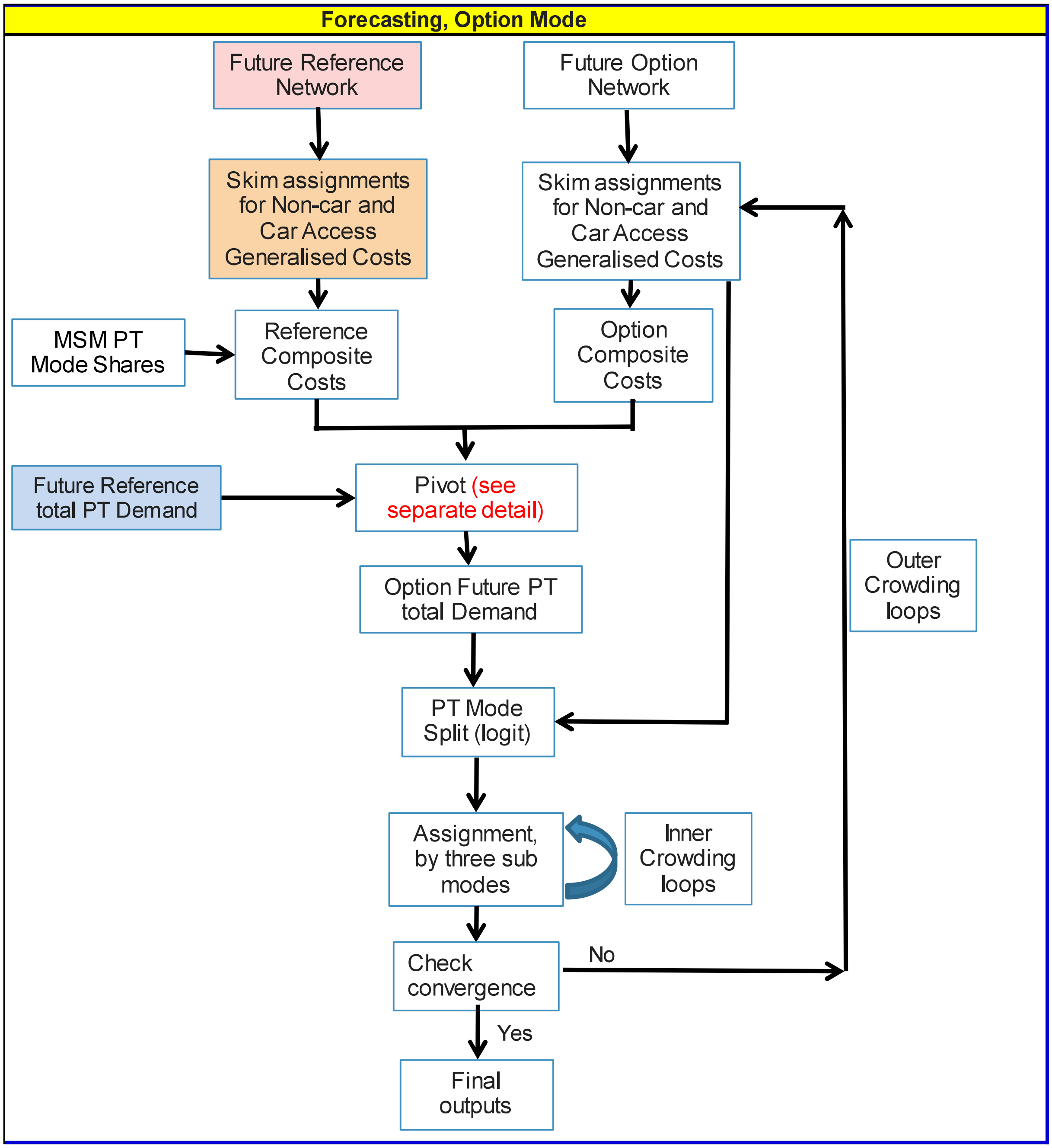


Figure 8-4 - Structure of MPT Future Option (Pivot) Model

MSM PT mode share comes from the MSM Reference scenario and it was used in the calculation of Option composite cost as well.

8.3 Growth Factor Option Assessment (Task 3.1)

As previously discussed, an objective of Phase 2 is to improve the consistency of the Macro Strategic and Macro PT model forecasts. A review of the growth forecasting method was undertaken, and, as identified in the Phase 2 Specification, a modified, cell-based growth factor method was preferred to assist with:

- Removal of the gravity distribution model to better retain the trip patterns from the 2016 observed matrices in future year forecasts;
- Improving consistency with the Macro Strategic Model by direct use of the growth factors from that model; and
- Improving the consistency and efficiency of the models by removing the various sub-interfaces with the Macro Strategic model, including the PT trips associated with TDM initiatives, changes in car cost, and school bus demands.

Three general processes were considered for developing future year matrices in the Macro PT model:

a) Option A applies PT growth to the observed PT matrix at a PT trip end level and then Furness this to PT trip end growth.
b) Option B applies PT growth to the observed PT matrix at a matrix cell level.
c) Option C applies mechanised growth at a general trip level with the PT trips being generated solely within the Macro PT model (i.e. with a separate mode split model).

In Options A and B, growth factors would inherently include the effects of both land use changes and network performance. This means that the regional mode split would primarily come from the Macro Strategic Model. However, the pivot model could be used to assess localised PT initiatives in more detail directly in the Macro PT model, without requiring a re-run of the Macro Strategic Model. Option C would involve a separate mode-split model within the Macro PT model.

The following table summarises the benefits and implications of the three identified methods.

Table 8-1 - Option Assessment for the Growth Factor Methods

Option	Benefits	Disbenefits
Option A (Trip End Growth)	• Less sensitive to zero cell and extreme or negative growth issues • Simple structure	• Potential loss of base year trip patterns • Inconsistency with Macro Strategic OD patterns • More reliant on Macro PT car-PT mode split
Option B (Cell Growth)	• Greatest consistency with Macro PT • Simple structure	• More sensitive to zero cells or extreme growth • More reliant on MSM's car-PT mode split
Option C (Mechanised Growth)	• Theoretically more precise PT costs used in car-PT mode split • Less reliant on running Macro Strategic Model	• New inconsistency with Macro Strategic model • New Car-PT models to calibrate • More complex structure

Overall, it is considered that Option C would work against the project objective of increasing consistency between the models as it introduces a second primary mode split prediction between car and PT. Option A is considered to contribute to the project objectives but is inferior to Option C. The sensitivity of Option B to zero cells or extreme growth values have been addressed in other models.

Following concept-testing of this method, Option B was suggested as the preferred approach. This concept testing is documented in the Macro PT Model Specification (**Appendix B**), along with implementation details in the separate Model Testing Report.

8.4 Option B – cell-based growth (Preferred) (Task 3.3)

This task documents specific tasks undertaken with regards to the preferred Option B cell-based growth method. Specifically, it seeks to address key design questions, namely:

- What is the general method, and how to best deal with cells with zero values, either in the observed or synthetic matrices;
- When and how the disaggregation between the Macro Strategic and Macro PT zone systems would occur;
- Whether to use additive or multiplicative growth methods; and
- What segmentation to use, such as by purpose or WTP segment.

8.4.1.1 Growth Factor Method

This section considers decisions around dealing with zero-cells, extreme growth, and additive versus multiplicative methods.

A general method for growth factoring of an observed matrix is covered in the RAND research paper undertaken by Daly, Fox, Patruni, Milthorpe (2012). This method was considered and has been adopted in a number of regional models.

The general concept of applying growth factors from a synthetic model to an observed matrix is becoming more accepted as a preferred approach. The broad concept is simple, including three steps:

1. Growth 'factors'[12] are developed between Base year ($\mathbf{S_B}$) and Future ($\mathbf{S_F}$) year synthetic demand matrices
2. Those factors are applied to the base year Observed ($\mathbf{O_B}$) demand matrices
3. A 'normalisation' process to balance matrices or match regional control totals if needed.

The complexity occurs in a cell-based method where there are unusual values or trends in the three input matrices, such as:

- Zero cell values in any of the input matrices;
- Unusual combinations of zero and non-zero values;
- Very large growth in the synthetic cells; and/or
- Significant growth in new (greenfield) areas.

[12] These may not be multiplicative factors as such, but the term 'factors' is used for ease of reference.

The RAND paper addressed these through the 8-case model. These ‘cases’ are summarised in Table 8-2.

Table 8-2 - Summary of the 8-case model

Case	Observed Base (B)	Synthetic Base (S_B)	Synthetic Future (S_F)	Predicted	Comment
1	0	0	0	0	Empty cell
2	0	0	>0	S_F	Greenfield cell
3	0	>0	0	0	Remove development
4a	0	>0	>0 (S_F>X_1)	S_F-X_1	Extreme Growth - use additive growth over X_1
4b	0	>0	>0 (S_F<X_1)	0	Growth under X_1
5	>0	0	0	B	Use observed
6	>0	0	>0	B+S_F	New development
7	>0	>0	0	0	Remove development
8a	>0	>0	>0 (S_F>X_2)	$B.X_2/S_B + (S_F-X_2)$	Extreme growth - use multiplicative under X_2 and additive over X_2
8b	>0	>0	>0 (S_F<X_2)	$B.S_F/S_B$	Use Multiplicative growth

The X_1 and X_2 values determine what is defined as ‘extreme growth’. In Case 8, the X_2 threshold determines the point where growth switches from being multiplicative to being additive. The RAND paper recommends:

$$X_1=X_2=k_2.S_B$$

Where K_2 is to be determined, but a default value of 5 is used.

The detailed implementation and adoption of final parameters is documented in the separate Model Testing Report.

8.4.1.2 Matrix Disaggregation

With regards to the PT cell-based growth factor method, the option is to disaggregate the trip matrices either before or after growth factoring. The following table summarises the key attributes of both options.

Table 8-3 - Option Assessment for PT Demand Disaggregation

Option	Benefits	Disbenefits
Before growth factoring	• Allows more granular factoring that could better reflect certain activities such as schools (this improvement would only occur if the disaggregation process is altered in forecasting to reflect land use changes) • This approach would be required if the zone system in the Macro Strategic model PT assignment was to be refined • Simpler model operation with only a single zone-system used in main MPT models	• More likely to have zero-cell or extreme-growth issues
After growth factoring	• More aggregate zones mean less processing issues with zero-cell or extreme growth	• Would not reflect growth at the localised level, especially for specific

Option	Benefits	Disbenefits
		activities • More complex model operation as two EMME scenarios required for every model period to accommodate the dual zone systems

For the Macro PT model disaggregating before growth factoring was preferred for the following reasons:

- It allows for the eventual consideration of special growth activities at a more granular level;
- It is more consistent with any subsequent refinement of the zone system in the Macro Strategic model assignment (either as part of this Phase 2 work or later); and
- It simplifies the model structure by avoiding multiple zone systems within a scenario (i.e. disaggregation would be applied as demands are first input to the Macro PT model, meaning only a single zone system was required).

8.4.1.3 Matrix Segmentation

The growth factoring is sensitive to trip numbers, especially zero values. With regards to growth factoring, undertaking the cell-based growth factoring at the most aggregate level (i.e. without segmentation) would minimise issues with very small trip values and 'extreme' growth. For this reason, it was deemed preferable for any segmentation to occur after growth factoring. However, it was decided that segmentation was not required in the Macro PT model.

8.5 Review Efficiency of Crowding Implementation (Task 3.4)

The Macro PT model has a significantly longer runtime with crowding applied, due to convergence needs for both an inner and outer iterative loop. This task investigates methods to improve the efficiency of that process. The use of the crowding module better reflects the balance between PT sub-modes, which otherwise tends to over reflect patronage on bus and under reflect patronage on rail. As part of the Phase 1 refresh, the 2016 base model was calibrated with the crowding functions in place, meaning that crowding is now required to be activated for most forecasting tests (it can be deactivated to undertake an 'unconstrained' forecast).

In the Macro PT model, the crowding has two iterative processes as follows:

- Inner Loop (Assignment). This process iterates the EMME assignment process with updates to the crowding factors; and

- Outer Loop (Demand). This process iterates the for the demand model (pivot and sub-mode split).

This work looked to identify ways to achieve a more efficient process in the Macro PT model, whilst retaining acceptable convergence and consistency with the Macro Strategic model.

Analysis of the model convergence identified an opportunity to modify the convergence criteria and include damping to reduce the number of iterations. The base 2016 model was calibrated with the original (extended) iterations to avoid complicating the calibration process. However, the opportunities to reduce iterations (and therefore runtimes) was further developed for forecasting. That testing and final recommendations for forecasting are included in the separate Model Testing Report.

8.6 Review Pivot Model (Task 3.5)

The pivot model is an optional method for future year forecasting that predicts incremental change in PT demand and flows from a change to the PT system. It 'pivots' relative to the Future Year Reference scenario. The change to the forecasting method for MPT also required a change to the existing pivot model, primarily by altering the pivot point from the base year to the reference scenario. That revised structure is outlined in the following figure.

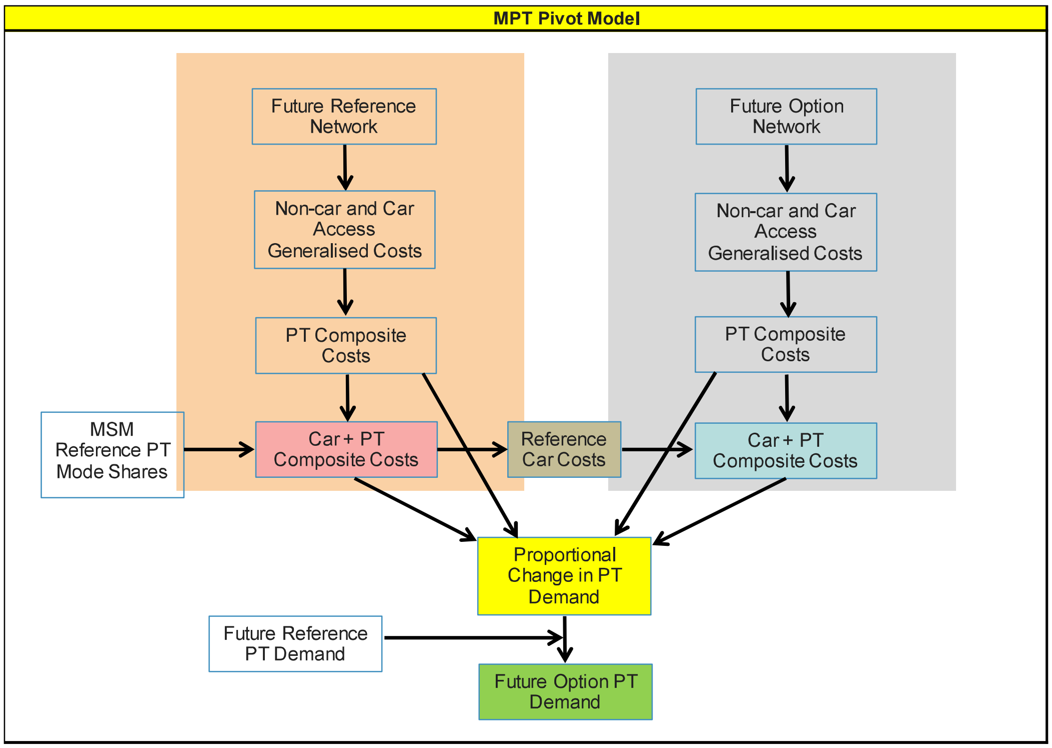


Figure 8-5 - Structure of Revised Pivot Model

The structure of the pivoting mechanism itself was retained, albeit with a review of the sensitivity parameters. That review was undertaken via comparison against the forecasting sensitivity of the MSM model, and as such is detailed in the separate Model Testing Report.

8.7 Review PT Sub-Mode Split and Assignment (Task 3.8)

The Macro Strategic and Macro PT models use different methods for the PT sub-mode split:

- The Macro Strategic model assigns a single PT matrix with sub-mode split done within the assignment strategies
- The Macro PT model uses a logit sub-mode split model followed by individual assignments of each sub-mode

The attached MPT Specification Report discussed options for this element of the MPT. At the technical workshop it was agreed that the existing structure would be retained, but that a separate assignment-based model would also be developed for use in specialist applications or as a check on the more detailed logit sub-split model.

8.7.1 Assignment-Based Sub-Mode Choice Option

An alternative assignment method was developed and tested for the MPT model, where the sub-mode choice (between rail, bus and ferry) is undertaken via the assignment process, rather than via the logit choice model.

This alternative method utilises the logit choice model to estimate the car (e.g. park and ride) and non-car access. The separate demand matrices for rail, bus and ferry were then recombined for use in the single assignment. Because the car-access trips are diverted through the identified park and ride zones, those choices are generally retained in the combined assignment.

Key differences between this method and the existing logit sub-mode split model are primarily centred on the applications of penalties or weights, with the single assignment including:

- Equal walk weights across all modes;
- A lack of a non-main mode boarding penalty; and
- A lack of non-main mode travel time penalties.

Further discussion on possible applications of this alternative method are included in **Section 9.7**.

8.8 Implementation of Model Updates

The use of the Macro PT model had always been restrictive due to the availability of only AM peak models (an earlier version of an IP model did exist but was rarely used and generally outdated). This means that often the Macro Strategic model was called upon for PT projects where the Macro PT model would have been more appropriate if IP and PM peak models were readily available. Historically there had not been the relatively complete dataset that makes up the HOP database which is now available to produce observed matrices.

With the HOP data now being available, it was possible to produce observed trip matrices for both the IP and PM periods. With greater consistency between the Macro Strategic model and the Macro PT model, significant components of the PT network and service descriptions that can be taken directly from the Macro Strategic IP and PM models.

This task therefore involved creating Interpeak and PM peak elements of the MPT model. This typically involved using the same structure as the AM peak model, albeit with revised input data. Certain aspects between the AM, IP and PM Macro PT models differ or needed accounting for. These include:

- The difference in bus services and frequencies across the three periods, with the potential for some of the network parameters and functions to vary between periods in order to suitably validate to observed data.

- The sub-mode split lambda parameters. The PM peak model shares the parameters used for the AM peak, whereas the IP model simply used the historic values as its parameters.

- Information from the Macro Strategic model, and their treatment within the Macro PT model. In particular, the Park-and-Ride catchment information and the process of adapting the existing convolution process to function correctly for the IP and PM peak models.

8.9 Implementation Tidy Up

Another aspect of the implementation process was a formal consideration and update of scenario and matrix numbering. The principles of this task were to:

- Keep the Reference and Option matrices together;
- Have flexibility, such as whether all three time periods (AM, IP, PM) are run for a scenario or not; and
- Minimise the number of unused matrices, while having spare matrices available for temporary use.

It was decided that we were to utilise an overall approach similar to that of the Macro Strategic model, where:

- A band of matrices is used for a scenario, with each band containing saved matrices and retaining a number for temporary use during a model run and post model run; and
- Unlike the Macro Strategic model, the time periods in the Macro PT model are unrelated, where any time period model can be run independently of the others.

Further documentation on this update process can be found in the User Manual.

8.10 Bus Travel Time Function Comparison

To enhance consistency between the two models the transit line information was extracted from interim versions of the Macro PT and Macro Strategic models and compared against observed data in both the inbound and outbound directions for the AM, IP, and PM peak periods.

The bus stop time per km for the IP and PM peak periods require consideration. The values used at this stage of testing were as follows:

- AM
  - Inbound direction = 1.36 min/km
  - Outbound direction = 0.81 min/km

- PM
  - Inbound direction = 0.81 min/km
  - Outbound direction = 1.36 min/km

- IP
  - Inbound direction = 0.81 min/km
  - Outbound direction = 0.81 min/km

Plots showing a comparison of modelled vs observed travel times in the Macro PT and Macro Strategic models are shown in to.

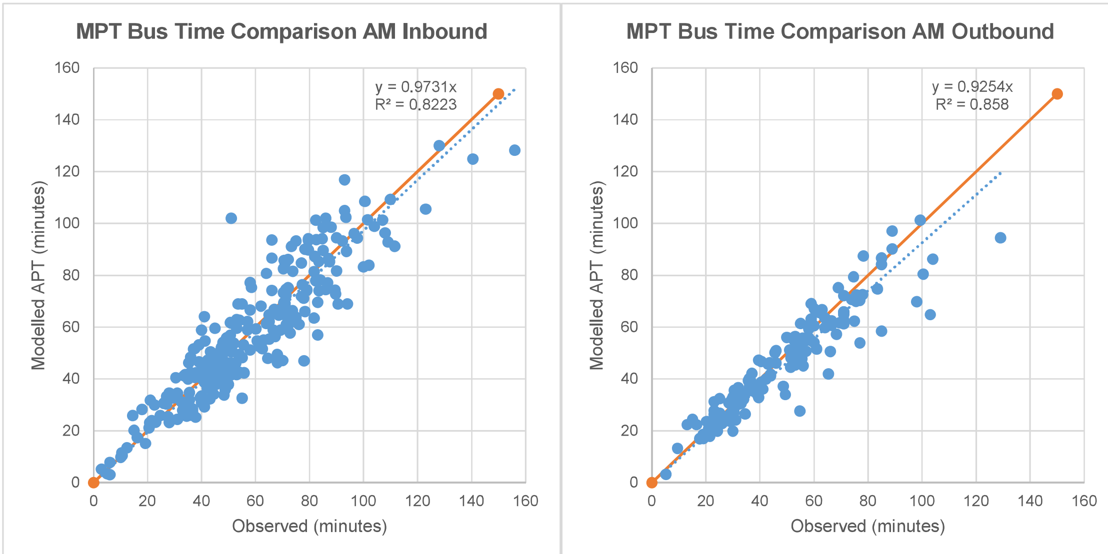


Figure 8-6- Inbound and Outbound MPT travel times (AM)

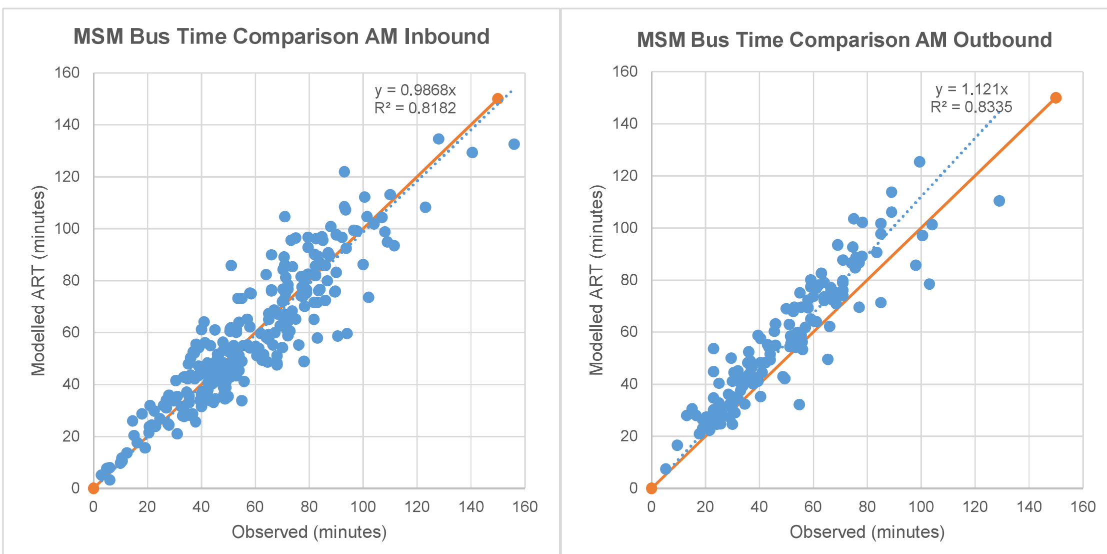


Figure 8-7- Inbound and outbound MSM travel times (AM)

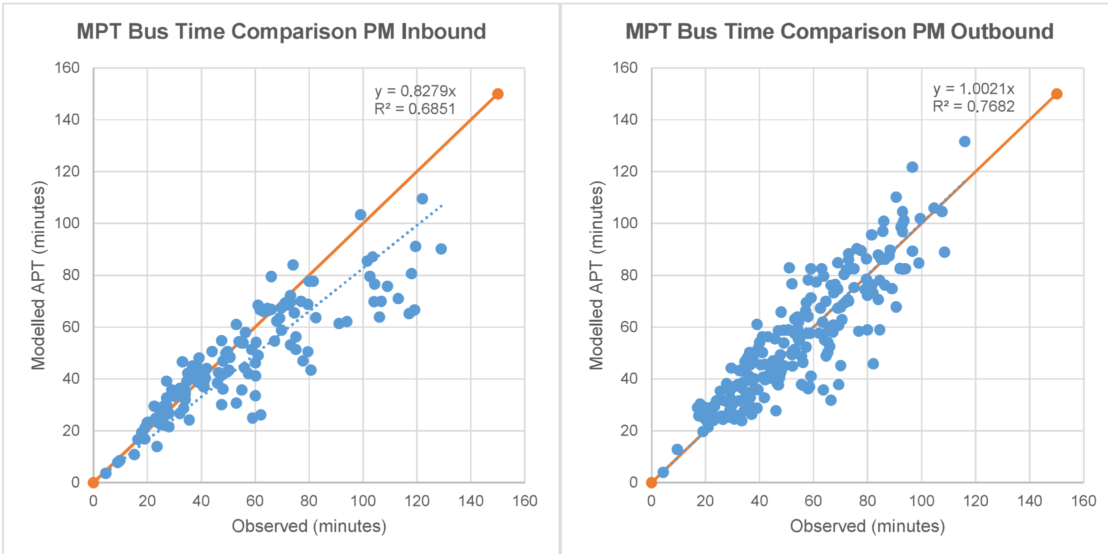


Figure 8-8- Inbound and Outbound MPT travel times in the PM inbound and outbound

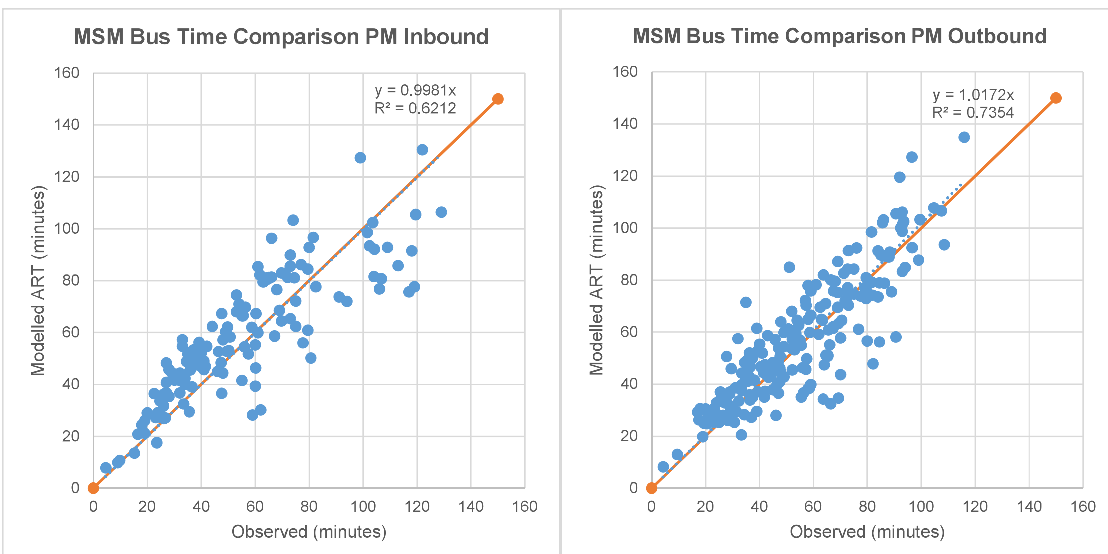


Figure 8-9 – Inbound and Outbound MSM travel times (PM)

