Waimea Road

Job No. 287

Issue No 2 (23 March 2009)

Calibration Report

Quality Assurance

Job Number:	287		
Title:	Waimea Road: Calibration Report		
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Issue	2	23 March 2009	Final

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Executive Summary

This report outlines the development and calibration of the S-Paramics Rutherford Street and Waimea Road corridor models built, on behalf of Nelson City Council, by baseplus Limited (baseplus).

The primary objective of the S-Paramics models is to provide a calibrated base from which to test the likely traffic effects of various bus priority schemes along the studied route.

Two base models have been developed to replicate the observed 2008 traffic conditions in the following periods:

- Morning Peak 0700-0900
- Evening Peak 1400-1800

The road network was constructed and calibrated utilising the S-Paramics suite of microscopic traffic simulation software. Detailed coding of lane and junction descriptions were created by using aerial photographs of the region, on-street measurements and local knowledge of the network operation. During the calibration process, model parameters have been adjusted, within industry standard limits, to improve the model operation. All changes that deviate from default parameters are described in this report.

The first stage of calibration of the S-Paramics model involved observation of the simulation to assess if the traffic was moving through the network in a realistic manner and to determine whether it matched observed existing conditions.

The second stage of calibration involved comparisons between the observed data and the modelled results for the following statistics:

- Turn Counts
- Link Counts
- Journey Times
- Queue Lengths

Turning count volumes provide an indication of how well the traffic demand matrices and traffic assignment processes are replicating observed conditions. Selected journey time survey routes and queue length approaches verify that the models are replicating realistic congestion on the main routes. The model calibration measures were compared for the peak hour of each model and over the full model period.

It is concluded, from the statistical analysis that the Rutherford Street and Waimea Road corridor models are appropriately calibrated for both the full model period and peak hours. The models replicate the existing conditions to an acceptable level of accuracy and are appropriate tools for future option testing.

1 Introduction

Nelson City Council commissioned baseplus Limited (baseplus) to develop an S-Paramics microscopic simulation model for the Rutherford Street and Waimea Road corridor. This report focuses on the aspects of the model development, operation and adherence to good practice and summarises the results of the model calibration.

1.1 Background

NCC have provided various potential Bus Priority Scheme Options along the Rutherford/Waimea corridor. These options are to be simulated and compared with each other and with the base model, to assess the benefits of each option.

For further information regarding background to this project, reference should be made to the following reports:

- Proposal: Rutherford Road and Waimea Road Corridor Modelling, baseplus, 28 August 2008
- Scheme Descriptions: Indicative Bus Priority Scheme Rutherford Street and Waimea Road Corridor, Nelson City Council, April 13, 2007

1.2 Purpose

The purpose of this project is to develop and calibrate a microscopic simulation model for Rutherford Street and Waimea Road corridor, to existing network and traffic conditions.

Calibrated models of the existing situation can then be used to assess future changes within the model and traffic impacts of various transport concepts. These assessments provide valuable information that can be used as input to decisions regarding the strategic future of this corridor. The foundation for this assessment is the creation of an agreed base case model.

Note, for the purpose of this project, once the 2008 base model has been calibrated a '2008 evaluation base' model will be created. This will ensure the option models can be compared against a base model which includes current committed developments (i.e. Phase A bus scheme.)

2 Micro Simulation Modelling

2.1 S-Paramics

The model suite used for this project is S-Paramics, version 2007.1C, developed by SIAS. S-Paramics represents traffic flow within a network by simulating individual vehicles and their interactions with other vehicles and the surrounding road environment. As with real traffic conditions, these interactions can vary for each model run, resulting in unique results. Furthermore, the inclusion of adaptive signals, as described in the following section, assists in randomising operation and hence varying results.

To obtain statistically meaningful results the average network performance is taken from multiple simulation runs. Previous experience indicates that five model runs are sufficient to obtain stable results for a corridor of this size, nature and purpose.

2.2 baseplusFuse

Within the traffic modelled corridor there are four signalised intersections, including a mid-block pedestrian crossing. However, the corridor is connected to the Nelson CBD model in which there are additional signalised intersections. All intersections are controlled by the computer signals management system SCATS (Sydney Co-ordinated Adaptive Traffic System).

The adaptive nature of SCATS means that throughout the peak traffic periods the signal operation adjusts according to the traffic flows detected. As a result, the signal cycle times and phase splits can vary over time. SCATS reacts and adjusts to the current traffic conditions by varying the signal operation constantly. This can result in the peak traffic demands proclaiming a unique signal operation on a day to day basis. For this reason, 'baseplusFUSE' has been incorporated into the modelling.

baseplusFUSE, is the interface that allows S-Paramics to replicate the actual on-street operation of SCATS. The operation and connectivity between the S-Paramics model and SCATS is shown in Figure 1. It shows baseplusFUSE as the link between the S-Paramics model and WinTraff, an RTA product that simulates multiple traffic signal controllers. These simulated controllers use the same personality as the on-street intersection does, thereby replicating the same on-street operation. The SCATS Region and Central Manager software is the same software that is used to control the signalised intersections on street.

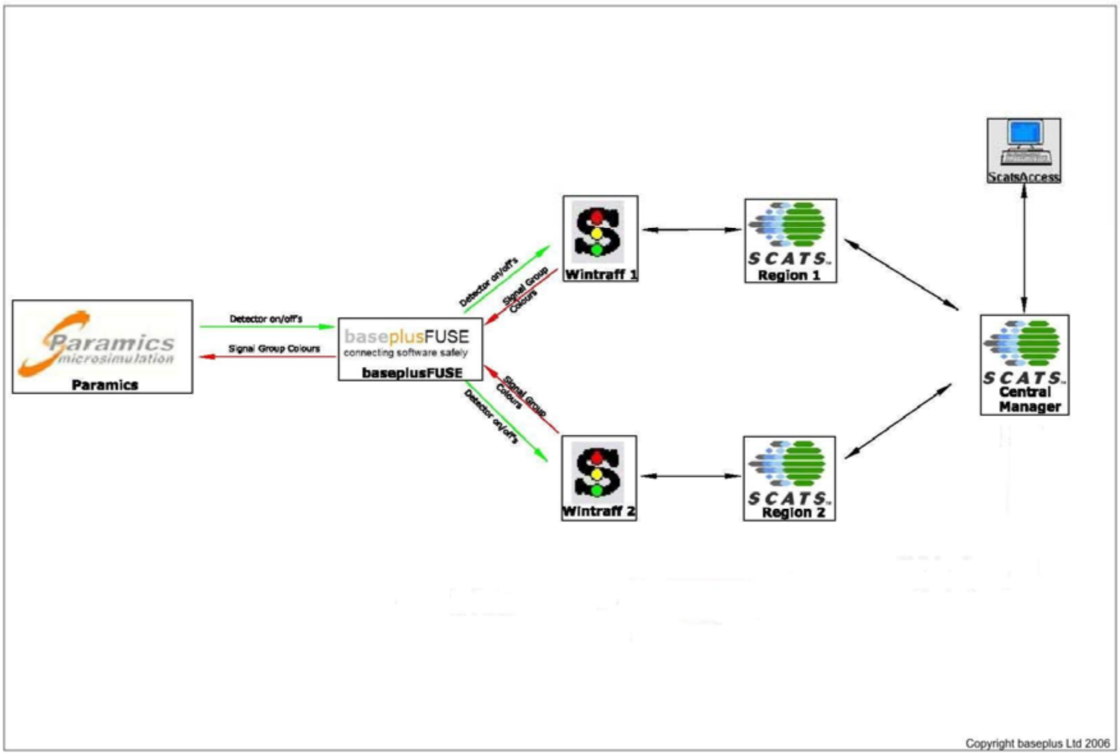

Figure 1 - baseplusFUSE connection to S-Paramics and SCATS

Incorporating baseplusFUSE into the model ensures realistic operational boundaries are set and a greater level of confidence can be achieved in regard to the representation of the existing situation and the confidence in the option tests.

3 Model Form

3.1 Base Model Network

The base model has been created based on the existing Nelson CBD model and extended to the south along the Rutherford/Waimea corridor. However, due to the Nelson CBD base only being calibrated for the evening peak, it could not be used for this project which requires both an AM and PM calibrated model. Hence, although the CBD network is contained within the corridor project model, it has been cordoned off from the Rutherford/Waimea corridor.

The base model Rutherford Street and Waimea Road corridor, is bounded by Bridge Street to the north and Whakatu Drive to the south, and includes Beatson Ave, as shown in Figure 2.

Figure 2 - Study Area

The base model was compiled using available digital aerial photography, with site visits to confirm the accuracy and operation of the modelled network. Based on the supplied data, the model was constructed to a 1:1 scale, ensuring correct vehicle operation and accurate reaction to the road geometry and other vehicles.

3.2 Model Periods

S-Paramics models have been developed for the following two peak traffic periods:-

- 0700-0900, plus a ½ hour warmup and flush out

- 1400-1800, plus a ½ hour warmup and flush out

The following peak hour periods have been calculated for each of the above model periods, based on observed survey data.

- 0800-0900
- 1630-1730

Model duration of two hours in the morning and four hours in the afternoon ensures the shoulders to the peaks are adequately modelled. This allows for the model to adequately accommodate peak hour spreading which may result from future growth within the network.

3.3 Site Inspection

A site visit was undertaken by baseplus on the 30 October 2008 to confirm the model's form and ensure realistic vehicle behaviour.

The main points from the site visit are summarised below:

- **Evening Peak, southbound:** During traffic congestion, major road traffic lets the minor road traffic into and across the major traffic flow. This is partly due to vehicles adhering to the yellow box hatching but also due to drivers allowing 'courtesy let in'. This observation is particularly relevant to the southbound traffic during the evening peak. In the Southbound direction during the evening peak, there is continuous slow moving traffic, which travels at free flow once it passes the merge south of Motueka Street. This slow stream of traffic extends as far back as Wellington Street during the 1700-1720 minute peak.
- **Evening Peak, northbound:** In the Northbound direction during the evening peak, there is generally continuous moving traffic
- **Morning Peak:** In both directions during the morning peak there is generally continuous moving traffic

4 Traffic Data Collection

Various traffic data was collected and supplied for the purpose of base model development and calibration. The following table summarises the traffic data collection with further details, including the location of collected data, in the following section paragraphs.

Data	Source	Date
Turn Count Surveys	TLD-Traffic Data Collection Specialists	30/10/08, 20/11/08
Loop Count Data	Provided by NCC	29/9/08 to 6/10/08
Journey Time Data	TLD- Traffic Data Collection Specialists	30/10/08, 20/11/08
Bus Information	Internet Bus timetables Bus stop locations and stop times provided by NCC	Current
Signal Information	Provided by NCC	

Table 1 - Traffic Data Collection

4.1 Turn Count Data

Thirteen intersections were surveyed, where turn counts were recorded by vehicle type in five minute intervals. The surveys were undertaken by TLD, on 30/10/08 for the period between 0700-0900 and 1530-1730. The intersections surveyed are shown in the following figure.

Due to various survey errors, additional surveys were undertaken by TLD at three intersections on 20/11/08 for the period between 0700-0900 and 1400-1800 at the following locations.

- Rutherford/Examiner Street, Waimea/Motueka and Waimea/Ridgeway
- Rutherford/Examiner Street, Waimea/Motueka and Waimea/Boundary

Figure 3 - Turn Count Survey Locations

4.2 Loop Count Information

Loop count information, in the form of tube counts, was provided by NCC for both the northbound and southbound directions for each 24 hour period between Monday 29/8/06 and Monday 6/10/08 for the following site

- Waimea Rd 916 Franklyn St 1228 Motueka St, Site Ref 391E

The data was provided as one hour counts over each 24hour period. Since this data could not be provided in smaller time intervals (such as 15minute intervals) it could not be used to construct the demand profiles.

4.3 Journey Time Data

GPS travel time surveys were undertaken in both directions for two journey routes, using handheld GPS recording devices. The surveys were undertaken by TLD on 30/10/08 for the period between 0700-0900 and 1530-1730. However, due to survey error the surveys were repeated on the 20/11/08 for the period between 0700-0900 and 1400-1800. That is, repeated at the same time as the repeated turn count surveys.

Each defined journey time route was traversed continuously in both directions by two vehicles. Data was then analysed within Excel. The routes surveyed are listed below:

- Waimea Rd/Rutherford St northbound from Whakatu Drive to Bridge Street
- Waimea Rd/Rutherford St southbound from Bridge Street to Whakatu Drive

4.4 Queue Surveys

Queue surveys were undertaken by TLD in conjunction with the turn count surveys. The surveys recorded the maximum number of queued vehicles on each relevant approach every five minutes. The surveyors are provided with various queue length brackets (e.g. 1-5veh, 5-10 etc) on their survey sheets, which they used to record the counted/ estimated maximum number of cars queuing within each period.

4.5 Bus Data Information

All bus route data was obtained from NCC and entered into the base models. Further details regarding the bus information provided and included in the models are detailed in Section 5.6 of this report.

4.6 Signalised Intersection Data

The following signalised intersections in the study area were activated and controlled in the model based on the existing SCATS program using baseplusFUSE:

- TCS 3 – Bridge
- TCS 2 – Hardy
- TCS 1 - Selwyn
- TCS 14 – Pedestrian Crossing between Van Diemen and Hampden

To incorporate SCATS into the model the following files were provided by NCC.

- **Signal Controller Personality Files** - SFT files for all the signal controller personalities were supplied for the operation of signals in the existing study area.
- **SCATS Sys.lx** - The existing sys.lx file has been incorporated into the model. This controls the SCATS operational boundaries and instructions for the XXX signal region.
- **SCATS Sys.RAM** – The sys.RAM file relates to the Nelson region and contains time-settings. This file has been provided and included in the model process.
- **SCATS Sys.Tc** – This file contains the time controls for all actions. This file has been included in the model process.
- **Controller Information Sheets (CIS)** – This describes what is coded in the SFT files. It includes the intersection layout, phasing and time setting information for each signalised intersection in the study area. The CIS have been provided for this project.
- **Central Manager database, Scms.mbd** – This file is desirable as it provides a graphical database for all existing intersections to check detector location and signal group mappings. This file is essential if the CIS have not been provided for the study area. For this project the Scms.mbd file have been provided.
- **System Monitor (SM) and Vehicle Loop (VS) data** – Onsite data, including phase splits, cycle lengths and vehicle counts, can be recorded by SCATS and provided for the same day that survey data was collected. This provides a calibration check for the resulting modelled signal operation.

