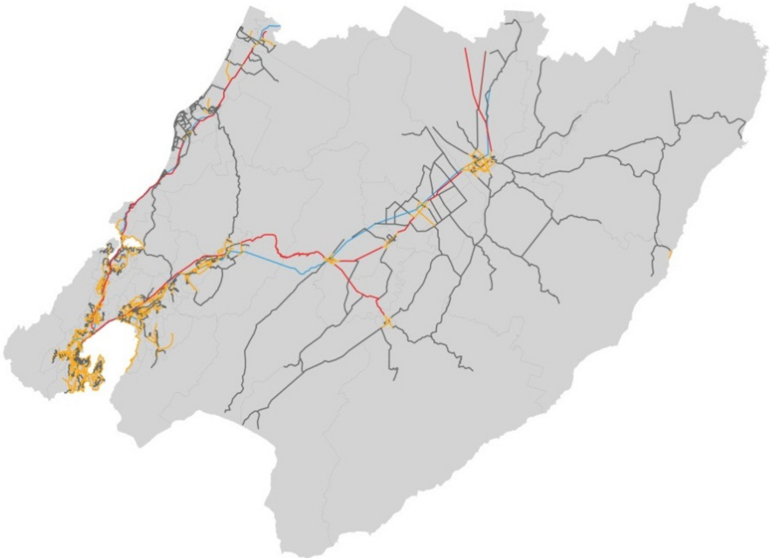
OPUS INTERNATIONAL CONSULTANTS AND ARUP

WELLINGTON TRANSPORT MODELS

Contract No C3079



Model Development Report

Date: December 2012

ARUP OPUS

Contract C3079
Wellington Transport Models Tender
WTSM update and WPTM development

ARUP

Wellington Transport Models

Model Development Report

Prepared By
Katie Levin / Andy Wilson / John Pell / Marius Roman
Transport Planners / EMME modellers

Reviewed By
Bruce Johnson / David Dunlop
Technical Leader / Project Manager

Opus International Consultants Limited
Wellington Office

Level 9, Majestic Centre, 100 Willis Street
PO Box 12003, Wellington 6144
New Zealand

Telephone: +64 4 471 7000
Facsimile: +64 4 471 1397

Date: December 2012
Reference: c3079 final development report 201212.docx
Status: Final
Revision:

Acknowledgements:

The WTSM and WPTM Project was developed in partnership between Greater Wellington Regional Council (GWRC), Opus International Consultants, Arup, and a number of other sub consultants working for GWRC. Sub consultants have been referenced in the documentation and provided inputs into the data collection, economic parameters, demographics and forecasting for the project.

The model documentation has been largely produced by Opus for WTSM and the general modelling system and Arup for WPTM, with inputs from GWRC and other sub consultants where appropriate.

John Bolland was appointed by GWRC as the independent peer reviewer and has been involved in the project from initial investigation through the sign off of the modelling system and the appropriate model documentation.

Executive Summary:

The GWRC carry out a core transportation planning and land-use function within the Wellington Region and the use of transportation modelling tools and projections is a mechanism to assist with strategic assessment, policy making decisions, monitoring and support the development of plans and projects.

The Opus and Arup team was appointed by GWRC in partnership with NZTA to update the current 2006 WTSM modelling system and develop a new public transport model (WPTM). This project was to be commissioned following the completion of the 2011 Census, however due to the Christchurch Earthquake this Census was postponed. Although the latest Census information was not available, GWRC and NZTA determined that the existing modelling system needed to be updated and a new passenger transport model created. This decision was based on a large number of significant transport projects being developed in the region and the importance of ensuring that these projects could be suitably assessed, they included:

- Wellington PT Spine Study;
- Wellington Regional Rail Plan;
- Wellington Bus Review; and
- The Wellington Northern Corridor Roads of National Significance (RoNS).

The 2006 WTSM model had limited PT capability and was not based upon detailed survey information, while the model itself also needed to be updated with current information and revised forecast projections.

GWRC determined that the WPTM would be created as an AM and Inter peak model with significantly more model definition than WTSM, this resulted in a 780 zone system which was linked to the 225 zone system utilised by WTSM.

The Project utilised an extensive data set collected for PT and vehicle travel between March and October 2011 and included; rail and bus surveys collected at stops, stations and on board; electronic ticket information; bus real time information; Wellington City cordon counts (all modes); vehicle loop counts; and journey time data. Information and data was utilised for demographics, forecasting and land-use projections.