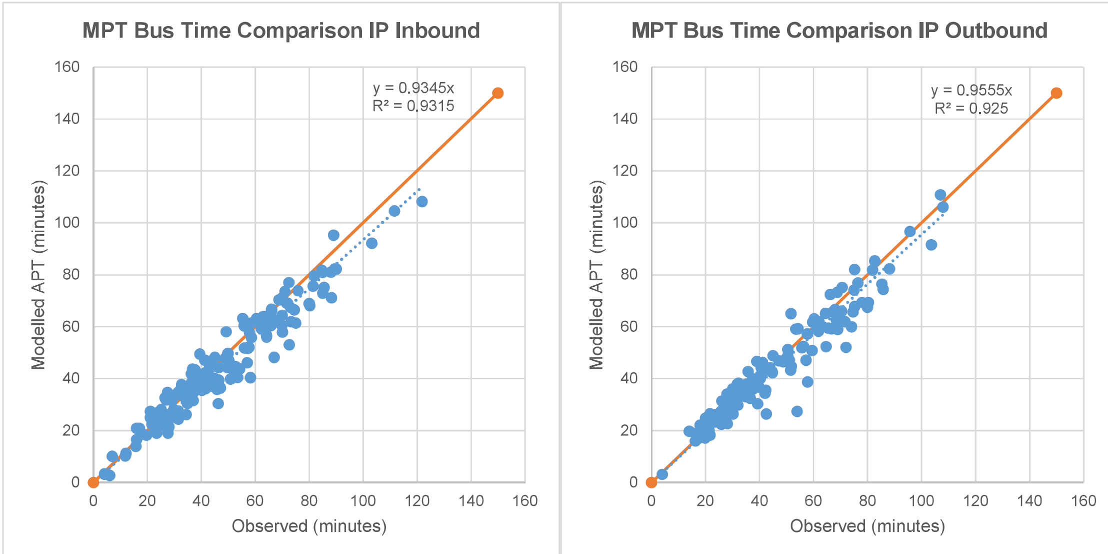


Figure 8-10– Inbound and Outbound MPT travel times (IP)

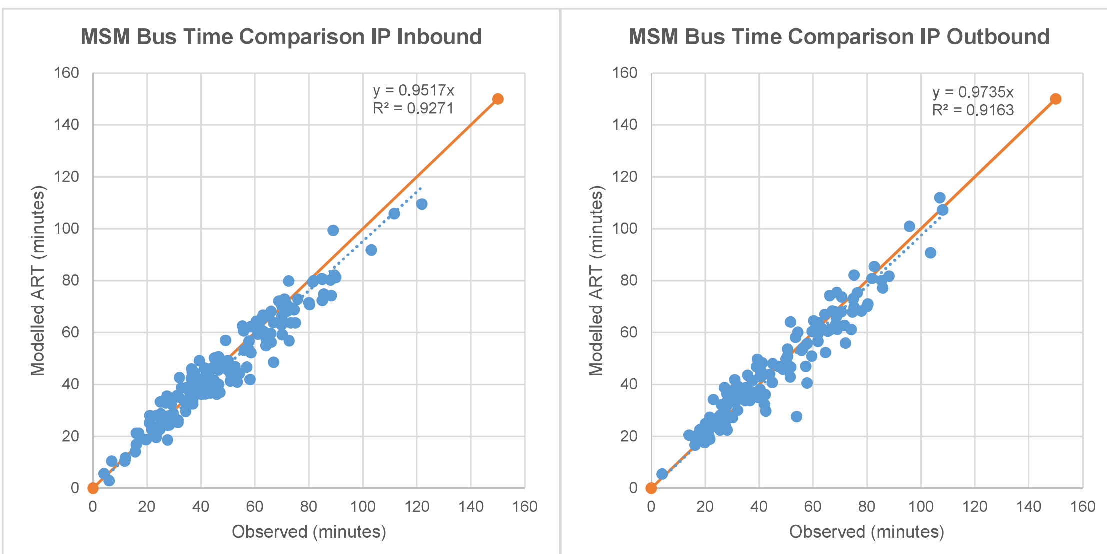


Figure 8-11- MSM travel times in the IP inbound and outbound

It was decided that the Macro PT model would adopt the travel time function from the Macro Strategic model. Those functions were included in the calibrated Phase 2 MPT model.

9 Phase 2 Consistency and Supplementary Tasks

9.1 Interface Automation (Task 4.6)

As touched on in Section 4.6, the Macro Strategic and Macro PT models interface in various ways. The Phase 1 2016 refresh had aligned many aspects where appropriate to enable simpler interfacing of networks and services. In order to facilitate further co-ordination, the following tasks have been undertaken:

- All Macro Strategic model information is now output to a folder that can be simply transferred into the Macro PT model folder structure.
- The interface process now passes information from the Macro Strategic model for all three peaks.
- The Park-and-Ride information from the Macro Strategic model extends upon the coding of station and catchment inputs to include transfer penalties, parking availability penalties, and parking costs.
- Where applicable, information from the Macro Strategic model are now exported in temporary matrices that can be read into the Macro PT model without modification.
- Airport, TDM, Car TDM, and Change in Car Cost information are no longer outputs from the Macro Strategic model, though a total PT matrix is now passed through that is inclusive of the airport matrix.

9.2 PT Travel Time Functions

In Phase 1, crowding factors were applied to both running (ul1) and stop time (ul2) for bus. However, for rail, crowding factors were only applied to running time (ul1) as rail dwell times were coded in the service line coding, not in travel time function attributes, and hence crowding factors were not able to be applied to dwell times for rail. For the ferry mode, the dwell time was excluded in the travel time function and therefore the crowding factor was only applied to the running time.

In Phase 2, the rail dwell times were calculated as a user attribute in the travel time function and therefore crowding factors were applied to dwell times. This means that the application of crowding factors is now consistent for bus and rail modes.

Also in Phase 2, the travel time functions for running and dwell time attributes, ul1 and ul2, were transferred to the segment attribute, us1. This will enable the modelling of different characteristics of PT services in forecasting, however it may be necessary to insert some coding for this functionality.

An extra segment attribute, @ivt which includes running and dwell times, was introduced in Phase 2 to store real in-vehicle travel time before the application of vehicle perception factors. This attribute was skimmed in the final PT assignment to get the real PT travel time matrix.

9.3 General Updates

Various other changes were made in the process of implementing and validating the model. These included the following:

- Where the Phase 1 Macro PT model considered 21 Park-and-Ride sites, the base year now uses observed data at 26 sites for the purposes of validation, all of which are treated as having no parking capacity constraints in the formation of the observed matrices. These additional five sites were previously omitted due to a lack of comprehensive data, however, they have now had their car and non-car access split estimated from the observed data of neighbouring sites.

- Minor zone connector additions in the CBD, in order to represent better access to the networks.

  These were:
  - A connection between the university and Kitchener Street via Albert Park; and
  - A connection between SkyCity and Albert Street.

- The bus services on Waiheke Island were updated to 2017 services across all three peaks. In response to this, the zone connectors for this region were also re-evaluated and the demand distributed more evenly.

- With the objective of achieving greater consistency between the Macro Strategic and Macro PT models in mind, the PT travel time functions from the Macro Strategic Model are now carried through into the Macro PT model. A result of this is the introduction of the integrated ticketing (a proportional reduction in stop time) switch in the Macro PT model. Likewise, additional Park-and-Ride information is now carried through.

- The Park-and-Ride Minimum Auto Distance parameter in MPT has been changed to 5km. This parameter had historically been set at 10km. This value inadvertently disallowed trips from the Orakei region travelling towards the CBD that could have used the Orakei Park-and-Ride site. This change had minimal impact elsewhere in the network and allowed for trips at the Orakei site, requiring an increase to the rail park-and-ride MSC value to adjust for the additional demand. This shifted some users to Bus in other areas, however these changes were both minor and better matched to the observed data.

- A change to the Sub-Mode split model, where the existing model was disallowing Park-and-Ride trips if an origin-destination pair does not have a viable bus alternative. This occurred irregularly within the model in very remote areas, such as the zones surrounding Helensville and Clevedon.

9.4 Additional PT Modes (Task 5.1)

The current models are structured around the 'traditional' PT modes of rail, bus and ferry. The MSM predicts the split between these sub-modes during the assignment, and as such can readily consider multi-modal trips (e.g. bus then rail then walk). The MPT can also address multi-modal PT journeys, however this relies more on the defined sub-mode hierarchy and uses a structured logit model to predict the sub-mode split. The MSM structure represents the vehicle 'quality' characteristics through the travel time functions and/or perception factors on the travel time. The logit model structure can include those link-based quality factors, but the modal characteristics are implicit to the calibrated logit structure (both via the logit scale parameter and the calibrated modal constants).

New or unfamiliar (to Auckland) vehicle technology can have different characteristics than the traditional modes, therefore requiring a new mode or vehicle type in the models. Emerging technology around service planning and payment (such as Mobility as a Service) is also likely to encourage more multi-modal journeys.

The rigid structure of the MPT model does not allow inclusion of a new 'hybrid' mode (such as light rail) at the same level as the other modes. Rather, they need to be defined as parts of the existing modes (e.g. either as rail or bus modes). The "new" mode services can be specified with link-based quality-factors, however these can become diluted when combined with the selected main mode.

The logit structure requires data on the new mode to allow specific calibration, which is not feasible as such modes do not currently exist in Auckland. Creating 'dummy' modes in the logit structure is not considered worthwhile as the appropriate structure is also dependant on the data. Such a dummy mode for potential later activation is not considered robust, as the structure and parameters would need to be assumed. It is not sensible to assume a generic structure without knowing what the mode is. Any such restructure would best be done only by exception for a specific, known study.

The simpler assignment-based method (such as in MSM) would allow initial forecasting of new modes with assumed quality parameters set relative to the traditional modes. This method would not require a restructure of the model, and means the new mode characteristics are used directly, rather than diluted.

The recommended method to consider new PT modes is therefore via an assignment-based sub-mode split. Although this already exists in MSM, an assignment-based method can also be used within the MPT. Such a method has been developed and found to provide similar level of base-year validation as the logit model. That alternative method is discussed in **Section 8.7.1.**

9.5 Discussion of PT Vehicle Quality Factors

Both the MSM and MPT models include parameters that reflect both the PT vehicle characteristics (such as speed and capacity) as well as perceived quality factors. These quality factors can be link-based in both models, as well as via a constant (ASC) in the MPT model. The link-based factors are applied to the In-Vehicle Time (IVT), and as such their effect is a function of the trip length. The constants applied in the MPT are fixed for any length of journey. Both types of quality factors are set relative to a particular vehicle/mode (i.e. one selected vehicle type has a factor of 1, with the others set with smaller or larger factors). It is however important to consider both the link-based factors and the ASC constants when interpreting the implied vehicle quality.

Although consistency of factors is desired between the two models, this is not directly feasible because:

- MSM does not have a modal constant, so the link-based factors may need to be increased to match the same level of modal adjustment in MPT.
- The link-based factors are journey time (link-based) dependant, and so are only comparable with constants for certain journey lengths
- The MSM only includes the main mode split (car versus PT), so in some locations the IVT perception factors were required to address that relative choice. The MPT model only needs to consider the relative choice between PT modes
- In MPT the modal constants vary by time period and access mode (walk-up versus auto-access)

The calibration process and resulting parameters are included in the subsequent Validation chapter, but the vehicle quality factors are repeated below.

Table 9-1 - Vehicle Perception Factors and MSC values in MSM and MPT

	IVT Factors		MSC[13] (Minutes)			
	MSM	MPT	MSM	MPT-AM	MPT-IP	MPT-PM
Buslane	1.0	1.0	0	0	0	0
Normal Bus	1.2	1.1				
Busway	0.7	0.9				
Ferry	0.8	0.8		-10	3	-16
Rail	0.9	0.9		2	4	2

[13] Non car access MSC for MPT

9.6 Incorporation of Phase 1 Outcomes (Task 5.5)

A number of research papers were undertaken as part of Phase 1 (see **section 1.3**). The following Table 9-2 shows the research undertaken and states the recommendations as to if it should be included into Phase 2 or not, and also provides further commentary.

Table 9-2- Phase 1 Research

Research	Phase 1 Recommendation	Comments
Weekends	No further action in Phase 2	No further action
Trip frequency impacts	No further action in Phase 2	No further action
Network resilience	Recommendation for further consideration	Re-visit as research develops further. No action in Phase 2
Active modes	Yes, for consideration	AFC agreed no further action on this task
Behaviour change	Recommendation for further consideration	Phase 1 recommended to consider increasing the elasticity of the Time of Day choice model for commute trips. Extra elasticity response added to the ToD in Phase 2, although not specifically for this issue. This remains a scenario-testing opportunity, rather than a predictive functionality.
ITS	Recommendation for further consideration	Some additional ITS measures could be included in the modelling eg additional “mode”. Most other possible measures are more suitable for microsimulation or mesoscopic models. No specific actions in Phase 2
Reliability of travel times	No further action in Phase 2	This could involve developing a post-processing module. No change in model structure in Phase 2..
Representation of couriers, taxis, etc	No further action in Phase 2	No further action
New disruptive vehicle technologies	Yes, for consideration	Discussed in Section 9.7
Dealing with uncertainty	No further action in Phase 2	No further action
Measure economic carrying capacity of a corridor	No further action in Phase 2	No further action
Time of Day models	Recommendation for further	Phase 1 Recommendation to leave model unchanged and account for

	consideration	lower relative growth in the IP through adjustment of under reporting factors. Phase 2 added additional elasticity response
Review Auto Assignment	Recommendation for further consideration	Path-based assignment added to MSM in Phase2.

9.7 New Vehicle Testing Functionality (Task 5.6)

This task considers options to represent potential new vehicle technologies, such as electric, autonomous or shared-mobility services. Electric vehicles currently only differ by motive power (and hence running costs), while the other technologies have the potential to significantly alter travel behaviour.

Vehicle operating costs will alter demand and are represented as fleet-average operating costs in MSM. This means that the demand impact of changes in fleet-averaged running cost (such as from greater take-up of electric vehicles), can be represented, but not the specific effect on just the electric vehicles. Such effects may only be relevant where there are operational priorities available to such vehicles (such as EV lanes or access to other priority lanes).

It is not considered feasible (nor within scope) to consider creating a new vehicle segment within the demand model structure, due to the lack of data from which to create such segmentation. Any such model would also be directly reliant on the take-up of electric vehicles, which would be an assumed input. However, it would be feasible to create operational assignment models which used vehicle segmentation in the assignment to assess such operational priorities. Demands could be directly assumed as a proportion of the total vehicle demands. Given the operational nature of such studies, it is likely that these would be better implemented directly into a more detailed project model, rather than the MSM.

The impact of autonomous vehicles remains highly uncertain, both in terms of their impact on capacity and on demand. The change in behaviour with full autonomous take-up appears to be potentially so significant as to challenge the very structure of the existing MSM model. As such, any attempt to add functionality to the existing structure could not be considered a reliable forecasting tool. However, the model could be used as a scenario testing tool (i.e. where the models estimates the impact of assumed changes, rather than predicting those changes). Such methods have already been applied in the previous ART model.

The impact of mobility as a service technology also remains highly uncertain. However, it is feasible that it could make multi-modal journeys much more common (including car+PT+shared service). Perceived barriers to such multi-modal journeys may reduce as travellers are provided information, certainty and easy payment for such connected journeys.

Those kind of journeys may be better predicted via an assignment algorithm, rather than via the more traditional and rigid mode choice models. Traditional modelling software would not appear readily able to do this (combing auto and PT assignment), although some crude proxy could be feasible such as defining cars as a PT mode with special attributes. All journeys would then be assigned simultaneously.

In summary, the lack of data and proven model structures makes it impractical to alter the MSM structure to allow generic consideration of possible future technology-driven vehicles or modes. Rather, the MSM could at best be used as a scenario-testing tool, to measure the overall impact of assumed changes asserted to the model.

10 Model Validation Results

This chapter summarises the statistical comparisons between the Macro Strategic and Macro PT models and the observed data. The detailed comparisons are contained in **Appendix D** and **Appendix E**

10.1 Validation Criteria and Guidance

Effective from 01 April 2014 (First edition, Amendment 01), the NZ Transport Agency produced a Transport Model Data Comparison Guideline (TMDCG) that provides recommended comparisons for a range of transport model types. The Macro Strategic model falls into Model Type A:

> **Regional Transport model (3, 4 or more Stage or Activity Based)**
>
> *Regional models include representation of land-use activities, demographics etc. They are commonly developed to assess the strategic impacts of land-use changes, larger scale transport and PT projects, and the effects of policy changes on wider regions.*

The TMDCG states that the information “generally expected to be provided” is:

- Screen line summaries and movement GEHs and count band comparisons
- XY scatter plots
- RMSE statistics

Specifically excluded are individual turning/link GEHs and count band comparisons. The TMDCG are generally consistent with the data provided in the validation of the 2006 Macro Strategic model which are provided in **Appendix D** for:

Vehicles:

- total volumes across screen lines
- volumes on screen line links
- road travel times on routes

Passenger transport (noting no TMDCG criteria for these outputs):

- total PT patronage
- bus patronage by sector and into the CBD
- ferry patronage by service
- rail boardings by station on each line

MHCVs:

- total volumes across screen lines

The Macro PT model statistics provided in **Appendix E** are consistent with the 2013 model build, comparing modelled and observed data for:

- trip demands by mode – regional and by sector,
- flows by mode across screenlines,
- boardings and alightings at busway and rail stations, and ferry termini, and at park-and-ride sites,
- line profiles on rail, ferry and selected bus routes.

10.2 Adopted Model Calibration Parameters

During the model validation/calibration against observed data, a series of parameters were tested and discussed with the AFC. The following adjustments were made to a range of model parameters in both the macro strategic and macro PT models. These adjustments include:

- **PT Wait Time weighting**: adding a 'quality' component to MSM wait time weighting based on station quality (previously global weighting of 2, only MSM)
- **PT assignment GC (walk-only)**: PT assignment method cannot preclude walk-only trips so GC set to have a minimum of at least 1 boarding to address. Also most walk trips are in the CBD. Hence walk trips (i.e. boarding = 0) generalised costs were increased by 4 times for the CBD zones (243-250) to discourage walk only trips.
- **Walk Speeds:** Speeds varied between MSM (4kph) and MPT (MPT varied between 3.7-4.8 between CBD and non-CBD) and so have been made consistent at 4kph.
- **Park and Ride access**: MSM now uses access by 'P-Connectors', and with MPT using the previous matrix convolutions method.
- **Park and Ride transfer**: Original model treats P-Connectors as PT 'access' without transfer penalty. Redefined as 'mode' with car costs (as above) and also include a transfer penalty
- **Park and Ride parking availability cost**: Includes a representation of parking constraint
- **Park and Ride Sites and catchments**: these are now consistent and only for formal park and ride sites in both the MSM and MPT.
- **Station Parking Cost**: functionality has been added to allow (future) parking fee at PnR Station
- **Global PT Assignment Penalty**: MSM PT modal transfer penalty applied at assignment has been re-calibrated from 15 minutes to 10 minutes to match HOP transfer numbers. This penalty is been removed in the GC calculations.
- **Station Wait time functions:** Wait time functions at stations have been updated for 'planned' or 'unplanned' arrivals and now they are consistent between MSM and MPT. Unplanned arrival was only used for the ferry stations.
- **PT vehicle codes and capacities**: Updates based on new data provided by AFC (averaged from surveys) with consistency between MSM and MPT.
- **CBD walk-access time**: Updated to include perceived walk cost for auto trips in CBD areas (i.e. from car park to destination, MSM only).
- **Parking Cost Proportion**: Updated to reflect the forecast proportion of people paying the parking cost (in MSM only)
- **Parking cost allocation**: How parking costs are applied: Base model splits 50% to each journey leg, but only applied to destination (in MSM only) – now applied to and from parking zones
- **Starting GC for DMS**: GC matrix imported from earlier calibration runs (in MSM only)
- **Under-reporting**: Under-reporting factors added to car matrices post DMS using 2016 screenline data (in MSM only)
- **HBE under 14yr and school bus adjustment**: The existing model does not have HBE <14 years. School bus trips are removed before assignment. (in MSM only)
- **Tertiary trip adjustment**: Trips to and from tertiary zones are adjusted to match HOP data, but maintain daily total (in MSM only)
- **HBE adjustment in DMS**: HBE (tertiary, under 14 and private school bus) adjustments as described in Section 5.8 are included in the DMS loops before the crowding PT assignment which calculate crowding factors (in MSM only)

The final adopted parameters and reasonings are included in **Appendix D** and **Appendix E.**

10.3 Vehicle Quality Perception Factors and MSC

The pre-refresh MPT model (formerly known as APT) already has vehicle quality perception (IVT) factors and MSC for each PT mode.

In the model refresh, global PT MSC was introduced in MSM but currently set it at zero. No specific validation parameter was available in MSM for different PT modes. Hence vehicle quality perception factors were introduced to validate individual PT modes in MSM.

Table 10-1 - Vehicle Perception Factors and MSC values in MSM and MPT

	IVT Factors		MSC (minutes)			
	MSM	MPT	MSM	MPT-AM	MPT-IP	MPT-PM
Bus lane	1.0	1.0	0	0	0	0
Normal Bus	1.2	1.1				
Busway	0.7	0.9				
Ferry	0.8	0.8		-10	3	-16
Rail	0.9	0.9		2	4	2

IVT factors for MSM and MPT are generally consistent, however slightly different parameters were adopted for Busway and Normal Bus and these are further explained below.

We consider IVT factors for MPT are intuitive (i.e. based on reliability and quality of PT modes).

In MSM, the IVT factor for busway was 0.7 which is lower than the rail IVT of 0.9. We consider busway IVT factor serves two purposes in MSM, to represent quality/reliability factor of busway and to address potential PT demand issue (i.e. mode split between car and PT). In MPT, PT demand is fixed (i.e. using observed matrix) and hence there is no demand issue. IVT factors only represent quality/reliability factor of PT modes and these only control PT sub-mode splits. Hence we consider it is appropriate to have different IVT factors for MSM and MPT as they serve different purposes.

10.4 Modelling of PT Boarding

A limitation of the EMME software is that PT trips can be assigned to be walk-only. That is, PT trips are able to simply walk between the origin and destination without using any PT services. These trips are typically only for short trips where there are competing walk-only options. This results in a low generalised cost for those “PT” users. This was addressed in the MSM demand model by setting a minimum generalised cost which has at least one boarding. However, there are some walk only trips in the assignment as there is no mechanism to ban walk only trips in the current PT assignment procedure.

For reporting of total boarding numbers, this was addressed by estimating the number of walk-only trips and adding them to the assigned boarding’s. The procedure for correcting the numbers of boarding is described below:

- Total actual boarding’s were assessed as: Total PT trips minus intra-zonal trips and plus transfers
- Walk-only trips are the difference between the actual boarding’s (as above) and the total assigned boarding’s
- Walk-only trips were manually allocated between the sub-modes, based on accessibility to competing walk-only routes (for example ferry trips were not assumed to have competing walk-only options)
- Total boarding’s by sub-mode were assessed as the assigned boarding’s plus the walk-only trips

10.5 Macro Strategic model validation

A summary of relevant TMDC guidelines and how the MSM performs are outlined below, with more details information provided in **Appendix E**

Table 10-2 - GEH Statistics on screenlines (MSM Vehicle Screenline Flows)

GEH	Target Directional screenline	AM	IP	PM
<5	>60%	61%	75%	68%
<10	>90%	86%	100%	93%
<12	n/a	96%	100%	100%

Table 10-3 - GEH Statistics for individual links (MSM)

GEH	Target individual links	AM	IP	PM
<5	>65%	41%	46%	39%
<10	>85%	70%	77%	71%
<12	>95%	81%	84%	78%

Table 10-4 - % Directional Screenline (MSM)

%age	Target Directional screenline	AM	IP	PM
within 10%	>80%	93%	100%	93%

Table 10-5 Overall Model Statistics for directional screenline volumes (MSM)

Statistic	Target	AM	IP	PM
R^2	>0.85	0.992	0.996	0.993
Gradient	Y=0.9x-1.1x	0.972	0.98	1.003
RMSE	<30%	7%	5%	5%

Table 10-6 - Journey Time Summary (MSM)

Total route directional peak journey time	Target % of routes	AM	IP	PM
within 15% or 1 minute (if higher)	>80%	79%	99%	69%
Within 15th to 85th percentile observed range	-	100%	99%	97%
2006 within observed range	-	67%	63%	44%

10.6 Macro PT model validation

The Macro PT model also falls into TMDCG Model Type A for the development of public transport demands at a regional level.

