particularly to the level of segmenting ‘car available’ and ‘no car available’. In this model car available is further segmented to:

- Competition, which refers to people in a household competing for cars where the number of cars are less than the number of people in the household, and
- Choice, where all people in a household have a car available, that is the number of cars in the household are equal to or greater than the number of people in the household.

This approach allows flexibility in developing and calibrating the mode split models for each trip purpose and is consistent with best practice.

9.2.2 Generalised Costs

Generalised costs have been skimmed from the AM and Interpeak networks and combined by proportion of travel over 24 hours, with the AM used to represent the PM peak. This is considered an acceptable approximation.

For intra-zonal trips an estimation of generalised cost is required given that they cannot be measured off the network. The approach applied in WTSM is to apply either a minimum time or the minimum inter-zonal cost to account for smaller zones. Another option would have been to relate intra-zonal generalised cost to zone size. However this would not be a major issue as constants have been applied to calibrate intra-zonal trips.

9.2.3 Statistical Methods, Model Structures and the Calibration Programme

This section provides background to the distribution and mode-split model development. These issues are discussed in detail in the following sections.

9.3 Appendix A – Generalised Cost Calculations

This section deals with the technical specification of generalised cost. Key comments are:

- The value of time should ideally be based on Wellington not nationally derived values. However it is understood that there is not a reliable value of time for Wellington, therefore the application of national values derived in the PEM values is appropriate as this is the only other source of value of time
- The interchange penalties are consistent with values used in other models including the Auckland Public Transport model in Auckland
- The wait time formula, which is linear with a constant of 1.5, and a headway factor of 0.25, seems reasonable. Often a headway factor of 0.5 is applied as a headway factor, but given Wellington public transport frequencies most people would time their trips based on timetable and 0.25 is a reasonable assumption.

9.4 Appendix B – Mathematical Form of the Model

It is noted that whilst mode choice and distribution of trips are undertaken at a zonal level, mode constants and constants for distribution have been estimated at a more aggregate level, for example TLA for mode constants. This is appropriate as the function will have more significance being developed from a larger survey sample.

9.4.1 Mode Split

There are two constant values applied to mode split. One is the mode constant and the other a geographic constant. Having two constants, rather than one, provides more flexibility to calibrate and explain the constants. It is standard practice to apply a mode constant, which is necessary to calibrate the mode split accounting for perceived benefits that influence mode choice such as comfort and convenience. Its application in forecasting often causes debate, for example where improvements to comfort and convenience results in further perceived benefits for a mode.

A reasonably standard practice is to apply the calibrated DLTA (the geographic mode constant) to future years, and this is understood to have been adopted by the modelling consultant. However an issue to be aware of is that the DTLA's inevitably relate to the area's demographic and socio-economic characteristics that will vary over time. There may be an argument that the DTLA will vary in the forecast year.

9.4.2 Distribution

This section outlines the distribution model that includes a constant. As with mode split there could be an argument that the constant may change in the forecast year. However it is standard practice for the calibrated constant to remain the same in forecast years.

The productions and attractions are balanced for each trip purpose prior to the distribution and mode choice models, with the home based purposes balanced to production totals. For the non-home based trips the trip productions generate the overall number of trips for each purpose, with the attractions scaled back to these totals. This is a standard approach that recognises that trip productions rather than attractions are the most reliable database. We have reviewed this process and confirmed its application.

9.5 Appendix C – Treatment of Walk and Cycle Trips and Costs

Appendix C outlines the treatment of the walk and cycle trips and costs in WTSM. The inclusion of walk and cycling in strategic transport models is always difficult given they generally relate to short distance trips that are often overlooked or under-reported in home interview surveys. This often implies a higher level of detail (in both supply and demand) than a strategic model is capable of delivering.

One of the objectives, from the stakeholder group, was to include walking and cycling in WTSM. SKM/Beca explored several alternative methods of incorporating slow modes in the model structure. The adopted approach was for each purpose to apply a standard factor to either the car or public transport demand following mode split. The selection of mechanised mode to apply this factor was based on the profile of the mode split against travel distance. The mode with the sharpest reduction in mode share for shorter distances was chosen – suggesting this is the mode least likely to compete with the slow mode trips.