Incorporating SCATS into the model was undertaken by a qualified SCATS Operator, Bill Sissons of baseplus Limited, previously the Signal and SCATS Operation Manager at Christchurch City Council.

5 Traffic Demands and Assignment

5.1 Zone Structure

The S-Paramics model zone structure was developed based on the zone locations of the existing Nelson CBD model and then additional zones were added to the south for the external links to the Rutherford/Waimea corridor. Some zones from the original Nelson CBD model had to be modified and new zones constructed within the CBD part of the model, so that the corridor model could be cordoned from the CBD. All zones relevant to the corridor model are numbered 100 to 130.

The zone layout of the corridor model is shown in Figure 4.

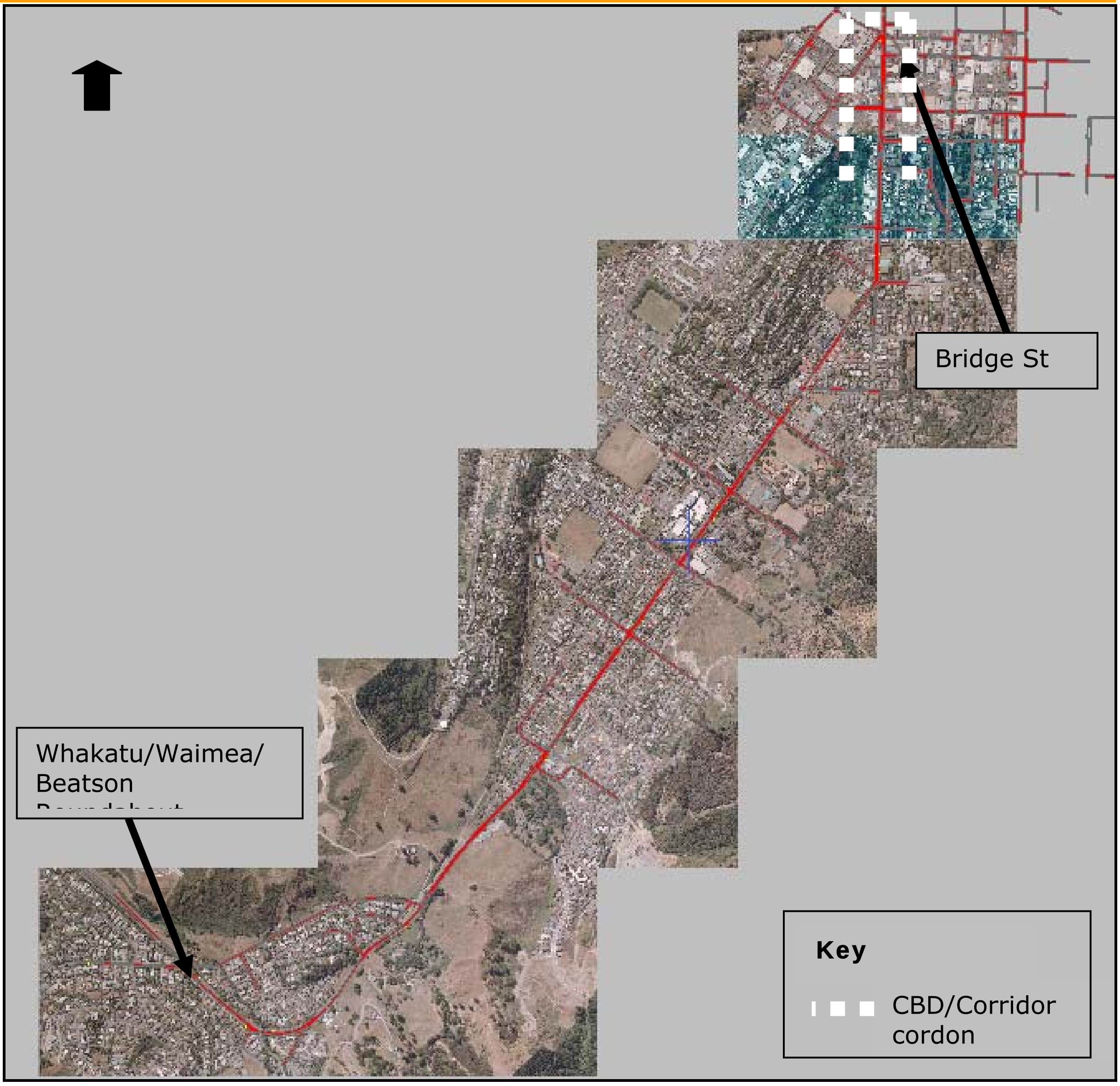

Figure 4 - Network Zone Configuration

5.2 Demand Matrix Levels

In total two vehicle demand matrices have been assigned to the network, one for the morning network and another for the evening network. For the warmup and flushout periods the same demand matrices have been applied, but with an appropriate reduction factor, based on the results of the turncount surveys.

5.3 Matrices and Vehicle Characteristics

The assigning of vehicle types to each demand matrix is presented in the following table. The S-Paramics vehicle types and kinematics are those used in the Nelson CBD model, but with the addition of Heavy Vehicles, Fixed Route Vehicles and Buses.

Note, values relating to familiarity, perturbation and generalised cost factors are associated with each vehicle type. However, since this model has little route choice these values are of little relevance to the model operation.

Note, with respect to their being route choice along Beatson Ave, it is assumed no vehicles currently use Beatson Avenue as a cut-through as it has speed humps and it was the general observation made on site. These values have therefore been left as the values applied in the Nelson CBD model and have not been specifically detailed in this report.

Vehicle Types	Description	Matrix	% of Matrix
1-7	Various Car Types	1	98%
15	Heavy Vehicle	1	2%
8	Fixed Route Vehicle	Not related to the matrix. Put in as fixed route to simulate the times of the GPS surveyed journeys.	
20	Bus	Not related to matrix. Put in as fixed route based on bus info.	

Table 2 - Vehicle File Summary

5.4 Demand Matrices Development

This model has limited route choice, that is, only potential route choice through Beatson Ave. Therefore, the demand matrices were developed within Excel based on intersection turn count surveys. During this process a number of assumptions were made, as detailed below.

- There were a number of intersections where the exit counts from one intersection were inconsistent with the approach counts to the adjacent intersection.
- Any significant issues were generally corrected by reviewing the survey data and correcting any obvious recording errors.
- Smaller discrepancies were then corrected by smoothing the recorded turncounts. Northbound the counts were smoothed commencing from the Waimea/Whakatu roundabout and progressing north. This method has resulted in overall higher turncounts than those recorded, but this is considered conservative. Southbound the counts were smoothed commencing from the Rutherford/Bridge intersection and progressing south. This has also resulted in overall higher turncounts than those recorded.

5.5 Demand Profiles

Profiles were used to assign different traffic demands in defined time intervals over the model period. Release profiles have been developed at each model entry approach. The profiles were developed based on the turn count data. As is always the case, smoothing of profiles was only undertaken where the preliminary model results suggested this was required to reflect more realistic loading of traffic at certain locations.

Using turn counts to create profiles also means that it is the throughput profile as opposed to the release profile that is being created. Where this was observed problematic the profiles were appropriately modified.

In total 30 profiles were applied, one to represent the demand release profile at each zone, with the exclusion of zone 101 which is an entry zone only.

5.6 Public Transport

5.6.1 Bus Routes

All bus routes in operation in the study area have been included in the model. Figure 5 shows the bus route within the study area, highlighted in blue. Route and schedule information was obtained from the Nelson Coaches website and entered into the base models. In total, two bus routes have been applied to the model; Richmond to Nelson (northbound) and Nelson to Richmond (southbound), which both travel along the blue highlighted route in the following figure.

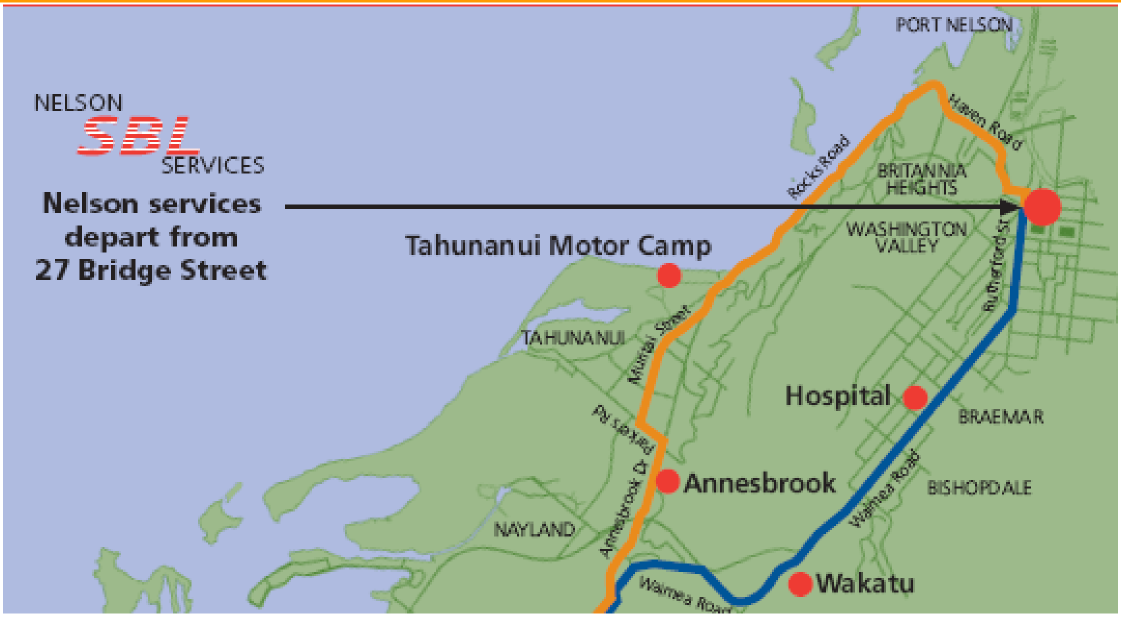

Figure 5 – Nelson Bus Routes along Waimea/Rutherford

5.6.2 Bus Stops

In total there are 24 bus stops in the models as defined below:

- Nine for the southbound bus route, two of which represent the start and end of the route and hence are not actual 'stops'
- Eleven are for the northbound bus route, two of which represent the start and end of the route and hence are not actual 'stops'
- Four stops represent the start and end locations of the fixed route vehicles, put in to simulate the surveyed GPS journeys and hence and not actual 'stops'.

5.6.3 Bus Schedules

Information regarding the bus schedules was obtained from the public bus timetables provided on the internet. For the northbound route, the bus departure times are based on the 'Whakatu' timetabled departure time and for the Southbound route, the 'Nelson' departure time. The bus schedules applied to the model are detailed in the following table.

Bus Route	Bus Schedule	
	0630-0930	1330-1830
Richmond to Nelson – all stops on route	7.25, 7.55, 8.30	14.40, 15.30, 16.35, 17.40
Nelson to Richmond – all stops on route	7.40, 9.00	14.50, 15.40, 17.10

Table 3 – Bus Schedules

5.6.4 Bus Stop Dwell Times

NCC provided information regarding busstop use. For each stop on the two relevant bus route directions, the level of use was assigned as low, medium or high, which they equated to a dwell time of 20, 30 or 60 seconds respectively. Some stops were assigned a high level of use only during the morning or evening peak, hence in the opposing period these stops were assumed to have low use.

Note the dwell times not only include the physical time the bus is stopped at the bus stop but also accounts for the bus slowing down into the bus stop as well as the time for the bus to re-join the main traffic stream.

5.7 Traffic Assignment

The modelled network has no relevant route choice within the study area and thus an "all or nothing" assignment has been deemed acceptable and employed for this study. The following parameters have not been adjusted from the settings in the Nelson CBD model as they are considered irrelevant in a model:

- Generalised Cost Factors
- Feedback Period
- Perturbation
- Familiarity
- Road Hierarchy Major/Minor Classification
- AggAw Method

6 Model Coding

For the purpose of calibrating these models a number of viable adjustments have been made to the modelling parameters to ensure the model replicates the existing observed traffic conditions.

This section addresses the contents of relevant model files, excluding those changes made to the traffic assignment parameters, as this is discussed previously in this report in Section 5.7.

6.1 Behaviour

Default values have been retained.

6.2 Categories

In the categories file, 24 categories have been defined with 12 being used in the model. The categories generally reflect the speed of the roads within the network along with associated number of lanes.

Along Rutherford St/Waimea Road the speed limit is 50kph, with the exception of a section between Beatson and Whakatu where the speed is 70kph. However, analysis of the GPS data suggests vehicles do not travel at these speed limits even in free flow conditions. This suggests there may be side friction (e.g. activities along the side of the road) which impedes vehicles from reaching the speed limit. To reflect this in the model, the road categories used were 45kph and 65kph. The exception to this is on the link where right turn traffic from Motueka St merges with the southbound traffic, where the link speed of 25kph has been applied to ensure the merge operation is realistic.

6.3 Configuration

The following table summarises the significant parameters applied in the Categories file for this model which has been developed in S-Paramics Version 2007.1C. Further explanation of each of these parameters and others are detailed in the subsequent paragraphs.

Parameters		Value
Time Step		2 seconds
Queue Definition		
In Queue State if	Queue speed	<7 kph
	Queue distance	<5m
Out of Queue State if	Queue speed	>7.5 kph
	Queue distance	>6m
Mean Target Headway		0.8
Mean Reaction Time		1.0
Network Minimum Gap		1.6

Table 4 - Categories Files (S-Paramics Version 2007.1C)

Seed

The random seeds used as a key factor in the initial generation of variable model runs and also to assist in testing model stability were initially set to one. Following these tests, and for the purposes of calibration, five random seed runs, with a seed value of 0 set, have been analysed.

Release Style

The release style of precise has been used.

Time Step

The default time step value of two is used in the models.

Queue Definition

The standard baseplus Ltd queue definition parameters have been applied, which are:

- In queue speed 7 kph
- In queue distance 5 m
- Out queue speed 7.5 kph
- Out queue distance 6 m

General Tab:

A vehicle is defined as queued when its speed drops below **7 kph** and when the gap in front drops below, **5** m. A vehicle is no longer queued when its speed rises above **7.5 kph** or the gap in front of it rises above **6** m

Other settings include:

- minimum queue length **2** m
- recurse signal queues backwards by **8** links
- **toggle off** include signalised links in non signal queues

- For multiple queues, select propagate first queue to end

Mean Headway

The mean target headway specifies the global mean target headway, in seconds, between a vehicle and a following vehicle. The default value is 1.0 second and this is what has been applied.