Validation of the Macro PT model requires the selection of MSC values. The values used are as follows:

Table 10-7- MSC Values

Mode	AM	IP	PM
Bus	0	0	0
Bus_PnR	6	14	-15
Rail	2	4	2
Rail_PnR	-2	8	-5
Ferry	-10	3	-16
Ferry_PnR	1	7	-8

Without TMDC guidelines, headline model statistics for the three peak periods are outlined below, with more detailed information provided in **Appendix E.**

Table 10-8 - AM Public Transport Modelled Patronage (Macro PT)

Mode	2016 AM observed patronage	2016 modelled	Difference	% difference
Bus	40,821	40,752	-68	0%
Bus_PnR	2,503	2,578	75	3%
Rail	12,775	13,028	253	2%
Rail_PnR	5,279	5,165	-114	-2%
Ferry	1,864	1,928	64	3%
Ferry_PnR	2,468	2,459	-9	0%
Total	65,710	65,911	201	0%

Table 10-9 - IP Public Transport Modelled Patronage (Macro PT)

Mode	2016 IP observed patronage	2016 modelled	Difference	% difference
Bus	17,829	17,929	100	1%
Bus_PnR	347	346	-1	0%
Rail	3,743	3,957	214	6%
Rail_PnR	751	722	-29	-4%
Ferry	543	536	-7	-1%
Ferry_PnR	476	474	-2	0%
Total	23,689	23,964	275	1%

Table 10-10 - PM Public Transport Modelled Patronage (Macro PT)

Mode	2016 PM observed patronage	2016 modelled	Difference	% difference
Bus	33,378	33,406	27	0%
Bus_PnR	2,187	2,207	21	1%
Rail	10,420	10,774	354	3%
Rail_PnR	4,075	3,989	-85	-2%
Ferry	1,584	1,554	-31	-2%
Ferry_PnR	2,168	2,128	-40	-2%

Mode	2016 PM observed patronage	2016 modelled	Difference	% difference
Total	53,812	54,058	246	0%

Table 10-11 - GEH on Screenlines (Macro PT Model)

GEH	Target Directional screenline	AM model	IP model	PM model
<5	>65%	100%	93%	82%
<10	>85%	100%	100%	100%
<12	>95%	100%	100%	100%

11 Summary

There were 3 key objectives for the Phase 1 model refresh:

- 2016 base year update
- Incorporating Willingness to Pay segmentation in the Macro Strategic Model
- Incorporating PT crowding effects

These objectives have been achieved as follows:

- For the 2016 base year update, an acceptable and 'fit for purpose' update and validation for the 2016 model has been achieved that is, in many ways, better than the original 2006 model (such as through improved match to observed travel time and traffic flow data).
- With regards to Willingness to Pay, the specified methodology has been successfully implemented and demonstrates an improved model response and ability to analyse the impacts of pricing.
- In terms of PT crowding, the required crowding functionality has been successfully implemented into MSM with acceptable runtime, convergence and increased consistency with MPT.

In addition to the objectives, the efficiency of the two model systems has been significantly enhanced through greater rationalisation of shared inputs and processes.

The key objectives for the Phase 2 update were as follows:

- Clarify the role of the two models and their intended use
- Remove or reduce remaining inconsistencies between the models so that they can be operated more seamlessly, within their designated purpose and with greater certainty on which forecasts are used
- Consider options to address new or disruptive modes or technology.

These objectives have been achieved as follows:

- Preparation of a model guidance report
- Creation of inter and PM peak models in MPT along with significantly improved consistency and integration of the two models.
- Discussion of potential options along with an alternative sub-mode split model for MPT for use in specialist applications

Overall, it is considered that both models have successfully been updated and enhanced, with a level of validation suitable to this type of model. As such, it is considered that the 2016 base year models have met the key project objectives.

Appendix A Research papers

Appendix B Macro PT Model Specification Report

Appendix C Phase 1 Technical Papers

Appendix D MSM Validation

Appendix E MPT Validation

Eastern Busway - Base 2018 Model Update Report

Prepared for Auckland Transport (AT)
Prepared by Beca Limited

28 February 2019

Contents

Appendices

List of Abbreviations

Abbreviation	
ADTA	Auckland Dynamic Traffic Assignment (model)
AFC	Auckland Forecasting Centre
AMETI	Auckland-Manuka Eastern Transport Initiative
AT	Auckland Transport
GEH	Gesellschaft zur Erhaltung alter und gefährdeter Haustierrassen (statistic)
JDF	Junction Delay Function
MSM	Macro Strategic Model
NZTA	New Zealand Transport Agency
QLD	Queensland model (Aimsun model in Australia)
SCATS	Sydney Coordinated Adaptive Traffic System
TPF	Turn Delay Function
VDF	Volume Delay Function
EB	Eastern Busway

Table of Figures

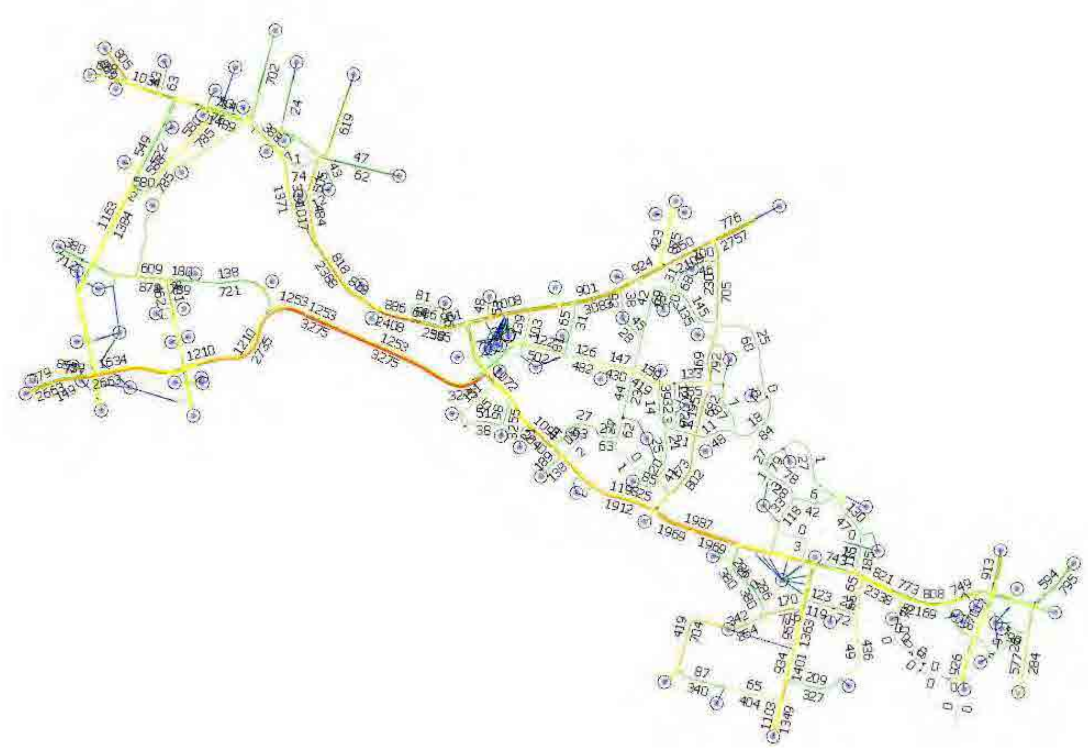


Table of Tables

Revision History

Revision Nº	Prepared By	Description	Date
1.0	**Ling Hoong**	Draft for client comments	1 March 2019

Document Acceptance

Action	Name	Signed	Date
Prepared by	Ling Hoong		1 March 2019
Reviewed by	Caleb Deverell / Nyan Aung Lin		1 March 2019
Approved by	Andrew Murray		1 March 2019
on behalf of	Beca Limited		

Executive Summary

This report details the update and calibration/validation of the Aimsun model for the Eastern Busway Project. The purpose of this model is to provide a consistent and common base for project developments in the East Auckland Area, primarily along Ti Rakau Drive for the EB 2 and EB3 detailed design work.

The model covers two three-hour peak periods (6.30 am – 9.30 am, and 3.30 pm – 6.30 pm). The modelled periods were chosen to capture the congestion typically experienced in the modelled area.

The model consists of macro and micro tiers with the respective assignment methods: static assignment and microscopic dynamic assignment (DTA). The macro tier provides an interim stage to calibrate the demand through demand adjustment and to generate 80% of paths for the micro DTA. Based on previous modelling of the area, an 80-to-20 split in static versus dynamic path assignment was considered appropriate. This gave better control of modelling route choice in the area and sense-checks during the model development process showed that route distribution in the model is reasonable.

Various observed data were provided by Auckland Transport (AT) for the model development. These included traffic counts, travel time, public transport timing, and signal timing.

The traffic demands come from the AMETI EMME traffic model and were processed before assigning to the Aimsun model. This demand interface process includes a minor refinement of AMETI traffic model zones and application of 2-to-3 hour expansion factors to fit the Aimsun model period. Demand adjustment as part of the validation process was done manually.

The model network was developed in line with the Auckland Dynamic Traffic Assignment Model (ADTA) network coding guideline, which sets out the recommended network coding methodology for Aimsun models in Auckland. This included a standard system of classification and labelling of different turn movement types which were important function variables in the ADTA-developed cost functions also adopted in this model for calculating junction and turn delays.

Model validation showed that the model meets the validation target criteria for Category C: Urban Area in NZTA Model Development Guidelines on individual link flows and turn flows for each hour between 7am – 9am, and 4pm – 6pm. Travel times in the model fit reasonably well with the observed.

Overall, the base year model is considered acceptably calibrated and validated for the purposes of the EB2/3 design work.

1 Introduction

1.1 Background

This report documents the calibration and validation of the Aimsun model to the year 2018.

The Eastern Busway project is focused on developing an integrated multi-modal transport system that supports population and economic growth in East Auckland and Manukau. This involves providing more and better transport choices and aims to significantly enhance the safety, quality and attractiveness of passenger transport, walking and cycling environments.

Beca Ltd (Beca) was commissioned by the Auckland Transport (AT) to update the existing microsimulation model in Aimsun software for testing scenarios relating to the Eastern Busway project. Figure 1 shows the extent of the model. The model was calibrated to 2018 observations and will be used to forecast operational performance for various future scenarios in 2026.

Figure 1 - Snapshot of Aimsun model network and zone structure

1.2 Report Structure

The remainder of this report is structured as follows:

Chapter 2 Describes the model's background and structure;

Chapter 3 Details the model's data inputs;

Chapter 4 Details the model's parameter inputs;

Chapter 5 Presents the calibration and validation results;

Chapter 6 Presents conclusions of this report;

2 Model Background and Structure

2.1 Background and Focus

Previously, an update of the Base model had been undertaken in 2017, focusing on the area around the Panmure Town Centre, including the Panmure roundabout, King's Roundabout and Lagoon Drive, which were of interest for the EB1 project. SCATS and manual traffic counts and observed travel time data were used to validate the model to a 2016 base year for EB1 option-testing.

This update focuses on the EB2/3 corridor which is along Ti Rakau Drive from Pakuranga Highway to Botany (Figure 2). This base year for this model update is 2018 where 2018 input demand were sourced from the AMETI traffic model and calibration/validation process used 2018 counts and travel time information.

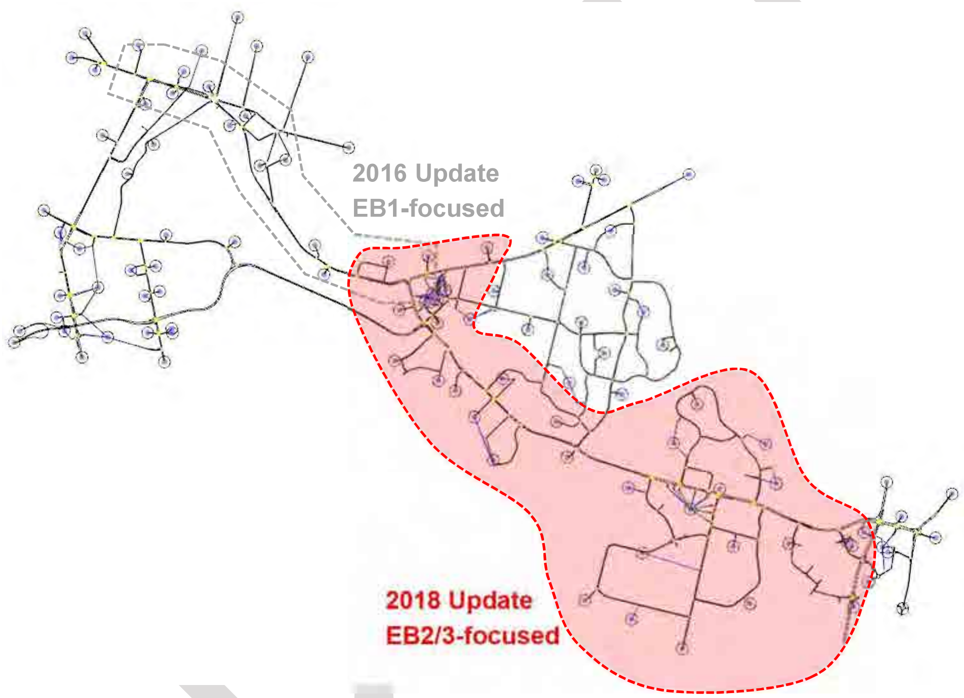


Figure 2 - Aimsun model focus areas: 2016/ EB1-focused (grey) and 2018/ EB2/3-focused (red)

2.2 Model Structure

The Aimsun model follows the hierarchical modelling structure that has been used successfully on other major projects in Auckland since the early 1990's. This involves the following three components:

- A strategic multi-modal **Demand (Macro Strategic Model, MSM)** model (an EMME model developed by AFC) that relates forecast land use (such as population and employment), to travel patterns at a strategic, region-wide level;
- A **Traffic Assignment** model (an EMME model developed by Arup) that has a more refined network representation for the wider study area. It takes the demand matrices from the Demand model and is calibrated to match traffic conditions particularly in the study area of interest. This model provides the cordon matrices for the Project Operational model.
- A **Project Operational** model (an Aimsun model and the focus of this report) that has a more refined network in a smaller project area. This model loads the vehicle trip patterns predicted by the assignment model onto the road network to test various options and investigate the traffic effects at a more detailed level.

It is the **project operational** model, developed in Aimsun that is detailed in this report.
The **demand** model was developed in EMME and is the Macro Strategic Model (MSM) developed by AFC. Also AMETI traffic assignment model was developed in EMME software.

The overall model structure is shown schematically in Figure 3 which comprises a hierarchical structure with the MSM model providing the multi-modal demand forecasts, and the EMME traffic assignment model and the Aimsun project model used for assignment and network performance modelling.

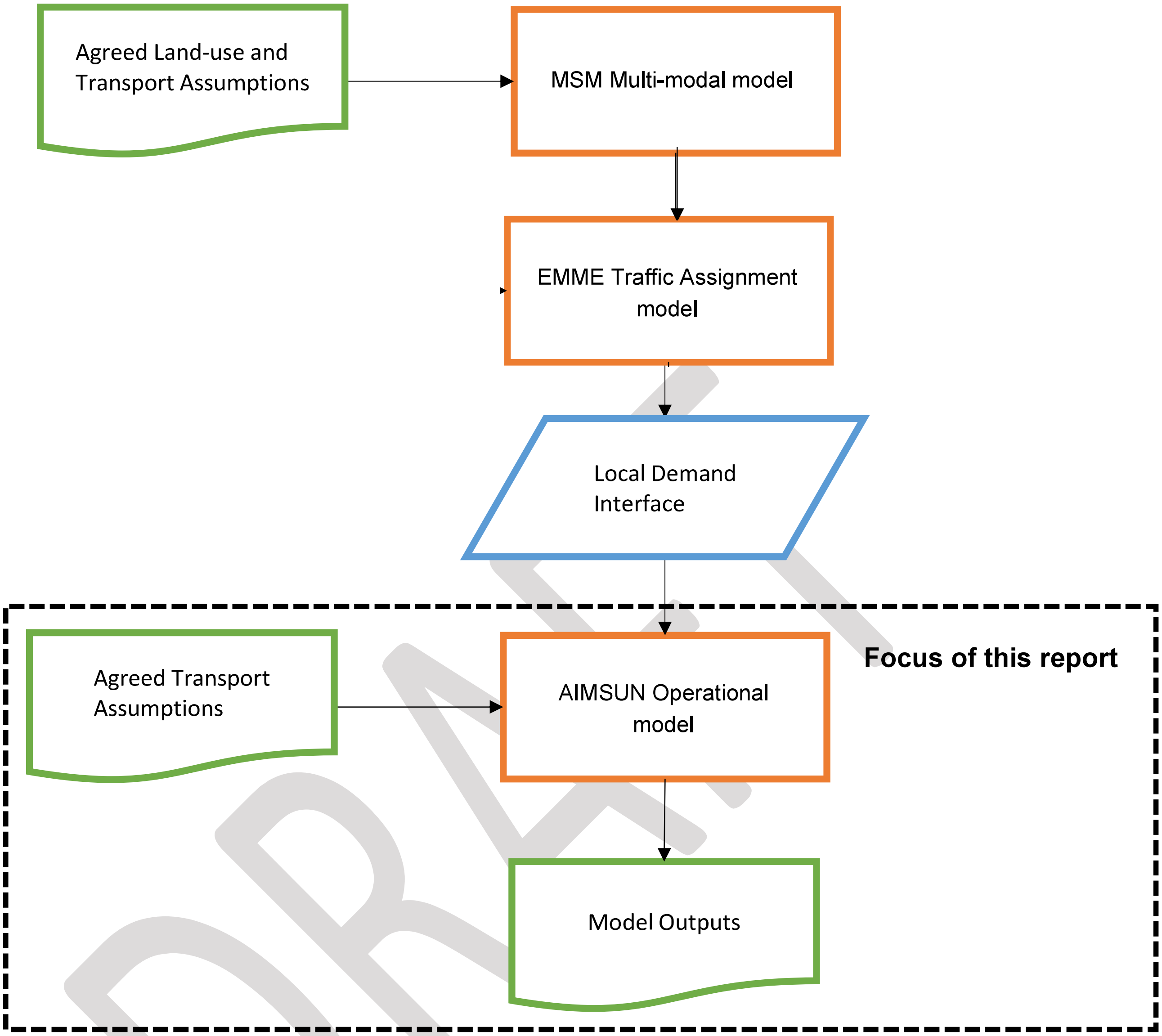


Figure 3 - Model Structure

2.2.1 MSM Demand Model

The MSM model is a traditional 4-step multi-modal model. The original model was developed for the year 2006, using the 2006 Census data and observed travel data. The model was updated in 2017/ 2018 using Census data from 2013, and validated to 2016 conditions. Separate models exist for the morning and evening commuter peaks and weekday inter-peak periods.

The model itself comprises the following key modules:

- **Trip Generation.** This is where the number of person-trips are estimated as a function of the land use data (population, employment, school roll etc.);
- **Mode Choice.** This is where the choice of preferred travel mode is determined, based on the relative attractiveness of the various modes. The key modes are car-driver, car passenger, bus passenger, train passenger and ferry passenger. A process is used to also consider 'slow' modes, such as walking and cycling;

- **Trip Distribution.** This is where the trips produced in each zone (generally by the households), are matched to a preferred destination. This distribution is predicted as a function of the relative attractiveness of each destination zone (generally related to employment), and the travel costs to reach each destination;
- **Time of Day.** This is where the proportion of daily trips occur in each peak. The proportion occurring in each peak changes in future-year models in response to the changes in travel time and costs; and
- **Trip Assignment**. This is where the resulting travel demands, in the form of origin to destination trip tables, are loaded to the road and public transport networks. An iterative process is used to firstly identify the lowest-cost route between each origin and destination, followed by an estimation of the speeds and delays on each route associated with the predicted traffic flows on the route.

The MSM model is operated by AFC and is implemented in the EMME software, which is a well-used and proven platform for this kind of analysis.

It is therefore the MSM model that predicts the overall regional traffic patterns, based on the inputs and forecasts of population and employment growth, together with the assumed level of road and public transport infrastructure.

The MSM standard model years are 2016, 2026 and so on. To get the 2018 regional demand, a demand interpolation process was undertaken between 2016 and 2026 scenarios. The 2016 scenario is the validated MSM base year scenario. As part of this project, a 2026 scenario was developed using the today network layout and bus service patterns.

2.2.2 EMME Traffic Assignment Model

This model was originally developed by Arup in 2010 and was peer-reviewed. This peer-reviewed model was used as the traffic assignment model for the previous AMETI project. The model takes its traffic demands from the MSM model and has the same model extent as MSM but has a more refined network representation in the wider study area of interest (Manukau and Auckland City areas). A zone refinement process was undertaken as an interface between the MSM and traffic assignment models.

2.2.3 Aimsun Operational Model

The Aimsun model is only a traffic operational model in that it takes the localised traffic demands from the EMME traffic assignment model, assigns them to the road network and tests the operation of the network. Land use data is not directly used in this part of the model, and it only considers vehicle traffic i.e. it represents bus vehicles but not passengers.

2.3 Model Time Period

The Aimsun model models two peak periods:

- AM: 6.30am – 9.30am
- PM: 3.30pm – 6.30pm

The traffic counts and typical traffic conditions were evaluated to determine that these time periods are suitable to capture the peak traffic on the network and ending at a time when traffic cooldown is typically observed. Each peak consists of a 15 minute warm-up prior to the peak start time in order to generate an appropriate level of demand inside the network before the official start of the peak.

3 Model Data Inputs

3.1 Network

Most of the road network was formed from the previous version of the Aimsun model (updated for 2016 base year). Additional road network was added in around Cryers Road and Burswood Road in the South East area of the model. Further refinements or error-checking over the whole model were conducted based on ADTA network coding conventions (Ref. 160520_DTA_Template_JMAC_v2.1.3). Network parameters are detailed in Chapter 4.1.

3.2 Demand

The initial demand was from the AMETI assignment model (refer to Chapter 2.2.2) and restructured to match the zone structure in the Aimsun model.

3.2.1 Demand Expansion

The two-hour to three-hour demand expansion factor for each peak was 1.38. This has been applied to the two-hour EMME demands to create a three-hour demand as a starting point for model calibration/validation.

3.2.2 Zone Disaggregation

As discussed earlier, most of the zone refinement was undertaken between the MSM and AMETI traffic assignment models. Only a very limited zone was further refined in the demand interface process between the AMETI traffic and Aimsun models. This process was retained from the previous base model 2016. A zone to zone correlation table is provided in Appendix A.

3.2.3 Demand Release Profiles

For developing traffic release profiles, the zones in the Aimsun model were grouped into six sectors: Panmure, West, Internal, North, East and South (Figure 4). Within the Internal sector, a subset of zones was created to separately represent the region nearest the Panmure Bridge and assigned its own demand profile.

Figure 5 and Figure 6 show the sector-to-sector profiles applied in the Aimsun model. Traffic count profiles at key locations on the network were used as a guideline to develop these demand profiles.

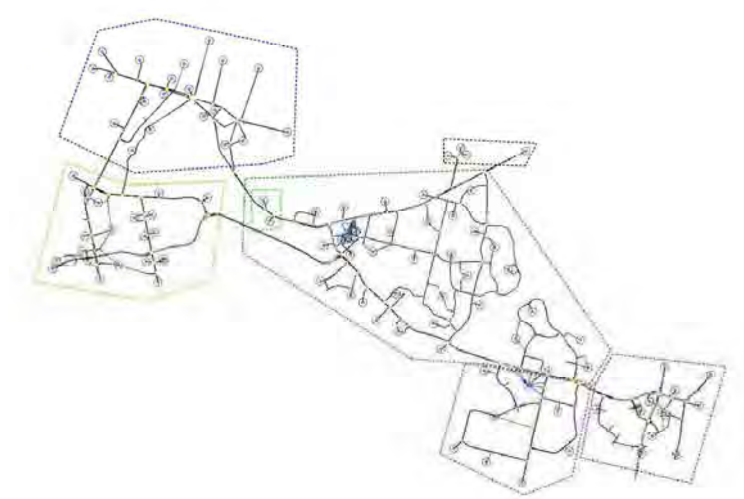


Figure 4 - Aimsun model sectors: Panmure (blue), West (yellow), Internal (dark green) with Panmure Bridge subset (light green), North (black), South (Pink), and East (purple)

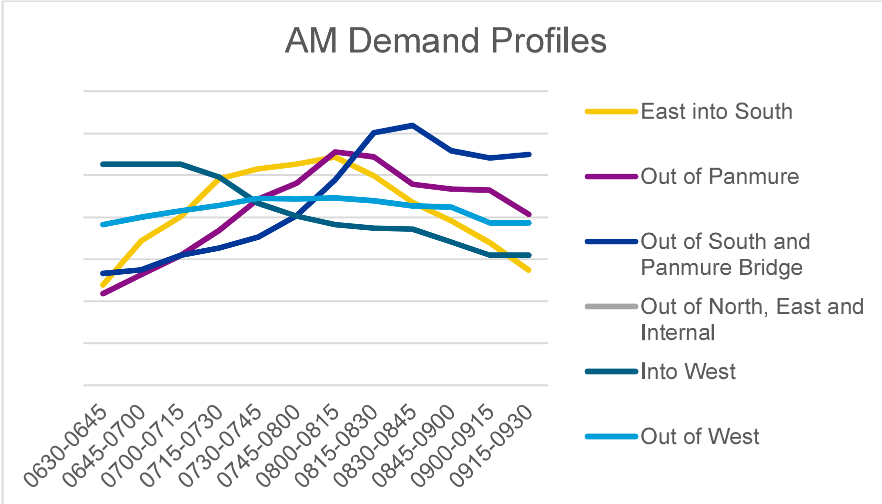


Figure 5 - AM Demand Profiles

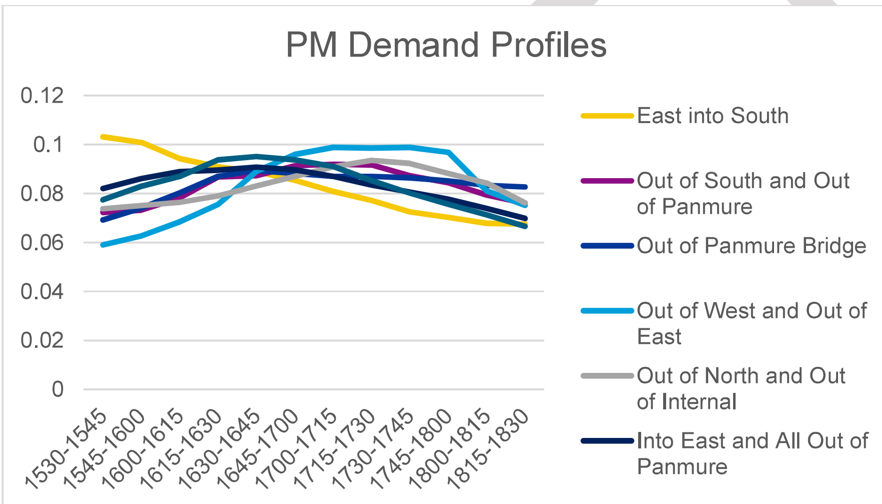


Figure 6 - PM Demand Profiles

3.3 Count Data

All count data for 2018 were provided by AFC, including SCATS detector counts and some manual counts. The locations of these counts used for link validation and turn validation (refer to Chapter 5) are shown in Figure 7 and Figure 8 respectively.