We have some concerns on the slow mode approach generally regarding the logic of grouping slow modes with PT or car to split and the profile of that split. The approach we have often used in the past based on a car available/non car available segmentation extracts slow modes from motorised demand based on trip distance profile. However SKM/Beca encountered convergence issues when testing other models.

Overall we believe that the approach to slow modes has limitations, but is reasonable approximation given the problems associated with modelling slow modes in strategic models.

An issue with grouping the slow modes with either car or public transport demand is the potential impact when testing road pricing or public transport improvements. In the model, over short distances, public transport generally cannot compete with car because of walk and wait time penalties. Therefore short distance trips (the majority of slow modes are short distance trips) are reasonably insensitive to policy changes and given the model structure it is unlikely that there would be a significant impact on slow modes.

Auto distance was used as a proxy for the calculation of trip distance for the proportion of slow mode trips - it is common practice to use the auto distance as a proxy for slow mode distance. Whilst there are a number of one-way streets in Wellington, this is unlikely to have a significant impact based on the size of the zones.

9.6 Home Based Work

A simultaneous distribution and mode split model is applied for home based work.

The constants for intrazonals are significantly different from those for inter-zonals, which is not surprising given that costs are approximated for intra-zonal trips.

Some of the parameters in Table 3.3 do not appear to be significantly different, suggesting that these could have been collapsed such that segments could use the same parameter – eg. All ‘Choice PT Slow’ could use the same parameter. However the t-statistics for each parameter are shown to be significant.

Table 3-4 of the DMS Report shows a good fit between observed and modelled trips at segment level. This is to be expected as the constants and parameters have been chosen to give an exact fit over these segments. An Appendix has been provided in the DMS Report comparing the observed and synthesised trips by purpose at Transport Local Area (TLA) level. The distribution or trips between TLAs seems reasonable, with only Wellington to Lower Hutt being slightly high (27%). It is noted that this difference is corrected in the validation.

Table 3-5 shows a good fit on mean trip cost at segment level. This is to be expected as the constants and parameters have been chosen to give an exact fit over these segments. An

Appendix in the DMS Report has been provided comparing the observed and synthesised trips by purpose at TLA level.

9.6.1 Calibration Performance

The majority of the synthesised sector movements fall within the 95% confidence range, but there are a number of outliers, particularly in the public transport segments. However most outliers belong to sectors that generate low numbers of trips.

9.6.2 Slow Modes

The slow mode splits of the captive segment seem higher than we would have expected for the 3-4km band. The relationship between sectors seem plausible with the captive segment having a higher proportion of longer distance slow mode trips than choice and competition.

9.7 Home Based Education

The Home Based Education segment has been developed as a pre distribution mode split structure.

9.7.1 Distribution Model

The fit for Home Based Education is relatively poor compared to other segments as shown by some significant outliers particularly in Figures 4.6 for captive trips. This is possibly due to the sparseness of the matrix with a small number of attractors. However the captive segment is relatively small, approximately 10% of the education demand matrix, and is not considered to have a significant impact on the overall model results.

9.7.2 Mode Choice Model

Figure 4-9, which shows observed against modelled car proportions for combined choice suggests some differences in the mode choice model at sector level of up to 20% for car share.This is quite high at this level of aggregation, and given the application of different model parameters for different areas. However the modelled car and public transport trips shown in Figure 4.11 match observed trips reasonably well.

9.7.3 Slow Modes

The slow mode factors seem reasonable with slow mode trips having a significant share for shorter distance trips.

9.8 Home Based Shopping

9.8.1 Structure Model

The Home Based Shopping (HBSh) segment has been developed with a pre distribution mode split structure.

9.8.2 Distribution Model

The distribution calibration as demonstrated by the trip cost distributions presented in Figures 5.2 and 5.3 demonstrate a good fit for car and slow modes and a reasonable fit for public transport given the low number of trips.

