Greater Wellington
Regional Council

# WTSM 2006 Update Peer Review

Final Report

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Final Report

June 2008

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Job number 86349

ARUP



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|---|---|---|
| Job title | WTSM 2006 Update Peer Review | Job number<br>86349 |
| Document title | Final Report | File reference |
| Document ref | | |

| Revision | Date | Filename | 0001Report.doc | | |
|---|---|---|---|---|---|
| Draft 1 | 26/03/08 | Description | First draft | | |
| | | | Prepared by | Checked by | Approved by |
| | | Name | Dan Jones | Peter Dunn | |
| | | Signature | | | |
| Draft 2 | 09/06/08 | Filename | DraftReport_rev2.doc | | |
| | | Description | Update to incorporate changes made by the modelling consultants in response to the First Draft | | |
| | | | Prepared by | Checked by | Approved by |
| | | Name | Dan Jones | Peter Dunn | |
| | | Signature | | | |
| Draft 3 | 16/06/08 | Filename | DraftReport_rev3.doc | | |
| | | Description | Incorporate comments from GW | | |
| | | | Prepared by | Checked by | Approved by |
| | | Name | Dan Jones | Peter Dunn | |
| | | Signature | | | |
| Final | 30/06/08 | Filename | FinalReport.doc | | |
| | | Description | Final Report | | |
| | | | Prepared by | Checked by | Approved by |
| | | Name | Dan Jones | Peter Dunn | Peter Dunn |
| | | Signature | | | |

Issue Document Verification with Document ✓

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## Tables

# 1 Executive Summary

Arup was appointed to peer review the Wellington Transport Strategy Model (WTSM) 2006 Update. We have undertaken a detailed review and sensitivity testing.

Our overall assessment is that the updated model is compliant with the Greater Wellington (GW) briefed requirements. We are satisfied that the work has been carried out accurately and professionally, and that the 2006 model represents an improvement on the 2001 model it replaces. We consider that sound modelling principles have been applied, and good use has been made of the available data.

The validation of the highway assignment model has been reviewed and is considered to be of a high standard for a four-stage model.

We have some reservations about the quality of the bus and rail data used for model validation, firstly the age of the rail data and secondly the lack of consistency of the bus data. Notwithstanding this, the rail validation aligns reasonably well against the limited data available and the growth in modelled bus use[1] is replicated satisfactorily.

Tests we have undertaken to establish the sensitivities of the model indicate elasticities are reasonable, lying within the expected ranges. Cross-elasticities of car travel with respect to public transport costs are low, meaning that even quite significant improvements to public transport are likely to have only a small effect on region-wide car trips and kilometres. In individual corridors the effect may be stronger, we have not tested this. This is noted as a key feature of the model, not as a technical criticism.

It is the nature of a peer review to focus on the negative issues. A small number of components that we feel merit further discussion are addressed in this report. This does not reflect on the appropriateness of the model overall - the great majority of components require little or no comment because they function well.

In summary, WTSM 2006 meets and in many ways exceeds international standards for four-stage models, and we recommend that the updated model is fit-for-purpose.

[1] Between 2001 (WTSM Base) and 2006 (WTSM 2006 update)

# 2 Introduction

Arup was appointed to undertake the peer review for the Wellington Transport Strategy Model (WTSM) 2006 Update. This report presents our findings.

## 2.1 Background

In 2001, Beca and Sinclair Knight Merz (SKM) were appointed by Wellington Regional Council to develop WTSM to a new base year of 2001. This was a comprehensive redevelopment of the existing WTSM, including re-specification of procedures and model structures. An extensive dataset of travel and traffic data for model calibration was collected, supplemented by socio-economic data from the 2001 Census. The model was peer-reviewed and signed-off by Arup, late in 2003, and since then it has been used successfully on many projects.

Late in 2006, Greater Wellington (GW) invited bids to update WTSM to a new base year of 2006 using 2006 Census and other newly collected data, and to address some perceived technical deficiencies specified in the brief. SKM was appointed to the role of modelling consultant, and Arup to the role of peer reviewer.

## 2.2 Objectives and Approach

The objective of the peer review is to ensure satisfactory completion of the agreed modelling brief for the 2006 Update to WTSM in line with GW expectations and international best practice, by review and provision of comments on:

- technical scoping papers produced throughout the duration of the project
- the base year validation report
- the future year forecasting report
- the electronic models (to confirm the coding, verify the validation, undertake sensitivity tests and to assess usability).

To achieve the objectives, we have checked that amendments have been applied correctly, the changes to inputs and assumptions, the validation, the sensitivity characteristics, and the usability of the updated model.

## 2.3 Outputs

The outputs from the peer review are:

- provision of comments on the technical scoping papers during the course of the study
- a letter of support or otherwise for the completed model
- this report, outlining the methodology, findings and recommendations.

## 2.4 Documents Received

The following documents have been received and reviewed:

**Table 1 – Documents from Greater Wellington**

| Name | Version | Date |
|---|---|---|
| *Brief for Modelling Consultant*<br>Wellington Transport Strategy Model 2006 Update – Provision of Professional Services, Contract 3073 | - | November 2006 |
| *Brief for Peer Reviewer*<br>WTSM 2006 Update Peer Review – Provision of Professional Services, Contract 3074 | - | January 2007 |

Table 2 shows the Scoping Notes provided to Arup by SKM for review. Arup returned comments on the scoping notes prior to the model development phase.