The modelling system was developed and reported based upon a series of technical notes that were developed for key parts of the model development and project delivery. These include:

- TN1 Network Preparation
- TN2 Survey Sampling Methodology
- TN3 ETM Data Cleaning and Analysis
- TN5a Bus Intercept Survey Analysis
- TN5b Rail Intercept Survey Analysis
- TN6 WPTM Specification
- TN7 PT Matrix Development
- TN8 Airport Survey Methodology
- TN9 Airport Model WTSM (draft document and not part of the core package)
- TN13 Base Model Car Ownership
- TN15 Input Parameters
- TN16 WTSM and WPTM PT Assignment Comparison
- TN17 Validation Guidelines and Criteria - WTSM and WPTM
- TN18 WTSM Calibration and Validation
- TN19 WPTM Calibration and Validation and Addendum to TN19
- TN20 WPTM Forecasting

- TN21 Model User Guide and WTSM – WPTM Interface (live document and not part of the core package)
- TN22 WPTM Sensitivity Testing
- TN23 Future Year Base Networks and Services
- TN24 Baseline Forecasting Report
- TN29 Demographic Inputs to WTSM

Key features of the WTSM and WPTM project include:

- Network now covers all current PT links and bus stops;
- PT lines comprehensive update using General Transit Feed information;
- Intersection lane capacities within Wellington CBD linked to the Wellington Traffic Model;
- New assignment options in EMME;
- Amended HCV matrices;
- Consistency and compatibility between WTSM and WPTM;
- Updated economic forecasts and projections; and
- Updated demographic and forecast information.

An airport model has also been developed as part of the project, however due to timeframes and the very low PT demands from the Wellington Airport it was decided that the model would not form part of the validation process or core modelling system at this time.

WTSM has been successfully validated to a similar standard to other strategic 4 stage models nationally and internationally, resulting in a better level of validation than the 2001 model and a similar level to that of the 2006 model.

WPTM had significant data sources and was a new model; as a result the validation was extremely good when compared with other international models. The level of validation and model definition provides a robust tool for PT assessment, planning and decision making.

The modelling system has been designed so that WTSM can be used in isolation to WPTM or in parallel, allowing flexibility for the users and a level of detailed PT modelling which is significantly more robust to that experienced using WTSM in the past.

The model has been considered fit for purpose to be utilised for strategic assessment, transport planning and the extraction of demand matrices for more detailed project modelling for those key projects identified above. Other projects in the region should consider the suitability of the modelling system prior to utilising outputs.

During the model development process, the Opus and Arup team worked with a number of GWRC staff and trained them to use the modelling system. This approach aims to ensure a robust understanding of the modelling system, the models strengths and weaknesses, and ensure the Region has a resource in which to carry out assessment, planning and delivery of transport policy and projects during a significant time of change.

Contents

Acknowledgements: i

Executive Summary: ii

1 Introduction 1
- 1.1 Background 1
- 1.2 Project Brief and Objective 1
- 1.3 Structure of This Report 1

2 Design Investigation 3
- 2.1 Model Investigation Report 3
- 2.2 Airport Model Design 3
- 2.3 WPTM Model Design 4

3 Data Collection and Input Preparation 5
- 3.1 Network Inputs 5
- 3.2 Economic Research 6
- 3.3 Demographic Research and Land-use Inputs 6
- 3.4 Traffic Counts and Airport Occupancies 8
- 3.5 Bus and Rail Counts 9
- 3.6 PT Users Survey 10
- 3.7 Highway Journey Times Survey 12
- 3.8 Base Observed PT Matrices 12

4 Model Development, Calibration and Validation 14
- 4.1 Base WTSM Development 14
- 4.2 WTSM Base Model Calibration and Sensitivity Testing 15
- 4.3 Airport Model Calibration 16
- 4.4 WTSM Validation 17
- 4.5 WPTM Base Model Development 18
- 4.6 WPTM Base Model Calibration and Sensitivity Testing 19
- 4.7 2011 WPTM Validation 20
- 4.8 WTSM – WPTM Transit Assignment Comparison 23
- 4.9 WTSM – WPTM Interface 23

5 Model Forecasting 26
- 5.1 Future Baseline Networks and PT Services 26
- 5.2 Forecast Parameters 26
- 5.3 Demographic Forecasting 27
- 5.4 Future Baseline Model Runs and Analysis 28
- 5.5 WPTM Forecast Model Design 29

6 Conclusions and Recommendations: 30

1 Introduction

1.1 Background

Greater Wellington Regional Council (GWRC) has contracted the services of Opus International Consultants and Arup to rebase and validate the Wellington Transport Strategic Model (WTSM) and to complete the development of the Wellington Public Transport Model (WPTM). The project team worked in partnership with GWRC to complete this project, with significant input to the project being provided by GWRC staff and resources.

The postponement of the 2011 Census to March 2013 means that the full recalibration of WTSM will not be undertaken until a time after this update has been completed. Consequently, this update will focus on ensuring that WTSM / WPTM is capable of providing robust transport forecasting in the interim.