Mean Reaction Time

The mean reaction time of each driver, in seconds, is associated with the lag in time between a change in speed of the preceding vehicle and the following vehicles reaction to the change. The default value is 1.0 second and is utilised in this model.

Network Minimum Gap

The network minimum gap parameter sets the gap between each vehicle when a queue forms. Extensive research undertaken by baseplus has revealed that a value of 0.8, for version 2005.1 or earlier and 1.6 for versions 2006.1 and onwards, results in an appropriate modelled gap of 2m. A value of 1.6 has therefore been utilised in the presented models which run in version 2007.1.

New Zealand Left Turn Rule

New Zealand left turn argument has been enabled with all models.

Signal Settings

The global signal settings used in the models are irrelevant given the inclusion of baseplusFUSE with the model with SCATS taking over these values.

6.4 Controllers

The SNMP port is set to 2100, a default assumed by baseplus in connecting to baseplusFUSE.

6.5 Hazards

The default node signposting is 250m for urban links and 750 for highway links. Changes to the defined signposting have been made through the model where appropriate lane choice is required. Changes to signposting can adjust the point where vehicles make a lane change to a more realistic position. The reduced signposting distance has been used where the default signposting was causing unrealistic lane changing behaviour at an upstream intersection.

This is done in preference to lane restrictions as lane restrictions can sometimes mask the true problem encountered within the model.

Users of the model should be aware of the changes made to hazards with regards to any future modelling that may be undertaken. Hazards that have been changed from default can be viewed from the hazards file within the model.

6.6 Incidents

No incidents have been applied to the model.

6.7 Links

Flags

GA look next has been used on the majority of short links upstream of the approaches at priority intersections. This has been used to ensure vehicles give-way to traffic at the appropriate distance.

Links that load vehicles on to the network are coded as highway links to ensure vehicles are loaded at speed where appropriate.

Modifiers

As part of the calibration process certain link modifiers have been adjusted in line with industry practice and guidelines.

Visibility has been included at various locations in the model to ensure observed intersection operation is achieved.

Restrictions

Restrictions have generally been applied as a last resort where appropriate observed lane choice could not be modelled any other way. However, in this mode no restrictions have been required.

6.8 Next Lanes

Next lanes have been used in various locations through out the network.

These have generally been applied at signalised intersections and over shorter links, to ensure appropriate and realistic lane behaviour.

6.9 Periods

Periodic modelling has been applied to the model, as detailed below.

- 0630-0700 – AM warmup
- 0700-0900 – AM Peak
- 0900-0930 – AM flushout
- 0930-1400 - Non modelled period
- 1330-1400 – PM warmup
- 1400-1800 – PM Peak
- 1800-1830 – PM flushout
- 1830-0630 – Non modelled period

The model is setup to store all the relevant files for all periods in the one model. The files which are required for each period are stored within the one model in the folder 'Period Specific Files'. This folder includes the following files:-

- Busschedules, differences in the bus schedules
- Configuration, differences relate to the model start time;
- Itscontrollers, this relates to the use of the speed controller
- SpeedControl, this relates to the use of the speed controller
- Measurements, reflect the differences in start and end times for each period,
- Profile, different release profiles are used in the AM and PM models

- Stoplines & Nodes, the node and stop line locations have been modified at Boundary Road between the two period models as discussed further in section 6.11 of this report.

Within the folder 'Periodic Specific Files' there are three .bat files. Selecting the appropriate one copies the files from above into the model directory thus creating the model required.

6.10 SpeedControl

At the merge along Waimea Road, where right turn traffic from Motueka merges with southbound traffic along Waimea Road, site observations suggest that the traffic does not merge smoothly. To replicate this in the model, a Speed controller has been added at the peak times so that the south bound traffic slows down and lets the Motueka traffic merge appropriately at this location. This operation results in a shockwave effect north along Waimea Road

6.11 Stoplines and Nodes

At Boundary Road vehicles appear to operate differently during the morning and evening peaks. In the morning peak there is a constant queue of vehicles heading north which appears to be due to a combination of issues including traffic volume, merge issues and courtesy let-ins. In the PM model the northbound traffic is generally freeflow, hence the northbound congestion issues apparent in the AM are no longer evident.

This is particularly the case at Boundary Road where in the AM model there are northbound queues and minimal traffic from Boundary Road. In the PM model the Boundary Road traffic volume is greater and is more able to exit out onto Waimea Road.

To replicate these observations, the approach node and stoplines at Boundary Road have been slightly modified between the AM and PM model.

6.12 Version

The model has been developed in version 2007.1C of S-Paramics. This was the latest current version at the time of model development.

6.13 Units

Units are set to metric in the model.

7 Model Stability

The overall network statistics for the modelled periods are presented in the following tables. The tables below summarise the statistics and present the coefficient of variance (COV) for each model period. The COV is a measure of the variation between model runs. Typically 5% is considered a good level of correlation. The coefficient of variance is calculated by divided the mean by the standard deviation as follows:

$$COV = \frac{SD}{\mu} \times 100$$

Where: SD = Standard Deviation

μ = Mean

Log Run	Average Travel Time (s)	Total Distance (m)	Total Number of Vehicles	Mean Speed (kph)
1	222	23,302,454	9,619	39
2	223	23,327,478	9,610	39
3	221	23,262,550	9,606	39
4	219	23,261,440	9,595	40
5	223	23,250,742	9,586	39
Mean	221	23,280,933	9,603	39
Std Dev	2	32,631	13	0
Min	219	23,250,742	9,586	39
Max	223	23,327,478	9,619	40
Range	4	76,736	33	1
CoV	0.8%	0.1%	0.1%	0.8%

Table 5 - Morning Model 0630-0930, Network Statistics (Five Runs)

For the Morning Period network statistics, the CoV is under 1% for all statistics. This means the variation of these statistics is acceptable. Overall it is concluded that the AM model is stable.

Log Run	Average Travel Time (s)	Total Distance (m)	Total Number of Vehicles	Mean Speed (kph)
1	225	54,326,192	24,159	36
2	221	54,306,120	24,154	37
3	224	54,370,136	24,168	36
4	218	54,304,232	24,139	37
5	225	54,338,340	24,152	36
Mean	223	54,329,004	24,154	36
Std Dev	3	27,038	11	0
Min	218	54,304,232	24,139	36
Max	225	54,370,136	24,168	37
Range	7	65,904	29	1
CoV	1.3%	0.0%	0.0%	1.3%

Table 6 - Evening Model 1330-1830, Network Statistics (Five Runs)

For the Evening Period network statistics, the CoV is under 2% for all statistics. This means the variation of these statistics is acceptable. Overall it is concluded that the PM model is stable.

8 Model Calibration

8.1 Calibration Criteria

Model calibration is necessary to ensure that a model accurately represents an existing traffic situation and can be used with confidence to test alternatives. All data collected for calibration was used to calibrate the model, no independent data has been used for validation. Model calibration for this model has been based on the following:

- **Vehicle Behaviour**: Undertaking a visual check to confirm the observed on-street vehicle behaviour is consistent with that observed in the model;
- **Turn Counts**: Comparing observed and modelled turning movements for general traffic over both the modelled peak hour periods and the full modelled periods;
- **Link Counts**: Comparing observed and modelled link counts for general traffic over the modelled peak hour periods and the full modelled periods;
- **Journey Times**: Comparing surveyed and modelled journey times along strategic routes over the modelled periods;
- **Queue Lengths**: Undertaking a visual check to confirm the modelled queue operation is consistent with those observed on site and reinforcing this by comparing queue length statistics at key intersection approaches.

Two sets of criteria, recommended by different sources, have been referenced to assess the acceptability of the level of calibration achieved in the model. These are presented in full in the following two tables.

Criteria and Measures	Calibration Acceptance Targets
Individual Link Flows	
Within 15%, for 700 veh/h<Flow<2700 veh/h	>85% of cases
Within 100 veh/h, for Flow<700 veh/h	>85 of cases
Within 400 veh/h, for Flow>2700 veh/h	>85% of cases
Sum of All Link Flows	Within 5% of sum of all link counts
GEH Statistic < 5 for Individual Link Flows*	>85% of cases
GEH Statistic for Sum of All Link Flows	GEH<4 for sum of all link counts
Travel Times, Model Verses Observed	
Within 15% (or 1 min, if higher)	>85% of cases

Table 7 - US Department of Transport 'Traffic Analysis Toolbox Volume III: Guidelines for Applying Traffic Micro-simulation Modelling Software'

Criteria and Measures	Calibration Acceptance Targets
Hourly Link Flow, Modelled Verses Observed	
Individual Link Volumes	+ 20%
Screenline Volumes	+ 10%
R2 value for modelled versus observed flows for all individual links	>0.85
R2 value for modelled versus observed flows for all screenlines	>0.85
GEH statistic < 5.0 for individual link flows	>60% of cases
GEH statistic < 10.0 for individual link flows	>95% of cases
GEH statistic < 12.0 for individual link flows	100% of cases
GEH statistic < 4.0 for screenline flows	Most cases
Root-Mean-Square Error (RMSE) for entire network	<30%
Vehicle Kilometres Travelled (VKT)	
Modelled VKT	Within 5% of Observed
Intersection Flows and Delays	
Modelled Turning Flows	Within 30% of Observed

Table 8 - New Zealand Transport Agency (NZTA), Economic Evaluation Manual (EEM)

Detailed comparisons between observed and modelled calibration statistics are presented in the following chapters. Where applicable the results reference the criteria as set out in the NZTA EEM. The majority of measures in the above tables have been used for calibration; however some have not due to their non-applicability to the corridor model. The overall performance of the model, against each set of criteria used for calibration, is presented in summary at the end of this chapter.

8.2 Turn Count Calibration

The following sections compare the observed and modelled turn counts for each peak hour period, by organising the observed counts into volume ranges. This allows the data to be assessed with more emphasis placed on the higher volume movements. The comparison includes averaged modelled results from all five runs. Graphical comparisons are also presented for each period for both the peak and full modelled periods.

NZTAs' guidelines recommend modelled link flows to be within 30% of observed values.

8.2.1 AM Peak Turn Count Comparisons

The following table shows the results achieved from comparing the observed and modelled count for each individual link with a survey target during the peak AM hour 0800-0900. The turns have been organised into ranges by their observed count.

Criteria and Measures	Flow Bracket	Peak Hour Period (0800-0900)	
		% Meeting Criteria	Number Meeting Criteria
Modelled Turning Flows +/- 30%	flows <99 vph	59%	49 of 84
	100-199 vph	89%	8 of 9
	200-499 vph	67%	12 of 18
	500-999 vph	100%	11 of 11
	flows >1,000 vph	100%	5 of 5
	All	67%	85 of 126

Table 9 – AM Peak Hour (0800-0900) Observed Verse Modelled Turn Counts

The table illustrates that in the higher volume ranges (>500 vph), 100% of the modelled turning counts are within 30% of the observed volume. Within the 200-499 vph range, there are a number of turn flows outside the 30% criteria. This is a result of survey data smoothing, as discussed in section 5.4 of this report. Note, in these cases the model counts are higher than the observed, as expected and as shown in the following graphs.

The following graphs show a plot of observed counts against modelled counts for the AM peak hour and full peak period respectively. The graphs also present the 30% variation envelope, which is NZTA's recommended range of target calibration for turn counts.