**Table 2 – Scoping Notes from SKM**

| Name | Version | Dated |
|---|---|---|
| Task 5.3.5: CV Route Choice | 3 | 14/03/07 |
| Task 5.2.6: CV Matrix and Forecasting Model | 2 | 16/03/07 |
| Task 5.2.7: Review 2001 Trip Rates | 4 | 16/03/07 |
| Task 5.3.2: Park-and-Ride Sub Mode Choice | 3 | 19/03/07 |
| Task 5.3.3: PT Capacity Constraint | 2 | 19/03/07 |
| Task 5.3.4: Multiclass Assignment | 2 | 20/03/07 |
| Task 5.2.9: CV PCE Factor | 2 | 20/03/07 |
| Task 5.2.13: Traffic Data and Screenlines | 2 | 20/03/07 |
| Task 5.2.8: Actual vs. Usually Resident Population | 2 | 28/03/07 |
| Task 5.2.1: Updated Input rates | 2 | 28/03/07 |
| Task 5.3.1: Intersection Delays and Merges | 3 | 02/04/07 |
| 2006 CV Matrices | - | 22/08/07 |
| Updated Input Values | - | 22/08/07 |

**Table 3 – Reports from SKM**

| Name | Version | Dated |
|---|---|---|
| WTSM Update Specification Report | - | May 2007 |
| WTSM Update Validation Report | Final | Feb 2008 |
| Baseline Forecasting Report | Final | Feb 2008 |
| WTSM Update – New Validation and Forecasting Results | - | 28/05/08 |
| WTSM Update – Validation Results | - | 20/06/08 |
| WTSM Update Validation Report | Final | June 2008 |

**Table 4 – Electronic Models from SKM**

| Name | Version | Dated |
|---|---|---|
| Base Year, 2006 | - | 15/02/08 |
| Future Year Do-Minimum and RTP, 2016, 2026 | - | 15/02/08 |

## 2.5 Report Structure

This remainder of this report is structured as follows:

- Section 3 – Scope of Work
- Section 4 – Review of Tasks
- Section 5 – Review of Base Model and Validation
- Section 6 – Review of Future Year Model
- Section 7 – Model Usability
- Section 8 – Recommendations and Conclusions

# 3 Scope of Work

## 3.1 Brief to the Modelling Consultant

The brief to the modelling consultant prescribed the tasks to be undertaken to update the model to a 2006 base. The tasks were arranged into two groups: primary (essential) and secondary (optional).

A series of scoping notes were prepared by SKM containing analysis and recommendations for each task. These were forwarded to Arup for comment. Discussions between GW and SKM culminated in an agreed list of the tasks to be taken forward and confirmation of the scope of work. This was set out in 'WTSM Update Specification Report'.

## 3.2 Primary Tasks

Fifteen primary tasks were identified in the brief. These are the key tasks considered necessary by GW to update the model to a new base year of 2006, and to develop future year models for 2016 and 2026.

During the scoping phase, it was agreed that 3 of the 15 tasks (5.2.7, 5.2.8, 5.2.9) would be removed from the project scope.

**Table 5 – Primary Tasks**

| Task | Description | Actioned? |
|---|---|---|
| 5.2.1 | Update input rates for vehicle operating costs and values of time | Yes |
| 5.2.2 | Review the road network coding and update the transit lines | Yes |
| 5.2.3 | Enhance the road network detail | Yes |
| 5.2.4 | Validate the auto assignment | Yes |
| 5.2.5 | Validate the passenger transport assignment | Yes |
| 5.2.6 | Revisions to the commercial vehicle matrix | Yes |
| 5.2.7 | Change 2001HTS trip rates | No |
| 5.2.8 | Actually vs. usually resident population | No |
| 5.2.9 | Higher PCE factor for CVs | No[2] |
| 5.2.10 | Update the vehicle fleet emissions factors | Yes |
| 5.2.11 | Update demographic projections | Yes |
| 5.2.12 | Car ownership model | Yes |
| 5.2.13 | Traffic data and screenline review | Yes |
| 5.2.14 | Bus patronage data and screenline review | Yes |
| 5.2.15 | Rail patronage data and screenline review | Yes |

[2] In the Update Specification Report for Task 5.2.9 the approach was scoped to extend the current process of capacity reductions based on fixed M/HCV PCEs, but in the event this could not be done (see Section 7.2)

## 3.3 Secondary Tasks

Eight secondary tasks were identified in the brief as optional improvements, to be discussed and implemented only if cost effective. Discussions between GW and SKM led to the decision to take three of these tasks forward.

**Table 6 – Secondary Tasks**

| Task | Description | Actioned? |
|---|---|---|
| 5.3.1 | Intersection delays and merges | Yes |
| 5.3.2 | Park and ride sub mode choice model | No[3] |
| 5.3.3 | Passenger capacity constraint for rail and bus services | No |
| 5.3.4 | Multi-class assignment | Yes |
| 5.3.5 | CV route choice function | No[4] |
| 5.3.6 | Adjust flight related airport trips | No |
| 5.3.7 | Including traffic from the Interisland ferry | No |
| 5.3.8 | Industry specific employment forecasts | Yes |

[3] It was agreed that some changes would be made to existing ‘p-connector’ approach.
[4] It was agreed that CVs should be banned from selected links in the final assignment.