9.8.3 Mode Choice Model

For choice the observed and modelled car mode shares are not significantly different from 1. Forecasting of mode shift where significant improvements to public transport that service

HBSh may be an issue. The calibration is not as good for HBSh as for other purposes, however most sectors are within the 95% confidence range with those that are not generating small trip numbers. The mode choice model seems satisfactory.

9.8.4 Slow Mode Factors

The slow mode factors seem plausible with slow mode trips having a significant share at very short distances.

9.9 Home Based Other

9.9.1 Structure

The Home Based Other (HBO) segment has been developed as a pre distribution mode split structure.

9.9.2 Distribution

The general fit for car as shown by Figure 6.2 and 6.5 is good. Figures 6.3 and 6.6 suggest that the fit for public transport is poor for shorter trips and sectors with lower trip rates. This is a common weakness in strategic models and their capacity to represent short distance trips on public transport given the coarse network representation. However the number of public transport trips is small by comparison with car and therefore is not critical in terms of strategic forecasts.

9.9.3 Mode Choice Model

The fit for public transport is good for choice because there is effectively no choice, ie. in Figure 6.8 both observed and modelled car mode shares were not significantly different from 1.

9.9.4 Slow Mode Factors

The slow mode factors seem plausible with slow mode trips having a significant share at very short distances.

9.10 Non-Home Based Other

9.10.1 Structure

The final model structure for Non Home Based Other (NHBO) is the same as for the Home Based Shopping and Home Based Other purposes.

9.10.2 Distribution Model

A common problem is the under-reporting of intra-zonal NHBO trips in household interview surveys (ie trips that are easily forgotten) and this is most likely the case here. We understand that the quality of the survey data was high and has therefore captured as high a proportion of NHBO trips as can be expected. However the cost distribution fit for public transport as shown in Figure 7.3 looks to be poor, shows a similar trend as HBO with an under-estimation of shorter trips. As for HBO the number of public transport trips is small and not significant at the models strategic level. The overall distribution shown in Figure 7.4 appears to be good.

9.10.3 Mode Choice Model

The fit for NHBO is acceptable.

9.10.4 Slow Mode Factors

The slow mode factors look plausible with the majority of slow mode trips occurring at distance range of 0 – 1km.

9.11 Employers Business

9.11.1 Structure

The assumption that travel for employers business is either by car or slow modes is reasonable in the Wellington context, given that only 1% of EB trips use public transport.

9.11.2 Distribution Model

The model fit for the cost distribution as shown in Figure 8.2 appears to underestimate costs for short distance trips and overestimate costs for longer distance trips. Whilst there is a discrepancy, it is relatively small and applies to a smaller number of trips than other sectors.

9.11.3 Slow Mode Factors

The slow mode factors look plausible with the majority of slow mode trips occurring at distance range of 0 – 1km.

9.12 Overall Comments

Significant effort has gone into developing the most appropriate distribution and mode split model for each purpose. Various alternative models were tested and an appropriate distribution and mode split structure has been applied. There are some variations from sector to sector, which is common to all strategic models, but the significant differences have been identified and explained.

10. ASSIGNMENT

10.1 Highway Assignment

The highway assignment model is implemented using EMME/2 and utilises an equilibrium approach where the volume delay functions are updated during the assignment.

A common weakness in strategic four-stage models is that highway costs are often under-estimated as the network approaches capacity. The need to represent traffic congestion as accurately as possible was identified in the scoping of the WTSM redevelopment.

Therefore the principle that there is a need to represent intersection delay at some level in the Wellington Strategic Transport Model is appropriate given intersection delay is generally the capacity constraint in urban networks.

The complexity of the four step modelling procedures and need to provide converged and stable results that are explainable with acceptable run times mean that some compromises need to be made in terms of detail of network representation and assignment. The common methodologies are to represent intersection delay as either:

- part of the link delay function,
- as a delay at the exit node of a link or
- set fixed delays on turns.

The former is the most common method in strategic model where the focus is to represent travel cost between zones accurately at an aggregate level. Where assignment and assessment of transport corridors is considered important the latter two methodologies are often used.