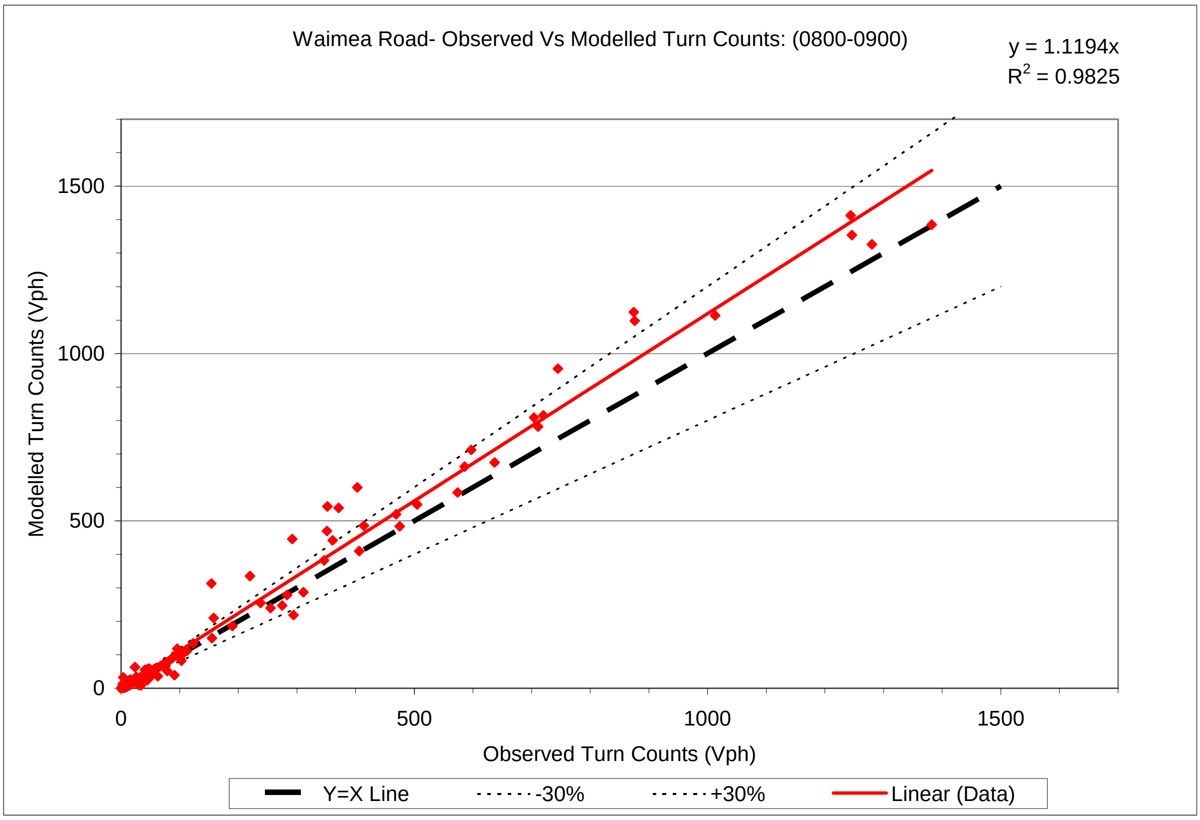

Figure 6 - AM Peak Hour (0800-0900) Observed Verse Modelled Turn Counts

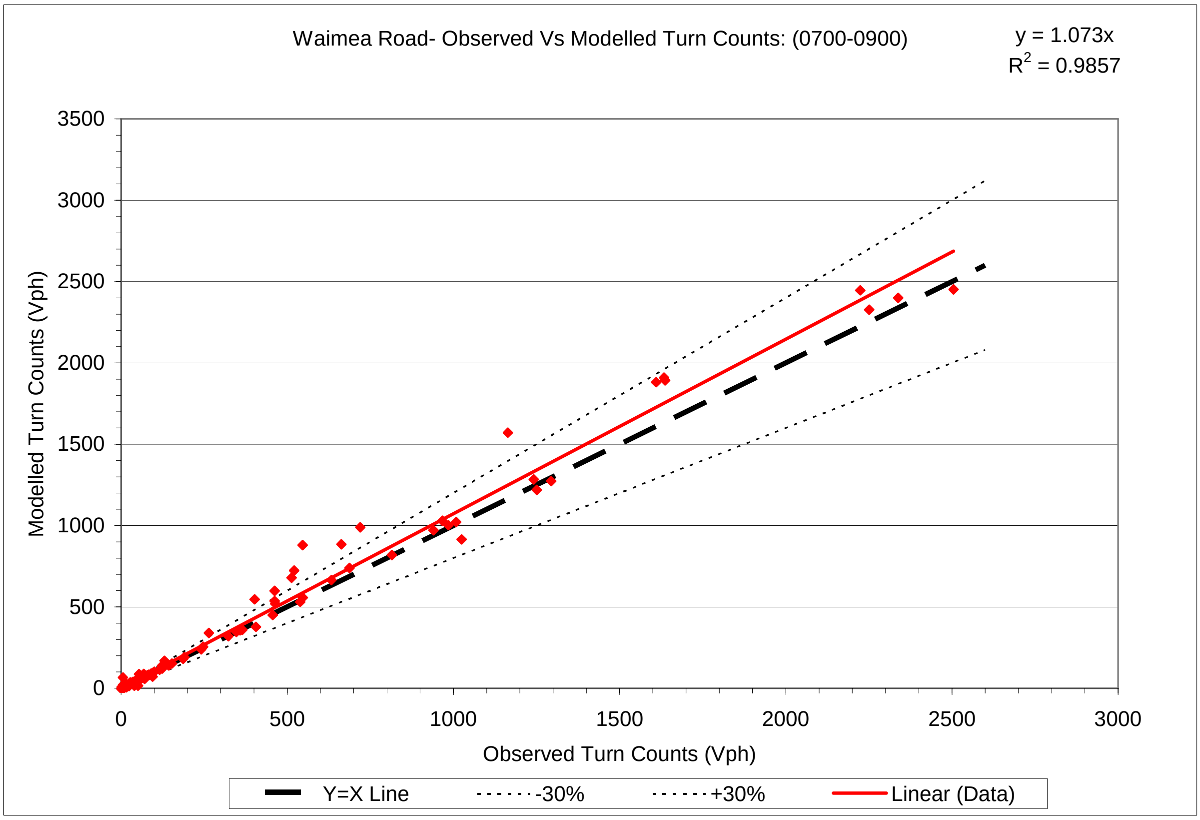

Figure 7 - AM Full Peak (0700-0900) Observed Verse Modelled Turn Counts

The graphs illustrate a generally good correlation between observed and modelled counts for both the peak hour and full period, reinforced by the R2 value of 0.98 in both cases. In both graphs there are some instances where the modelled flows are greater than the observed by more than 30%. This is expected due to results of survey smoothing and is considered a conservative approach.

8.2.2 PM Peak Turn Count Comparisons

The following table shows the results achieved from comparing the observed and modelled count for each individual link with a survey target during the peak PM hour, 1630-1730. The turns have been organised into ranges by their observed count.

Criteria and Measures	Flow Bracket	Peak Hour Period (0800-0900)	
		% Meeting Criteria	Number Meeting Criteria
Modelled Turning Flows +/- 30%	flows <99 vph	57%	43 of 83
	100-199 vph	100%	8 of 8
	200-499 vph	93%	14 of 15
	500-999 vph	100%	14 of 14
	flows >1,000 vph	100%	8 of 8
	All	67%	91 of 128

Table 10 – PM Peak Hour (1630-1730) Observed Verse Modelled Turn Counts

The table illustrates that in the higher volume ranges (>500 vph), 100% of the modelled turning counts are within 30% of the observed volume.

The following graphs show a plot of observed counts against modelled counts for the PM peak hour and full peak period respectively. The graphs also present the 30% variation envelope, which is NZTA's recommended range of target calibration for turn counts.

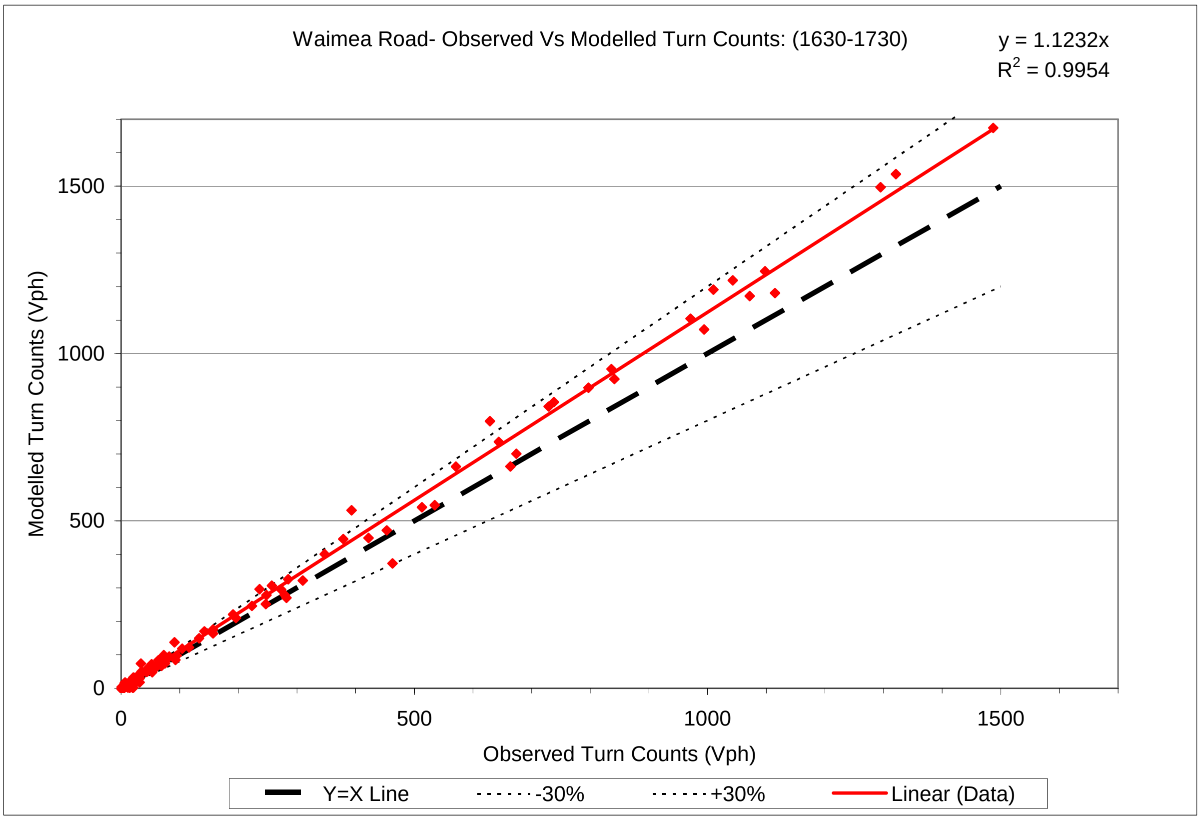

Figure 8 - PM Peak Hour (1630-1730) Observed Verse Modelled Turn Counts

Figure 9 - PM Full Peak (1530-1730) Observed Verse Modelled Turn Counts

The graphs illustrate a good correlation between observed and modelled counts for both the peak hour and full period, reinforced by the R2 value of 0.99 in both cases. In both graphs the modelled flows are generally greater than the observed, although by less than 30%. This is expected due to results of survey smoothing and is considered a conservative approach.

8.3 Link Count Calibration

Link counts have been compared based on approach link flows at intersections. That is, the same set of data used for turn count comparisons.

The following sections compare the observed and modelled link counts for each peak hour period, by organising the observed counts into volume ranges. This allows the data to be assessed with more emphasis placed on the higher volume movements. The comparison includes averaged modelled results from all five runs. Graphical comparisons are also presented for each peak hour and full peak periods.

NZTAs' guidelines recommend modelled link flows to be within 20% of observed values, with a minimum R2 of 0.85 and a GEH less than 12 for all cases.

8.3.1 AM Peak Hour Link Count Comparisons

The following table shows the results achieved from comparing the observed and modelled count for each individual link with a survey target during the AM peak hour period, 0800-0900. The links have been organised into ranges by their observed count.

Criteria and Measures	Calibration Acceptance Targets	Flow Bracket	% Meeting Criteria
Individual Link Volumes +/- 20%	100% of cases	<99 vph	60%
		100-199 vph	100%
		200-499 vph	67%
		500-999 vph	71%
		>1,000 vph	80%
		All	71%
R2 for modelled versus observed flows for all individual links	>0.85		R2 = 0.96
GEH statistic < 5.0 for individual link flows	>60% of cases		80%
GEH statistic < 10.0 for individual link flows	>95% of cases		96%
GEH statistic < 12.0 for individual link flows	100% of cases		100%

Table 11 - AM Peak Hour (0800-0900) Observed Verse Modelled Link Counts

The table illustrates that in the medium and higher volume ranges (>100 vph) the majority of modelled link counts are within 20% of the observed volume. It also shows all GEH statistics are within acceptable limits.

The following graphs show a plot of observed counts against modelled counts for the AM peak hour and full peak period respectively. The graphs also present the 20% variation envelope, which is NZTA's recommended range of target calibration for link counts.