Link validation data was based on the average SCATS data of Tuesdays to Thursdays in March 2018. Turn validation data was based on the average of manual counts taken between Tuesday 12 June 2018 to Thursday 14 June 2018.

A sense-check of count continuity across the network was carried out and only counts that were consistent with adjacent counts were retained. This consisted of the majority of counts. All manual turn counts were checked for continuity with adjacent relevant SCATS counts and all were retained regardless of continuity since manual counts are considered more robust in general and these had been specifically provided by AFC for turn validation in the focus area. All counts used in validation were used as-is, without any further smoothing or processing.

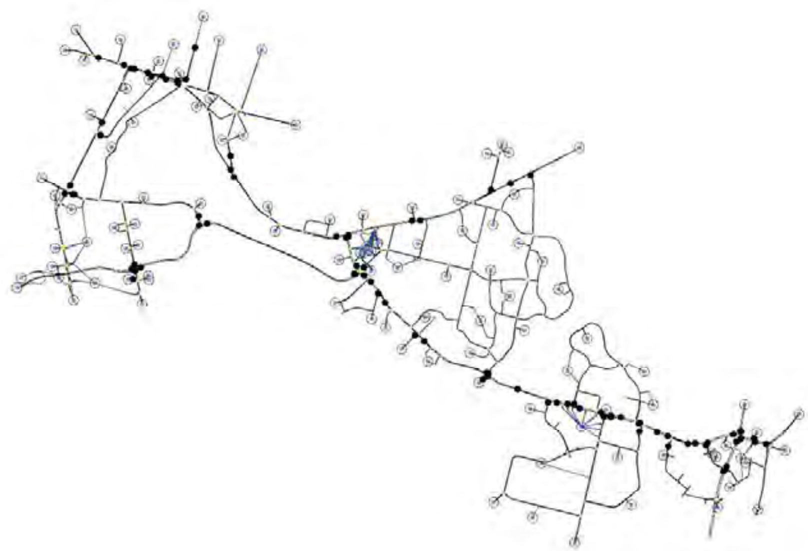


Figure 7 - Count locations used for link validation

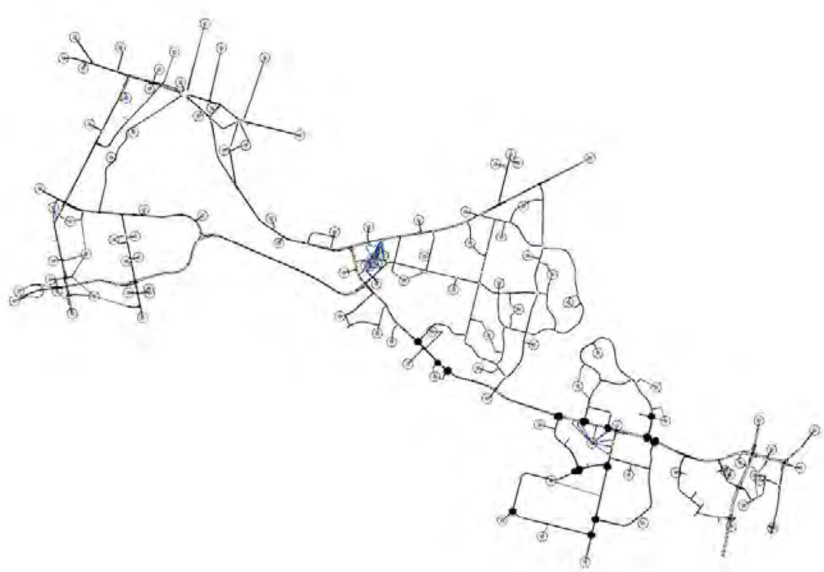


Figure 8 - Count locations used for turn validation, specifically for the model's focus area

3.4 Travel Time Data

The general traffic travel time data for key routes on the network (Figure 9) of Tuesdays to Thursdays in June 2018 was provided by AFC as summarised by Snitch GPS data. The full routes were provided in segments in order to understand the travel time and condition along the route. Following a sense-check of the travel times on Google, only the mean travel time on Ti Rakau Drive between Pakuranga Road and Pakuranga Highway was adjusted. All other travel times were accepted and retained for use in the validation.

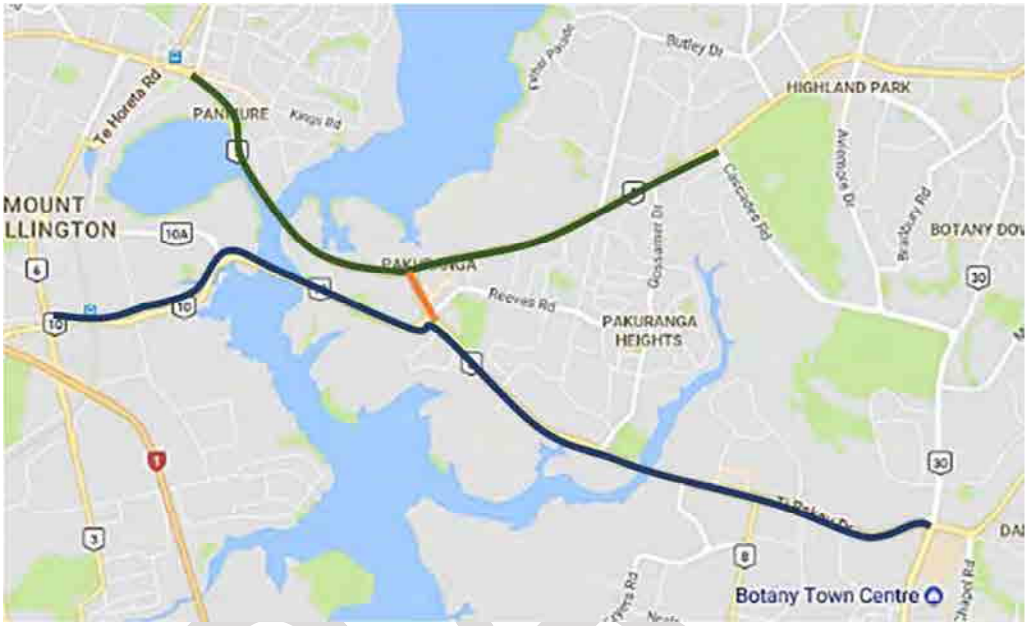


Figure 9 - Travel time routes from Snitch GPS data for reporting travel time validation in Chapter 5

3.5 Public Transport Data

All bus schedules and bus routes were obtained from the Auckland Transport (AT) website. Bus dwell time at bus stops were fixed at 30 sec mean stop time and deviation of 5. Bus travel time data was provided by AFC for March 2018 which included detailed timing of when each bus arrives and leaves each bus stop for each route. Following a sense-check of the travel times calculated from the raw data against AT's Journey Planner App, the average and maximum travel time of the routes were adjusted. The full list of bus services in the model is provided in Appendix D.

3.6 Signal Timing Data

The SCATS signal timing data of 7 March 2018 was provided by AFC for every signalised intersection within the model area. This was used to derive the signal timing coded into the model.

Average of maximum and minimum green times was used to develop the actuated control plan used in the dynamic assignment and initially used in the static assignment. During the model development process, it was noted that a fixed signal plan was more appropriate for model stability in the static assignment. Average green time from the single-day SCATS data was used as a starting point for developing the fixed control plan. Priority was placed on obtaining realistic turn delays and ensuring appropriate route choice distribution across the network rather than strict adherence to the average green times reported from that single day.

4 Model Parameter Inputs

4.1 Network Parameters

4.1.1 Road-Type Parameters

Road type distribution on the model network is summarised in Figure 10. Road type parameters were mostly retained from the ADTA model and provided in Appendix B. Adjustments were made to user-defined cost, third user-defined costs and capacity as part of the calibration process of route choice on the network. Lane-changing cooperation was also adjusted on certain road types to reflect the level of congestion as seen on Google's traffic view modes, and the travel time data.

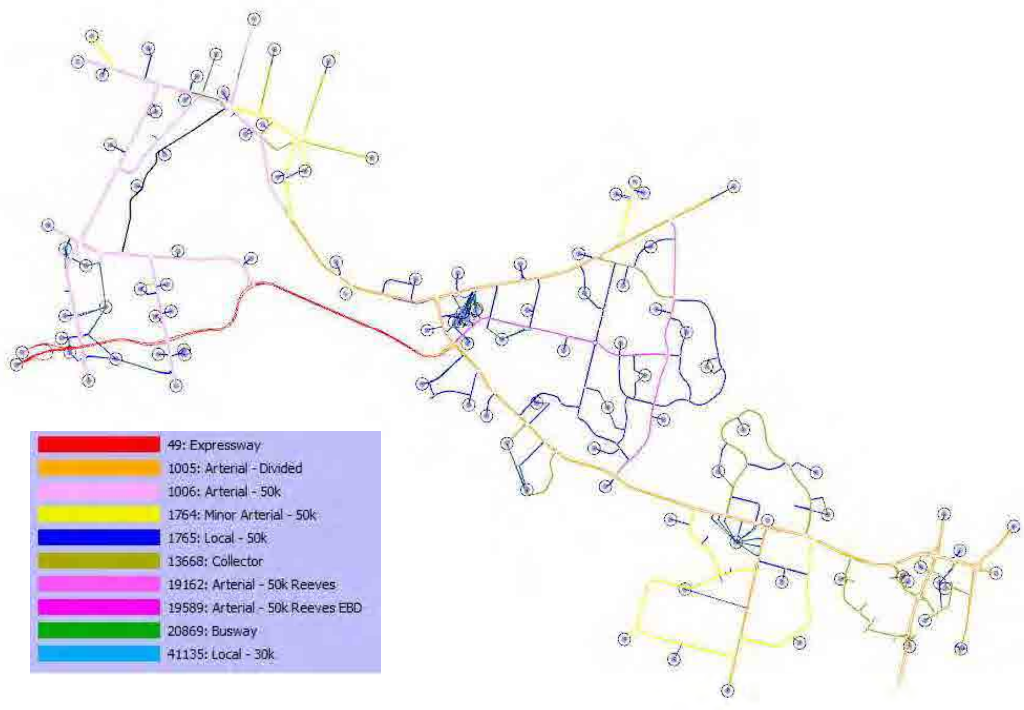


Figure 10 - Road Type Definition in the Aimsun Model

4.1.2 Attribute Overrides

The parameters of some sections and turns were controlled during assignment runs using Aimsun's attribute override functionality. This approach allows parameter values to be adjusted to a value more suitable than the default calculations at a particular section or turn. The parameter values that have been adjusted using attribute overrides are:

- Section maximum speed
- Turn capacity
- Turn look-ahead distance
- Lane-changing cooperation

The full list of these attribute overrides applied in the model is provided in Appendix E.

4.1.3 Traffic Management

Traffic management schemes on the network were applied using Aimsun's traffic management functionality. This approach also allows certain conditions of the road to be applied when they are typically observed during the modelled period and not necessarily throughout the period. Traffic management schemes in the model applied are:

- Panmure Bridge Eastbound Lane Closure: 1 Lane Closed, 6 am – 11 am
- Panmure Bridge Westbound Lane Closure: 1 Lane Closed, 3 pm – 8 pm
- Pakuranga Highway Maximum Speed Change to 55 km/h: 7.15 am – 8.45 am
- Pakuranga Highway Maximum Speed Change to 60 km/h: 4.15 pm – 6.15 pm

Ideally the speed reduction on Pakuranga Highway should be reflected by the model response, rather than the inputs. However this behaviour is hard to replicate in the model due to the unique nature of the road. For example, there is a hidden queue extended from the Pakuranga Highway and Carbine Road intersection to the Wipuna Road in the AM peak. The local drivers reduce their speeds on the bridge accordingly as they know there is a hidden queue in the downstream at the sharp corner. This traffic management inputs were not introduced in this update, they area inherited from the previous model.

4.2 Vehicle Parameters

Vehicle parameters were determined based on comparison and sensitivity testing with those adopted in existing Aimsun models such as ADTA (AFC), and QLD (Aecom) as well as input from the NZTA Axel Classification system. List of key vehicle parameters in the model are provided in Appendix C.

4.3 Cost Calculation

All functions related to calculating the cost of travel time and travel distance in the model were adopted from the ADTA model and used in the static assignment only. The travel time component consists of 1) link travel times, represented by a Volume Delay Function (VDF) on Sections, and 2) delays associated with making a turn at an intersection, represented by a Turn Penalty Function (TPF) and Junction Delay Function (JDF). Cost function scripts used in the model are provided in Appendix G.

The travel distance component reflects perceived vehicle operating costs and helps stabilise the traffic assignment.

4.3.1 Volume Delay Function

The VDF is based on the Akçelik VDF, which is widely adopted by strategic models in New Zealand, including MSM. Its formulation is as follows:

$$t=t_0 \{1 + 0.25r_f [z + (z_2 + 8J_A x / (Qt_0 r_f))_{0.5}]\}$$

where:

t = average travel time per unit distance (seconds per km)

t0 = free flow travel time per unit distance (seconds per km)

J_A = Akçelik friction parameter

z = x – 1

x = q / Q = degree of saturation

q = demand flow rate (pcu/hr)

Q = capacity (pcu/hr)

rf = the ratio of flow period to minimum travel time

The distance component, which is added to the travel time cost, is as follows:

d= df x rf x L

where:

d = the distance cost

df = distance factor (0.5 for cars and 1.0 for Trucks)

rf = road type factor

L = length of the section

This function was applied to every Section in the model, including centroid connectors. Different values of free flow speed, link capacity and Akçelik friction factors were defined by road type using Section attributes (Appendix B).

4.3.2 Intersection Delays – Signalised Movements

Aimsun provides default TPFs for signalised turning movements based on their respective green time split, adopting the procedures from Chapter 18 of the Highway Capacity Manual (HCM) 2010.

This procedure requires a movement capacity as an input and in the model this was estimated based on the following formula:

$$Q = Q_s \times I \times g / C$$

where:

Q = capacity of the turning movement (pcu/hr)

Q_s = saturation flow at signal for the turning movement (pcu/hr/lane)

I = number of lanes for the turning movement

g = green time for the turning movement

C = cycle time at the signal

The saturation flow Qs estimation was adopted from the ADTA model and is based on the relationship between saturation flow and turning speed from simulation tests conducted in Aimsun (Figure 11).

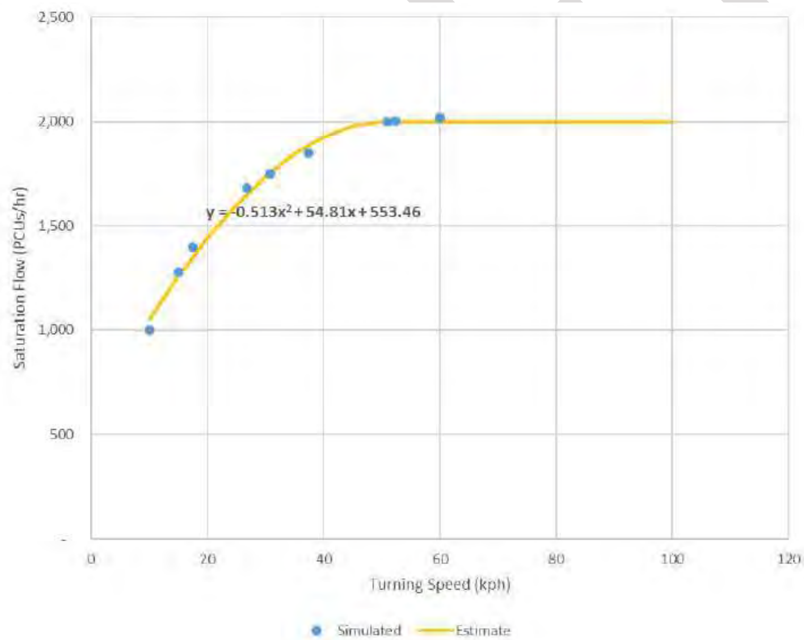


Figure 11 - Adopted Relationship between Signal Saturation Flow and Turning Speed. The line of best fit through the simulated saturation flows for turning speeds between 10 and 50 km/hr, where 10 km/hr is the minimum turning speed applied in ADTA. The saturation flow was capped at 2,000 pcu/hr/lane for turning speeds higher than 50 km/hr.

4.3.3 Intersection Delays – Priority Movements

Delays at priority-controlled intersections were represented by JDFs.

Relationships between the capacity of priority movements and the opposing flow were estimated using a linear relationship:

Q = Qs – r x fo

where:

Q = capacity of the turning movement (pcu/hr)

$\mathbf{Q_s}$ = saturation flow for the turning movement i.e. capacity of the turning movement at zero opposing flow (pcu/hr); intercept

r = the rate at which the capacity decreases as opposing flow increases; slope

$\mathbf{f_o}$ = the flow opposing this turning movement (pcu/hr)

The resulting turn capacity **Q** was applied to the Akçelik VDF formula from Chapter 4.3.1 assuming a friction factor of 1.0 to calculate the corresponding turning delay for the priority movement.

The calibrated capacity intercepts and slopes for all priority turning movement types as used in the ADTA model is provided in Appendix F.

4.4 Model Assignment Parameters

4.4.1 Assignment Methodology

Based on previous modelling, an 80-to-20 split in static versus dynamic path assignment was considered appropriate for the microscopic simulation. This gave better control of modelling route choice in the area and sense-checks during the model development process showed that route distribution in the model was reasonable and supported the use of the method.

4.4.2 Static Assignment Parameters

Table 1 shows the key parameters of the static assignment used in the Aimsun model.

Table 1 - Key Static Assignment Parameters

Static Assignment Parameters	
Assignment Engine	Frank and Wolf Assignment
Maximum Iterations	50
Relative Gap	0.1 %

4.4.3 Dynamic Assignment Parameters

All dynamic assignment parameters (Table 2 and Table 3) were determined based on comparison and sensitivity testing with those adopted in existing Aimsun models such as ADTA (AFC), and QLD (Aecom).

Table 2 - Key Dynamic Assignment Parameters

Dynamic Assignment Parameters		
Main		
Network Loading	Microscopic Simulator	
Assignment Approach	Stochastic Route Choice	
Using Warm-Up	(5% of demand, 15 min)	
Using a Saved Initial State	No	
Attributes Overrides	(refer to Appendix E)	
Performance Settings:		
Simulation Threads	4	
Route Choice Threads	4	
Behaviour		
Car Following:		
Two-Lane Car-Following Model	No	
Apply Slope Model	No	
Lane Changing:		
Distance Zone Variability	40%	
Two-Way Two-Lane Overtaking Model	No	
Queue Speeds:		
Queue Entry Speed	1 m/s	
Queue Exit Speed	1 m/s	

Table 3 - Key Dynamic Assignment Parameters continued

Dynamic Assignment Parameters					
Reaction Time					
Simulation Step	0.8 sec				
Reaction Time Settings	Fixed				
Reaction Time at Stop	1.15 sec				
Reaction Time at Traffic Light	1.35 sec				
Arrivals					
Global Arrivals	Normal				
Dynamic Traffic Assignment					
Costs:					
Cycle	5 min				
Number of Intervals	3				
Attractiveness Weight	5				
User-Defined Cost Weight	1				
Use Link Costs from Replication	None				
Group Route Choice Intervals	No				
Fixed Routes:	Following OD Routes	Following Input Path Assignment			
Car	100%	80%			
Truck	100%	100%			
Max. Paths to Use From Input Path Assignment	All				
Stochastic Route Choice:					
Model	C-Logit				
Enroute	No				
Enroute After Virtual Queue	No				
Stochastic Route Choice - Basic:					
Path Calculation	Source	Max. Number of Initial Paths to Consider			
	K-SP	1			
Max. Paths per Interval	For All Veh	3			
Stochastic Route Choice – Parameters:	Origin	Destination	Scale	Beta	Gamma
	All	All	12	0.15	1

5 Calibration and Validation Results

5.1 General Approach

Calibration and validation for the model were undertaken with reference to criteria for Category C: Urban Area in NZTA Model Development Guidelines (Criteria) on individual link flows, turn flows and travel time for each hour between 7am – 9am, and 4pm – 6pm.

Adjustments to demand and network during the calibration process were carefully considered with respect to implications on model response and forecasting.
Several sense-checks were made as part of the calibration process including checks on route-choice, turn delays in the static assignment, demand profiles, HCV counts and visual congestion on the network.

5.2 Demand Adjustment

5.2.1 Manual Adjustment

All demand adjustments for the model were done manually and summarised in Table 4 - Table 9. During the demand adjustment, care was taken to retain the demand distribution from the strategic model. Adjustments were made to resolve majority of the network issues in the first instance, before demand adjustments were made.

Table 4 – AM Post-Adjusted Sector-to-Sector Demands

	East	Internal	North	South	Panmure	West	
East	3,465	1,664	210	6,545	940	2,889	15,713
Internal	965	1,101	1,160	1,922	1,570	2,769	9,487
North	520	1,301	0	860	4,128	3,451	10,260
South	3,716	1,268	90	2,865	374	499	8,811
Panmure	493	558	982	448	4,957	5,700	13,137
West	1,177	1,001	1,039	992	3,931	8,024	16,164
	10,336	6,892	3,481	13,632	15,900	23,331	73,572

Table 7 - PM Post-Adjusted Sector-to-Sector Demands

	East	Internal	North	South	Panmure	West	
East	4,374	2,299	916	3,808	1,104	1,881	14,382
Internal	2,293	1,224	1,867	1,239	733	1,431	8,787
North	131	1,582	0	169	1,296	1,319	4,498
South	8,000	2,248	229	3,166	873	793	15,310
Panmure	928	1,671	3,528	507	4,548	4,777	15,958
West	1,867	3,065	4,493	375	5,892	7,621	23,314
	17,592	12,089	11,033	9,264	14,447	17,823	82,249

Table 5 - AM Sector-to-Sector Demand Adjustment

	East	Internal	North	South	Panmure	West	Total
East	-651	-77	-37	21	74	217	-454
Internal	-506	-68	17	-180	-154	12	-880
North	-397	-50	0	-104	-576	0	-1,128
South	-537	-192	-185	64	2	117	-731
Panmure	-99	-85	230	-417	-1,187	-433	-1,991
West	-25	-6	-3	172	-198	-276	-336
Total	-2,216	-478	22	-444	-2,040	-364	-5,520

Table 8 - PM Sector-to-Sector Demand Adjustment

	East	Internal	North	South	Panmure	West	Total
East	800	420	162	-218	420	299	1,882
Internal	-216	-21	566	-348	-131	-36	-185
North	-370	356	0	-341	99	-432	-688
South	11	378	-471	599	134	126	778
Panmure	-216	42	976	-129	-335	425	763
West	2	593	-269	-20	141	-1,035	-586
Total	11	1,768	964	-456	329	-653	1,963

Table 6 - AM Sector-to-Sector Demand Percent Adjustment

	East	Internal	North	South	Panmure	West	Total
East	-16%	-4%	-15%	0%	8%	8%	-3%
Internal	-34%	-6%	2%	-9%	-9%	0%	-8%
North	-43%	-4%	0%	-11%	-12%	0%	-10%
South	-13%	-13%	-67%	2%	1%	30%	-8%
Panmure	-17%	-13%	31%	-48%	-19%	-7%	-13%
West	-2%	-1%	0%	21%	-5%	-3%	-2%
Total	-18%	-6%	1%	-3%	-11%	-2%	-7%

Table 9 - PM Sector-to-Sector Demand Percent Adjustment

	East	Internal	North	South	Panmure	West	Total
East	22%	22%	21%	-5%	61%	19%	15%
Internal	-9%	-2%	44%	-22%	-15%	-2%	-2%
North	-74%	29%	0%	-67%	8%	-25%	-13%
South	0%	20%	-67%	23%	18%	19%	5%
Panmure	-19%	3%	38%	-20%	-7%	10%	5%
West	0%	24%	-6%	-5%	2%	-12%	-2%
Total	0%	17%	10%	-5%	2%	-4%	2%

5.2.2 Turn Delay Check

Turn delays from the static assignment were monitored to ensure that no major delays were adversely affecting path assignment and route distribution, as well as to gauge model stability.

To facilitate stability of the static assignment, a fixed signal control plan was used (whereas an actuated control plan was used in the dynamic assignment). Priority was placed on reducing turn delay and ensuring appropriate route choice distribution across the network rather than strict adherence to the maximum green times reported from the single-day SCATS data.

5.3 Static Assignment Results

5.3.1 Convergence

The static assignment for each modelled period was stable and attained the relative gap (rgap) before 50 iterations (Figure 12 and Figure 13). 80% of the path assignments from the static assignment was set to be retained during the dynamic assignment.