Arup has had experience using 4-stage models where detailed intersection modelling is applied at the assignment stage with delay represented at a turn level with opposed capacity calculated and signalised intersections are optimised during the assignment. Such assignment methodologies can cause instability in the four-stage process. The key issue is the non-diagonal nature of the intersection delay function, which is reliant on the assigned traffic on the intersecting links. Where the non-diagonal relationship is dominant, this does not guarantee a unique solution and leads to instability, particularly with congested networks. Recent assignment techniques implemented in EMME/2 for Auckland traffic models have used a process that modifies the equilibrium process to recalculate intersection parameters during the equilibrium process, which provides a more stable solution assuming the process is applied consistently.

The methodology proposed for WTSM suggests a broader approach where delay is estimated for an approach rather than a turn. Capacity is either specified or calculated and updated during the assignment based on changing traffic demand. We provided the following advice and highlighted key issues to the modelling team:

- The assignment process should be kept as simple as possible given the strategic nature of the model. Coarse zoning and network definition will result in some inaccuracies in the assignment and therefore detailed turn delay functions are not appropriate.
- It is important that the auto assignment provide stable results given the iterative nature of the 4 stage process. This requirement may compromise the level of representation of the network desired.
- Based on the previous point we had concerns about the calculation and updating of opposed capacities from the minor approach of a priority intersection during the process. An option would have been to estimate opposed capacity from a warm start using ranges of opposing flows to calculate the opposed capacity. However we have tested the model and found the model to respond well to increased demand given capacities are monitored
- The process to estimate signalised intersection capacity may be too detailed given the approximations that would be made – for example estimating the number of phases is an approximation. Perhaps a warm start could have been used to estimate capacity and calculate green splits. However we have tested the model and found the model to respond reasonably well to increased demand. However intersections where high delays are estimated should be monitored
- Fixed capacities have been used in dense areas of the network where there were convergence issues. This can be an issue in strategic models as it can bias the assignment in future year scenarios. This should be monitored for forecasting
- The peak factor estimation process proposed is very detailed for a 4-stage model. Normally such an approach would be more appropriate for a detailed traffic model. However Beca/SKM found issues with the validation, which required such a factor.

We reviewed the process as implemented in WTSM and found that generally the delays calculated were not excessive and within an acceptable range in the base year. The intersections where high delays were estimated were on the edge of the network and therefore constrained. Having undertaken sensitivity tests with increased demand we found that the model responded reasonably although, not surprisingly, more intersections experienced significant delay. The model converged. It is concluded that the intersection coding needs to be closely monitored particularly in the future year scenarios to ensure realistic travel costs are estimated.

10.2 Public Transport Assignment

Public transport assignment is undertaken using EMME/2's standard public transport assignment. This implements sub-mode split (eg. bus vs rail) and passenger route choice based on a probabilistic generalised cost algorithm. This is standard practice in region wide models where some imbalance between sub modes can be accepted given the overall mode split to public transport is acceptable.

To model Park and Ride special centroid connectors have been attached from rail stations to zones in the identified park and ride catchment. A speed flow relationship has been developed to represent all access modes to the station. This is common practice for strategic models, for example ART in Auckland. More detailed modelling of park and ride could be undertaken using the matrix convolution facility in EMME/2 to provide more accurate estimates of the car travel cost portions of the park and ride trip and including a park and ride sub-mode split in the model structure. However this would add significantly more detail to the model, require survey data to establish the parameters and would require significant re-calibration.

The adopted approach does have some limitations for example the demand using the special centroid connectors are not loaded onto the road network and therefore congestion on local roads may be underestimated. Such limitations are not critical at a strategic level. It is suggested that if further analysis of park and ride is required that this could be undertaken using output of the strategy model, as one would for a road project by developing a project model.

11. VALIDATION

11.1 Preliminary Analysis of Model Error

11.1.1 Planning Data

It was noted that during the model development the census data was re-processed and the definition of adults was changed from 15 to 17 years and over and this reflects the difference quoted in Table 2.2 in the Model Validation Report.