# 4 Review of Tasks

Our comments on the completion of the primary and secondary tasks are provided in this section, with the exception of Task 5.2.4, Auto validation, and Task 5.2.5, PT validation, which are reviewed in Section 5.

## 4.1 Task 5.2.1 – Input Rates

The values of time and vehicle operating costs were updated to 2006. The new values are provided in Chapter 5 of the Validation Report. These appear to be soundly derived and appropriate for demand modelling and economic evaluation purposes.

The revised values of time have also been used to update the route choice equation (the balance of time and distance costs in assignment). In our experience, route choice parameters would normally be calibrated as part of an assignment calibration process, and would not be periodically updated. But in this case, the changes made were small, and SKM advised that small changes in the route choice equation have had little impact. Given the restricted routes available in the region, this seems reasonable. There is also the benefit that consistency has been maintained between assignment and demand models.

In future years, values of time and vehicle operating costs have been updated for demand forecasting, based on forecast increases in income per head and fuel cost/efficiency expectations respectively. For assignment, no changes were made in future years to the base year ratio of time and distance costs. We support this approach.

A 10% real increase in rail fares between 2001 and 2006 has been applied to PT generalised costs between zone pairs that are likely to use rail as the main mode, representing the average change to the real rail fare over this period. The rail fare increase has been applied to all PT (including bus), restricted to broad sector movements where rail is likely to be the main mode. This approximation is reasonable for a strategic model - fares are added to generalised costs after assignment, which restricts the options. There may be advantages in applying fares in the assignment[5] in future model updates and we would recommend that this be considered.

Parking costs have been updated for Wellington CBD only, the review of parking charges in other locations being outside the scope.

## 4.2 Task 5.2.2 – Road network coding and transit lines

Spot checks on changes to the base road network coding indicate that coding has been carried out satisfactorily.

The HOV scheme at Mana has been defined as 1.3 lanes per direction, on the basis that there are 2 lanes per direction but only 27% of vehicles have access to the inner lane (2+ occupants only). This is a reasonable approach for strategic modelling.

The transit line coding has become more complicated in the updated model through separation of the rail station nodes into two: one for car access and one for walk/bus access. This is to avoid misuse of p-connectors (see Section 4.12) but it means that extra care is required in transit line coding. We understand that GW has developed a bespoke spreadsheet to automate this process, to minimising such errors.

We have made a comparison of modelled rail headways and journey times against current timetables and found it to be satisfactory.

[5] This would allow separate testing of bus and rail fare policy. A secondary benefit may be to improve the realism of routing. In one sensitivity test that we ran, a proportion of rail travellers from Linden to Wellington first travelled north to Porirua, and then changed to a southbound train, some of which stop at Linden. This is a minor problem for a strategic model, but with fares coded on the network this type of ‘U-turning’ behaviour would be less likely to occur.

## 4.3 Task 5.2.3 – Enhance the road network detail

Spot checks on the revised road network suggest that coding has been carried out accurately.

## 4.4 Task 5.2.6 – Revisions to the commercial vehicle matrix

This task has highlighted the relatively poor quality of data currently available. The three data sets available – the 2001 and 2006 screenline counts, and the 2005 matrix produced by Booz Allen Hamilton – being somewhat inconsistent.

The approach taken to estimate a new CV matrix for the 2006 model was to factor the existing 2001 CV matrix at a sector-to-sector level to replicate, as closely as possible, the 2006 CV counts taken at screenlines. The multiplicative factors derived for the base year were then applied to the 'raw' future year CV matrices. This, we would agree, is the best approach available given the restricted data.

Some of the multiplicative factors shown in Tables 14 to 16 of the Validation Report are quite significantly different to 1, For projects focusing on commercial vehicle movements, we recommend that CV trip end locations are reviewed against land use data, and that modelled CV flows in the area of interest are sense-checked and confirmed against observed flows.

## 4.5 Task 5.2.10 – Update the vehicle fleet emissions factors

Assumptions for reduced vehicle emissions in future years have been applied to the evaluation of future year modelling results. There are some large differences between car and HCV emission rate reductions (Baseline Forecasting Report, Table 41), which we would not expect. These emission factors were provided from the Vehicle Fleet Emission Model (VFEM) and are known by GW to be out-of-date. It is understood that these are to be updated as better information becomes available.

## 4.6 Task 5.2.11 – Update demographic projections

SKM obtained socio-economic data for 2006, 2016 and 2026 from MERA Ltd for use in WTSM base and future year models. In the Baseline Forecasting Report, the changes between 2001 and 2006 are summarised as: population +7%, households +6%, employment +9%, and education places +24%. Arup has not been provided with the trip generation models, therefore the use of this data could not be peer reviewed.

The MERA future year projections for 2016 and 2026 were developed with considerable input from the territorial authorities, and issued in 2007. The forecasts were reissued twice, firstly in December 2007 to incorporate growth in some specific areas, and secondly in January 2008 to control to newly revised Statistics NZ 2006 totals.