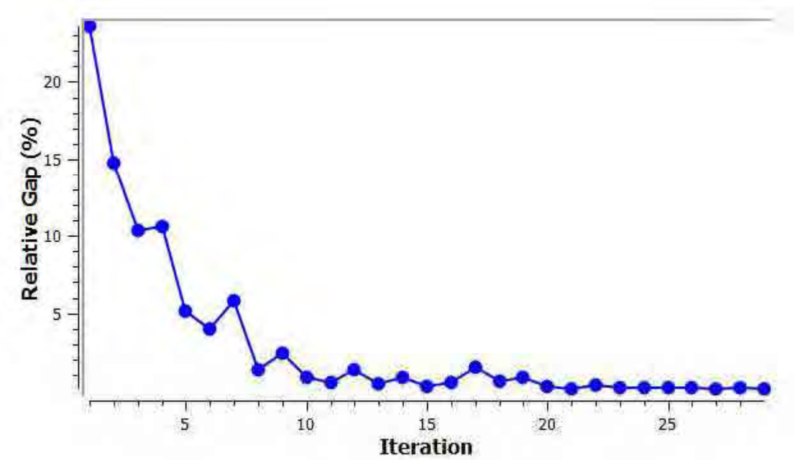


Figure 12 - AM Peak Static Assignment Convergence

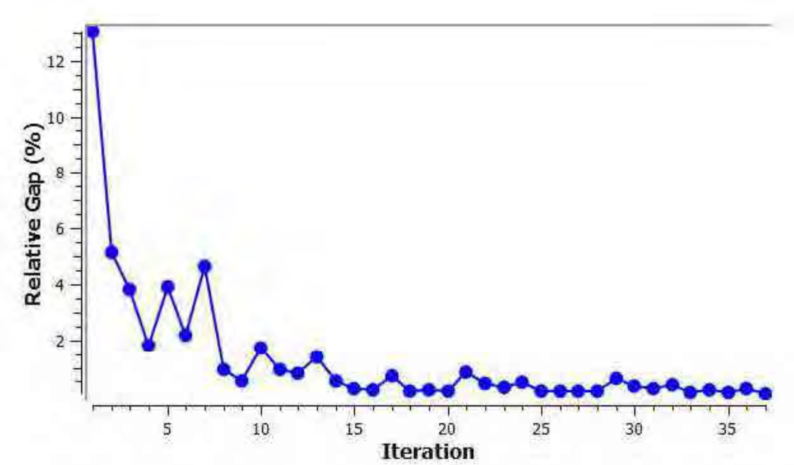


Figure 13 - PM Peak Static Assignment Convergence

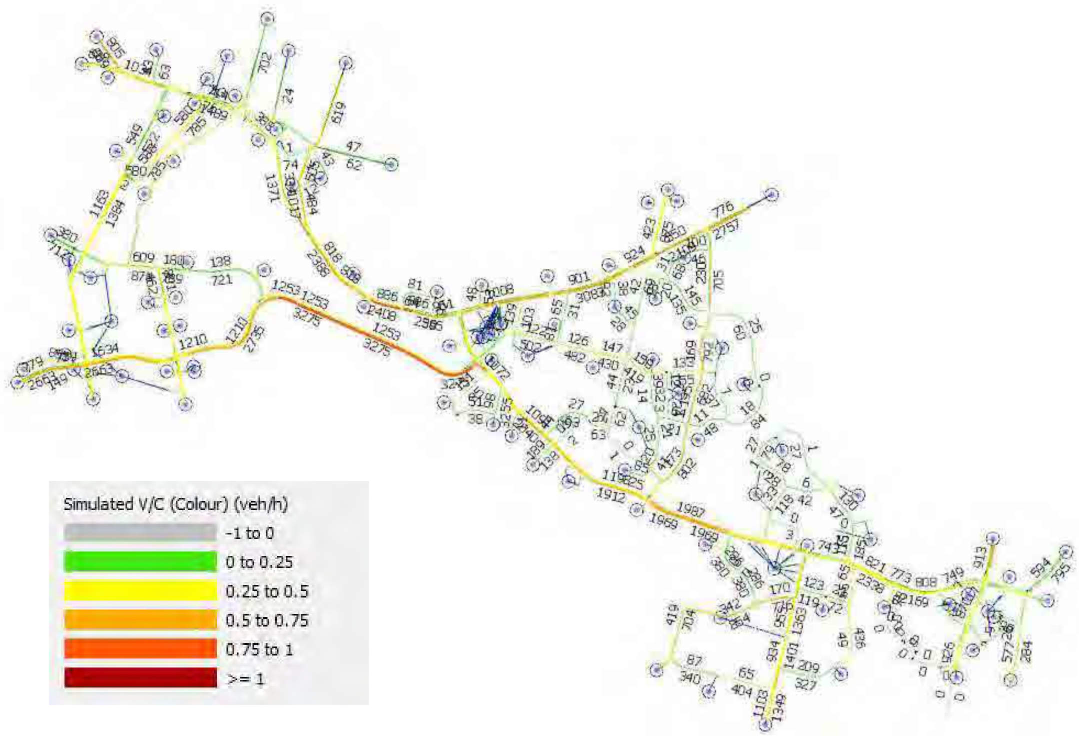


Figure 14 - AM Peak Assigned Flow in PCU/hr (6.15 am – 9.30 am)

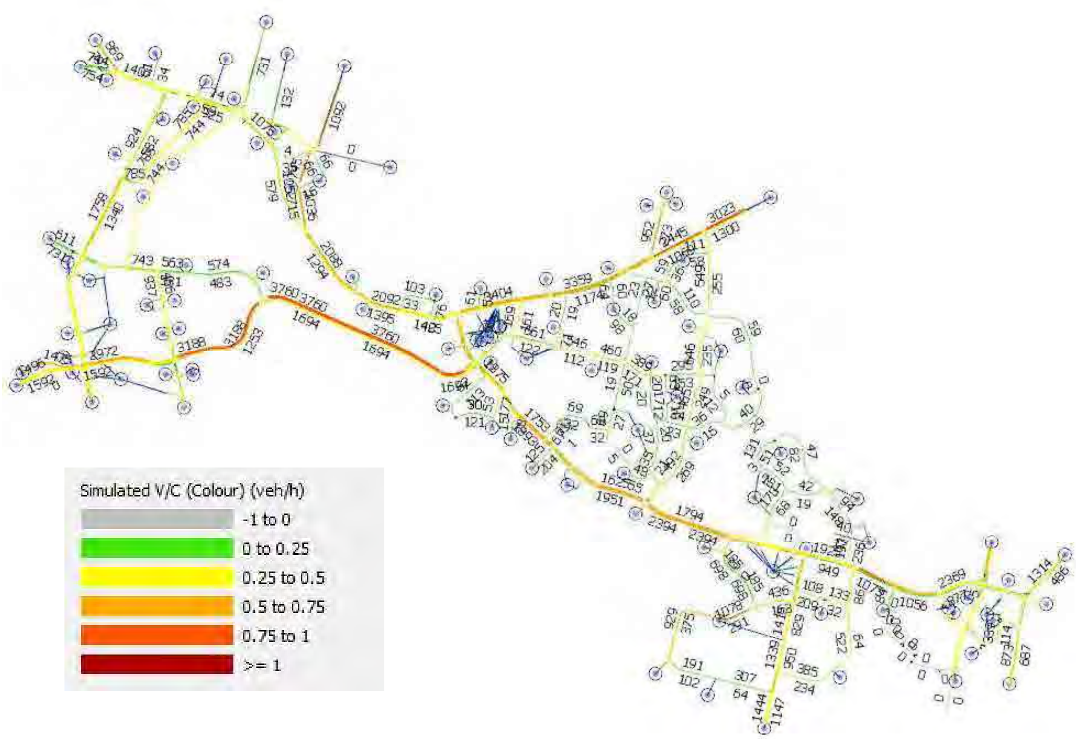


Figure 15 - PM Peak Assigned Flow in PCU/hr (3.15 pm – 6.30 pm)

5.4 Validation Results

5.4.1 Link Counts Validation

Results for individual link counts (Table 10 and Figure 16) network-wide show that the model satisfies the validation criteria for GEH, R^2 and RMSE.

Table 10 - Summary of Individual Link Counts Validation Results across Network

	AM (%)		PM (%)		NZTA Guideline
	7am - 8am	8am - 9am	4pm - 5pm	5pm - 6pm	Category C
GEH <5	85	85	91	87	>80%
GEH <7.5	94	95	98	99	>85%
GEH <10	99	98	99	100	>90%
R^2	0.98	0.98	0.99	0.99	>0.95
RMSE	12	13	10	9	<20%

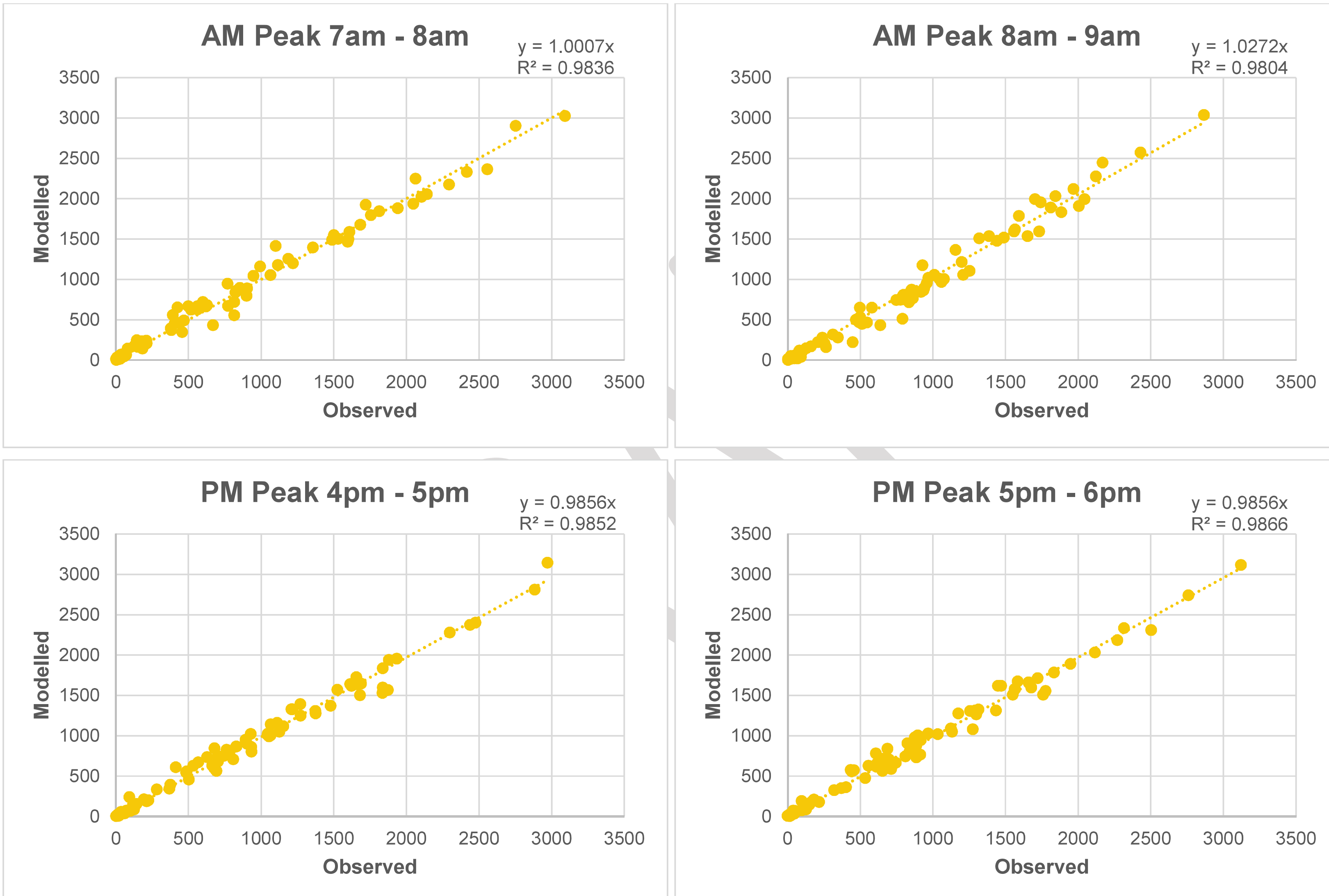


Figure 16 - Link Counts Validation Scatter Plots

5.4.2 Turn Counts Validation

Results for individual turn counts (Table 11) in the focus area show that the model satisfies the validation criteria for GEH, R^2 and RMSE. Where the modelled counts did not meet the GEH <5 criteria, the manual counts at that turn were either found to be unreasonable when cross-checked with adjacent counts or there was lack of information on reliability and therefore given less priority for validation.

Table 11 - Summary of Individual Turn Counts Validation Results in Focused Area

	AM (%)		PM (%)		NZTA Guideline
	7am - 8am	8am - 9am	4pm - 5pm	5pm - 6pm	Category C
GEH <5	84	85	78	84	>80%
GEH <7.5	93	91	94	94	>85%
GEH <10	96	98	99	100	>90%
R^2	0.99	0.98	0.99	0.99	>0.95
RMSE	19	19	19	14	<20%

5.5 Flow Profile Validation

Flow profiles at key locations across the network (Figure 17) were monitored. Overall, the modelled flow profiles follow the observed profiles reasonably well (Figure 18 and Figure 19).

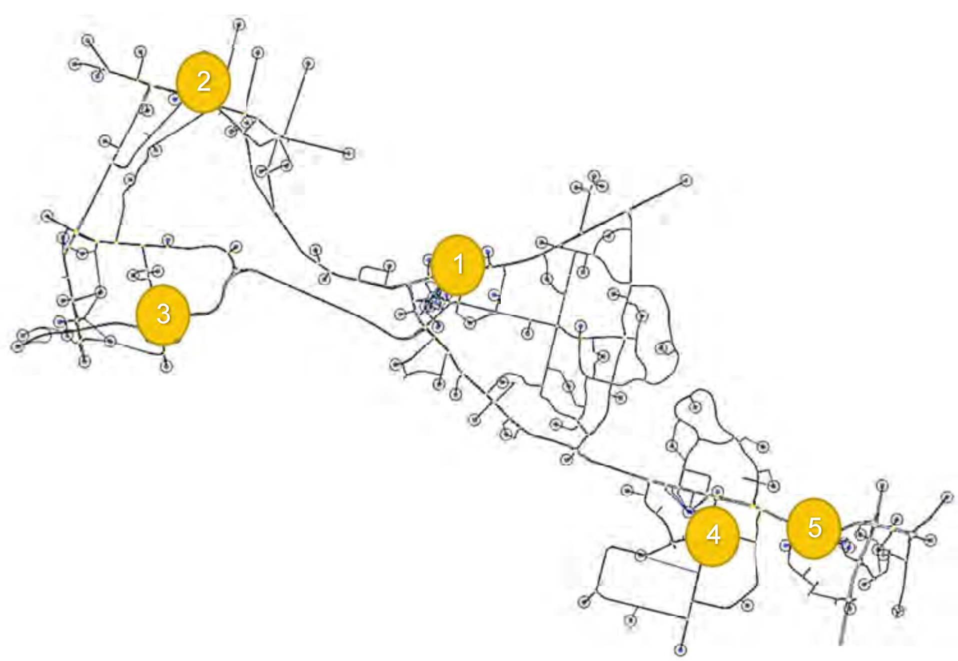
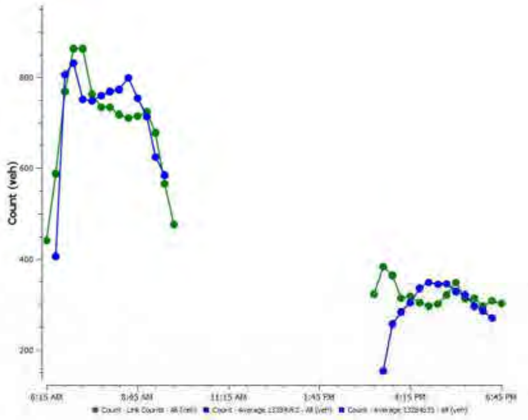


Figure 17 - Profile Validation Locations

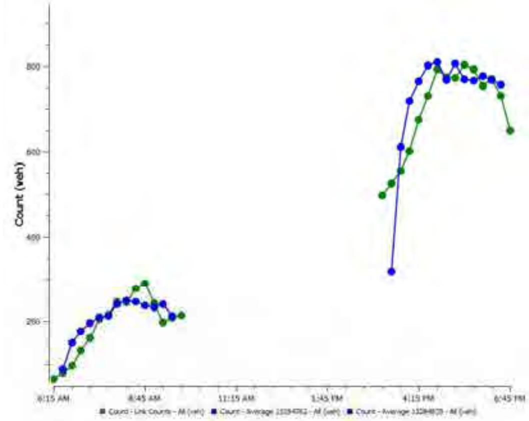
1 – Pakuranga Road / Lewis Road

Westbound



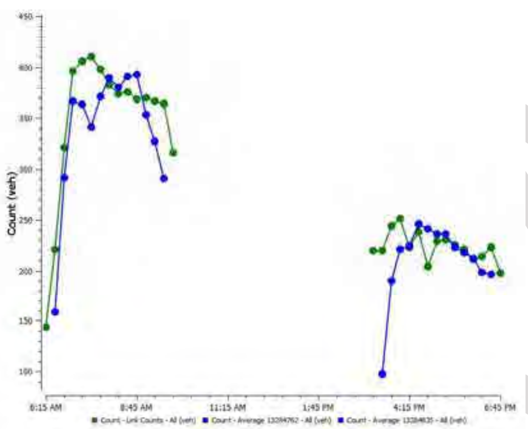
1 – Pakuranga Road / Lewis Road

Eastbound



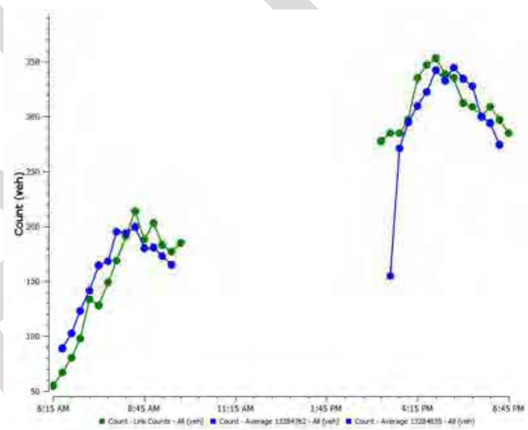
2 – Panmure Roundabout, Mount Wellington Approach

Westbound



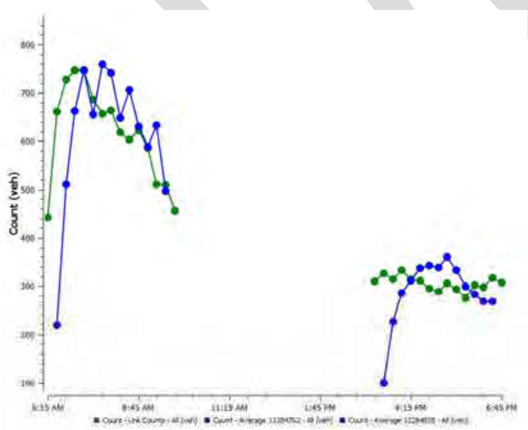
2 – Panmure Roundabout, Mount Wellington Approach

Eastbound



3 –South-Eastern Highway / Carbine Road

Westbound



3 – South-Eastern Highway / Carbine Road

Eastbound

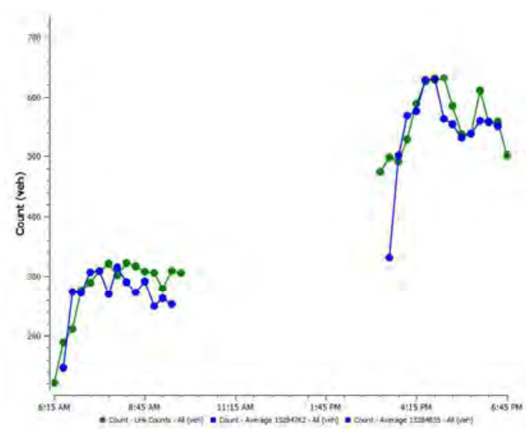
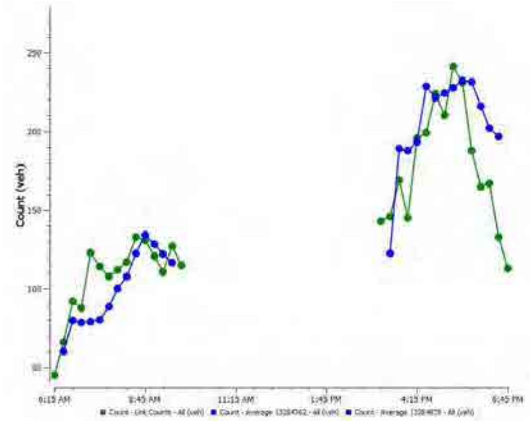


Figure 18 - Flow Profile Validation (modelled in blue, observed in green)

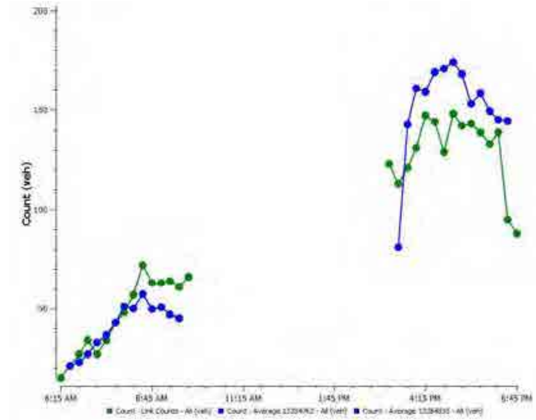
4 –Ti Rakau Drive / Harris Road

Harris Road Westbound



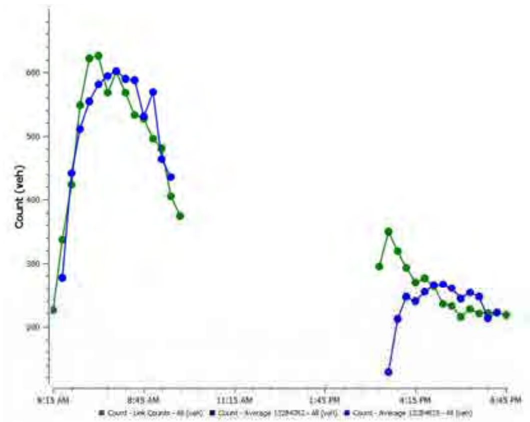
4 –Ti Rakau Drive / Harris Road

Harris Road Eastbound



5 – Ti Rakau Drive / Huntington Drive

Westbound



5 – Ti Rakau Drive / Huntington Drive

Eastbound

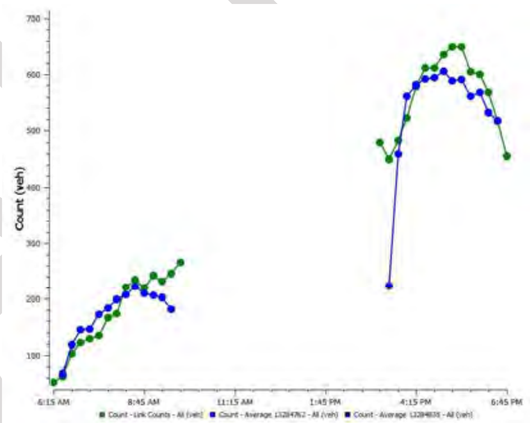


Figure 19 - Flow Profile Validation (modelled in blue, observed in green) continued

5.6 HCV Count Validation

A sense-check of the modelled proportion of vehicles assigned as NZTA Axel Class 4 and above (medium and heavy vehicles) was made at key locations across the network. Estimates of car to HCV proportions were made based on available tube count data and judgement. Overall, the modelled proportions match the estimates reasonably well (Figure 20).

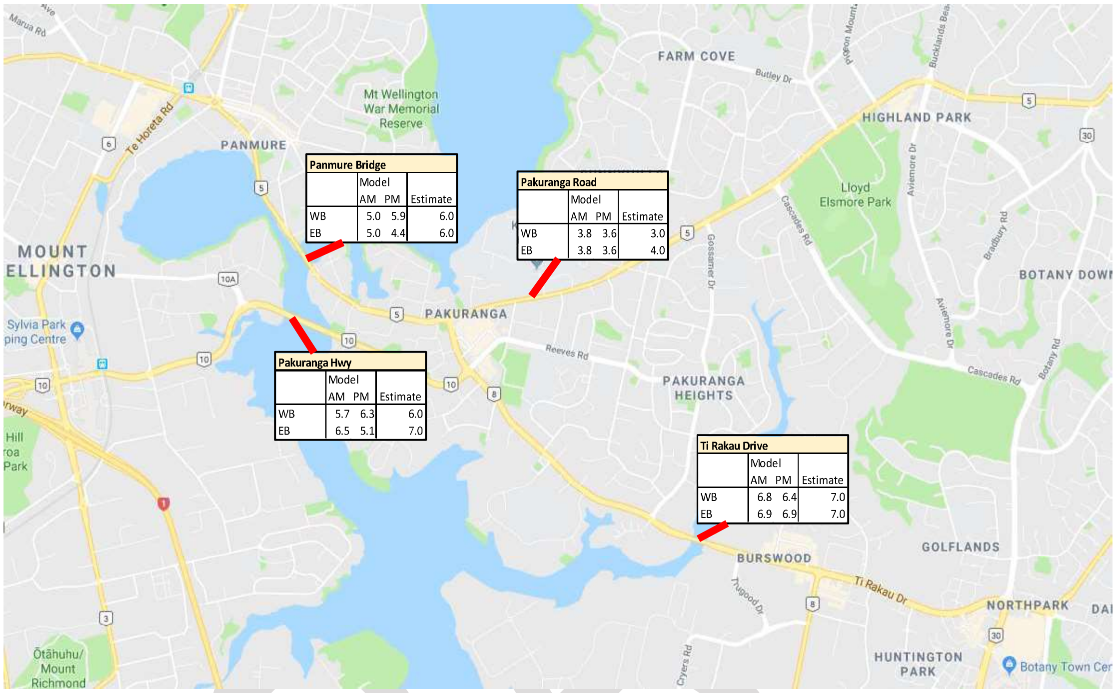


Figure 20 - Comparison of HCV percentage at key locations on the network

As described, the HCV includes MCV counts and we understand the survey at intersections only include pure HCV and hence this data was not used in this validation.