11.1.2 Family Structure Model

Figure 2.1 in the Model Validation Report shows the correlation of synthesized against observed population proportions allocated to each household category by sector. This graph demonstrates a reasonable correlation of the family structure model.

11.1.3 Trip End Models

Table 2.5 suggests that 'total' trips from Carterton District, South Wairarapa and Porirua City are over-estimated by between 9 – 27% and that trips from Masterton District are under-estimated by about 11% overall.

It is noted that corrections have not been made to South Wairarapa and Porirua District because the number of trips are small and the difference not considered statistically significant. In the case of Porirua this error does not seem to be passed on to the traffic assignment screenlines, referring screenline P3 as representative of Porirua, which suggests if anything a trend to underassign. However for South Wairarapa, the screenline does suggest a significant over-assignment, suggesting inaccuracies in the forecasts at the edge of the model. Referring to Table 2.4 the trip attractions to Carterton District appear low.

11.1.4 Networks

Checks have been undertaken of routeings, link lengths and delay calculations.

11.1.5 Distribution & Mode Choice Model

Observed versus synthesized matrix comparisons are provided in Appendix B of the Model Validation Report. This demonstrates the checks during the validation process and the impact of the full model process on the distribution calibration. The model parameters were updated during the validation process resulting in the final distribution table of synthesised new trips across TLA's. We note that the total number of home based education trips have reduced from 90,915 in the initial calibration to 73,602 in the final calibration. We have been advised by Beca/SKM that the demand table has been report without primary school trips in the final model. The trip productions that are input to the DMS are of the order of 88,800 and therefore don't result in a significant overall reduction in trips following the initial calibration. The key difference in the distribution validation seems to be an apparent over-estimation of trips from Lower Hutt to Wellington City for HBW, HBSh and HBO of between 20 to 40%.

11.2 Time Period Models

Some minor adjustments have been made to the time period factors to achieve validation. This is acceptable, given it is documented in the final report.

11.3 Highway Assignment Model

A strategic model would not be expected to meet the criteria the validation requirements of the Transfund PEM, but provide a sound basis for developing a project model, which is capable of meeting the criteria.

The correlation coefficients (r^2) described in the Validation Report of 0.97 for total screenline counts and between 0.86 and 0.92 for individual counts are acceptable for a strategic model. In particular it provides a good basis to develop a project model that achieves Transfund guidelines of an r^2 greater than 0.85 and greater than 0.95 in the vicinity of the project.

Over all of the traffic screenlines modelled flows are on average 5% higher than observed which could be due to a systematic bias. Whilst there are some significant outliers in certain areas, they are often at the edge of the network and on lower volume routes. However there are a few significant screenlines such as the W1 (Wellington CBD cordon), W5, L3 and L4 where modelled flow differ from observed counts by over 10% in the evening peak. Overall based on past experience the road screenline validation is reasonable for a strategic model of this nature.

Model results for screenline W3 across Karori are noticeably high. We suspect this may be due to the coarse zone definition in this area and perhaps the location of the screenline. We note that zone 30 is loaded onto Karori Road at Donald Street and therefore most traffic is assigned to Karori Road from this point to the east.

Matrix estimation has been applied to the highway demand matrix to achieve an improved validation as a basis to develop project models.

11.4 Highway Travel Times

Modelled travel times were compared to observed travel times on seven routes in each direction for the three time periods. Most modelled travel times are within the maximum and minimum times recorded along those routes.

Generally the modelled travel times seem to be consistent with a slight over assignment of traffic. On route 7, that is City to Woburn, in the northbound direction the model significantly over estimates travel time in the evening peak period, which seems to be due to higher link delays than observed on the Motorway and Hutt Road.

There are shown to be a few significant delays at nodes (eg route 4 and 6) that are shown to be more than observed delay, however they do not result in a significant over-estimation of travel time over the whole route.

Notwithstanding the issues described above, the travel time validation is reasonable for a strategic model.

11.5 PT Assignment

The overall validation of public transport assignment is poor compared to highway, which is expected given the low levels of existing public transport mode share and the relative lack of data available to develop the public transport parameters compared to car.