## 4.7 Task 5.2.12 – Car ownership model

The car ownership sub-model of 2001 WTSM was not able to accurately replicate the growth in car ownership between 2001 and 2006, particularly in respect of growth in multiple-car households (Validation Report, Table 18). The 2001 car ownership sub-model has also been criticised for having no saturation (maximum) level to car ownership although, in practice, this does not appear to have led to unrealistic car ownership estimates over the forecasting horizon of WTSM.

SKM has addressed both issues by respecifying the car ownership model in line with the car-ownership sub-model developed for ART3, the strategic model of Auckland. The new model has a saturation parameter set to 0.8 cars per person and is demonstrated to replicate the observed total car ownership growth between 2001 and 2006 (Baseline Forecasting Report, Appendix C). We consider that the new car-ownership sub-model is a significant improvement on the previous one.

## 4.8 Task 5.2.13 – Traffic data and screenline review

It is clear that SKM went to considerable efforts to obtain a consistent and plausible set of traffic counts data for the auto validation. Where counts obtained from territorial and roading authorities were found to be inconsistent with 2001 data, or implausible, further data was obtained or new surveys commissioned[6].

New journey time survey data was collected over the same routes as in 2001[7].

SKM reviewed screenlines definitions and we agree with their conclusions.

A thorough review was undertaken, resulting in a good quality data set for auto validation.

## 4.9 Task 5.2.14 – Bus data and screenline review

A complete set of Electronic Ticket Machine (ETM) data was obtained from bus operators. No details of its processing are documented, though we understand that the quality of it was found to be uncertain, and that it required considerable interpretation to convert it into useable spatial data. We have had similar experiences with ETM data in other studies.

We have concerns about some large and unexplained differences between the 2001 and 2006 ETM data. Changes in the location of screenlines have made comparison difficult, but comparisons can be made at screenlines W2 (Miramar), W3 (Karori) and W4 (Johnsonville and Hutt), which have not changed. At these locations we found considerable differences between 2001 and 2006 ETM datasets that cast doubts over the quality, or at any rate the consistency, of the bus data.

Independent data suggests that overall growth in bus patronage over the period was around 22%[8]. In the absence of supporting evidence that bus patronage is changing in the ways implied in ETM data, we have doubts about its reliability. The implications of this for validation are discussed in Section 5.

## 4.10 Task 5.2.15 – Rail data and screenline review

No new rail data was collected, though it states in the brief that “if observed data is not available, it will be necessary to commission the appropriate surveys” (Modelling Brief, Task 5.2.5). It also appears that the March 2006 ticket data and guards counts referred to in the brief under Task 5.2.15 could not be obtained. Instead, the data used for development of the 2001 model was again used for the 2006 update, uplifted by global factors of 10% for peak and 14% for interpeak, representing GW’s best estimate of rail patronage growth over the period.

Late in the project, some limited rail count data from 2006 was obtained, and was used as independent source for verification of peak rail volumes arriving at Wellington.

[6] Given these problems, consideration could be given to creation of a count database to hold multiple observations over a number of years. This would allow for weighted average or time-series-based estimates to be made for the counts used in future validations.
[7] For validation of alternative strategic routes between Kilbirnie and the CBD, and between the CBD and Ngauranga, it might be worth considering an additional route from Kilbirnie to Ngauranga via Evans Bay Parade, Jervois Quay and Hutt Road.
[8] From “4760_monthlypassenger_s9595.xls” posted on the GW website

## 4.11 Task 5.3.1 – Intersection delays and merges

The procedures have been improved in two ways:

- correction of errors found in the specification of the Q and Ja parameters in the volume-delay functions;
- improved convergence of intersection delays through amendments to the convergence procedures and the capping of green times at 50% of cycle time

Consideration was given to specification of a merge function, but this was rejected at the scoping stage. Our experience with WTSM and other models is that a merge function could still be a valuable addition, even for a strategic model, in the next upgrade.

SKM advises that the correction of the volume-delay function error had a significant impact on speeds on certain roads – Paekakariki Hill Road was given as the example – but the strategic (corridor level, sector-to-sector) speeds and capacities did not change significantly.

## 4.12 Task 5.3.2 – Park and ride sub-choice model

The option of respecifying the choice model to include an additional sub-choice for park-and-ride was rejected, a decision with which we agree, as it would require a significant overhaul of the model structure and necessitate recalibration.

Two enhancements were made to the existing p-connector approach:

- Recoding of p-connector links to ensure that p-mode-only 'through trips' via station nodes cannot be made on these links;
- Assigning the car part of the p-connector demand.

The first amendment is a sensible solution to what has been a problem with the 2001 model; the second amendment does no harm, though given the approximations involved the benefits seem quite minor.

P-connectors are now coded in one direction only (from zone to station in AM, the reverse in PM), and the problem of p-mode 'through trips' has been solved.

On reviewing the results, we have doubts about whether an assignment based approach to determine the rail-access mode can work effectively (see our further comments in Section 5).

## 4.13 Task 5.3.4 – Multi-class assignment

It was agreed with GW that a multi-class assignment would be adopted in the final assignment (only), allowing HCVs and other vehicles to be separated for reporting purposes. This allows for HCV bans to be effected on selected streets, improving the plausibility of model outputs for the non-technical audience.