1.2 Project Brief and Objective

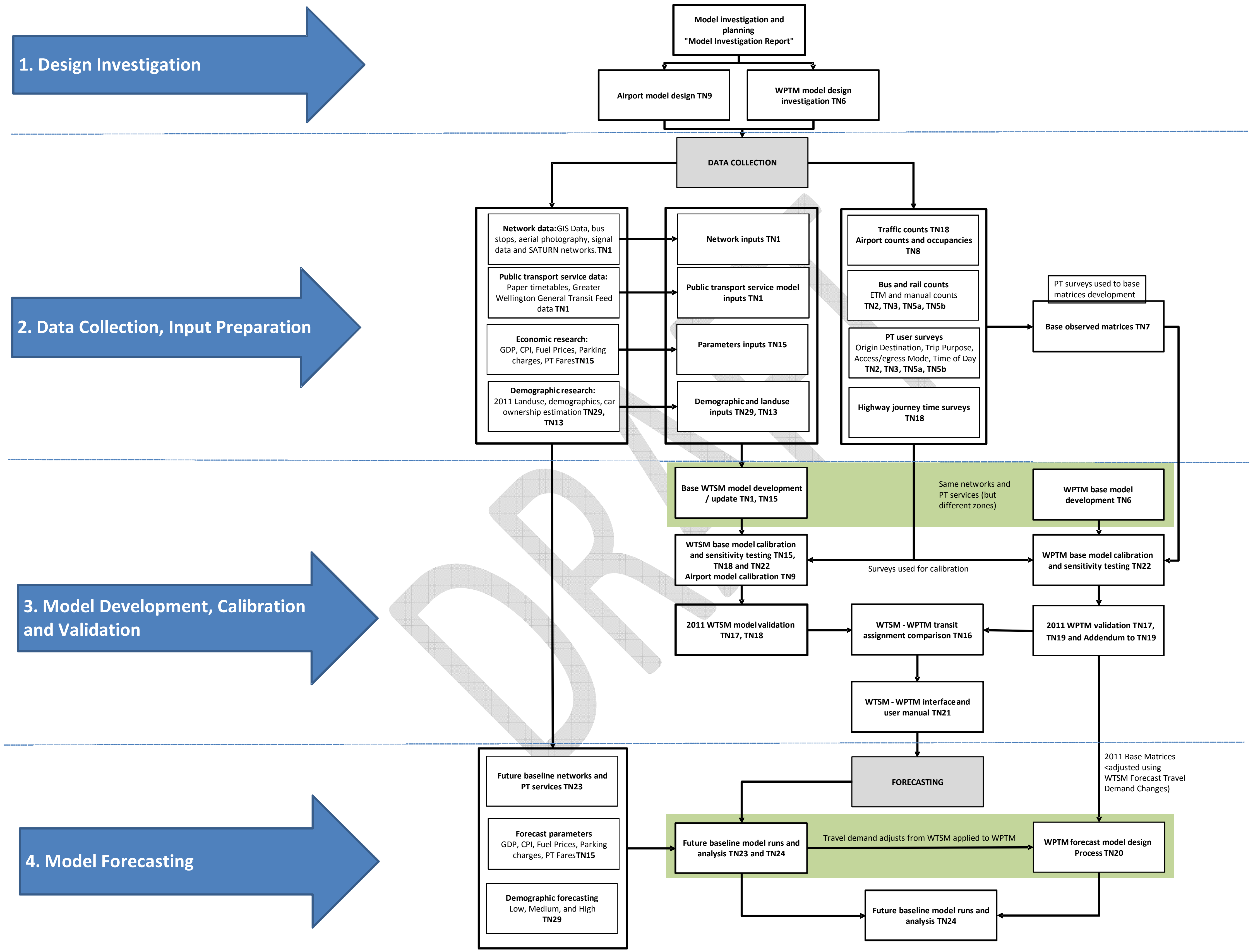
The overall objective of the project is to update the modelling tools maintained by GWRC to a 2011 base and develop enhanced predictive capabilities for public transport usage. The models are to be completed in a timely manner to provide the assessment platform for the Public Transport Spine Study (Railway Station to Regional Hospital) ("the Spine Study") and assist with other significant transportation projects in the Wellington Region such as the Wellington Bus Review and the Roads of National Significance (RoNS) project. This project will provide a modelling tool that is current and can better meet the needs of transport planning, public transport development and land-use integration in the region.

1.3 Structure of This Report

This report summarises the approach taken in the update of WTSM to 2011 and the development of the WPTM. It follows the flow chart in Figure 1-1 below which shows the process of each step and how they inter-relate and the technical note that relates to each of those steps. This report summarises those technical notes to provide an overview of the modelling process and should be read in conjunction with the technical notes that provide greater detail of the individual steps undertaken as part of the project.

The project process can be split in to four basic steps:

- Design Investigation;
- Data Collection and Input Preparation;
- Model Development, Calibration and Validation; and
- Model Forecasting.