5.7 Travel Time Validation

Journey time versus distance graphs show that the modelled travel times were generally a good fit to the observed travel time (Figure 22 - **Error! Reference source not found.**). Signals at the modelled intersections were actuated based on minimum and maximum green times provided from the SCATS data of 7 March 2018. Adjustments were made up to five seconds above and below the maximum green time where required to calibrate travel times. Despite these adjustments, it is noted that:

- For the AM peak, modelled travel time from Edgewater Drive to Pakuranga Highway on Ti Rakau Drive is slightly low in the second hour. Overall 92% of the routes meet the Criteria for the AM peak.
- For the PM peak, modelled travel time from Jellicoe Road to Ti Rakau Drive is slightly low in the second hour. Overall 92% of the routes meet the Criteria for the PM peak.

Nevertheless, all modelled travel times (routes summarised in Figure 21) were within the 15th and 85th percentile of observed travel time. Therefore, the model is considered acceptably validated for travel time.

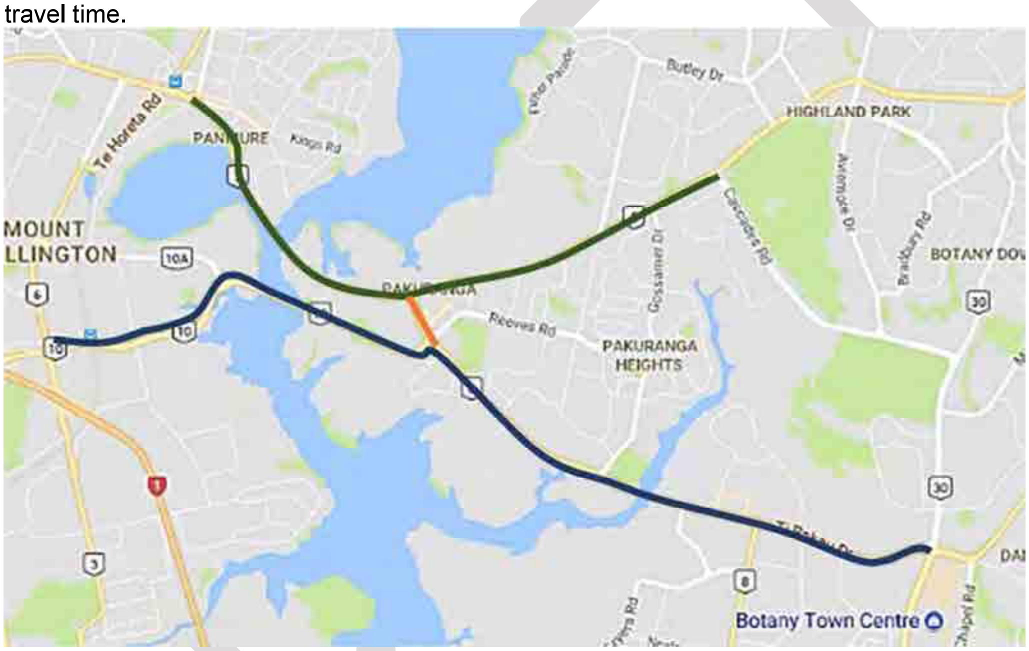


Figure 21 - Travel time routes (traffic) from Snitch GPS data for reporting travel time validation in Chapter 5

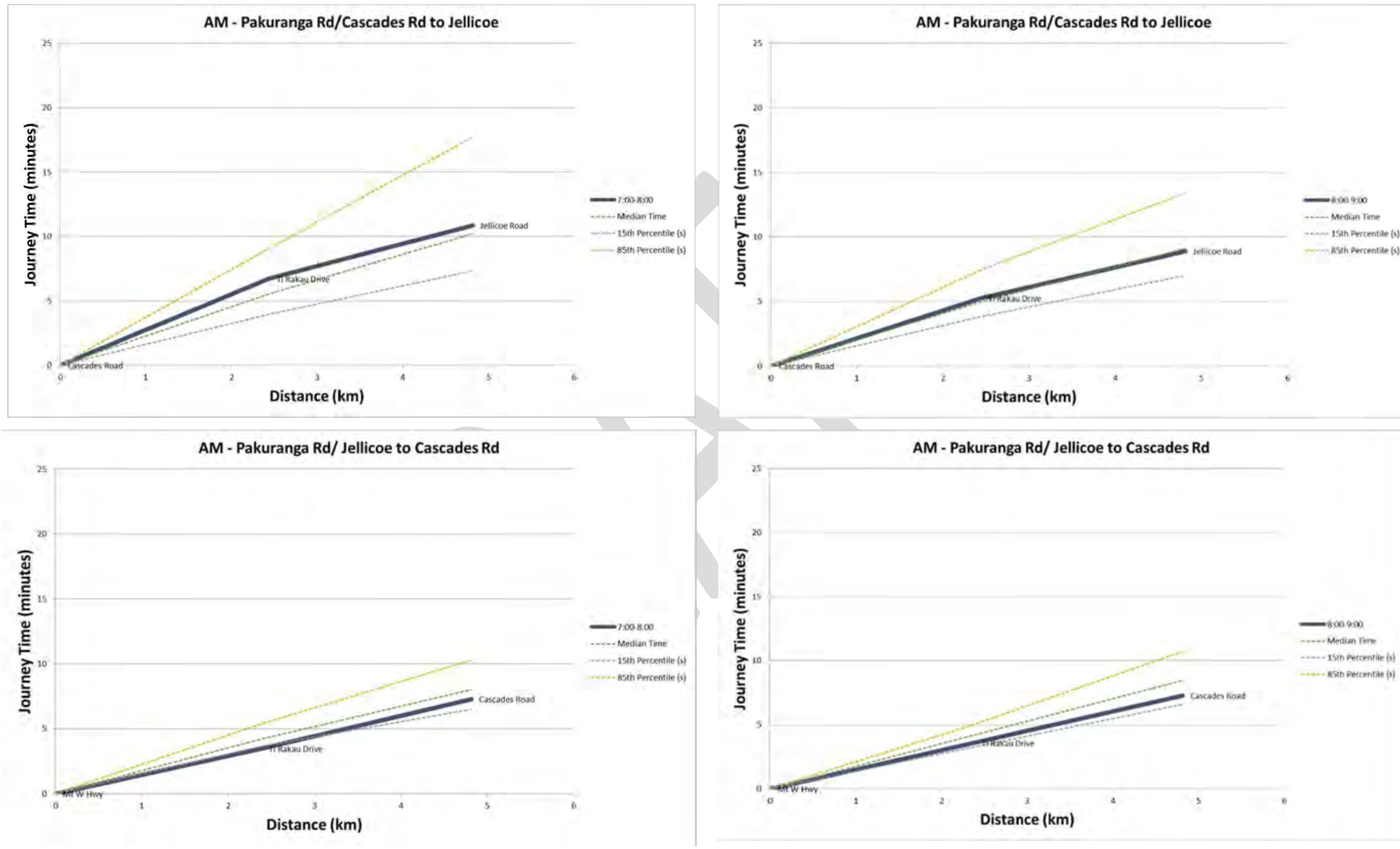


Figure 22 - Travel Time Validation Graphs: AM Pakuranga Road/ Cascades Road to Mount Wellington Highway

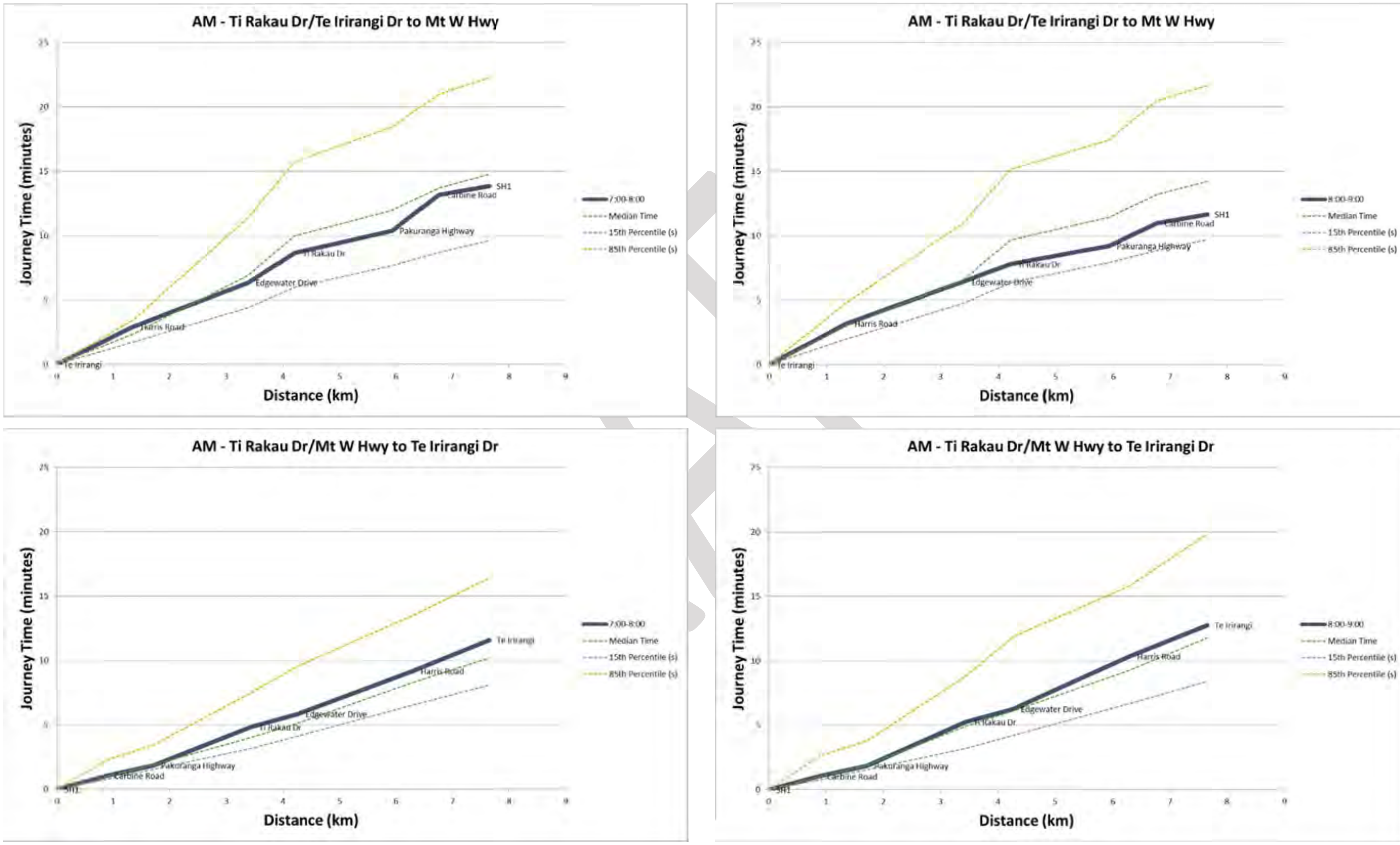
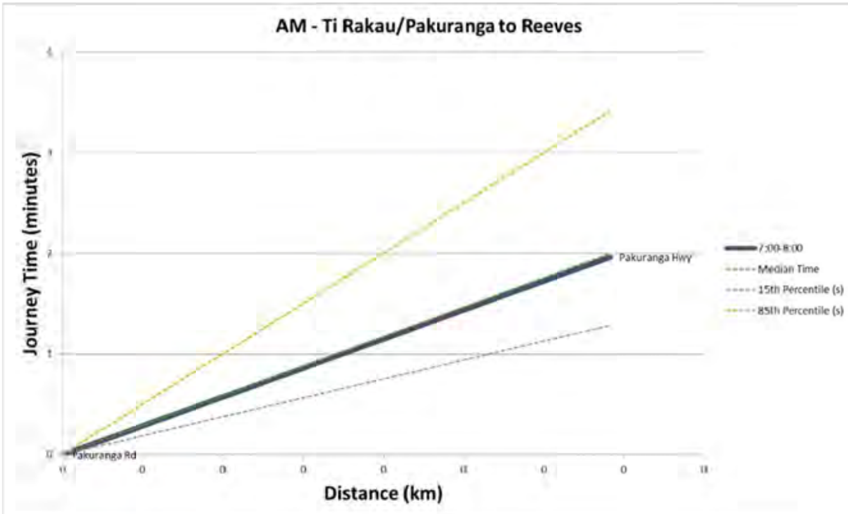
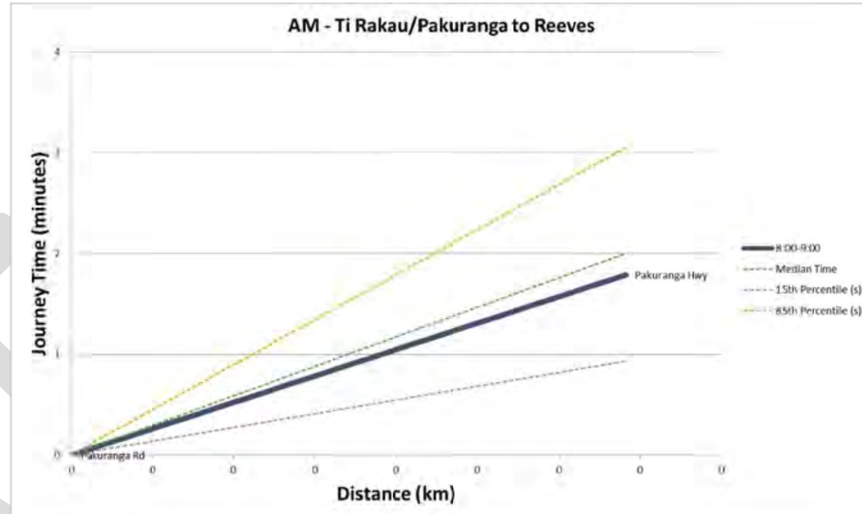
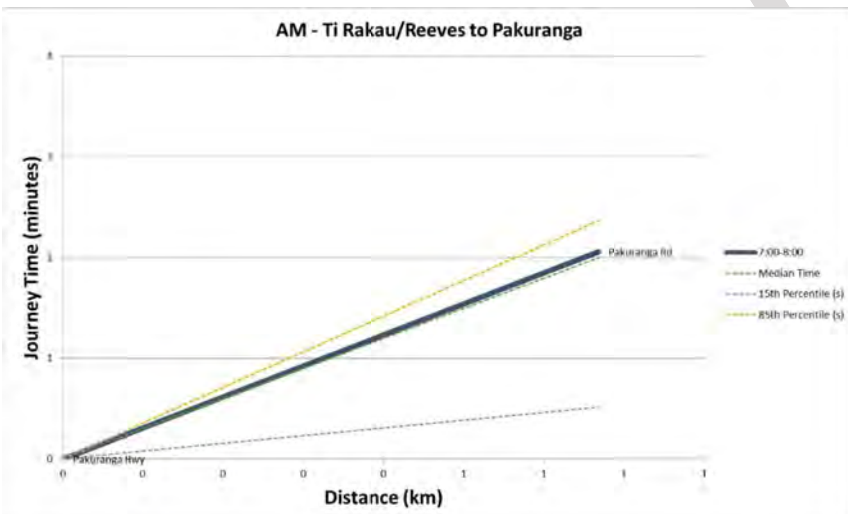


Figure 23 - Travel Time Validation Graphs: AM Ti Rakau Drive/ Te Irirangi Drive to Mount Wellington Highway







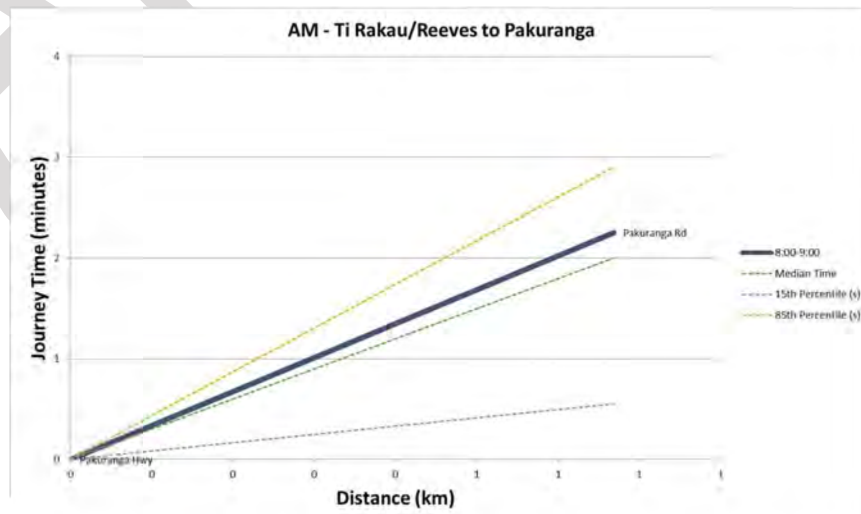


Figure 24 - Travel Time Validation Graphs: AM Ti Rakau Drive/ Pakuranga Road to Reeves Road

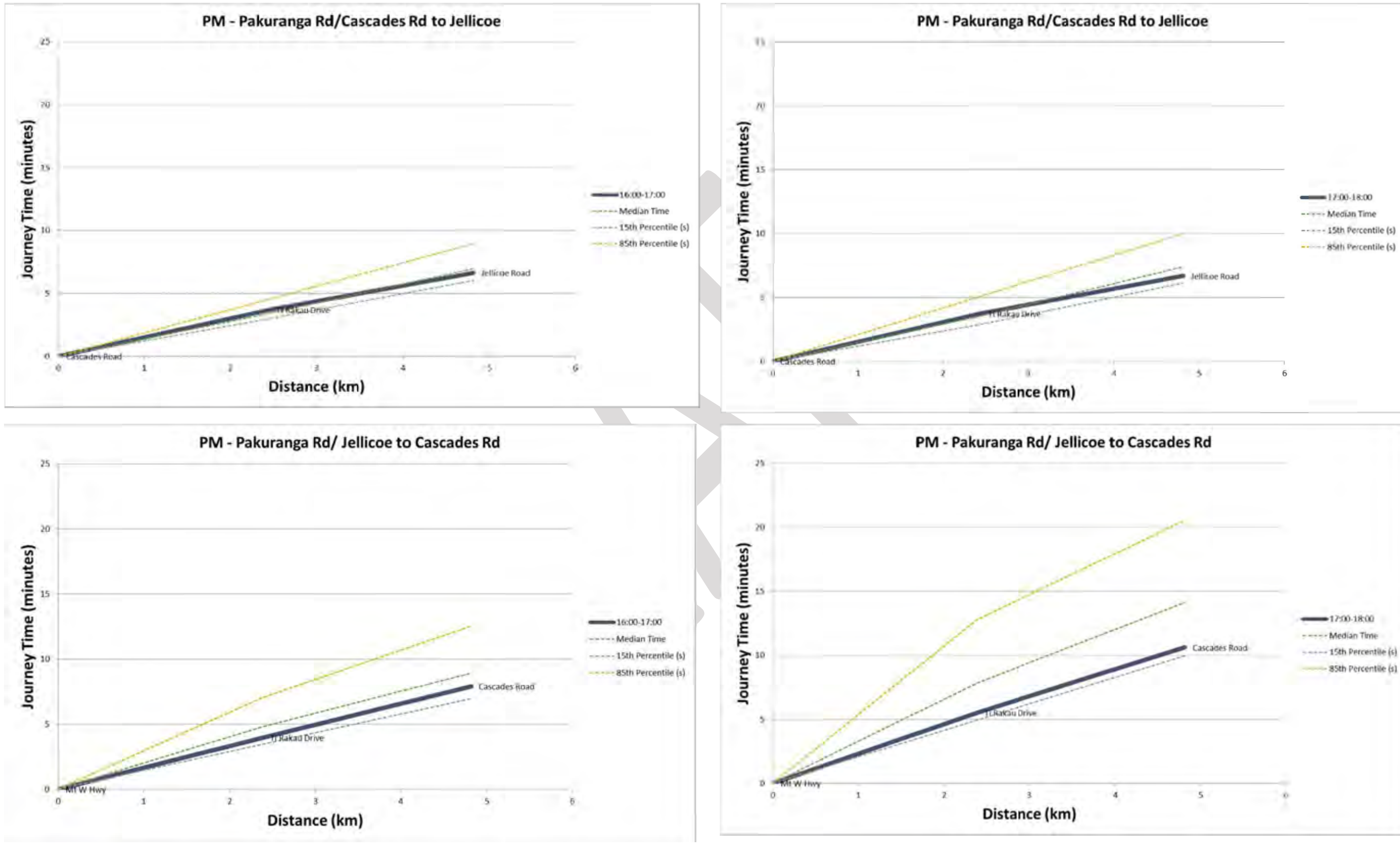


Figure 25 - Travel Time Validation Graphs: PM Pakuranga Road/ Cascades Road to Mount Wellington Highway

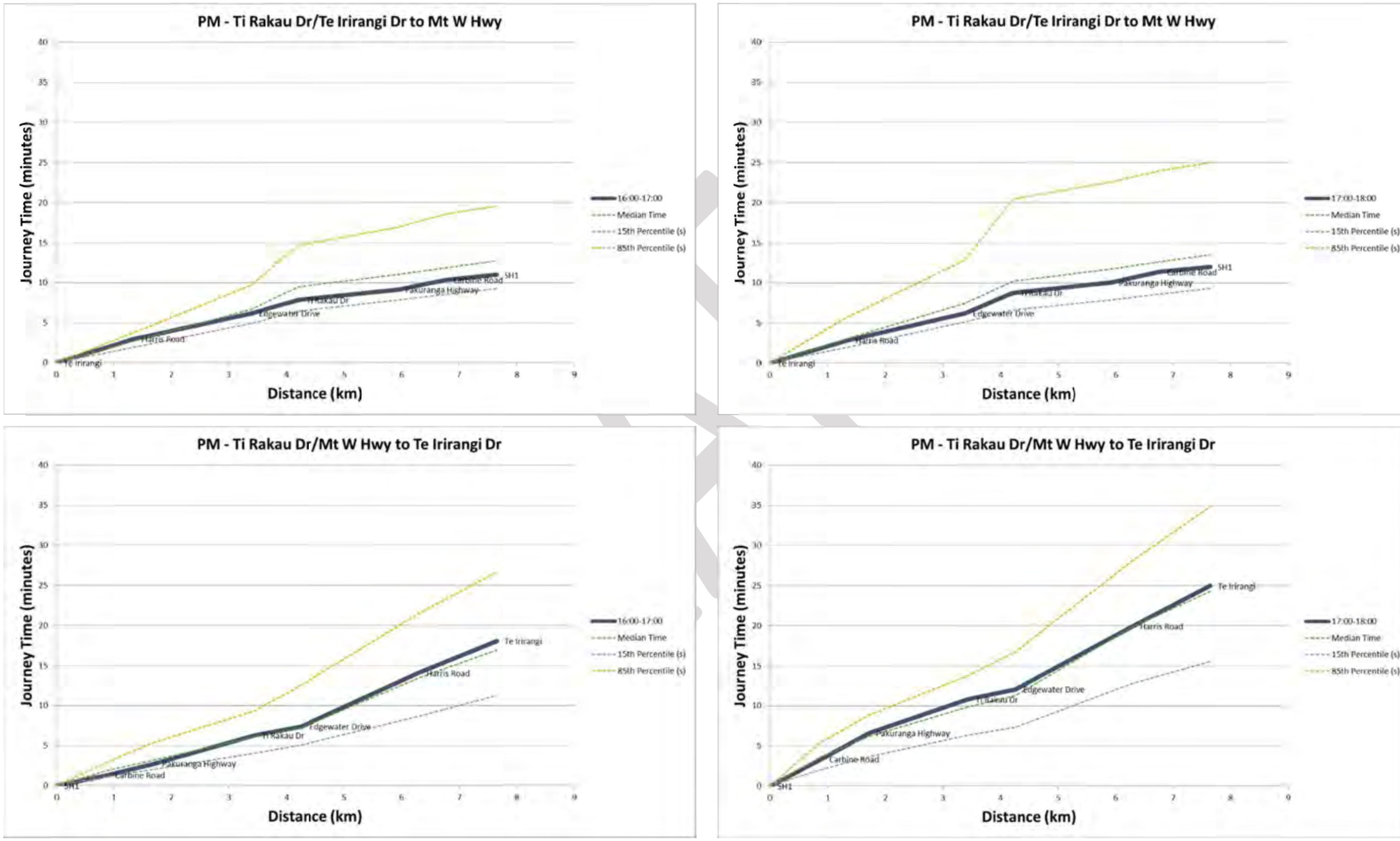


Figure 26 - Travel Time Validation Graphs: PM Ti Rakau Drive/ Te Irirangi Drive to Mount Wellington Highway