## 4.14 Task 5.3.5 – CV route choice function

A CV specific route choice function was deemed unnecessary at the scoping stage. This seems reasonable for most applications of the strategic model, but in some corridors, the performance difference of cars and HCVs (and therefore route choice) might be an important consideration, for example in the modelling of Transmission Gully where HCV performance would be severely affected by the ascent to and descent from the Wainui Saddle and, furthermore, HCVs could potentially obstruct general traffic, depending on lane usage. For studies such as this, a refined model may be required.

## 4.15 Task 5.3.8 – Industry-specific employment forecasts

This was not reviewed.

# 5 Review of Base Model and Validation

## 5.1 Trip matrices

The modelled growth in trips between 2001 and 2006 of 5-8%[9] is reasonable, given the changes in population, households and employment of 6-9% over the same period[10]. There is greater growth in the AM peak than the PM peak[11], perhaps reflecting the fact that capacity is more constrained.

Public transport patronage shows a higher growth rate than car in the peak, which is as expected given the higher traffic congestion in the peak than the interpeak. The small changes in peak mode share appear reasonable[12].

Comparison of Census and modelled PT shares by sub-region are very consistent[13], which gives confidence in the quality of the mode choice modelling.

No changes were made of the daily to assignment-period factors, as this was not in the agreed scope.

## 5.2 Auto validation

The auto assignment has been validated for AM peak (07:00-09:00), Inter-peak (IP, 2 hour average from the period 09:00-16:00), and PM peak (16:00-18:00).

The approach to auto validation is appropriate and makes good use of the extensive data set collected for model validation. The changes made to calculation of intersection delay lead to an efficient and stable assignment convergence for all periods.

Overall we consider the validation to be as good as can reasonably be expected from a four stage model and to a standard consistent with the 2001 model. Some changes were made to trip attraction factors in a bid to improve the screenline volumes - a fairly major change - but we are satisfied that the approach is justified.

In all time periods, there is a deficit of traffic travelling between Wellington and Porirua (screenline P3), which should be taken into consideration when modelling this movement.

The journey time validation[14] shows generally very accurate representation of journey times. The section of highway that has been difficult for SKM to validate is SH2 between Petone and Ngauranga (Route 2, Nbnd, PM). We understand that a great deal of time and effort was expended by SKM on this, with various tests undertaken, but no satisfactory solution could be found.

An unusual feature is that in the PM peak, both speeds and vehicle kilometres increase between 2001 and 2006[15]. Overall, the changes in the model between 2001 and 2006 look reasonable and the validation is better than we might have reasonably expected.

The HCVs are now validated as a separate class (in 2001 HCVs and car were not separated for validation), adding further confidence.

[9] Validation Report, Table 23
[10] Ditto, Table 1
[11] Ditto, Table 24
[12] Ditto, Table 26
[13] Ditto, Tables 27 and 28
[14] Ditto, Appendix B
[15] Ditto, Table 25

## 5.3 Public transport validation

The PT assignment has been validated for AM peak and IP periods, as was the case in 2001. A PM peak PT assignment has also been produced, for completeness, though its validation was not required in the scope.

### 5.3.1 Rail validation

The rail assignment has been validated by comparison of observed and modelled:

- rail passengers alighting at Wellington station; and
- build up of loadings on inbound rail services, by station.

Tables 7 and 8 show the comparison of observed and modelled rail passengers arriving at Wellington station for AM and IP periods respectively.

**Table 7 – Rail Validation at Wellington Station: Arrivals (AM, 2 hour)**

| Model | Inbound rail passengers at Wellington | Difference |
|---|---|---|
| 2006 AM observed (calculated from 2001 observed plus 10%) | 9,736 | |
| 2006 AM modelled | 11,278 | +16% |

Source: WTSM Update – Validation Results 20 June 2008

**Table 8 – Forecasts of Wellington rail passenger arrivals (IP, 2 hour)**

| Model | Inbound rail passengers at Wellington | Difference |
|---|---|---|
| 2006 IP observed (calculated from 2001 observed plus 14%) | 943 | |
| 2006 IP modelled | 928 | -2% |

Source: WTSM Update – Validation Results 20 June 2008

The number of inbound passengers into Wellington shows a satisfactory match in the IP, within 2% of observed.

In the AM peak, the modelled flow is 16% higher than observed. This may indicate that the model is predicting too many rail trips, or there may be an error in the assumption that rail use in the AM peak has grown by only 10% since 2001. To check this, we examined an independent data source: 2006 guards' counts, provided by GW. The data is incomplete but, nevertheless, it gives an indication that arrival loads in the AM peak at Wellington station are around 4,800 from the Western line and 4,200 from the Hutt line. If 1,300 passengers are added for the Johnsonville line[16] and a further 800 for the Capital Connection, Wairarapa and Melling services combined[17], this gives a total of around 11,100 passengers arriving at Wellington in the AM peak. If this is estimate is reliable, the model would be within 2% in the AM peak. To confirm usage, we would recommend a survey is commissioned at Wellington station to verify current rail use by time period and route group.

The build-ups of demand on each line in the inbound direction are closely matched in the AM peak, and acceptable in the IP.

No validation of rail journey times was provided, though the GW brief states that assignment validation will include "comparison of bus and rail journey times against observed data". Our

[16] From Validation Report, Figure 23.
[17] Arup assumption.

checks on rail journey times indicate that the modelled and timetable times are in close agreement.