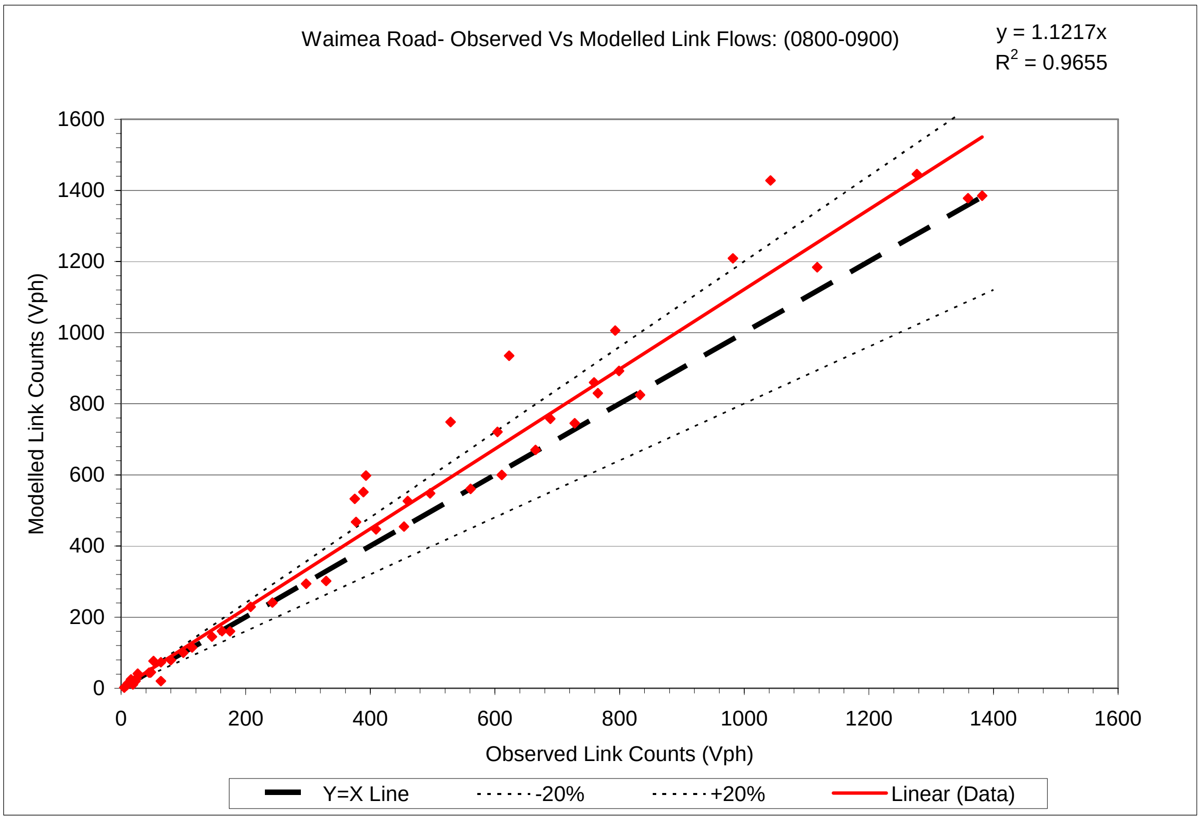

Figure 10 – AM Peak Hour (0800-0900) Observed Verse Modelled Link Counts

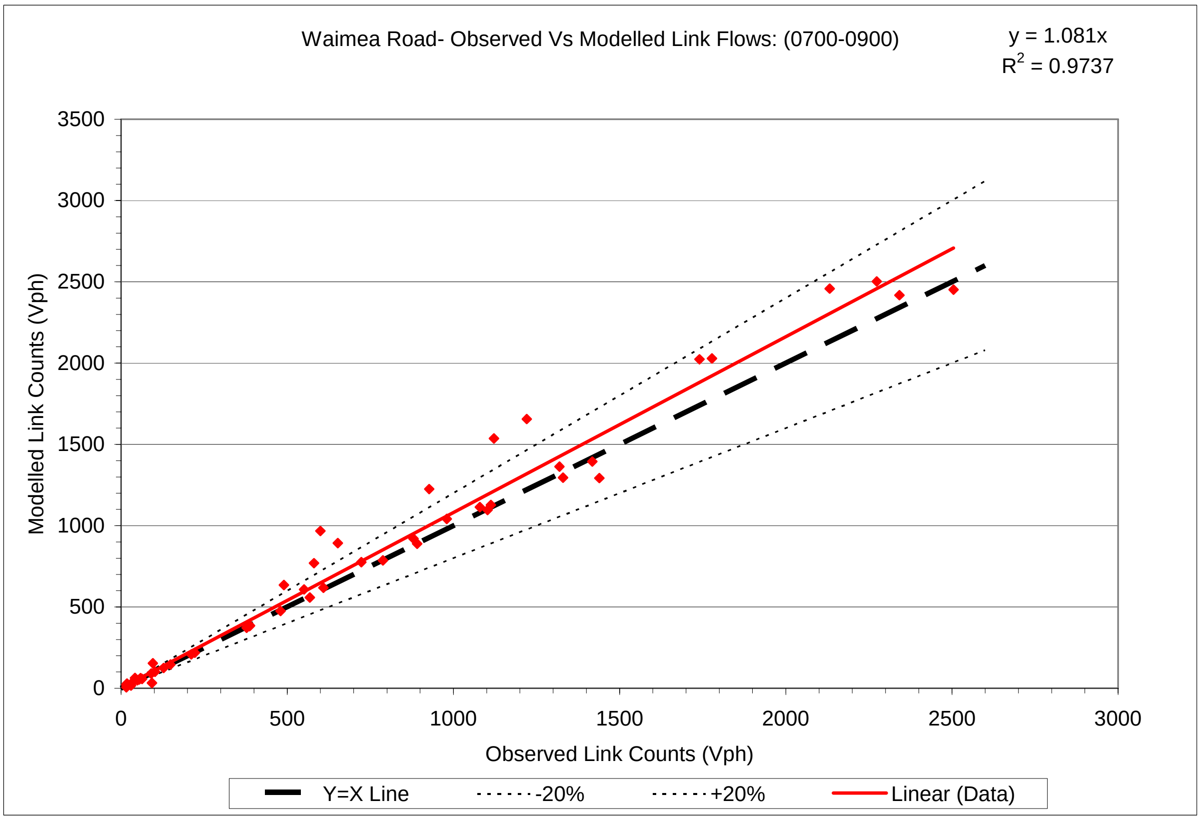

Figure 11 – AM Full Peak (0700-0900) Observed Verse Modelled Link Counts

The graphs illustrate a generally good correlation between observed and modelled link flows for both the peak hour and full period, reinforced by the R2 value of 0.96 and 0.97 respectively. In both graphs there are some instances where the modelled link flows are greater than the observed by more than 30%. This is expected due to results of survey smoothing and is considered a conservative approach. This result is consistent with the turn count calibration results.

8.3.2 PM Peak Hour Link Count Comparisons

The following table shows the results achieved from comparing the observed and modelled count for each individual link with a survey target during the AM peak hour period, 0800-0900. The links have been organised into ranges by their observed count.

Criteria and Measures	Calibration Acceptance Targets	Flow Bracket	% Meeting Criteria
Individual Link Volumes +/- 20%	100% of cases	<99 vph	64%
		100-199 vph	100%
		200-499 vph	88%
		500-999 vph	79%
		>1,000 vph	100%
		All	83%
R2 for modelled versus observed flows for all individual links	>0.85		R2 = 0.99
GEH statistic < 5.0 for individual link flows	>60% of cases		83%
GEH statistic < 10.0 for individual link flows	>95% of cases		100%
GEH statistic < 12.0 for individual link flows	100% of cases		100%

Table 12 - PM Peak Hour (1630-1730) Observed Verse Modelled Link Counts

The table illustrates that in the medium and higher volume ranges (>100 vph) the majority of modelled link counts are within 20% of the observed volume. It also shows that the GEH statistics are within acceptable limits.

The following graphs show a plot of observed counts against modelled counts for the PM peak hour and full peak period respectively. The graphs also present the 20% variation envelope, which is NZTA's recommended range of target calibration for link counts.

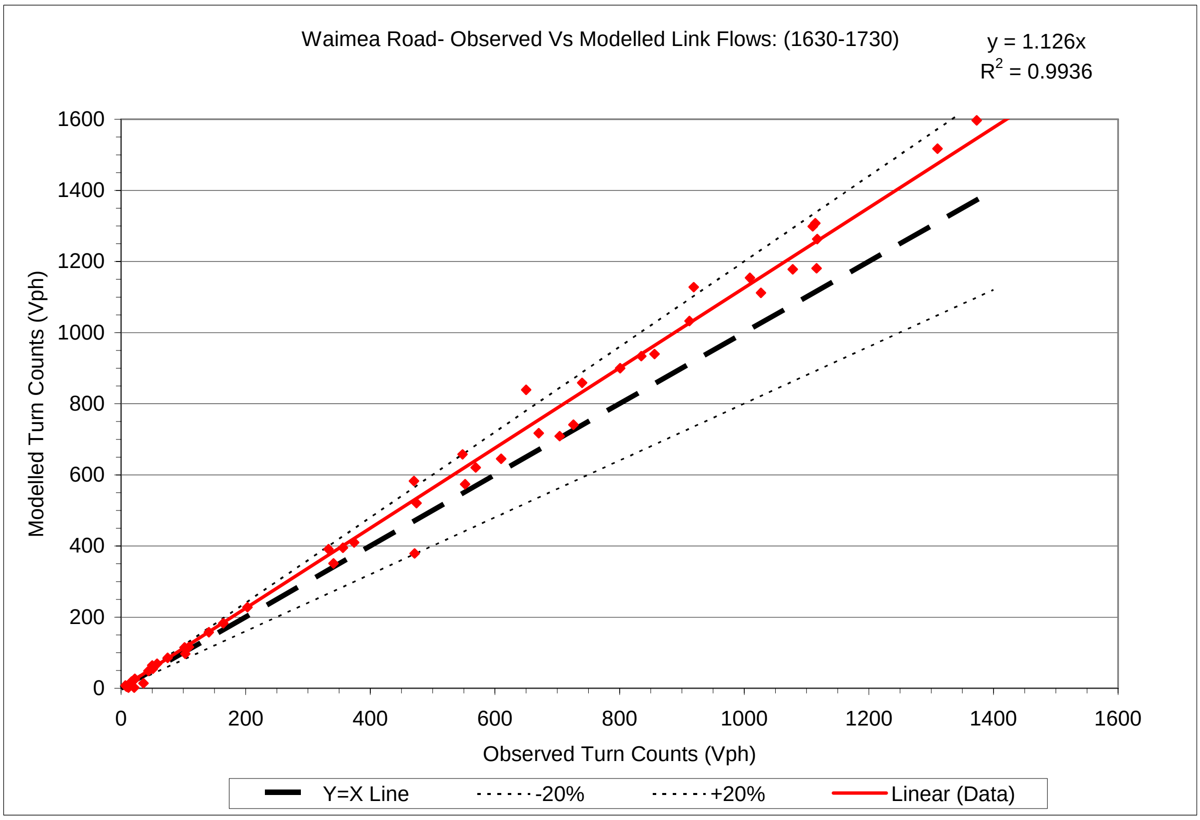

Figure 12 – PM Peak Hour (1630-1730) Observed Verse Modelled Link Counts

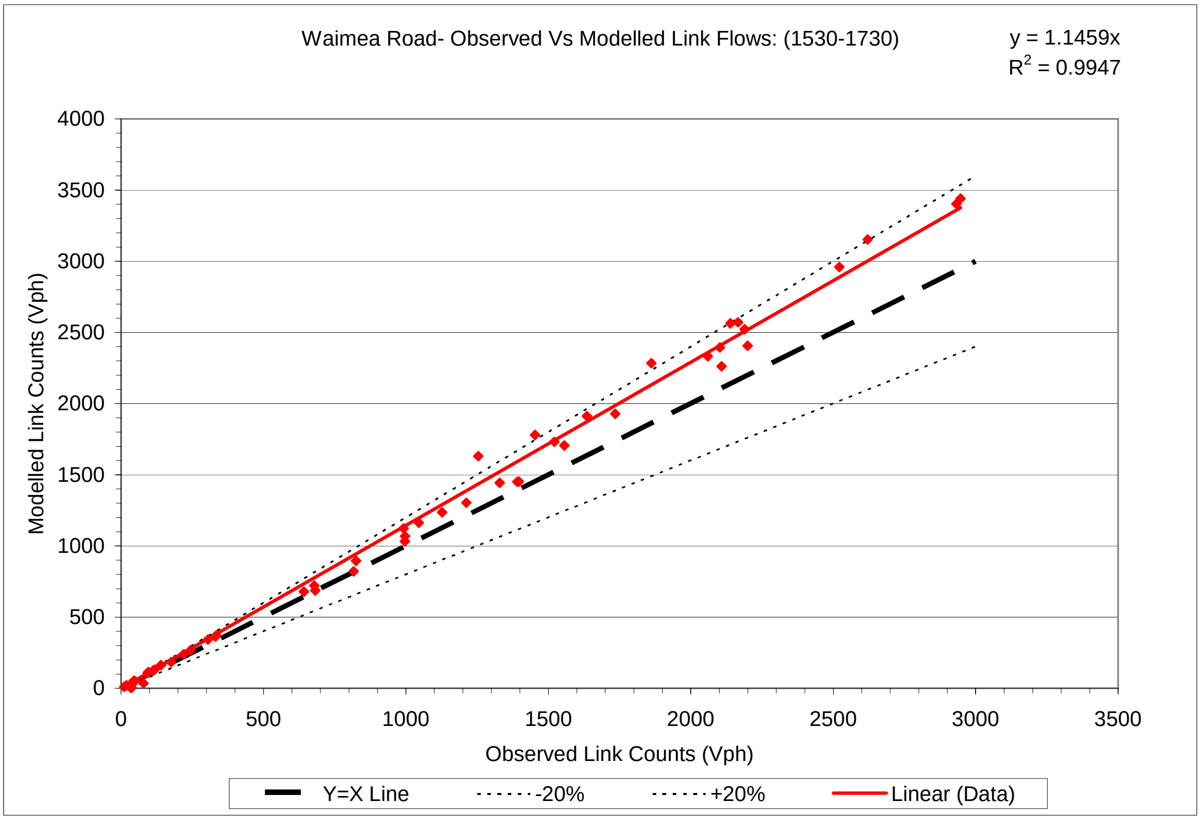

Figure 13 – PM Full Peak (1530-1730) Observed Verse Modelled Link Counts

The graphs illustrate a generally good correlation between observed and modelled counts for both the peak hour and full period, reinforced by the R2 value of 0.99 in both cases. In both graphs the modelled flows are greater than the observed, although by less than 20%. This is expected due to results of survey smoothing and is considered a conservative approach. This result is consistent with the turn count calibration results.

8.4 Journey Time Calibration

Journey time comparisons have been made for each modelled period, for the routes described earlier in this report in section 4.3.

The modelled journey times comprise the analysis of one vehicle, which has been modelled along the fixed journey route at the same time as the observed journey time. The modelled result of this single vehicle has been averaged over the five modelled runs.

NZTAs' guidelines do not provide any specific recommendation for calibration of Journey times. However, US Department of Transport recommend modelled journey times should be within 15%, or 1 minute if higher, for 85% of cases.

Journey time profiles have been constructed for each route direction and journey trip. However, only the significant journey profiles have been included in this report.

8.4.1 AM Peak Travel Time Comparisons

The observed and modelled journey times in the table below are presented for the AM model.

Route Name	Calibration Acceptance Target	No. Meeting Criteria	% Meeting Criteria	Observed Avg (Mins)	Modelled Avg (Mins)	% Diff
Northbound Waimea to Nelson	85% cases within 15% or 1 minute	11 of 12	92%	6.34	5.91	7%
Southbound Waimea to Nelson	85% cases within 15% or 1 minute	12 of 12	100%	6.02	5.55	8%

Table 13 – 0700-0900 Travel Time Calibration

The table illustrates that 100 of the southbound and 80% of the northbound modelled journey times for the AM period are within 15% or 1 minute of observed.

Southbound Journey Profiles

Southbound in the morning peak the flow is generally freeflow. An example of a calibrated period of freeflow is shown in the following figure, comparing the observed and modelled southbound journey times at 0715.

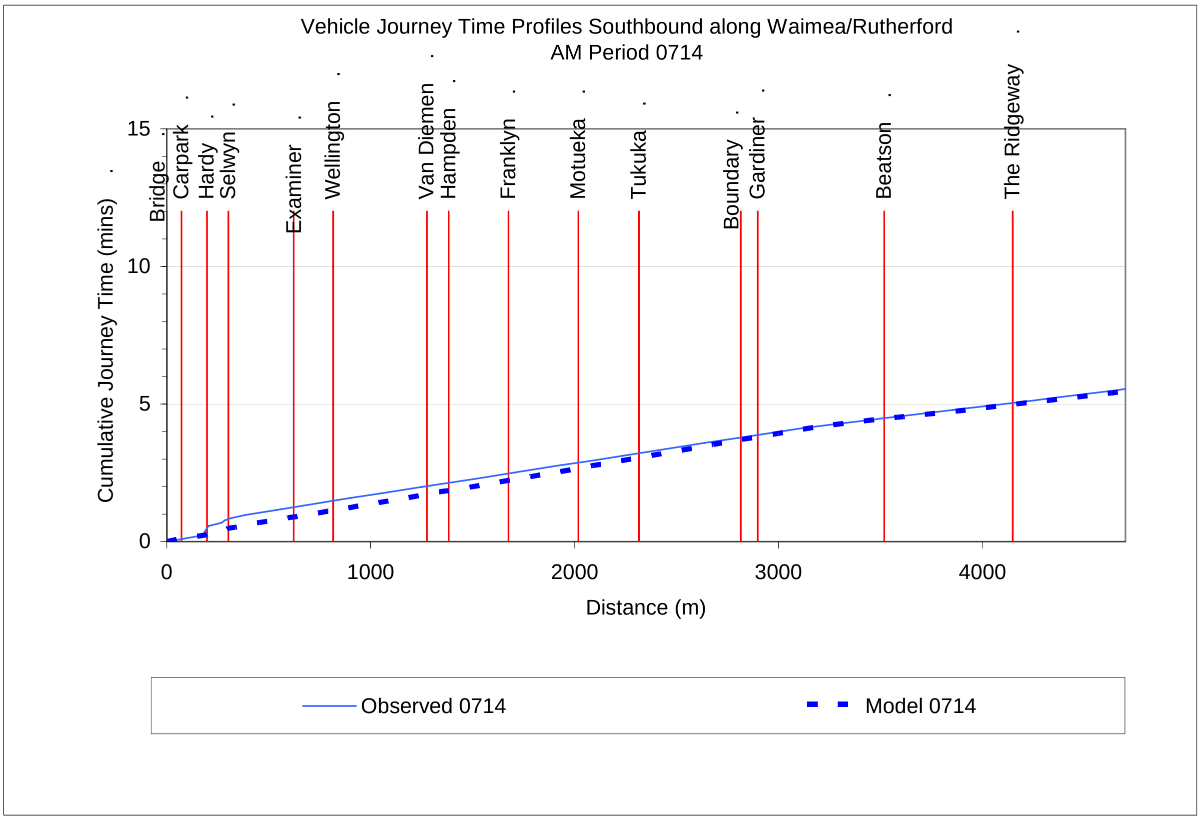

Figure 14 – Southbound Journey Profiles at 0715

The above figure shows good calibration throughout the southbound journey at 0715. This graph is similar to the other comparison southbound profiles developed during the AM period.