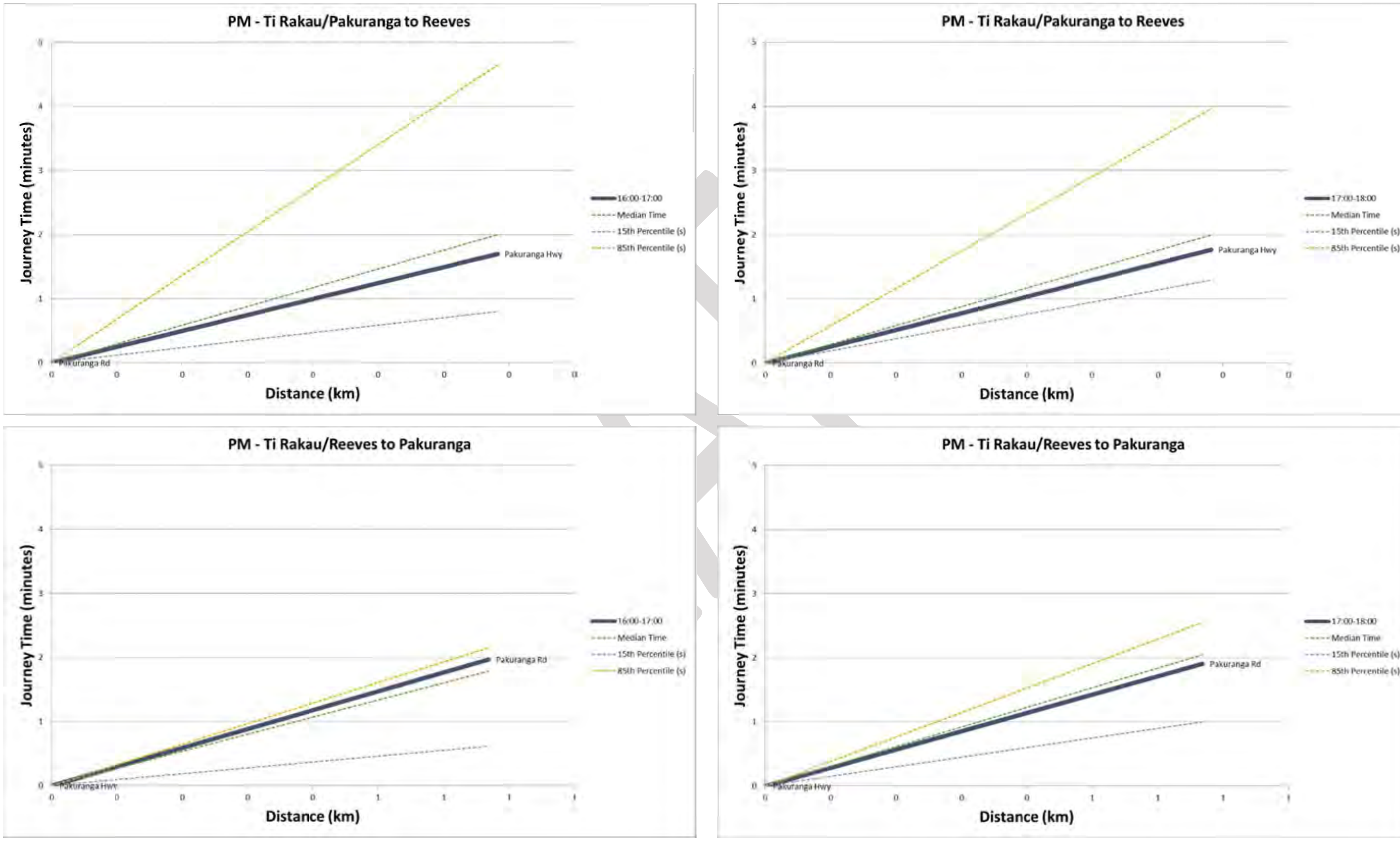


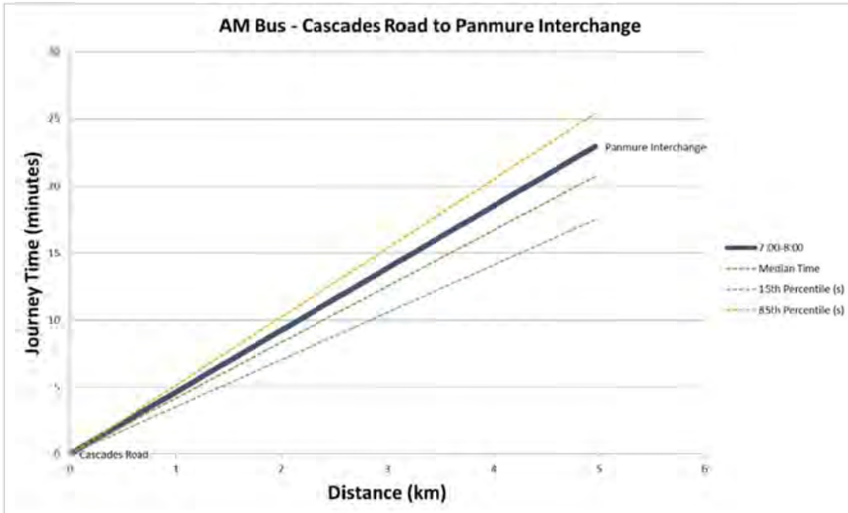
Figure 27 - Travel Time Validation Graphs: PM Ti Rakau Drive/ Pakuranga Road to Reeves Road

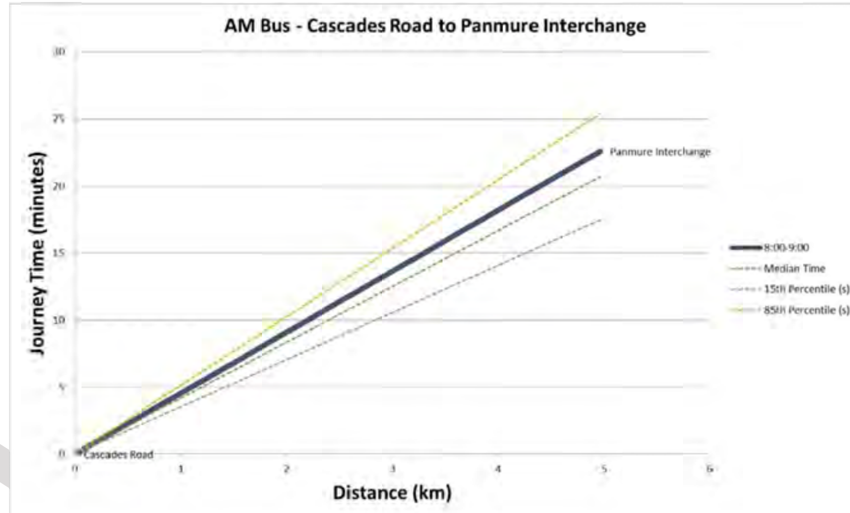
Bus travel time for key corridors in the model also fit reasonably well with observed (Figure 28 - Figure 29). The routes are:

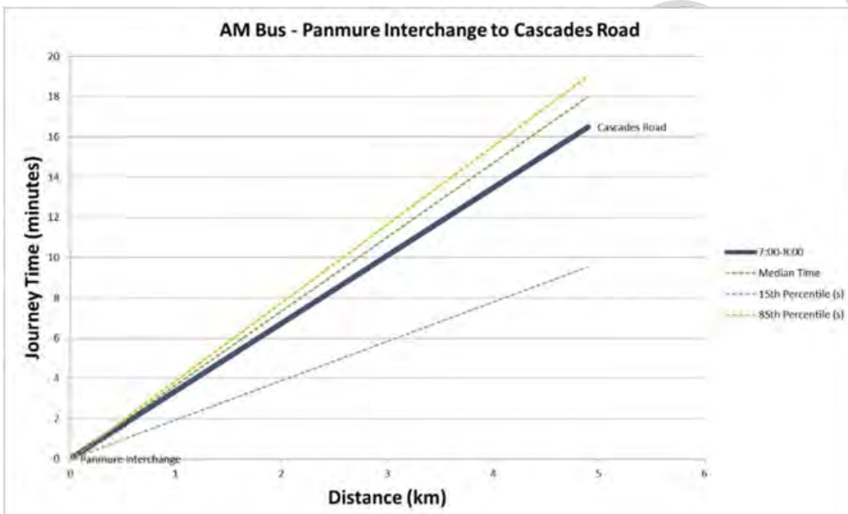
- Bus Route 70 – between Botany Town Centre and Panmure Interchange.
- Bus Route 72 – between Cascades Road and Panmure Interchange.

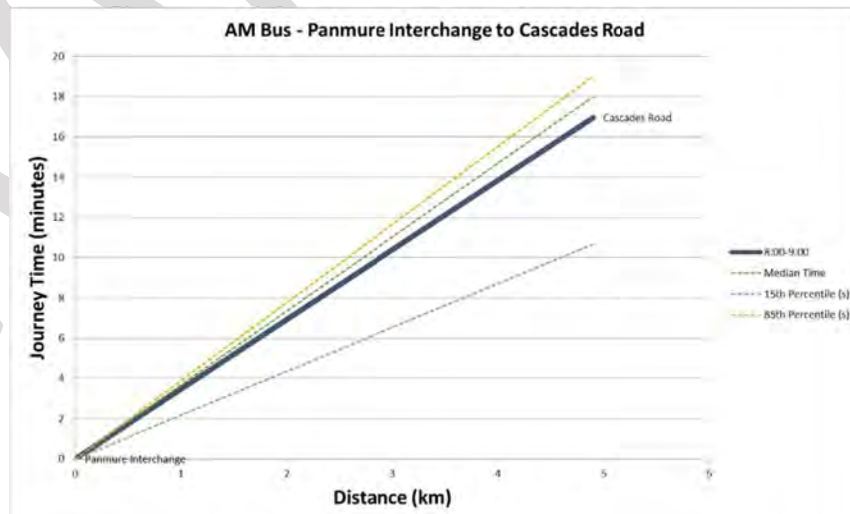
From the bus journey time graphs, it is noted that

- For the AM peak, modelled travel time from the Botany to Panmure Town Centre is low in the first hour. Overall 88% of the routes meet the Criteria for the AM peak.
- For the PM peak, modelled travel time between the Botany and Panmure from Jellicoe Road to Ti Rakau Drive is high in the second hour. The additional travel time is occurring in the Panmure area and does not impact on the focus area. For the future year, the bus travel time along this route will be monitored to ensure it does not increase unrealistically. Overall 75% of the routes meet the Criteria for the PM peak which is below the target 85%.


AM Bus - Cascades Road to Panmure Interchange
Journey Time (minutes)
Distance (km)
Cascades Road
Panmure Interchange
7:00-8:00
Median Time
15th Percentile (s)
85th Percentile (s)


AM Bus - Cascades Road to Panmure Interchange
Journey Time (minutes)
Distance (km)
Cascades Road
Panmure Interchange
8:00-9:00
Median Time
15th Percentile (s)
85th Percentile (s)


AM Bus - Panmure Interchange to Cascades Road
Journey Time (minutes)
Distance (km)
Panmure Interchange
Cascades Road
7:00-8:00
Median Time
15th Percentile (s)
85th Percentile (s)


AM Bus - Panmure Interchange to Cascades Road
Journey Time (minutes)
Distance (km)
Panmure Interchange
Cascades Road
8:00-9:00
Median Time
15th Percentile (s)
85th Percentile (s)

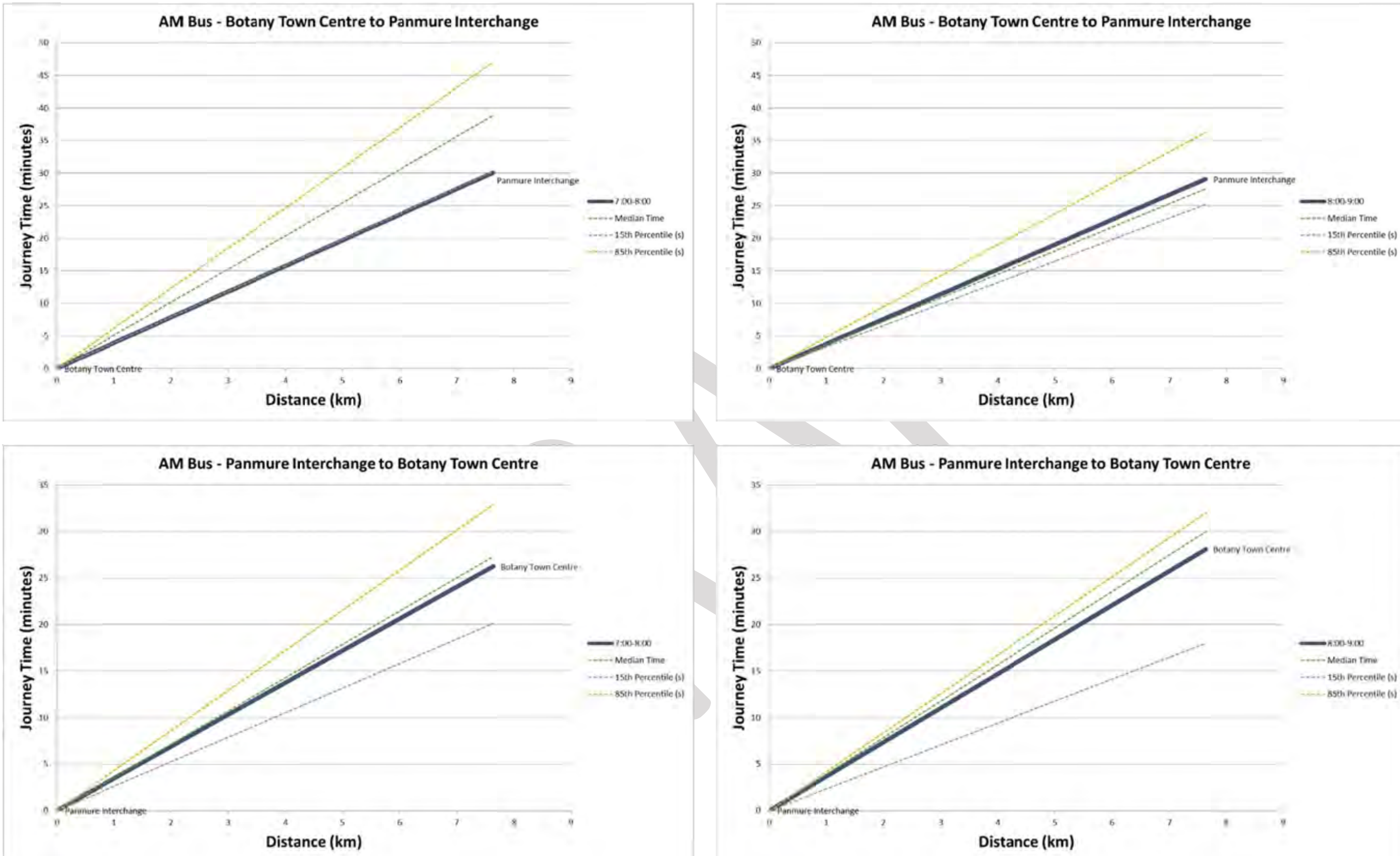
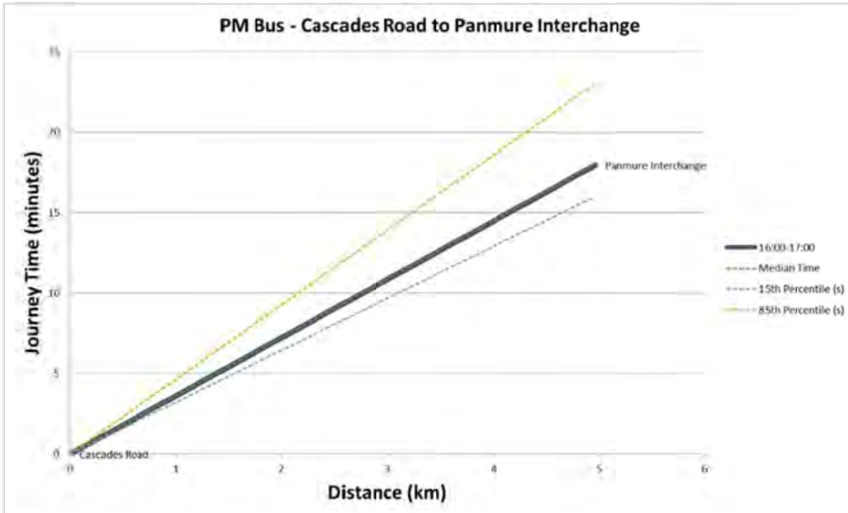
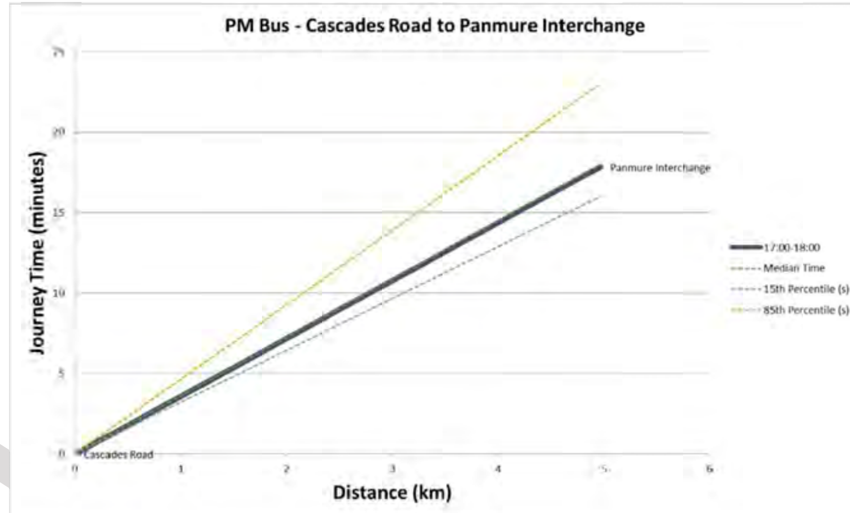
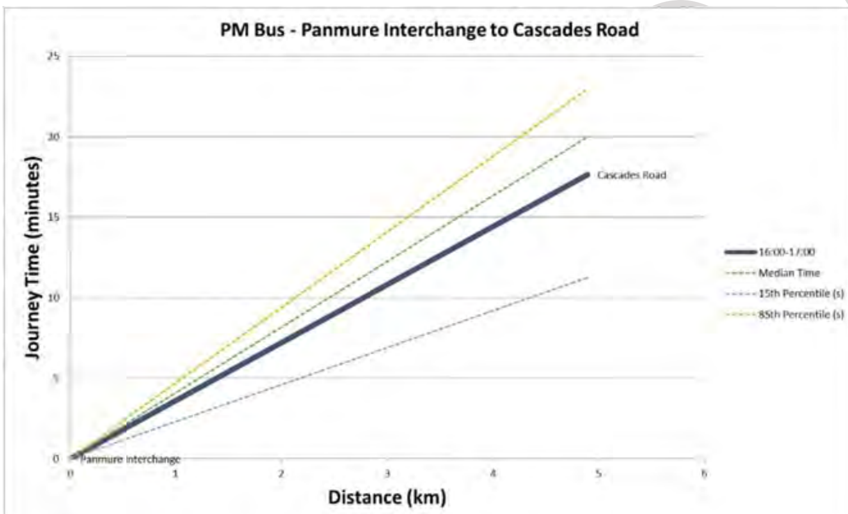
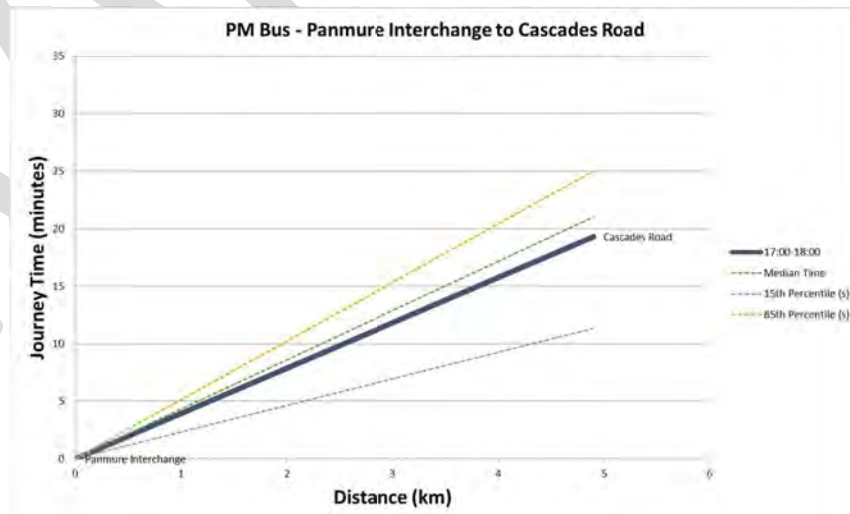


Figure 28 – Travel Time Validation: AM Bus


PM Bus - Cascades Road to Panmure Interchange
Journey Time (minutes)
Distance (km)
Cascades Road
Panmure Interchange
16:00-17:00
Median Time
15th Percentile (s)
85th Percentile (s)


PM Bus - Cascades Road to Panmure Interchange
Journey Time (minutes)
Distance (km)
Cascades Road
Panmure Interchange
17:00-18:00
Median Time
15th Percentile (s)
85th Percentile (s)


PM Bus - Panmure Interchange to Cascades Road
Journey Time (minutes)
Distance (km)
Panmure Interchange
Cascades Road
16:00-17:00
Median Time
15th Percentile (s)
85th Percentile (s)


PM Bus - Panmure Interchange to Cascades Road
Journey Time (minutes)
Distance (km)
Panmure Interchange
Cascades Road
17:00-18:00
Median Time
15th Percentile (s)
85th Percentile (s)

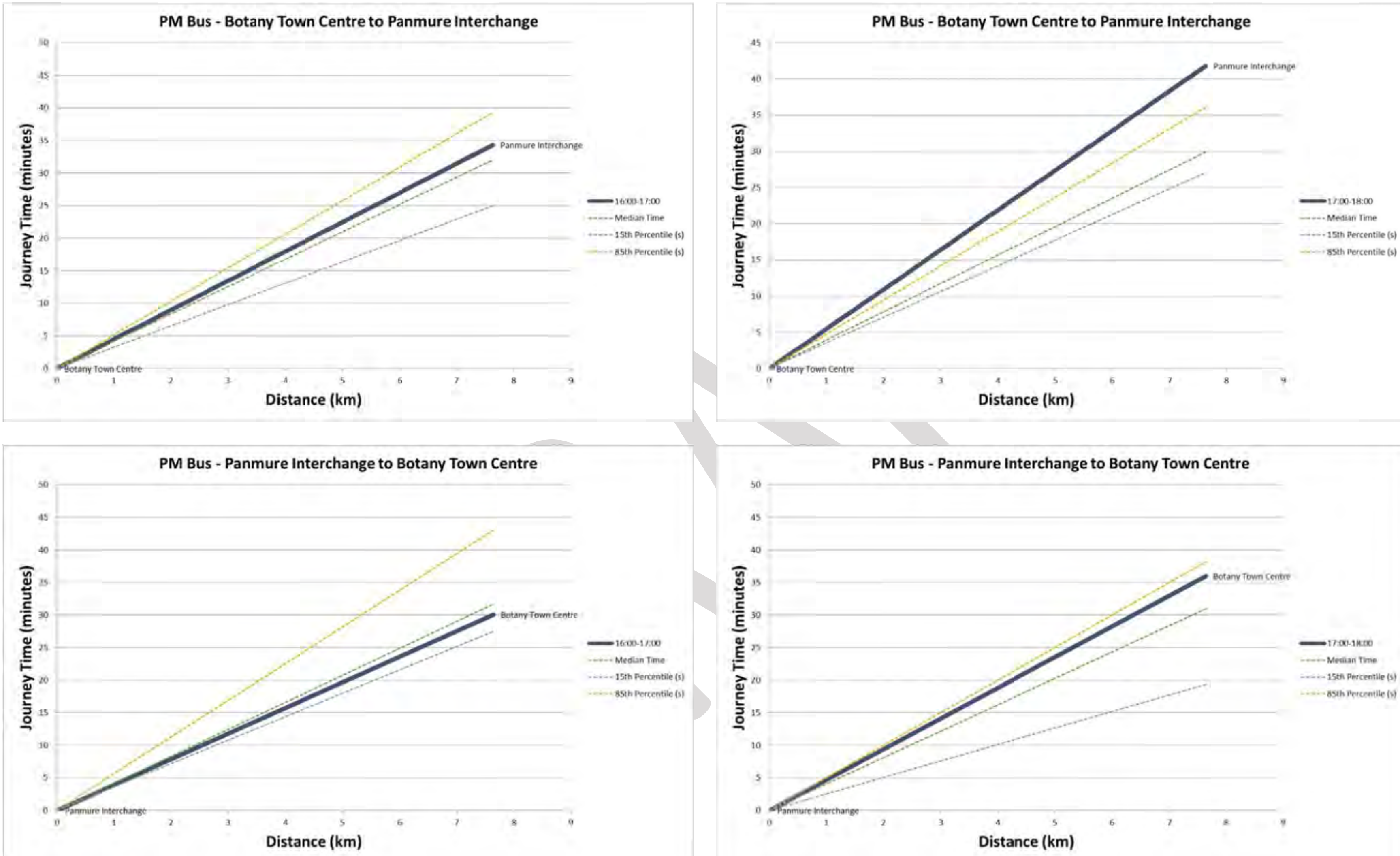


Figure 29 - Travel Time Validation: PM Bus

5.8 Traffic Congestion Check

Traffic count and travel time data are the principle measures of the model performance. Traffic congestion on the network was monitored as an additional sense-check of model performance.

Side-by-side comparison to Google's live traffic view-mode for Thursday 21 February 2019 show that the model represents congestion on the network reasonably well (Figure 30 and Figure 31). In the AM peak, less congestion was seen on Ti Rakau Drive Northbound in the model compared to observed, and this was reflected in the faster travel time for that segment. However, also in the AM, although less congestion was seen on Pakuranga Highway Westbound in the model compared to observed, this was not reflected in the travel time validation. In the PM peak, less congestion was seen on Ti Rakau Eastbound in the model, however this was not reflected in the travel time validation.