Report and Technical Note Descriptions

Model Investigation Report
TN1 Network Preparation
TN2 Survey Sampling Methodology
TN3 ETM Data Cleaning and Analysis
TN5a Bus Intercept Survey Analysis
TN5b Rail Intercept Survey Analysis
TN6 WPTM Specification
TN7 Public Transport Matrix Development
TN8 Airport Survey Methodology
TN9 Airport Model WTSM*
TN13 Base Model Car Ownership
TN15 Input Parameters
TN16 WTSM and WPTM PT Assignment Comparison
TN17 Validation Guidelines and Criteria - WTSM and WPTM
TN18 WTSM Calibration and Validation
TN19 WPTM Calibration and Validation & Addendum to TN19
TN20 WPTM Forecasting
TN21 Model User Guide and WTSM – WPTM Interface*
TN22 WPTM Sensitivity Testing
TN23 Future Year Base Networks and Services
TN24 Baseline Forecasting Report
TN29 Demographic Inputs to WTSM
Model Development Report
* Indicates live document

Figure 1-1: Methodology Flow Chart and Technical Notes

2 Design Investigation

2.1 Model Investigation Report

The Model Investigation Report (MIR) describes the process of investigation of the existing models and documentation. It outlines the intended overall model design and the associated approach the project team planned to take to achieve the goals of the study. This MIR was prepared at the commencement of the project to:

- Document key findings from the consultant's review of the existing WTSM model;
- Set out the proposed structure of and functionality of the WTSM and WPTM models where there is certainty and to identify topics for further investigation where there is no certainty; and
- Form an agreed basis against which the delivery of the consultant services will be measured.

During the preparation of the Model Development Report it was agreed that Technical Notes would be prepared for each of the core technical aspects of model investigation, planning, documentation, and performance.

Further Documentation: *Ref Model Investigation Report*

2.2 Airport Model Design

The current version of WTSM models travel for trips associated with the airport in two distinct ways:

- For airport employee travel, trips are modelled as part of the general overall WTSM four step process where airport workers are part of the overall home based work travel demand segment in Wellington; and
- For air travellers a separate model process is used to generate and distribute the landside element of trips to/from the airport as an additional demand segment. This process derives car trips which are then added to the more general Wellington wide resident travel market car travel trips prior to the overall vehicle assignment process.

The current air traveller model represents the airport with car trips only. This needs updating to give a better representation of the trip and travel patterns associated with the airport and allow for the possibility of changes in modal share, or choice modelling, for such trips.

Survey of movements entering and exiting the airport has been undertaken to allow this update of the airport model to occur, as outlined in TN8. Additionally flight passenger information was collected.

Further Documentation: *Ref TN8 Airport Survey Methodology and TN9 Airport Model WTSM. TN9 has been submitted in draft form to GWRC who will integrate the Airport Model as they see fit. No final version will be completed as this would result in altering all other documentation completed to date.*

2.3 WPTM Model Design

Key features of the proposed structure and operation of WPTM are described below:

- The model time periods will be 0700-0900 (AM peak) and 2 hour average of 0900-1500 (Inter peak (IP)).
- Base public transport demand matrices will be developed from observed data sources: rail on-board surveys, rail boarding and alighting counts, bus on-board surveys, and bus ticket sales data.
- Total observed public transport travel between zones will be established by adding the observed bus and rail demand (and ferry and cable car if available).
- The role of WPTM is to divide out the total observed demand among the available PT modes, routes, stops and network access options.
- The validity of the model will be judged by assessing how well WPTM replicates the split of base demand between bus and rail modes, routes and stations.
- The demand will be segmented by trip purpose, car availability status and age (child/adult). This will enable differing public transport choice behaviours and values to be represented. For example, a person with no car available cannot choose park-and-ride.
- Growth in public transport demand, as population and employment grows and as the transport system changes, will be determined by linkages to the regional 4-stage model, WTSM.
- Demand growth rates will be extracted from WTSM and applied to the observed PT demand in WPTM by multiplication (demand factoring) or by addition. Greenfield development zones are a special case, for which a different approach is proposed.
- The access choice decision for rail – whether to walk to the station or to take the car (Park and Ride (P&R) or Kiss and Ride (K&R)) – will be determined using a logit choice model. The proposal was to operate a choice model in 'absolute' formulation. This means that the observed shares are used only to calibrate the model: in application mode, the choice model predicts the shares. This allows for us to forecast in completely new markets as well as forecasting changes in existing markets.
- For those who choose P&R or K&R, there will be a second layer of choice to divide demand between the best three access stations. The car-access PT trips are then assigned via the nominated station. For the calibration of the base model, P&R and K&R will only be possible via rail as the first boarding. After alighting from rail, they are free to continue their journey by any mode (or on foot).
- In application of the model, new 'formal' P&R sites served by bus or new modes such as light rail can also be modelled.
- For those who choose walk-access to PT, the stop or station chosen, and the mode and route boarded will be determined through assignment.
- Mode specific preferences for bus and rail (and future modes BRT and LRT) will be represented through differential boarding times and/or in-vehicle time weights, coded on the EMME network. These will be informed by practice elsewhere and refined through calibration.
- The mode-specific preferences will give WPTM sensitivity to quality differentials between rail, light rail, BRT and bus, including capability to estimate benefits of upgrading from bus to light rail for example.
- The car times and distances required to calculate utilities for P&R and K&R will be obtained from the corresponding WTSM run; public transport times and costs will be calculated within WPTM.