Northbound Journey Profiles

Northbound, the observed journey times show free flow till 0745, with a slight increase in travel times between 0745 and 0800, and further congestion between 0815 and 0845. Journey profiles representative of each of these periods is shown below.

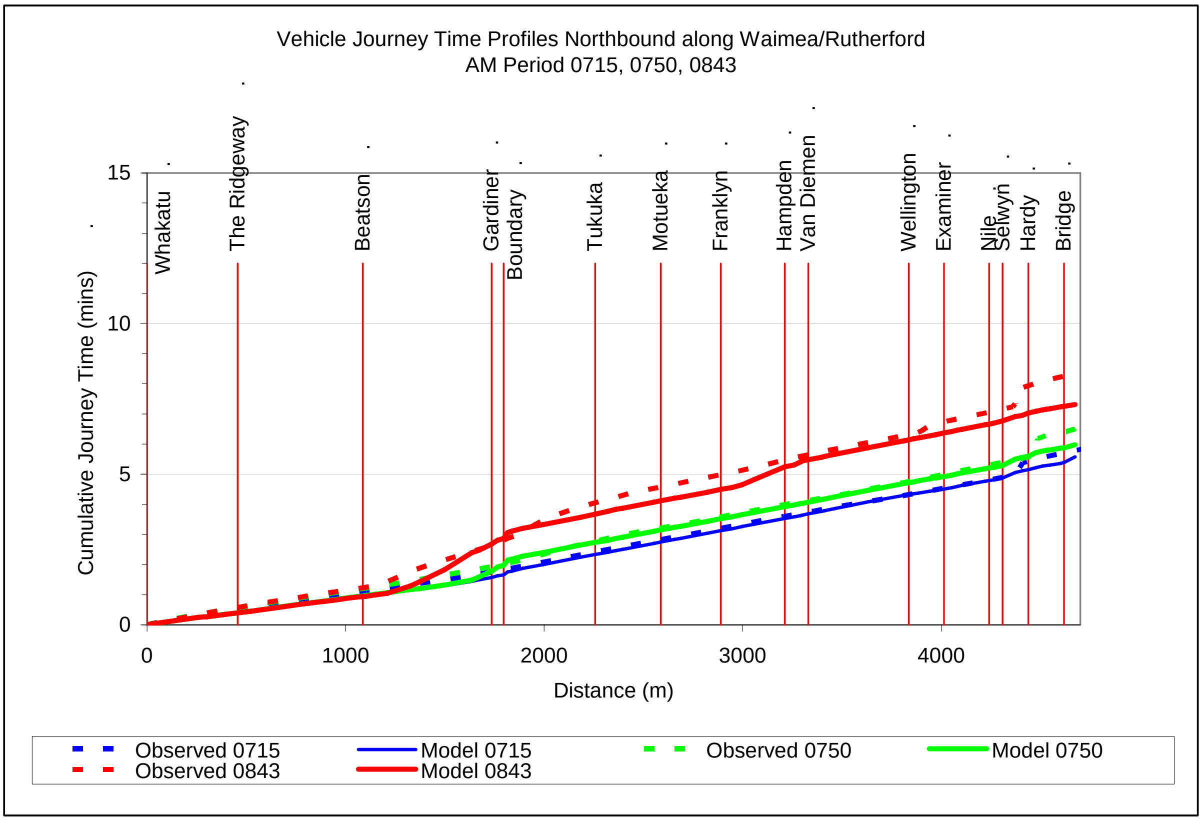

Figure 15 – Northbound Journey Profiles at 0715

The above graph shows at 750 and 843 the models do not display the same delay at Hardy St as the observed data. This is due to vehicles along the minor road (i.e. Hardy Street) not arriving in platoons as they would in reality, and hence less time is being given to the side streets by SCATS. This is a consequence of vehicles entering the network on the minor road from a zone and demand release profiles cannot be defined in less than five minute intervals. Furthermore, the modelled journey time comparison is of just one vehicle, hence it is dependant on whether the vehicle in the model has, by chance, had to stop at Hardy St on that particular journey.

With the exception of Hardy Street, the above figure shows good calibration throughout the northbound journey at 0715, 0750 and 0843.

8.4.2 PM Peak Travel Time Comparisons

The observed and modelled journey times in the table below are presented for the PM model.

Route Name	Calibration Acceptance Target	No. Meeting Criteria	% Meeting Criteria	Observed Avg (Mins)	Modelled Avg (Mins)	% Diff
Northbound Waimea to Nelson	85% cases within 15% or 1 minute	7 of 7	100%	6.24	5.77	8%
Southbound Waimea to Nelson	85% cases within 15% or 1 minute	11 of 12	92%	8.00	7.67	4%

Table 14 – 1400-1800 Travel Time Calibration

The table illustrates that 100% northbound and 92% southbound modelled journey times for the PM period are within 15% or 1 minute of observed.

Southbound Journey Profiles

Southbound in the evening peak, the main periods of congestion are between 1500 to 1530, and 1645 to 1730. Examples of calibrated periods during freeflow (1408) and the congested periods are shown in the following figures.

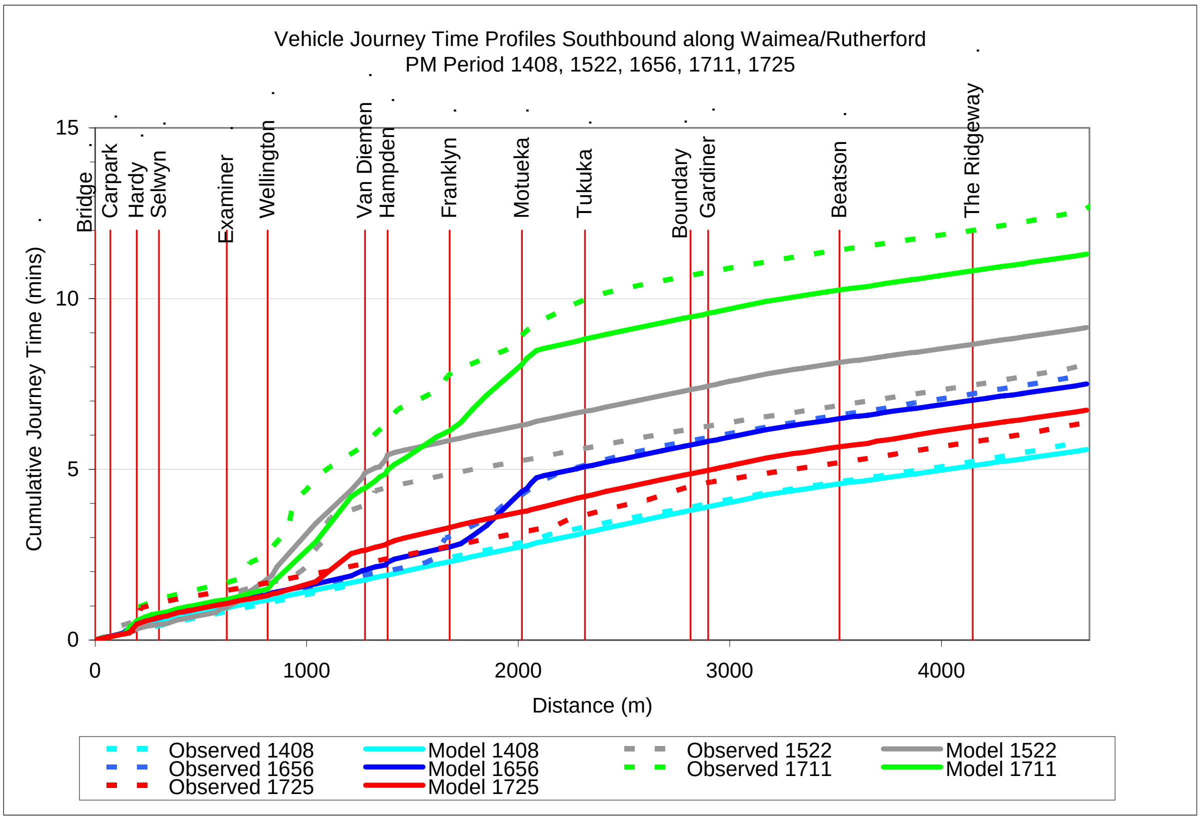

Figure 16 - Southbound Journey Profiles at 1408, 1522, 1656, 1711 and 1725

The above figure shows good calibration throughout the southbound journey at 1408, 1522, 1656, 1711 and 1725.

The 1711 profile shows the modelled journey speed decreases later in the model than reality. That is, the observed shows an increase in the profile commencing at Examiner Street but in the model this occurs closer to Wellington Street. However, the modelled journey time is within the 15% calibration recommendations and is consistent with the onsite observation that the queues southbound extend back to Wellington Street during the peak.

At 1522 the modelled journey time is greater than that observed, however, again it is within 15%. Furthermore, comparing model runs shows the journey times are quite variable as shown in the following figure.

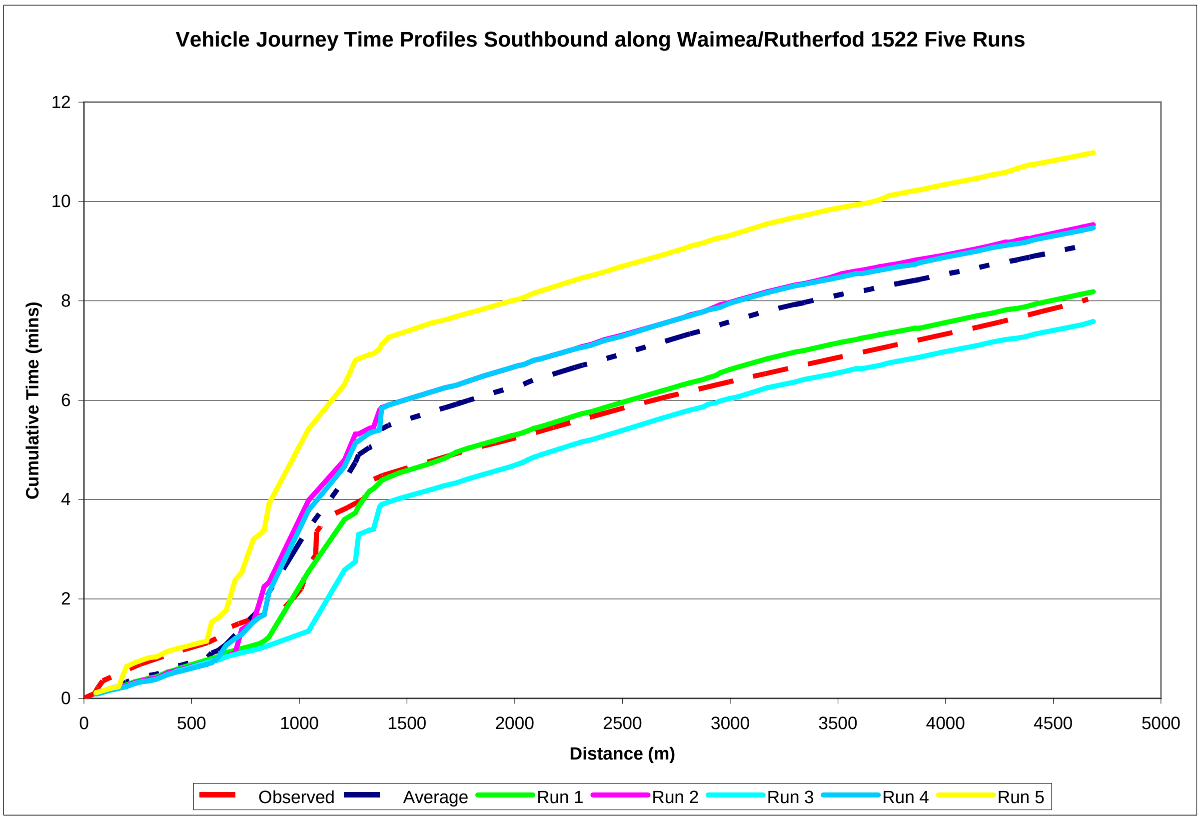

Figure 17 - Southbound Journey Profiles of Five Runs at 1522

Northbound Journey Profiles

Northbound in the evening peak, the flow is generally freeflow. An example of a calibrated period of freeflow is shown in the following figure, comparing the observed and modelled southbound journey times at 1416.