11.5.1 Bus

Some screenlines are significantly different and for bus boardings the general trend is for the model to underestimate bus trips – the exception being Johnsonville and Wellington CBD. The validation report suggests that shorter length bus trips such as primary school trips (which are removed from the model) and short feeder bus trips may result in an underestimation of bus trips in the model. The lack of bus survey data to calibrate against is a significant constraint to understanding the reasons for the discrepancies.

It is interesting to note that whilst Table 3-6 indicates an over-prediction of bus passengers across screenlines (as per the highway model) there is a general under-prediction of bus boardings across all areas (about 8% in the morning period and 17% in the interpeak). This suggests a general weakness to forecast shorter distance public transport trips, which is a common issue with strategic models.

There is a significant difference in the area south and east area of Wellington where the model underestimates observed trips by over 30%. This is an area in which over 40% of boarding occur in the Wellington region and is therefore a concern. However we accept the argument that a number of short distance trips are excluded including primary school trips and intrazonals that may be represented as walk.

Further confidence in the validation could be gained by undertaking on-board bus surveys and identifying the profile of users and travel patterns in more detail. In the absence of such data, the model makes best use of the available data. We recommend that the user be aware of these issues when interpreting the model.

11.5.2 Rail

The model is poorly forecasting sub-mode split between bus and rail in some cases, particularly in the Johnsonville corridor. Such issues are not uncommon in strategic models. More complex public transport models often employ a hierarchical logit mode split structure where public transport demand is split into bus and rail following the main mode split. Such a structure would require detailed bus survey information and would be more appropriate for a detailed public transport-forecasting model than a strategic model.

In the case of the Johnsonville corridor, the bus service is more direct than the rail, but less frequent during peak periods. Whilst the overall public transport demand assigned to this corridor is acceptable the assignment to bus is much higher than observed and correspondingly the assignment to rail is much lower. This may compromise the analysis of policies concerning rail or bus in this corridor. SKM/Beca had reviewed this issue and found that no logical or technically supportable adjustment could be made to the model to resolve this discrepancy. It was agreed that SKM/Beca would make an adjustment to the model as a variant to the base model to more accurately reflect the demand on bus and rail in this corridor.

11.6 Sensitivity testing

The sensitivity results presented in the Validation Report confirm that the model is responding in line with locally and internationally accepted elasticity's, particularly the response to bus fare is encouraging. Arup undertook further sensitivity tests that supported this conclusion.

11.7 Accuracy

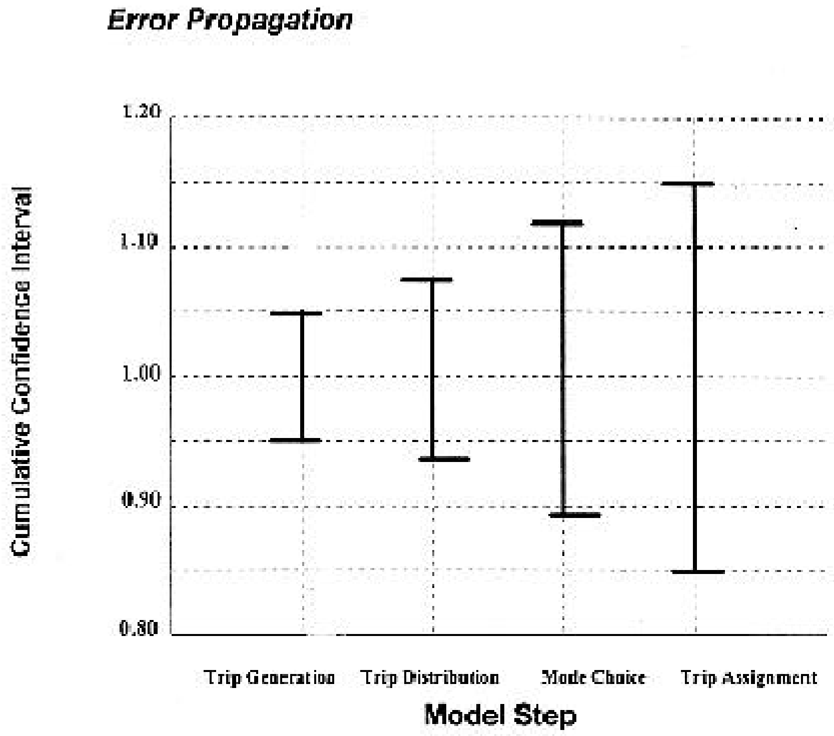
The following extracts from the Model Validation and Reasonableness Checking Manual, FWA 1997, provide an indication of typical accuracies for models of this type.