Further Documentation: *Ref TN6 WPTM Specification*

3 Data Collection and Input Preparation

3.1 Network Inputs

Unlike the 2006 WTSM update, where the previous (2001) model network was used as a base for the update, a new network has been developed for the 2011 update. This allowed much greater network coverage, more accurate link lengths and a model which captures all PT service routes.

Projects Driving Specifications for the Model Update Process

In the initial development of the network discussions revealed that immediate uses of the WTSM system (in addition to public transport studies) include continuing investigations of the Wellington Roads of National Significance (RoNS). WTSM has been the main source of highway travel demands used in project highway assignment models around the region for a number of years. These roading projects include:

- Wellington Inner-City Transport Improvements
- Aotea Quay to Ngauranga
- Linden to MacKays (Transmission Gully)
- Petone to Grenada
- Kapiti Expressway
- Peka Peka to Otaki

Aims of the Network and Transit Service Coding

The key goal for GWRC was to develop a regional public transport model of sufficient detail that it can be used to provide more refined assessment of improvements and changes in PT services. This translated into two core aims:

1. Increase confidence that forecast demand using specific corridors and services are more accurate => *operational planning*; and

2. Increase confidence that forecast demand for public transport facilities such as bus stops or stations is more accurate => *asset management*.

The second goal of GWRC, in cooperation with NZTA, was to maintain or enhance WTSM's ability to provide regional demands into sub regional NZTA project models. This translated into three core aims:

1. An increased confidence in the mode splits being generated;

2. Better representation of the network through link curving and other improvements; and

3. Improved modelling of intersections by loading of traffic at mid-point links as opposed to intersections.

Further Documentation: *Ref TN1 Network Preparation*

3.2 Economic Research

TN15 documents the process used to update the Wellington Transport Strategic Model (WTSM) input parameters from 2006 to 2011 and the approach to forecasting these parameters to 2021, 2031 and 2041. The approach differs significantly from the 2006 update in both the calculation of the base 2011 parameters and the forecast year parameters:

- Firstly, the 2006 update used nominal 2006 values whereas during this update it was decided to adjust nominal 2011 prices back to 2001 dollars using the Consumer Price Index (CPI). The reason for this was that trip distribution and mode choice models had been calibrated in 2001 prices so the model would respond to prices at these levels i.e. using inflated nominal prices “supercharged” model responses;
- Secondly, substantial investigations were conducted into adjusting input parameters for forecast scenarios. This included reviews of the approaches in Auckland, Christchurch, Waikato and Melbourne. The work was initially guided by the work of David Young who produced a memo for GWRC which has been included as an appendix to TN15. The memo contrasted the approaches of Auckland and Wellington (given the similarities of the models). Also contacted where NZTA and developers / users of the Canterbury, Waikato and Melbourne Travel Demand Forecasting Models for additional perspectives. Teleconference meetings were held with representatives of some interested parties while others were contacted for their views and experience directly; and
- Thirdly, in calibrating the 2011 model it became clear that there was excess Public Transport (PT) demand in the mode choice model. The reasons for this have been summarised in TN18 but the outcomes have also been reported in this TN15 due to the fact the manipulation was applied directly to the input parameters. The result of the investigations was that a factor of 1.2 was applied to the PT Generalised cost matrices.

Further Documentation: *Ref TN15 Input Parameters*

3.3 Demographic Research and Land-use Inputs

Car Ownership - One of the key inputs to WTSM is car ownership details. This provides part of the basis upon which trip makers decide what mode they will use – if they have a car available this can have a large impact on mode choice as opposed to those who do not have a car available.

The update of the WTSM car ownership model to a 2011 base year was undertaken by David Young Consulting. The update was undertaken by comparing actual car ownership in the Wellington region with the 2011 model forecast of the proportions of households by car ownership level (0 cars, 1 car, 2+ cars). The forecast is from the original model base year, 2001. An additive adjustment factor is applied which shifts the forecast up or down in order to fit the actual data.

As the 2011 Census was not undertaken the 2011 “actual” data has been estimated from analysis of historic Census data. Hence the “actual” is labelled as the target car ownership.

Land-use and Demographics – A further key input to the development of WTSM is land-use data which is used in the development of trip matrices. Travel demand within WTSM is determined by several factors, with the most critical being the demographic makeup of the region. This includes the number, age distribution, labour force status and location of residents, along with employment location. Prism Consulting provided the updated 2011 population and employment numbers using Statistics New Zealand outputs. This updated base demographic and land-use information has been documented in TN29.