**Link Amendments**

In early stages of the update, a range of walk and rail-access link lengths were amended in a bid to improve the rail validation. Whilst theoretically it is possible to replicate train boarding locations accurately with sufficient link amendments, presenting the appearance of a very good base year validation, it can be to the detriment of the model for forecasting and it is usually better to accept a small degree of error in the base year and avoid arbitrary link amendments. On review, the decision was made to remove the link amendments in the final updated model. We support this decision, and the validation of both rail volumes and boarding locations shows that the rail validation is satisfactory.

No validation is provided of observed and modelled access modes though the brief states that transit assignment will include “comparison of observed and modelled access modes at the major rail stations that have bus interchange and park & ride”.

We have checked access modes to rail. There are two ways that individuals can access rail: (1) via the dedicated ‘p-connectors’, representing multi-modal access, coded with times that weighted averages of the various access modes available including bus, car, cycle and walk; and (2) via the street network and bus services that run thereon.

In general, where a p-connector option is provided, 100% will use it[18]. This is satisfactory in terms of demand modelling – the generalised costs are reasonable. The problem arising is that multi-modal passengers (e.g. those who use bus feeder services to access rail) cannot be assigned to the services they use, which limits the ability of the model to assess bus sub-area networks, station catchments, and feeder interactions between bus and rail. This feature is common to both WTSM 2001 and the 2006 update, and we note this as an item for future review.

If changes to bus/rail connections are to be studied in sub-areas such as Wainuiomata, Porirua or Paraparaumu, further attention to rail access behaviour in the local area may be warranted.

It is not clear from the documentation what the correct methodology is for coding p-connectors to new rail stations, advice should be sought from SKM on this, though for studies of new stations, it may be more appropriate to investigate station choice outside WTSM.

### 5.3.2 Bus validation

The bus assignment has been validated by comparison of observed and modelled bus passengers crossing screenlines.

The validation tables[19] show some very considerable differences between the ETM data and the model, but it is unclear whether there is a problem is with the model, the ETM data, or both.

Our main concern is that the 2001 ETM data used to develop the original model and the 2006 ETM data used to update it to 2006 show some considerable differences. Our analysis revealed inferred growth rates over 5 years of the order of 50-100% which appear unrealistic. In our view, the model could not reasonably be expected to replicate this growth, given that the principal inputs of population, households and employment grow by less than 10%.

Comparison of 2001 and 2006 models[20] gives a forecast increase in bus use of 27% in the AM peak, and 23% in the interpeak over the period, which aligns well with independent

[18] Between 98% and 100% of passengers gain access to Porirua, Waterloo, Paraparaumu, Linden and Johnsonville via the p-connectors.

[19] Validation Report Tables 34 and 35 (removed in the published report for reasons of data confidentiality

advice from GW that bus patronage growth has grown by 22% overall. This provides some assurance that the model responds appropriately to a period of strong growth.

Given that this is a four stage model, a difference between observed and modelled flows of 30% at the screenline level would be a reasonable target for screenlines with flows above 100 passengers per hour. There are 12 screenlines, each with two directions, making 24 in total. In the AM peak, 16 of the 24 have more than 100 passengers per hour, and 12 of these are match within 30%. In the IP, there are 9, of which 7 are within 30%.

Overall, it is difficult to identify where the main errors lie given the uncertainties with the ETM data. Our advice is therefore similar to that given in the 2001 model peer review: that a lack of reliable data is a significant constraint to understanding the reasons for the discrepancies, and verification or refinement of the bus validation may be required in local areas for specific studies, using new data.

No validation of bus journey times was provided, though it is stated in the brief that there will be “comparison of bus journey times against observed data” and that “the Golden Mile of Wellington is of key importance”.

## 5.4 Model performance

We have assessed the performance and response of the updated model by setting up a series of sensitivity tests to estimate the elasticities of demand to 10% increases in key inputs.

The percentage change in AM peak trips and trip kilometres forecast by the model, resulting from a 10% increase in the input - all other parameters being held constant - are given in Table 9.

**Table 9 – Results of AM Sensitivity Tests (% changes)**

| Test | Description | Bus | | Train | | Car | |
|---|---|---|---|---|---|---|---|
| | | Boardings | Pass km | Boardings | Pass km | Trips | Veh kms |
| 1 | PT fare | -2.2 | -3.1 | -2.4 | -3.4 | 0.2 | 0.4 |
| 2 | Rail speed | 0.1 | -1.3 | 5.3 | 3.9 | -0.1 | -0.2 |
| 3 | Bus speed | 3.3 | 6.6 | -2.2 | -1.4 | -0.1 | -0.1 |
| 4 | Train frequency | -0.1 | -1.0 | 2.3 | 2.3 | -0.1 | -0.2 |
| 5 | Bus frequency | 1.8 | 1.9 | -0.4 | -0.1 | -0.1 | -0.1 |
| 6 | Fuel price | 2.1 | 3.5 | 1.8 | 3.0 | -0.9 | -2.5 |
| 7 | Highway speed | -0.9 | 1.0 | -3.9 | -4.6 | 1.2 | 2.6 |
| 8 | Parking charges | 1.2 | 1.3 | 1.0 | 0.9 | -0.3 (note 1) | 0.0 |

Source: Arup sensitivity tests. Note 1: percentage change in car trips to CBD only = -1.6

[20] Modelled bus passengers (2 hr): 01AM = 17315, 01IP = 6775; 06AM = 22000, 06IP = 8800.