In addition one should be aware of inaccuracies in the validation data, for example traffic counts often have an error of +/- 10% or more.

Estimated Accuracy of Some Parameters in the Travel Modeling Process

Parameter	Typical Magnitude	95 Percent Confidence Limit
Zonal Generation	2,000 person trips	✂< 50%
Interzonal Movement	Small	Extremely Inaccurate
Major Trip Interchange	40,000 person trips	✂< 10%
Minor Trip Interchange	15,000 person trips	✂< 16%
Highway Link Loading:		
Minor Link	5,000 vehicles	✂< 55%
Average Link	20,000 vehicles	✂< 27%
Major Link	50,000 vehicles	✂< 17%
Public Transit Loading:		
Average Urban Link	5,000 passengers	> ✂< 46%
Major urban link	20,000 passengers	> ✂< 23%

Source: J. Robbins, "Mathematical Models - the Error of Our Ways," Traffic Engineering + Control, Vol. 18, No. 1, January 1978, p.33.



11.8 Overall Comments

The model is validated to an acceptable level for a strategic model.

12. MODEL TESTING

The previous sections describe our review of the model development. Following our review of the sub-models we undertook detailed testing of the model. This is documented in a separate report.

13. SUMMARY AND CONCLUSIONS

13.1 Transfund Guidelines

Transfund's Project Evaluation Manual (PEM) provides transport model validation guidelines and clearly distinguishes two levels of the modelling process:

- Strategic demand models such as WTSM which incorporate the traditional 4 stage process
- The project model, specific to the project being evaluated, which is generally an assignment model, perhaps traversed from a sub-regional model.

The project model specification and validation guidelines are presented in Worksheet A3.11(a) and A3.11(b) respectively. These guidelines are relevant to the detailed traffic assignment models that are required for project models. It is therefore not appropriate to apply these guidelines for strategic models such as WTSM.

Worksheet A3.11(c) outlines strategic model checks for application of a strategic model including whether a peer review had been undertaken. No validation or calibration guidance is provided in the PEM for strategic models. We know of no absolute measures or thresholds that are used internationally to demonstrate that a strategic transport model is calibrated or validated. Calibration and validation guidelines for strategic models are also relatively rare internationally. This is because the requirements vary from model to model based on the objectives and transport and planning environment. Some documents that we are aware of are:

- Guidance on the methodology for multi-modal studies (Vol 2) DETR 2001
- Major Scheme Appraisal in Local Transport Plans, Part 3: Detailed Guidance on Forecasting Models for Major Public Transport Schemes, Department for Transport, UK, 2002
- Model Validation and Reasonableness Checking Manual, Federal Highway Administration February 1997.

Generally these documents provide comprehensive guidelines for the development of four-stage models including calibration and validation checks. We have used the principles espoused in these documents where appropriate, as a basis for this peer review.

Based on our review we believe that the model is suitable to be used as a strategic model to test transport policies in the Wellington region and as a basis to build project models notwithstanding the limitations discussed in Section 12.3 of this report.

13.2 Sub Models

13.2.1 Productions

Whilst the production model is very disaggregate, the final models were shown to be satisfactorily calibrated.

13.2.2 Attractions

The attraction models are typically more difficult to calibrate than production models as more data is available at the production end of the trip. The larger differences in the attraction models generally related to low trip generating sectors. The attraction model was satisfactorily calibrated, with balancing factors for attractions no greater than 6%.