Forecasts are critical as population has a causal relationship with travel demand. This information is required in the form of the number of employees, residents, households and students located in each WTSM zone. The forecast predictions used for WTSM have been based upon previous projections; however they have been rebased to 2011 to take into account current demographic information. Figure 3-1below displays the forecast population growth between 2011 and 2041 used for WTSM, displaying most of the growth projected to occur in Wellington City and Kapiti. Figure 3-2 displays the forecast employment growth between 2011and 2041 used for WTSM, displaying that all areas experience growth with Kapiti and Wellington City experiencing the greatest sustained growth.

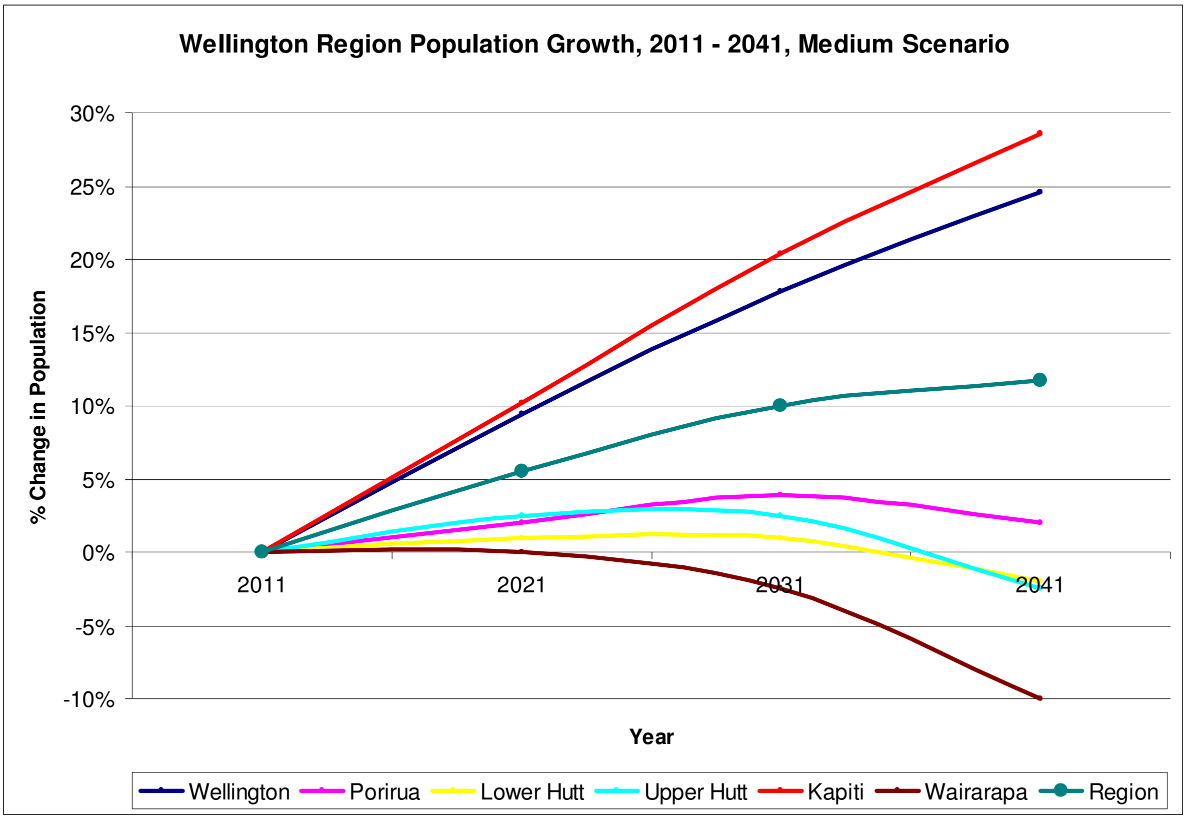


Figure 3-1: Wellington Region Population Growth by District

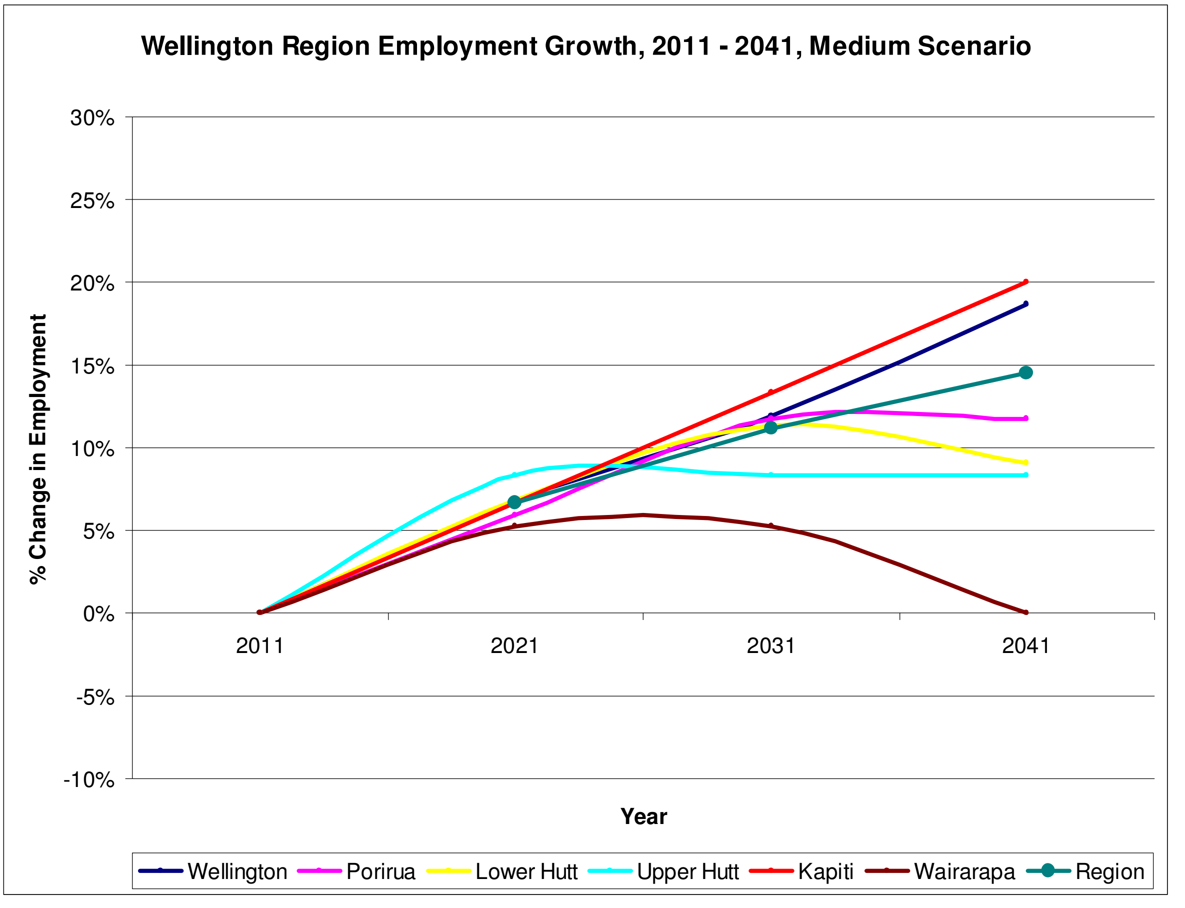


Figure 3-2: Wellington Region Employment Growth by District

As part of the development of the previous 2006 WTSM model, land-use projections were developed for low, medium and high growth scenarios for future horizon years. For the new 2011 model updated projections are needed for both the base year (2011) and horizon years (2021, 2031, and 2041). The 2011 update builds upon the work completed in 2006.

For the horizon years, matrices representing a range of different potential land-use scenarios have been developed. The basic future forecast scenarios are low, medium and high growth. In addition to the basic growth scenarios, three expansion scenarios were developed to capture travel demands which could result if land-use patterns changed in the future. Further Documentation: *Ref TN13 Base Model Car Ownership and TN29 Demographic Inputs to WTSM*