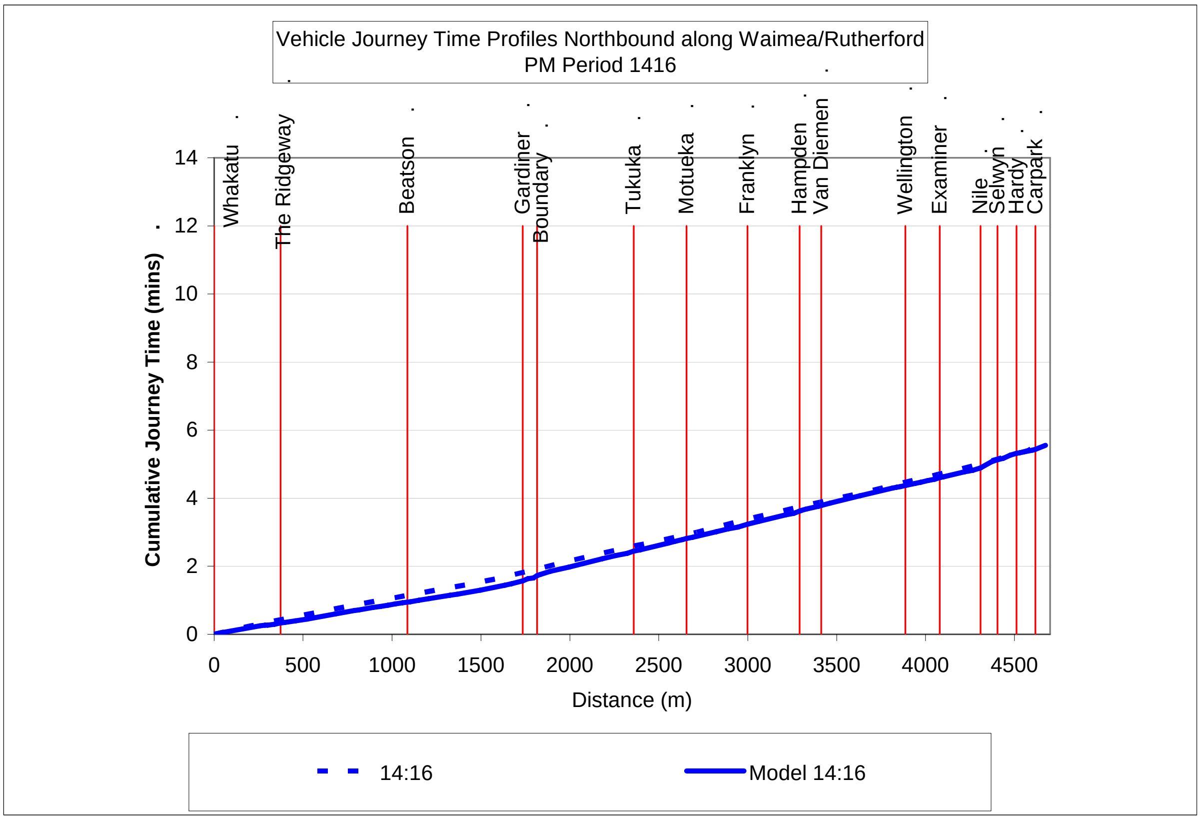

Figure 18 – Northbound Journey Profiles at 1416

The above figure shows good calibration throughout the northbound journey at 1416. This graph is similar to the other comparison northbound profiles developed during the AM period.

8.5 Queue Length Calibration

Queues were observed visually within S-Paramics over numerous model runs. In addition, comparisons have been made between observed queue length data and modelled queue length data.

Queuing is an inherently unstable phenomenon which can vary greatly from day to day. Queue measurements can be very subjective as the definition of what vehicles count as "queued" can differ between observers and between modelling packages.

Even though there are issues with queue variability, queue comparisons are still valuable and have been made between observed and modelled queue length data to ensure queue patterns are being appropriately represented in the model. Vehicle interactions and traffic flow characteristics were also checked visually and calibrated to match the observed on-site behaviour.

For this model, queue observations were made by TLD and baseplus staff throughout the survey periods and some queue data was collated by the surveyors during the survey process.

Queue comparisons have been made for both the morning and evening peak models for the significant modelled approaches. The comparison includes the modelled results from all five runs.

Note neither NZTAs' guidelines nor US Department of Transport provide detailed recommendations for modelled queue calibration.

8.5.1 AM Peak Queue Comparisons

The following figures display the observed five minute maximum queue range compared to the modelled maximum queue over five runs at the significant approaches of Whakatu/Waimea/Beatson roundabout and at Motueka Street west.

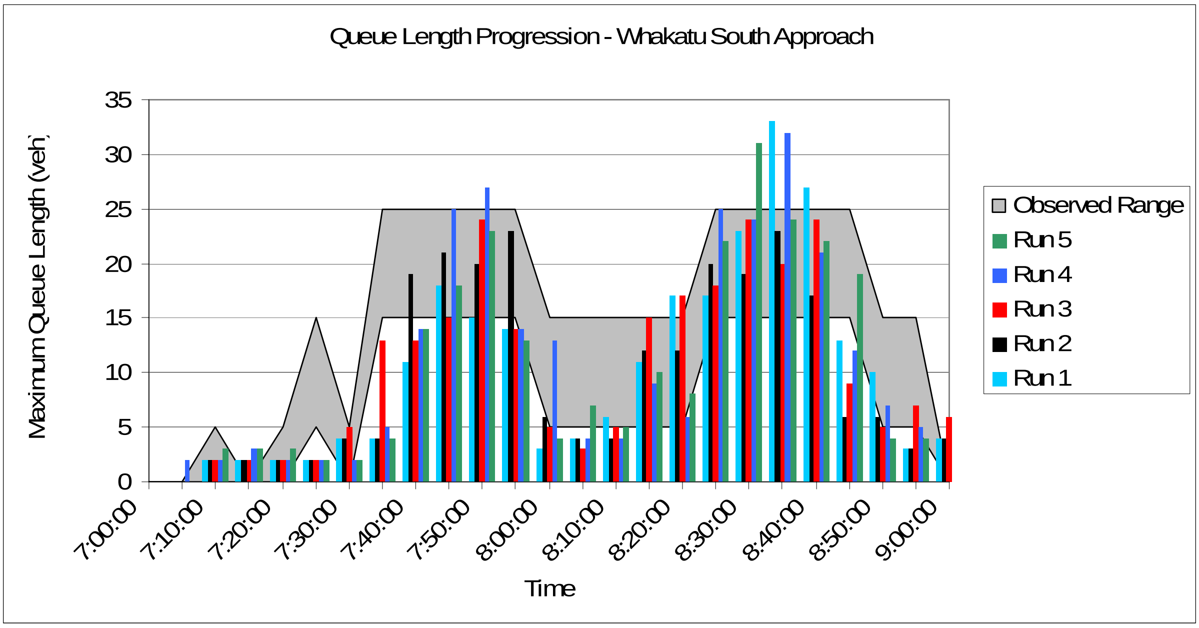

Figure 19 - Morning Peak Queue – Whakatu/Waimea/Beatson – Whakatu Approach

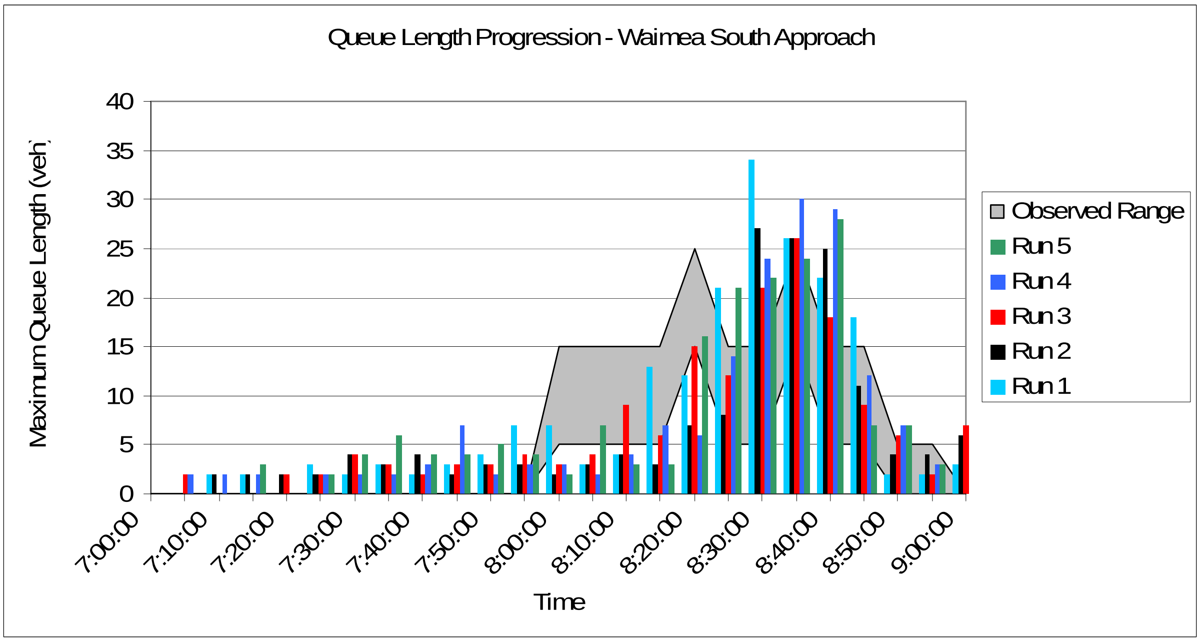

Figure 20 - Morning Peak Queue – Whakatu/Waimea/Beatson – Waimea Approach

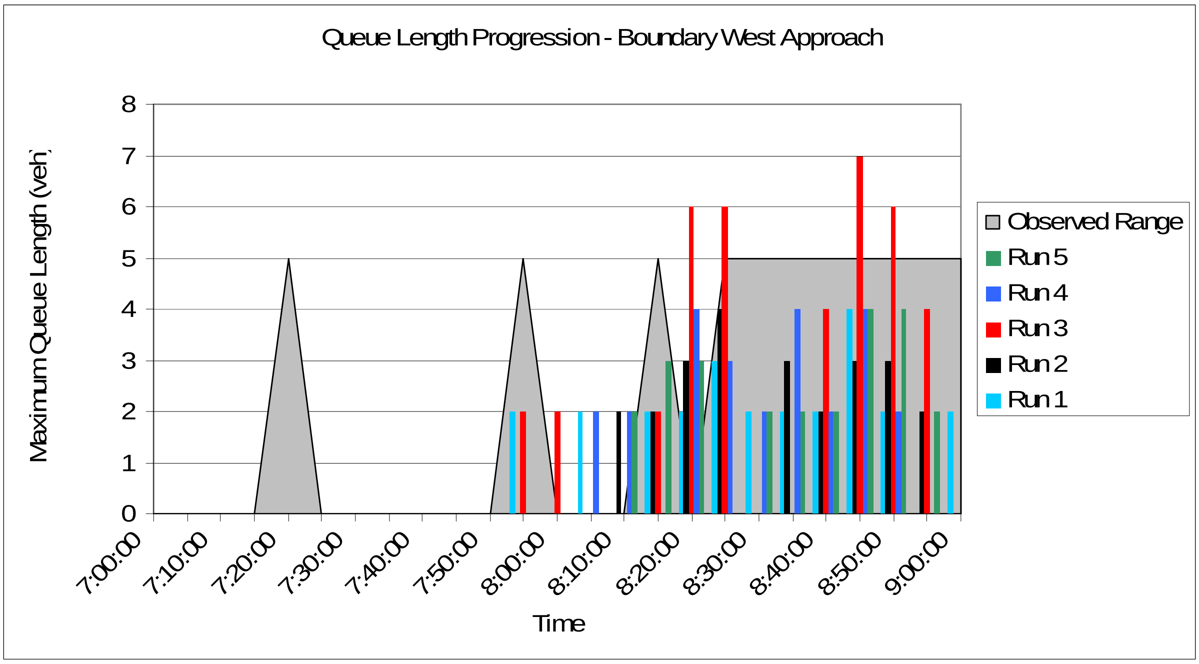

Figure 21 - Morning Peak Queue – Waimea/Boundary – Boundary Approach

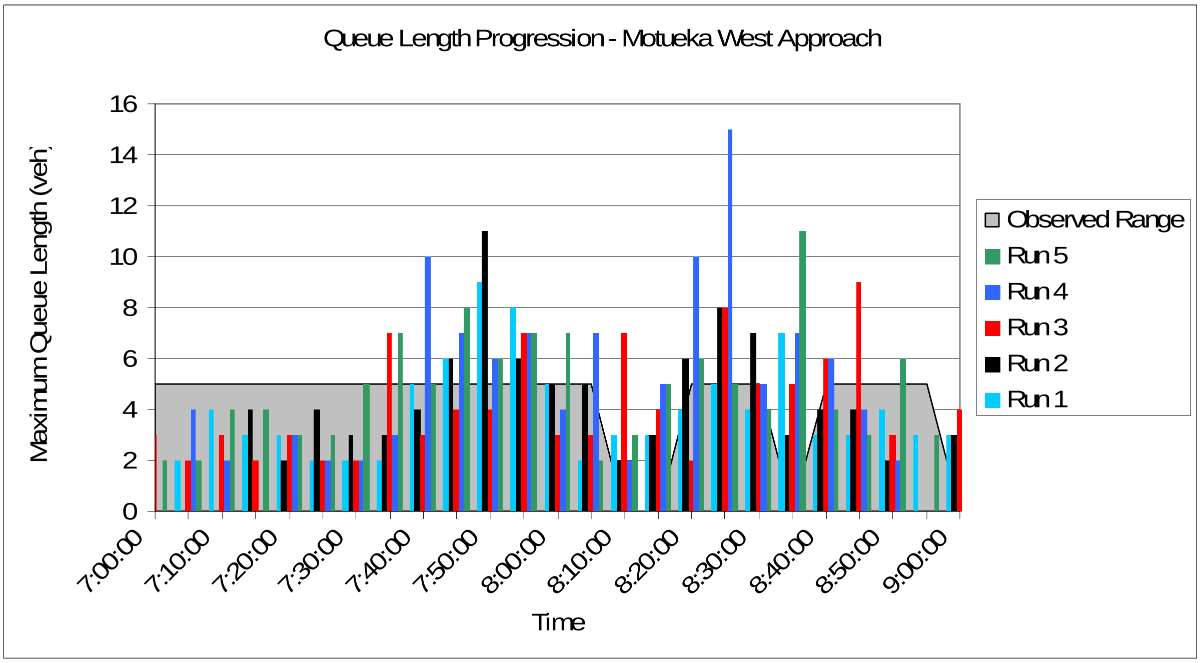

Figure 22 - Morning Peak Queue – Motueka/Waimea – Motueka Approach

Considering the volatility of queues, the above figures show good replicating of the queue propagations. Motueka Street West shows some peaks in the model which didn't appear in the observed data, however, on site observations from other days suggest that queue lengths up to ten vehicles are not uncommon at this site.

8.5.2 PM Peak Queue Comparisons

The following figures display the observed five minute maximum queue range compared to the modelled maximum queue over five runs at the significant approaches at Rutherford/Van Dieman and Motueka west. Note the observed queue data has only been collected from 1530.