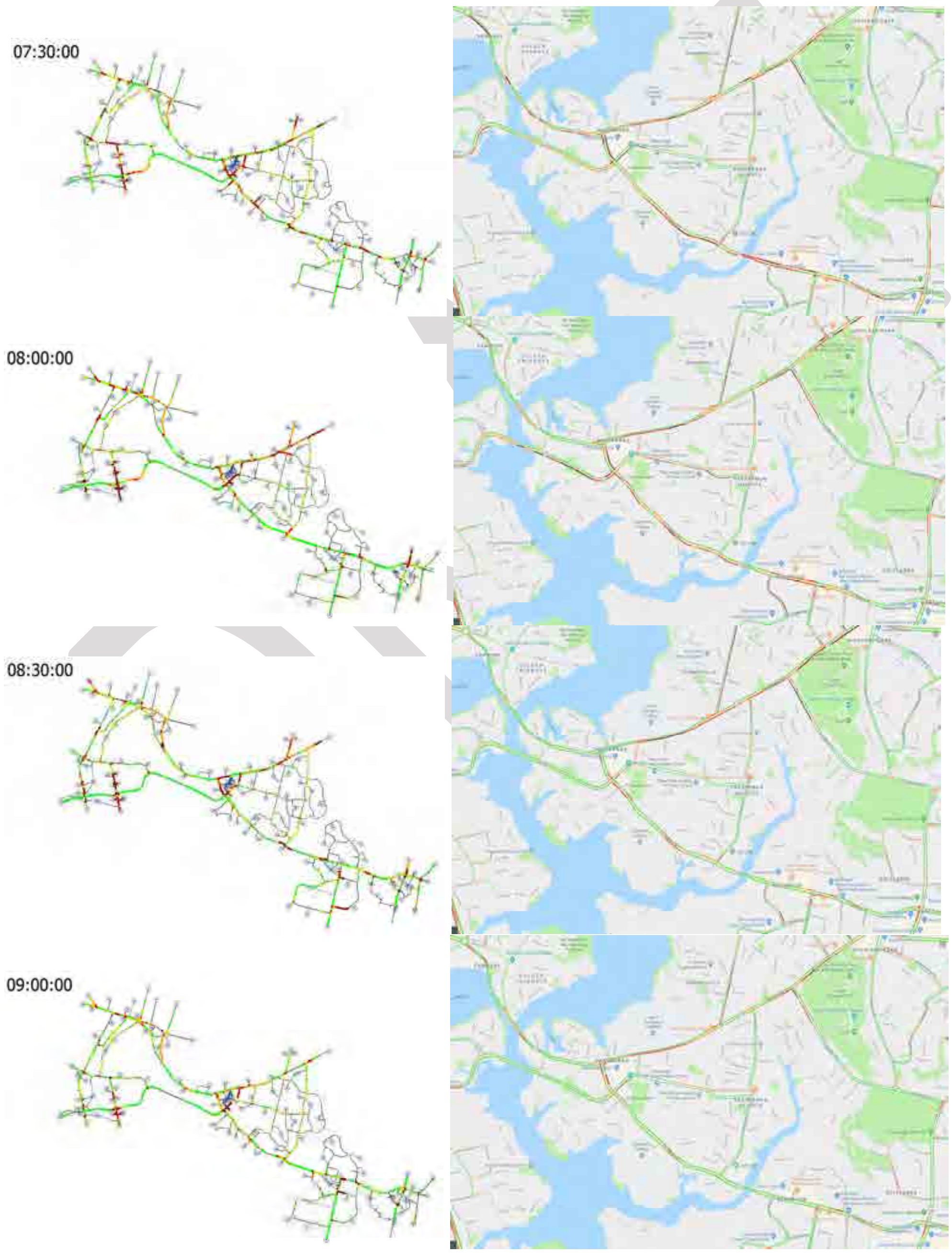


Figure 30 – AM Modelled Congestion versus Observed

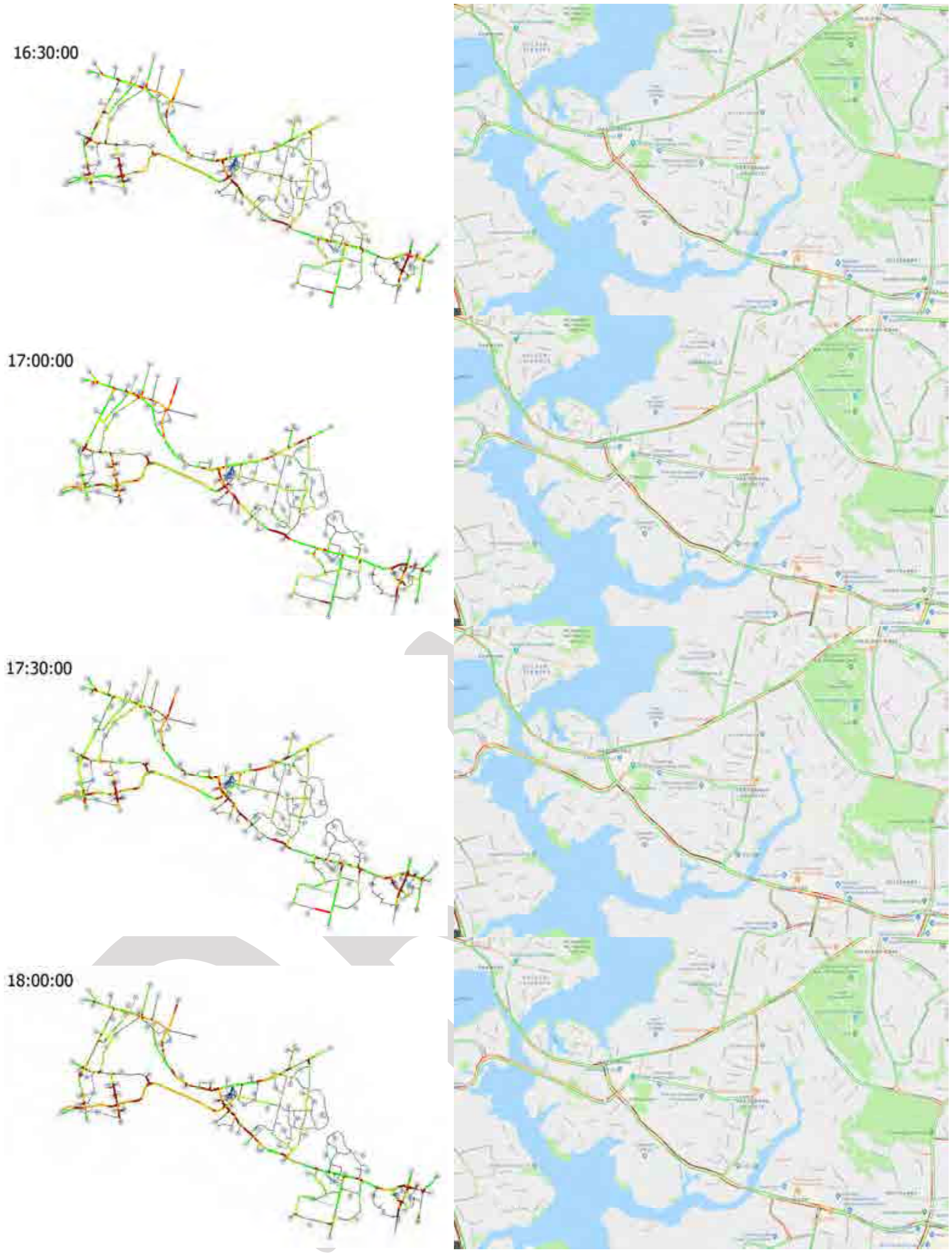


Figure 31 - PM Modelled Congestion versus Observed

This comparison is useful to understand the location of the congestion however the exact definition of congestion in Google's traffic is unknown. Hence it is used as an indication.

5.9 Route Choice Sense Check

Route choice in the model could not be directly calibrated and/or validated because there was no available data. However, sense-checks were made in the **static** model (which contributes 80% of the route choice) using previous experiences and observed traffic count-split information at intersections. Overall, route distribution in the model appears reasonable (Figure 32 - Figure 34).

Figure 32 - Route Choice Split: AM Panmure Bridge Westbound (left) and PM Panmure Bridge Eastbound (right)

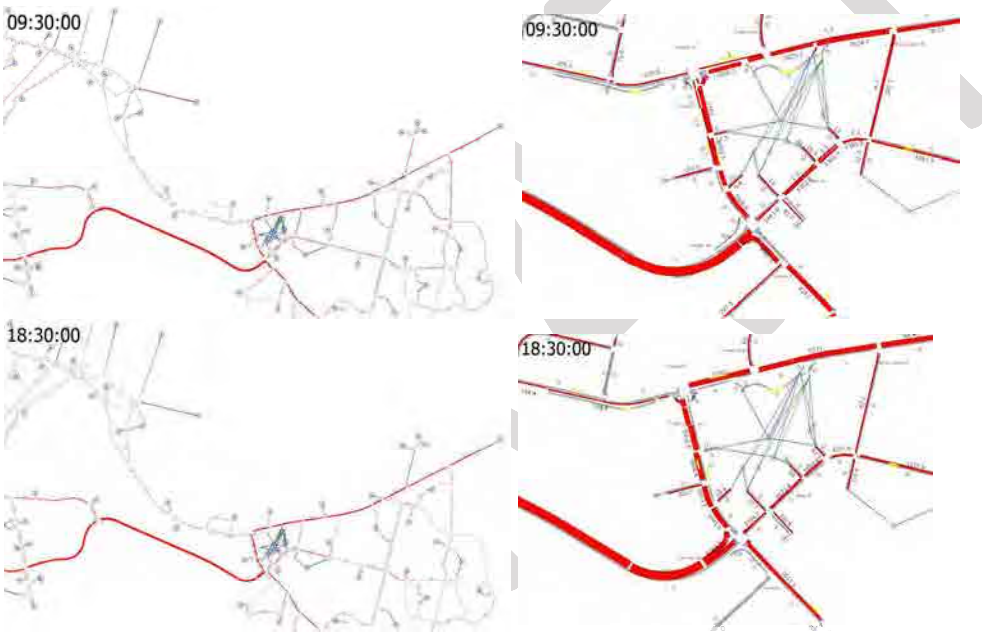


Figure 33 - Route Choice Split: AM Pakuranga Highway Westbound (above) and PM Pakuranga Highway Eastbound (below)

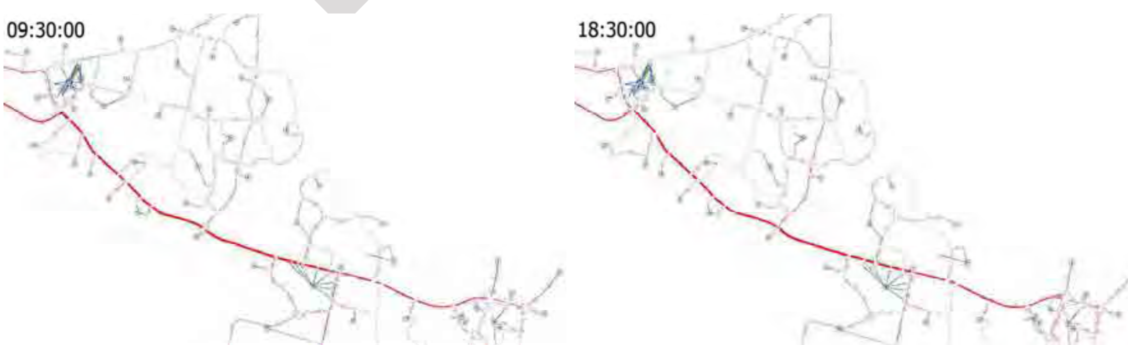


Figure 34 - Route Choice Split: AM Pakuranga Highway Westbound (above) and PM Pakuranga Highway Eastbound (below)

5.10 Model Stability

Model stability was monitored and found to be within acceptable thresholds of a coefficient of variance (COV) <5% across the modelled periods, except in the AM past 9am (Figure 35). However, since the demand and the total travel time are fulling at approximately the same profile, this is not an issue.

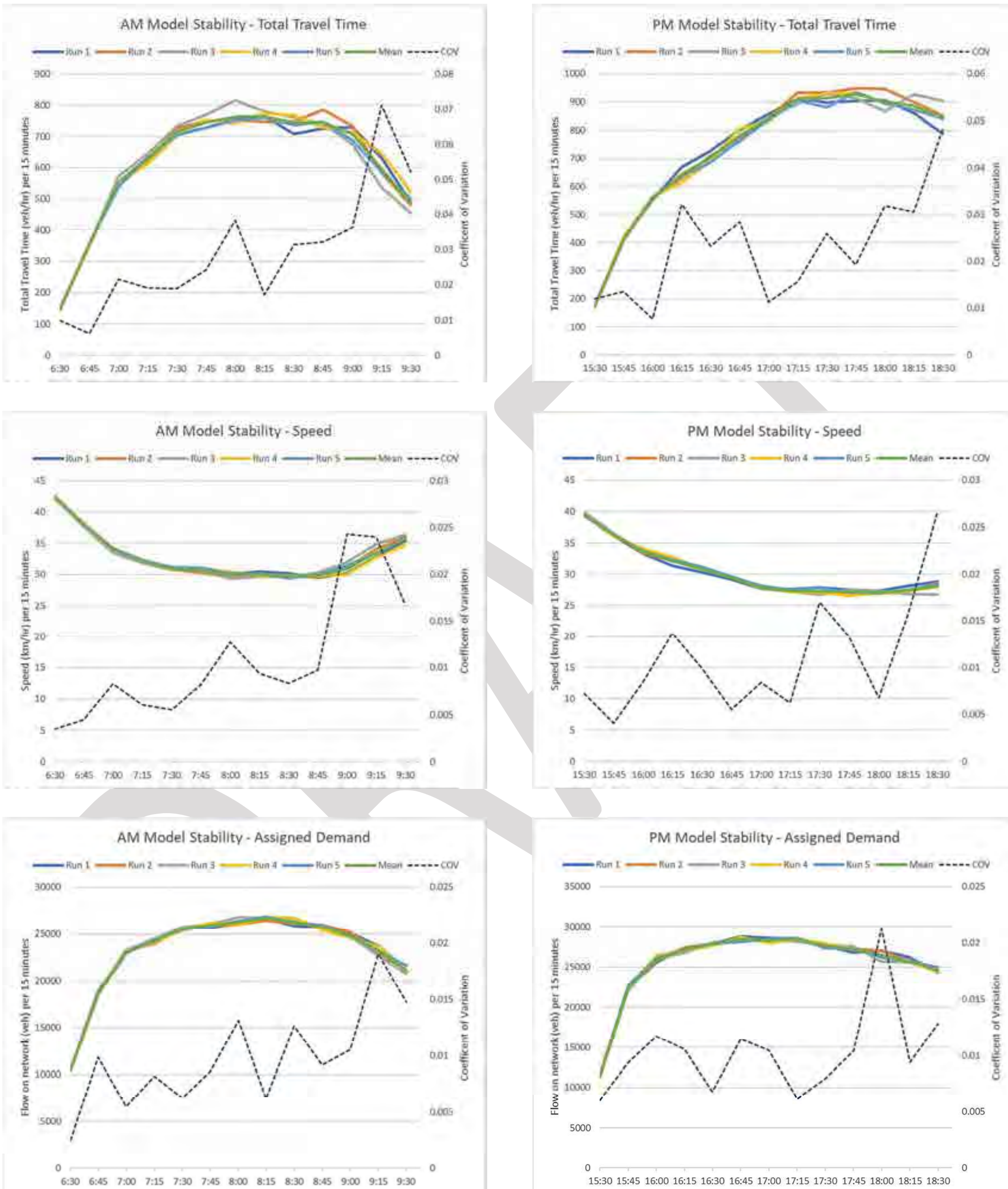


Figure 35 - Model Stability: Total Travel Time, Speed and Flow Plots

6 Conclusion

This report details the update and calibration/validation of the Aimsun model for the Eastern Busway Project. The purpose of this model is to provide a consistent and common base for project developments in the East Auckland Area, primarily along Ti Rakau Drive for the EB 2 and EB3 detailed design work.

The model covers two three-hour peak periods (6.30 am – 9.30 am, and 3.30 pm – 6.30 pm). The modelled periods were chosen to capture the congestion typically experienced in the modelled area.

The model consists of macro and micro tiers with the respective assignment methods: static assignment and microscopic dynamic assignment (DTA). The macro tier provides an interim stage to calibrate the demand through demand adjustment and to generate 80% of paths for the micro DTA. Based on previous modelling of the area, an 80-to-20 split in static versus dynamic path assignment was considered appropriate. This gave better control of modelling route choice in the area and sense-checks during the model development process showed that route distribution in the model is reasonable.

Various observed data were provided by Auckland Transport (AT) for the model development. These included traffic counts, travel time, public transport timing, and signal timing.

The traffic demands come from the AMETI EMME traffic model and were processed before assigning to the Aimsun model. This demand interface process includes a minor refinement of AMETI traffic model zones and application of 2-to-3 hour expansion factors to fit the Aimsun model period. Demand adjustment as part of the validation process was done manually.

The model network was developed in line with the Auckland Dynamic Traffic Assignment Model (ADTA) network coding guideline, which sets out the recommended network coding methodology for Aimsun models in Auckland. This included a standard system of classification and labelling of different turn movement types which were important function variables in the ADTA-developed cost functions also adopted in this model for calculating junction and turn delays.

Model validation showed that the model meets the validation target criteria for Category C: Urban Area in NZTA Model Development Guidelines on individual link flows and turn flows for each hour between 7am – 9am, and 4pm – 6pm. Travel times in the model fit reasonably well with the observed.

Overall, the base year model is considered acceptably calibrated and validated for the purposes of the EB2/3 design work.

Appendix A

Traffic to Aimsun Zone Correspondence

Aimsun Zone	NEW CORDON Aimsun-EMME REF
1	1
2	2
3	3
4	4
5	5
6	6
7	7
8	8
9	9
10	10
11	11
12	12
13	13
14	14
15	15
16	16
17	17
18	18
19	19
20	20
21	21
22	22
23	23
24	24
25	25
26	26
27	27
28	28
29	29
30	30
31	31
205	205
210	210
286	286
296	296
297	297
412	412
540	540
545	545
546	546
547	547
548	548
555	555
560	560
561	561
562	562
563	563
568	568
572	572
582	582
583	583
599	599
649	649
650	650
651	651
652	652
653	653
654	654
655	655
656	656
657	657
658	658
659	659
660	660
662	662
663	663
664	664

Aimsun Zone	NEW CORDON Aimsun-EMME REF
665	665
666	666
667	667
668	668
669	669
670	670
671	671
672	672
673	673
677	677
678	678
693	693
694	694
695	695
697	697
698	698
699	699
705	705
706	706
865	865
867	867
868	868
869	869
870	870
871	871
873	873
896	896
897	897
900	900
901	901
902	902
903	903
1013	13
1017	17
1654	654
1656	656
1902	902
1903	903
2903	903

Appendix B

Road Parameters

Table B1 – Key Road Type Parameters: Main

	Maximum Speed (km/h)	User-Defined Cost	Third User-Defined Cost	Capacity per Lane (PCUs/h)
Arterial	50	1.4	1.2	1600
Arterial - 50k Reeves	50	1.6	1.4	1200
Arterial - 50k Reeves EBD	50	1.6	1.4	1200
Arterial - Divided	60	1.2	1.1	1600
Busway	60	1	1.2	1600
Collector	50	2	1.4	900
Collector - Ireland	50	2	1.4	900
Expressway	80	0.9	0.2	2100
Local - 30k	30	5	2	500
Local - 50k	50	3	1.6	500
Minor Arterial	50	1.4	1.2	1400

Table B2 - Key Road Type Parameters: Dynamic Models

Road-Type Parameters								
Dynamic Models - Section Parameters								
	Lane Changing				**Side Lane**			**Consider Two-Lane Car Following Model**
	Cooperation (%)	**Aggressiveness (%)**	**Breaking Intensity**	**Imprudent Lane Changing**	**Cooperation Distance**	**Merging Distance**	**Merge: First veh on is first veh off**	
Arterial	50	0	Regular	No	Whole Lane	Default	Yes	Yes
Arterial - 50k Reeves	50	0	Regular	No	Whole Lane	Default	Yes	Yes
Arterial - 50k Reeves EBD	50	0	Regular	No	Whole Lane	Default	Yes	Yes
Arterial - Divided	80	0	Regular	No	Whole Lane	Default	Yes	Yes
Busway	50	0	Regular	No	Whole Lane	Default	Yes	Yes
Collector	50	0	Regular	No	Whole Lane	Default	Yes	Yes
Collector - Ireland	50	0	Regular	No	Whole Lane	Default	Yes	Yes
Expressway	80	0	Regular	No	Whole Lane	Default	Yes	Yes
Local - 30k	50	0	Regular	No	Whole Lane	Default	Yes	Yes
Local - 50k	50	0	Regular	No	Whole Lane	Default	Yes	Yes
Minor Arterial	50	0	Regular	No	Whole Lane	Default	Yes	Yes

	Queue Discharge		
	Acceleration Factor	**Additional Reaction Time at Stop (sec)**	**Additional Reaction Time at Traffic Light (sec)**
Arterial	No Change	0	0
Arterial - 50k Reeves	No Change	0	0
Arterial - 50k Reeves EBD	No Change	0	0
Arterial - Divided	No Change	0	0
Busway	No Change	0	0
Collector	No Change	0	0
Collector - Ireland	No Change	0	0
Expressway	No Change	0	0
Local - 30k	No Change	0	0
Local - 50k	No Change	0	0
Minor Arterial	No Change	0	0

Table B3 - Key Road Type Parameters: Dynamic Models continued

Road-Type Parameters						
Dynamic Models - Turn Parameters						
	Microscopic Model					
	Distance Zone 1 (m)	**Distance Zone 2 (m)**	**Additional Waiting Time Before Losing Turn (sec)**	**Yellow Box Speed (km/h)**		
Arterial	333.3	166.67	0	10		
Arterial - 50k Reeves	333.3	166.67	0	10		
Arterial - 50k Reeves EBD	333.3	166.67	0	10		
Arterial - Divided	333.3	166.67	0	10		
Busway	333.3	166.67	0	10		
Collector	277.78	138.89	0	10		
Collector - Ireland	277.78	138.89	0	10		
Expressway	555.56	277.78	0	10		
Local - 30k	277.78	138.89	0	10		
Local - 50k	277.78	138.89	0	10		
Minor Arterial	277.78	138.89	0	10		
	Giveway Model					
	Initial Safety Margin (sec)	**Initial Giveway Time Factor**	**Visibility to Give Way (m)**	**Final Safety Margin (sec)**	**Final Give Way Time Factor**	**Visibility along Main Stream (m)**
Arterial	3	1	25	1	2	60
Arterial - 50k Reeves	3	1	25	1	2	60
Arterial - 50k Reeves EBD	3	1	25	1	2	60
Arterial - Divided	3	1	25	1	2	60
Busway	3	1	25	1	2	60
Collector	3	1	25	1	2	60
Collector - Ireland	3	1	25	1	2	60
Expressway	3	1	25	1	2	100
Local - 30k	3	1	25	1	2	60
Local - 50k	3	1	25	1	2	60
Minor Arterial	3	1	25	1	2	60

Appendix C

Vehicle Parameters

Table C1 - Key Vehicle Parameters

Vehicle Parameters				
Main				
Length (m)	**Mean**	**Deviation**	**Minimum**	**Maximum**
Car	4.5	0.4	3.3	5.3
Truck	11.3	4.3	6.5	19.1
Bus	13	1	12.6	13.5
Width (m)	**Mean**	**Deviation**	**Minimum**	**Maximum**
Car	1.75	0	1.75	1.75
Truck	2.4	0	2.4	2.4
Bus	2.4	0	2.4	2.4
Max Desired Speed (km/h)	**Mean**	**Deviation**	**Minimum**	**Maximum**
Car	110	10	80	120
Truck	100	5	80	110
Bus	90	10	70	100
Dynamic Models - Main				
Speed Acceptance	**Mean**	**Deviation**	**Minimum**	**Maximum**
Car	1.05	0.1	0.9	1.3
Truck	1.05	0.1	1	1.1
Bus	1	0.1	0.9	1.1
Clearance (m)	**Mean**	**Deviation**	**Minimum**	**Maximum**
Car	1.5	0.5	1	2.3
Truck	2	0.5	1.5	3
Bus	1.5	0.5	1	2.5
Max Give Way Time (secs)	**Mean**	**Deviation**	**Minimum**	**Maximum**
Car	10	2.5	5	15
Truck	25	5	10	35
Bus	35	10	20	60
Dynamic Models - Experiment Defaults				
	Reaction Time	**Reaction Time at Stop**	**Reaction Time for Front Veh**	**Probability**
Car	0.8	1.15	1.35	1
Truck	0.8	1.3	1.7	1
Bus	0.8	1.3	1.7	1

Table C1 - Key Vehicle Parameters continued

Vehicle Parameters				
Microscopic Model - Main				
Max Acceleration (m/s2)	**Mean**	**Deviation**	**Minimum**	**Maximum**
Car	2.7	0.2	2.2	3.5
Truck	1.45	0.6	0.5	2.4
Bus	1	0.3	0.8	1.8
Normal Deceleration (m/s2)	**Mean**	**Deviation**	**Minimum**	**Maximum**
Car	3.5	0.2	3	4
Truck	3	0.3	2	3.5
Bus	2	1	1.5	4.5
Max Deceleration (m/s2)	**Mean**	**Deviation**	**Minimum**	**Maximum**
Car	6	0.5	5	7
Truck	5	0.5	4	6
Bus	5	1	4	6
Sensitivity Factor	**Mean**	**Deviation**	**Minimum**	**Maximum**
Car	1.1	0	1.1	1.1
Truck	1.1	0	1.1	1.1
Bus	1	0	1	1
Gap (secs)	**Mean**	**Deviation**	**Minimum**	**Maximum**
Car	1.1	0.2	0.5	2
Truck	1.3	0.2	0.5	2.5
Bus	1.1	0.2	0.5	2.5
Headway Aggressiveness	**Mean**	**Deviation**	**Minimum**	**Maximum**
Car	0	0	-1	1
Truck	0	0	-1	1
Bus	0	0	-1	1
Favours Stop and Go				
Car	No			
Truck	No			
Bus	No			
Lane-Changing Model	**Staying in Overtaking Lane**	**Imprudent Lane Changing**		
Car	No	No		
Truck	No	No		
Bus	No	No		
Margin for Overtaking Manouver (secs)	**Mean**	**Deviation**	**Minimum**	**Maximum**
Car	5	3	1	10
Truck	5	3	1	10
Bus	5	3	1	10

Table C1 - Key Vehicle Parameters continued

Vehicle Parameters			
Static Models			
	Transportation Mode	**PCUs**	
Car	None	1	
Truck	None	2.5	
Bus	None	2.5	

Appendix D

Bus Services List

Base 2018 Bus Services
31
35
70
72X
72M
72C
352
351
353
711
355
739
712
735
733
734
323
743
751