3.4 Traffic Counts and Airport Occupancies

Traffic Counts - All classified screenline count data has been collected by Traffic Design Group (TDG). Photos of tube sites were also supplied to reduce risk of uncertainty over count site location. Screenline validation tasks included:

- Confirming counts where useable. Compared 2001, 2006, and 2011 counts to try and account for major changes.
- Removed screenline U3 from validation procedures. This screenline is a single link to the Manor Park residential area, and in the review of the screenlines in 2008 it was

recommended that this should be removed in future updates to WTSM given its localised nature.

- Added extra Wellington screenline W6. This screenline is made up 5 new count sites:
  - Constable Street between Alexandra Road & Coromandel Street;
  - Manchester Street between Owen Street & Caprera Street;
  - Mt Albert Road between Lavaud Street & Volga Street;
  - Adelaide Road between Dover Street & Duppa Street; and
  - Happy Valley Road between Landfill Road & Murchison Street.
- Added screenline Kapiti Coast K1. Previous updates of WTSM had not included screenlines in the Kapiti Coast area and given the level of transport investment planned for this area through the Wellington Roads of National Significance (RoNS) it was considered appropriate that counts should be located in this part of the network. This screenline is made up 2 new count sites:
  - SH1 between Otaihanga Road & Kebbell Drive; and
  - Raikorangi Road between Poneke Drive & Ngatiawa Road.