The demand elasticities (**in bold**) and cross-elasticities (*in italics*) are given in Table 10.

**Table 10 – Results of AM Sensitivity Tests (elasticities)**

| Test | Description | Bus | | Train | | Car | |
|---|---|---|---|---|---|---|---|
| | | Boardings | Pass km | Boardings | Pass km | Trips | Veh kms |
| 1 | PT fare | **-0.23** | **-0.33** | **-0.26** | **-0.37** | *0.02* | *0.04* |
| 2 | Rail journey time | *-0.01* | *0.14* | **-0.54** | **-0.40** | *0.01* | *0.02* |
| 3 | Bus journey time | **-0.34** | **-0.67** | *0.24* | *0.15* | *0.01* | *0.01* |
| 4 | Train frequency | *-0.01* | *-0.11* | **0.24** | **0.24** | *-0.01* | *-0.02* |
| 5 | Bus frequency | **0.19** | **0.20** | *-0.04* | *-0.01* | *-0.01* | *-0.01* |
| 6 | Fuel price | *0.22* | *0.36* | *0.19* | *0.31* | **-0.09** | **-0.27** |
| 7 | Highway journey time | *0.10* | *-0.11* | *0.41* | *0.47* | **-0.12** | **-0.28** |
| 8 | Parking charges | *0.13* | *0.14* | *0.11* | *0.10* | **-0.03** **(note 1)** | **0.00** |

Source: Arup sensitivity tests. Note 1: elasticity with respect to CBD car trips only = **-0.17**

The key elasticities that are often examined for model validation purposes are for car: fuel costs, journey times, and parking charges; and for PT: fares and journey times.

The elasticity of car kilometres with respect to fuel prices is -0.27 is a very plausible result and similar to the -0.26 of the 2001 model. Benchmark values from models elsewhere are in the range -0.1 to -0.4. In the UK, a value of -0.3 is well established.

The elasticity of car kilometres to car journey time is -0.28, which is within the -0.2 to -0.33 range recommended in the EEM (A11.7).

The elasticity of CBD car trips to CBD parking charges is -0.17, again seems reasonable and in line with our expectations.

The elasticity of bus and rail trips with respect to PT fares are -0.23 and -0.26 respectively, again a plausible result, and close to the benchmark range for urban transport of -0.2 to -0.4 over the short to medium term. The PT journey time elasticities are between -0.34 and -0.67, which we also consider to be reasonable, and similar to the 2001 model.

The tests were also run for the IP period, giving similar results.

Our conclusion is that the principal direct (own-mode) elasticities are all reasonable.

Regarding the cross-elasticities, it is more difficult to benchmark against other models because the strength of this response varies with the level of competition between the modes. It is a key feature of this model that sensitivity of car demand (trips and kilometres) to changes in public transport costs and levels of service is small, which means that, overall, significant improvements to public transport may not have much effect on car congestion, though in individual corridors there could be some effect, this was not tested. As an example, a 30% increase in rail speed and service frequency across the network would, according to this model, reduce overall car kilometres travelled by 1%. We note this as a key feature of the model, not as a technical criticism, as we have no evidence to either support or reject it.

# 6 Review of Future Year Model

We have reviewed the Baseline Forecasting Report and the future year do-minimums for 2016 and 2026. The 2016 and 2026 Regional Transport Plan (RTP) scenarios were not peer reviewed.

## 6.1 Model Inputs

The land use and socio-economic data for future years has been provided by MERA. The growth in socio-economic variables appears to be much stronger for the first ten years (06-16) than the second 10 years (16-26), which is a feature of the Statistics NZ projections used by MERA.

## 6.2 Do Minimum

In general, the changes between 2006 and the two future years look plausible, and the model responds appropriately to changes in the inputs.

In the AM peak, growth in car use between 2006 and 2016 is forecasts around 1% a year for peak and inter-peak. Over the same period, PT use is predicted to grow by 1.6% a year in the peak and 0.6% a year inter-peak. Peak rail use at Wellington (alighters in the AM peak) is forecast to grow by 3.6% a year. Given the increasing congestion affecting cars and buses, these forecast growth rates seem plausible.

Spot checks were made on the road and PT network coding changes, and no problems were found. On a note of detail, the peak capacity on the approach to the Basin Reserve from Adelaide Road is very restrictive, leading to diversionary routes along unsuitable residential streets; further examination of the assumptions may be warranted.

WTSM converges satisfactorily in all scenarios, though in AM and PM models in 2016 and 2026, the model stops due to the maximum number of iterations being reached (set to 320) rather than through achieving the convergence criteria. Given this, we recommend that for future year projects, a sensitivity test is undertaken with the maximum iterations increased.

## 6.3 Regional Transport Plan (RTP)

No review has been undertaken for the RTP scenario.

# 7 Model Usability

## 7.1 Macros

The macro structure developed in 2001 to automate WTSM runs has been retained and further developed. We note that some parameters that the user may need to edit are hidden away inside macros. An example of this is the fuel cost. In order to test the effect of a change in fuel price, the user must search through and edit many lines of code in several different macros to run this test. It would be more straightforward for the user if the global model parameters[21] were collected together into a single user-friendly (i.e. well annotated) control file.