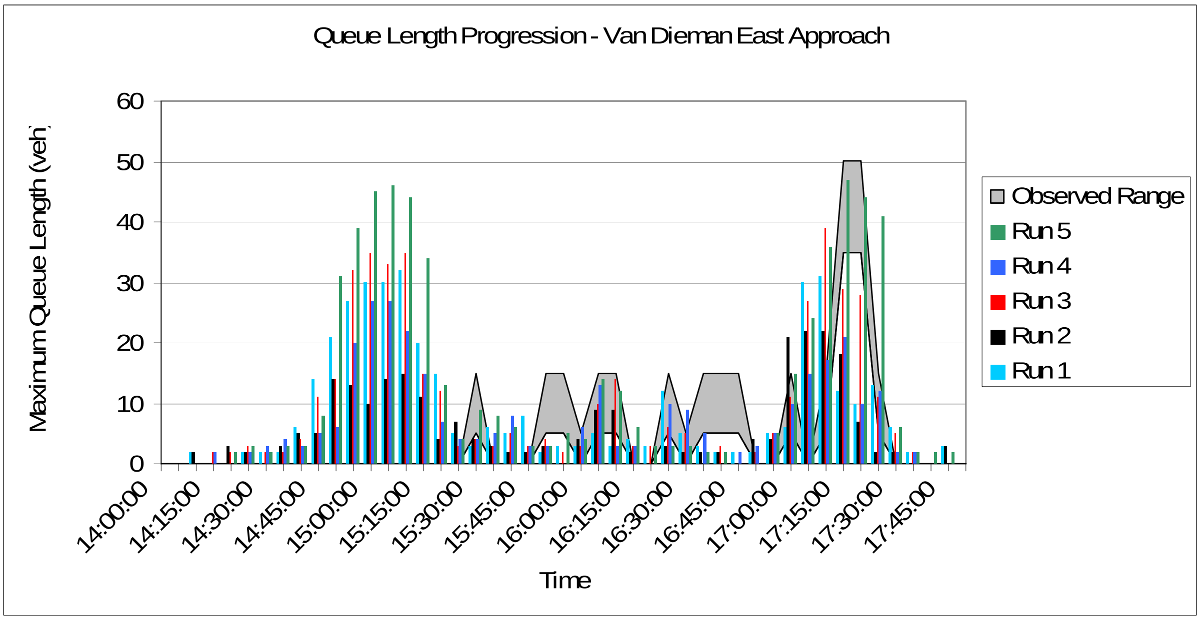

Figure 23 - Evening Peak Queue – Van Dieman/Rutherford – Van Dieman East Approach

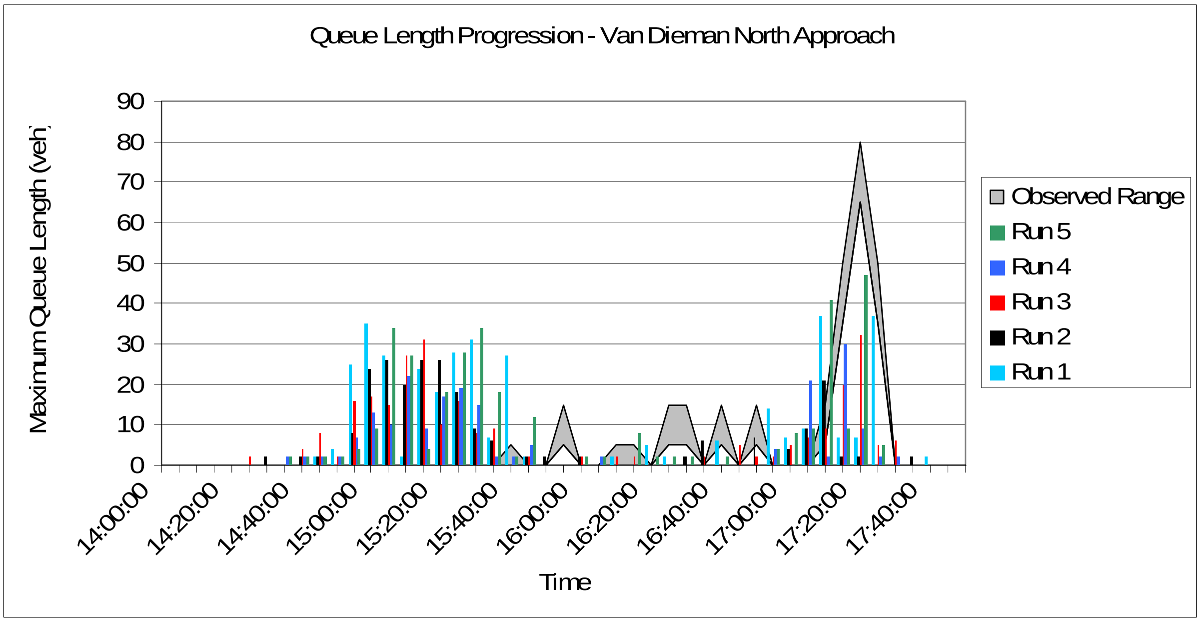

Figure 24 - Evening Peak Queue – Van Dieman/Rutherford – Rutherford North Approach

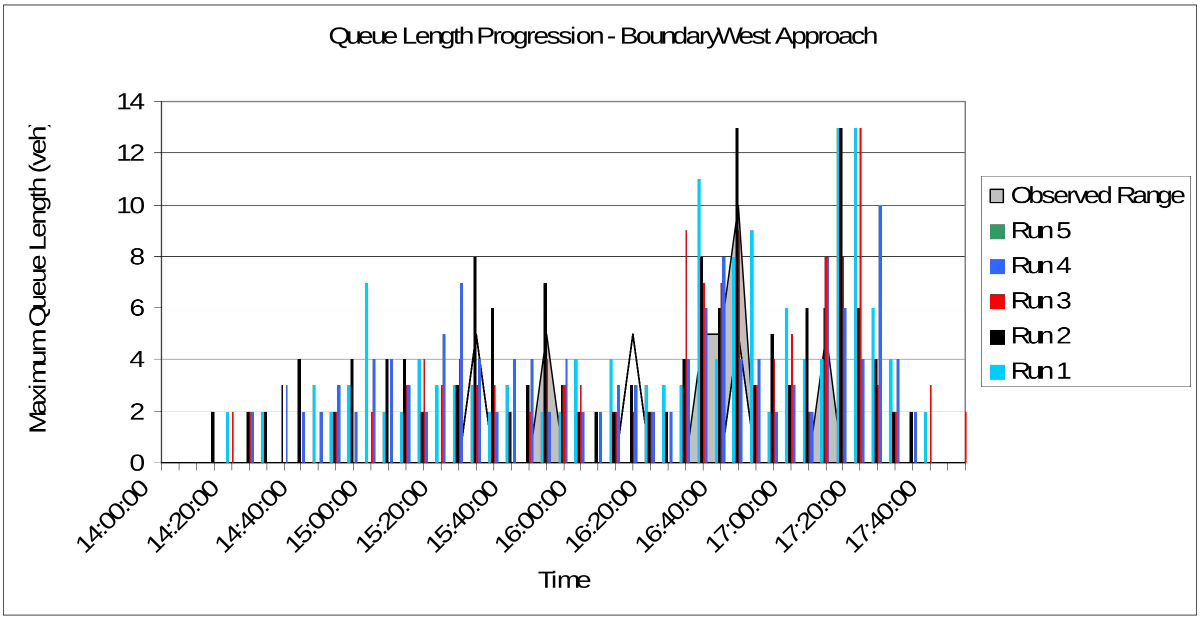

Figure 25 - Evening Peak Queue – Waimea/Boundary – Boundary West Approach

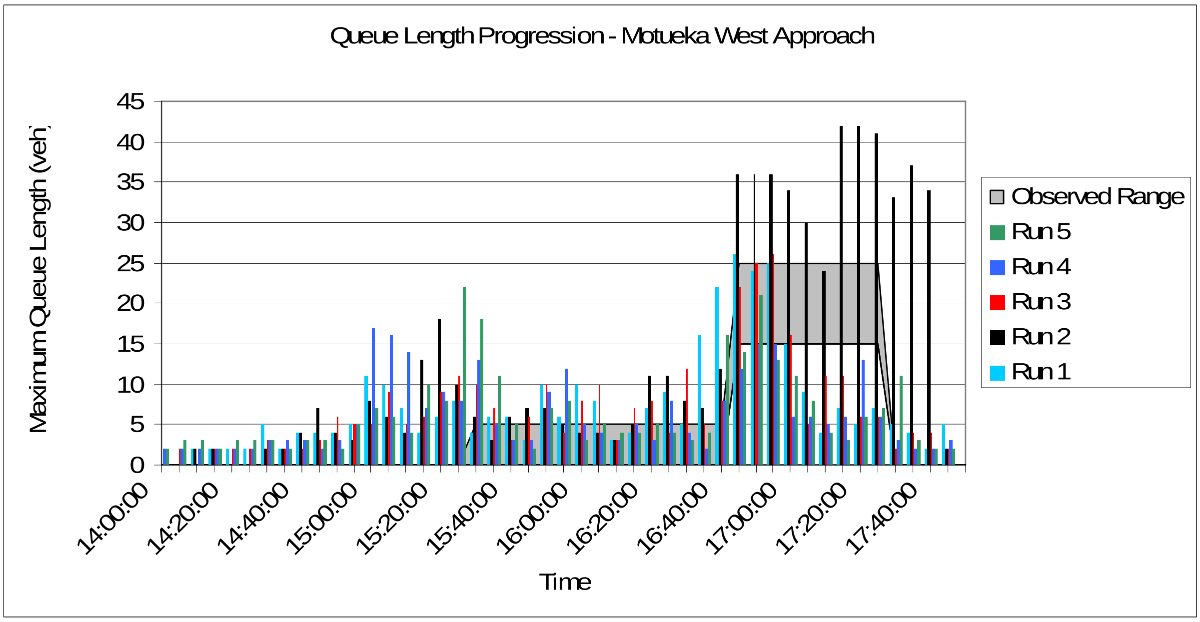

Figure 26 - Evening Peak Queue – Motueka/Waimea – Motueka Approach

The above figures confirm the volatility of queue lengths between model runs. Considering the volatility of queues, the above figures show good replication of the queue propagations.

8.6 Calibration Results Summary

Two sets of criteria, recommended by different sources, have been referenced to assess the acceptability of the level of calibration achieved in the model. These are presented in full in the following two tables.

In addition to the statistics referenced in the following two criteria sources, queue calibration has also been undertaken, as detailed in the previous section. In summary the queue comparisons showed:

- Observed queues are appropriately replicated by S Paramics and are representative of actual vehicle operation during each peak period

8.6.1 US Department of Transportation Criteria

The table below shows the criteria recommend by the US Department of Transportation with the results achieved during each period.

Criteria and Measures	Calibration Acceptance Targets	AM (Peak Hr)	PM (Peak Hr)
Individual Link Flows			
Within 15%, for 700 veh/h<Flow<2700 veh/h	>85% of cases	75%	68%
Within 100 veh/h, for Flow<700 veh/h	>85 of cases	85%	91%
Sum of All Link Flows	Within 5%	13%	12%
GEH < 5 for Individual Link Flows*	>85% of cases	82%	85%
GEH for Sum of All Link Flows	GEH<4	9	10
Travel Times, Model Verses Observed			
Within 15% (or 1 min, if higher)	>85% of cases	92% Nbd	100% Sbd
		100% Sbd	92% Sbd

Table 15 - US Department of Transport 'Traffic Analysis Toolbox Volume III: Guidelines for Applying Traffic Micro-simulation Modelling Software'

The above table illustrates the model meets most of the US Department of Transport criteria. In particular, the journey time calibration is sufficient with over 85% of journeys being within the criteria.

The majority of links have a GEH < 5, however the overall GEH and sum of all link flows is high. This is due to the models having a greater volume of traffic than observed.

However, the primary purposes of the model is to assess journey time through the Waimea Road corridor, including the assessment of bus lanes and assessment of signals at Motueka Rd and Boundary Rd. Therefore, given the acceptable level of calibration with the corridor journey times and queues at these significant intersections, the higher volumes of traffic in the model is not critical and is considered conservative.

8.6.2 New Zealand Transport Agency

The table below shows the criteria recommend by the NZTA EEM with the results achieved during each period.

Criteria and Measures	Calibration Acceptance Targets	AM	PM
Hourly Link Flow, Modelled Verses Observed			
Individual Link Volumes	+/- 20%	% links within 20%	
	flows >1,000 vph	60%	64%
	500-999 vph	100%	100%
	200-499 vph	67%	88%
	100-199 vph	71%	79%
	<99 vph	80%	100%
	All	71%	83%
R2 value for modelled versus observed flows for all individual links	>0.85	0.96	0.99
GEH statistic < 5.0 for individual link flows	>60% of cases	80%	83%
GEH statistic < 10.0 for individual link flows	>95% of cases	96%	100%
GEH statistic < 12.0 for individual link flows	100% of cases	100%	100%
Intersection Flows and Delays			
Modelled Turning Flows	+/- 20%		
	flows <99 vph	59%	57%
	100-199 vph	89%	100%
	200-499 vph	67%	93%
	500-999 vph	100%	100%
	flows >1,000 vph	100%	100%
	All	67%	71%

Table 16 – NZTA, Economic Evaluation Manual

The above table illustrates the model meets most of the NZTA criteria. In, particular all the GEH criteria are meet. For the turn flows and turn counts, which are not within the acceptance targets, the model has been conservative in modelling the counts higher than observed which is expected due to the survey smoothing that was required.

9 Summary and Conclusions

A traffic model for the Rutherford Street and Waimea Road corridor has been developed using S-Paramics simulation software version 2007.1 to model two periods 0700-0900 and 1400-0800, for a 2008 base year.

Statistical analysis shows that the modelled network and output results are stable.

Comparisons have been made between the following modelled and observed measures:

- Turn count
- Link counts
- Journey times
- Queues

Comparisons show the existing traffic conditions have been accurately represented by the models for both the peak hour and full model periods.

It is therefore considered that the Rutherford Street and Waimea Road corridor base models can be used for any traffic analysis constrained to the Rutherford Street and Waimea Road corridor.

If this model is to be used for analysis within the wider Nelson CBD area, further calibration and review would be required to ensure the corridor and CBD models merge appropriately.