13.2.3 Car Ownership

The effort put into the car ownership model was driven by the current high ownership and the expectation that this will not change greatly in the following years. This influenced the approach adopted, as it was perceived that whilst a car ownership model was required in some cases an enhancement to other sub models was a higher priority. Therefore in some cases simplifications were made.

The car ownership model was shown to reproduce the census figures and for short term forecasting the cross-sectional model and time series models produce similar results. If the model is to be used beyond 2021 and significant changes to the transport or land use environment the car ownership model should be reviewed.

13.2.4 Distribution and Mode Split

Significant effort has gone into developing the most appropriate distribution and mode split model for each purpose. Various alternative models were tested and an appropriate distribution and mode split structure has been applied. There are some variations from sector to sector, which is common to all strategic models, but the significant differences are mostly explainable.

13.2.5 Assignment

The validation has been reviewed and we found that WTSM has been validated to an acceptable level for a strategic model. The public transport assignment validation is not as strong as the traffic assignment validation (note: this is typical for strategic models) and there are some weaknesses in key areas for buses. However these generally relate to the coarseness of the model and the lack of bus survey data. The collection of bus travel data should further improve this validation. The model's limitations are discussed in Section 12.3.

13.3 WTSM Use and Application

Based on our assessment of the base model we conclude that WTSM is an appropriate tool to:

- assess transport strategies and policies in the Wellington region.
- assess the strategic impacts of major road and public transport projects
- assess the impacts of land use strategies on the transport environment
- as a basis to develop sub-regional traffic models with more detailed zone and network structure. The sub-regional models may employ more detailed representation of congestion and model junction delay in detail
- as a basis to develop project models for detailed assessment of road projects

The following comments should not be read as negative commentary of the model, which in our opinion is well calibrated and is fit for the purposes outlined above. As with all models, the modeller needs to be aware of limitations of WTSM in potential applications, including:

- Ultimately the model is reliant on the quality of the demographic forecasts fed into it
- Some enhancement may be necessary to assess corridor studies, if a high level of detail is required
- Johnsonville Corridor with the imbalance in the assigned split between rail and bus. A fix will be provided by Beca/SKM as an alternative to the base model
- Care will need to be taken in using the model to assess public transport projects in the sector to the south and east of Wellington CBD. The model demonstrated a significant discrepancy against the bus boarding counts (refer Table 3.5 of the validation report). This was shown to relate to very short distance trips that could not be accurately represented at the coarser zonal and network detail and the removal of primary school trips from the demand matrix. Further data collection – such as on-board bus surveys may be required to refine the model in this area should detailed analysis of public transport projects be required in this area
- The model is limited, as are other strategic models, in demonstrating the impacts of roading and public transport policy on slow mode demand. This is due to the necessary simplification of the structure of the model which aggregates slow modes with either car or public transport for mode split and applies proportions against a trip distance profile following mode split to derive slow mode demand. As the majority of slow mode trips are short distance trips and for short distance choice trips a significant penalty is required for car trips to switch to public transport, the impact on slow modes is not considered to be significant
- Whilst the model can test the broad road pricing policy impacts on travel in the Wellington region, it is not of sufficient detail for analysis required to support procurement of a tolling project

- Whilst the model includes representation of junction delay on approaches, it is necessarily approximate for a strategic model given the coarse network and zoning. Therefore the model is not sufficiently detailed to assess local road projects, such as junction improvements etc
- If forecasting is undertaken beyond 2031 the car ownership model should be checked as there is no saturation value in the time series model
- The model may have some limitations in forecasting impacts of significantly changed transport or land use conditions, eg. response to intensification in the inner city and very significant improvements to the public transport which may influence car ownership
- Modellers should be aware of the correction factor applied to Sector 41 if the model is used to assess future development in Petone. In this respect the model response should be checked
- For forecast years external growth factors should be reviewed if external demographics are available
- Because the observed mode splits are close to 1 forecasting of mode shift where significant improvements to public transport that service HBSh may be an issue
- Particularly with long term forecasting, the signalised intersections with fixed capacity (ie green times are fixed) should be reviewed to ensure they are responding to changed travel patterns.