There are files in the 'macros' and '311' directories that are not longer used in the current implementation of the model. It would help in model maintenance if these unused files were moved to a separate directory.

## 7.2 Tracking of ad-hoc coding amendments

One of the tasks[22] was to give consideration to extending/reviewing the existing practice of applying capacity reductions to links with high M/HCVs flows. But, in the event, the modelling consultants could find no documentation of what was done previously, and the amended links could not be reliably located.

We recommend that, in future, where a non-standard assumption is made, that this is applied as an update to the 'pure' network under macro control, producing a self-documenting record of network elements that differ from the default WTSM coding approach.

## 7.3 Software

The delivered model is an application of emme/2 software. Since the update project was commissioned, the software has been updated and released as emme/3. The new software, as far as we are aware, gives identical results to emme/2, but has a better graphical interface and additional interactive features that will benefit model users and managers. GW will be running the updated model on the new emme/3 software.

[21] I.e. parameters that apply across the model, rather than to specific origins, destinations, and OD pairs.
[22] Update Specification Report, page 5, Task 5.2.9

# 8 Recommendations and Conclusions

## 8.1 Summary of key findings

Our overall assessment is that the tasks set out in the brief have been completed and the resulting model is compliant with the GWRC's briefed requirements. The work has been carried out accurately and professionally, and we consider that the 2006 model represents a significant improvement on the 2001 model it replaces. Sound modelling principles have been applied, and good use has been made of the available data.

A good quality and comprehensive dataset was used for the highway validation. This gives significant credibility to the validation.

Our reservations about the quality of the bus and rail data used for model validation are firstly the age of the rail data and secondly the lack of consistency of the bus data.

The scope did not include the collection of a comprehensive set of public transport data. No new data was collected to validate rail movements, though some useful limited rail count data from 2006 was obtained late in the project, which was invaluable. And for bus, despite the acquisition of patronage data, we have doubts about its quality and consistency for validation purposes. Our review of the bus validation does not provide us with confidence in the derived validation data.

Notwithstanding this, the rail validation aligns reasonably well against observed data presented in the validation report, and with independent data provided subsequently; and a comparison of 2001 and the updated 2006 models shows that growth in bus demand is modelled with reasonable accuracy.

The match between census and modelled PT shares by area is very good - a considerable achievement for a model that has no geographical constants in the mode choice sub-model. We consider this is a strong validation of the underlying model and gives a good degree of confidence.

Sensitivity tests we have undertaken on fuel costs, PT fares, parking charges, car, train and bus speeds, and train and bus service frequencies all gave plausible elasticities, within internationally established normal ranges. A key feature of WTSM is its relatively small cross-elasticities of car demand with respect to PT generalised costs; we have no evidence to support or refute this.

Improvements have been made to p-connectors though our advice is that the ability of the model to forecast use of bus feeders to rail, park and ride use, and station catchment areas is limited.

## 8.2 Recommendations

Our recommendation is that the updated model is fit-for-purpose for strategic modelling purposes, with the following qualifications:

- analyses that require accurate representation of rail station catchment and access modes will require some model refinement or may be better treated outside WTSM
- for detailed project level modelling, the general advice would be to develop a sub-area model, based on WTSM but with enhanced detail and refined validation in the local area.

Based on the key findings above, we further recommend that:

- if and when new rail and bus data is collected, the public transport validation is verified
- as part of the next model upgrade, a comprehensive and consistent dataset is obtained for bus and rail movements, as well as highway. WTSM is a multi-modal model and PT

is an increasingly important part of transport packages: good modelling of bus and rail requires good data.

### 8.3 Conclusions

Arup was appointed to peer review the Wellington Transport Strategy Model (WTSM) 2006 Update. We have undertaken a detailed review and sensitivity testing.

Our overall assessment is that the updated model is compliant with the Greater Wellington (GW) briefed requirements. We are satisfied that the work has been carried out accurately and professionally, and that the 2006 model represents an improvement on the 2001 model it replaces. We consider that sound modelling principles have been applied, and good use has been made of the available data.

The validation of the highway assignment model has been reviewed and is considered to be of a high standard for a four-stage model.

We have some reservations about the quality of the bus and rail data used for model validation, firstly the age of the rail data and secondly the lack of consistency of the bus data. Notwithstanding this, the rail validation aligns reasonably well against the limited data available and the growth in modelled bus use[23] is replicated satisfactorily.

Tests we have undertaken to establish the sensitivities of the model indicate elasticities are reasonable, lying within the expected ranges. Cross-elasticities of car travel with respect to public transport costs are low, meaning that even quite significant improvements to public transport are likely to have only a small effect on region-wide car trips and kilometres. In individual corridors the effect may be stronger, we have not tested this. This is noted as a key feature of the model, not as a technical criticism.

It is the nature of a peer review to focus on the negative issues. A small number of components that we feel merit further discussion are addressed in this report. This does not reflect on the appropriateness of the model overall - the great majority of components require little or no comment because they function well.

In summary, WTSM 2006 meets and in many ways exceeds international standards for four-stage models, and we recommend that the updated model is fit-for-purpose.

[23] Between 2001 (WTSM Base) and 2006 (WTSM 2006 update)