Refer to TN18 for locations of screenlines identified above and the traffic data collection methodology and data.

Airport Occupancies – Up to date vehicle occupancy surveys were undertaken at the airport to improve the observed data and understanding of travel patterns. The surveys counted the different modes of transport entering and leaving the airport and the number of occupants inside each of those different transport modes.

In addition number plate surveys were undertaken at the entrance and exit points of the all car parks.

Passenger numbers were also collected for the aircraft movements landing and taking off at the airport. The exception to this was that the minor airline companies such as Sounds Air and Air2there were not counted which accounts for approximately 100 (0.72%) of the 14,000 passengers the airport caters for on a daily basis. The occupancy surveys and collected aircraft and passenger movements allowed a relationship between landside access and airside travel to be ascertained.

Further Documentation: *Ref TN8 Airport Survey Methodology and TN18 WTSM Calibration and Validation*

3.5 Bus and Rail Counts

Survey Sampling - The survey sampling methodology was primarily based on a qualitative assessment of the attributes of individual rail and bus services. The attributes of individual services that were considered important to capture as part of the overall routes to be surveyed are as follows:

- Geographic coverage;
- Routes servicing special generators such as hospitals, educational institutions and the airport;
- Stopping pattern of services (e.g. express versus all-stoppers);
- Service frequencies; and

- Bus routes servicing modal interchanges.

Building on this approach it was also identified that it was reasonable to preferentially omit some services where usage characteristics could be reasonably inferred from nearby services with similar characteristics. For example the catchment and user characteristics for local station feeder bus services in outlying areas can reasonably be estimated based on the limited geographic spread of catchment zones and applying user patterns relating to nearby services of a similar nature.

A supporting quantitative assessment of required sample sizes has also been undertaken to understand the number of service hours required to be surveyed. The quantitative analysis uses rail boardings from surveys undertaken in June 2011 and ETM bus patronage data along with specified confidence intervals and margins of error to estimate the required size of the population to be sampled. This is then compared to the number of completed forms that are anticipated to be returned based on the results of the bus and rail pilot surveys.

ETM data Cleaning - The Electronic Ticket Machine (ETM) data covers bus travel over the period 28 February to 28 April 2011 and has been provided under confidentiality agreement by Mana Coaches and NZ Bus.

The ETM data provides a key input to the derivation of the base year observed public transport demand matrices for the WPTM. These matrices are described in detail in TN6 and the analysis undertaken in their derivation is described in TN7. In order to prepare the data for the analysis described in TN7 a process of data cleaning was undertaken to combine the data sets from the two sources and prepare a consistent and reliable dataset of weekday travel as a basis for further work in the current project. Should a new set of base data be required for a future update of WPTM the detail reported provides information, for use by others with a fair understanding of database manipulation, to repeat the process of identifying and removing spurious records from the ETM data.

The data consists of records related to a ticket transaction of a specific bus trip (or in some cases trips by multiple people using the same ticket). The process of cleaning removed a small proportion of less than 1% of spurious records from the overall data and then separated out records for weekday travel for the ongoing analysis tasks. Details of the processes undertaken are provided in TN3.

Further Documentation: *Ref TN2 Survey Sampling Methodology, TN3 ETM Data Cleaning and Analysis, and TN7 PT Matrix Development.*

3.6 PT Users Survey

Bus and rail intercept surveys were carried out to inform the development of WPTM. The data collected in the surveys was coded, including geocoding of address details, by the survey firms and supplied to Opus and Arup in spreadsheet files.

Bus Surveys - The main bus intercept surveys were carried out on 30 to 31 August, and 5 to 9 September 2011. Twenty eight different bus routes were surveyed in the AM peak (7am-9am). Most of these were surveyed in the Inter peak also (a representative period

11am-1pm). No PM peak period surveys were undertaken. AM is defined as the passengers boarding the bus between 7am and 9am give or take a few minutes leeway if the bus was almost at the end of its route. IP is similarly defined as passengers boarding the bus between 11am and 1pm.

A total of 2751 forms were completed, and 2740 retained after geocoding. The number of passengers refusing forms was not recorded.

There were no extreme weather events during the survey period. New Zealand was hosting the Rugby World Cup during September and October. This may have affected travel patterns, for example more tourists than usual. A game between South Africa and Wales was held in Wellington on Sunday 11 September. It is not expected to have directly affected the surveys, but may have had an indirect impact.

In addition, two pilot surveys were carried out before the main surveys. The first was on the Island Bay route (Route 1). These had slightly different questions to the main surveys. It did not ask about journey start time or time to destination. The second pilot survey was on the Karori-Lyall Bay route (Route 3). During this, one of the buses broke down on the inbound leg resulting in some loss of data. Affected questionnaires were removed from the final dataset. The pilot survey data was combined with the main data, giving a total of 2976 records.

Rail Surveys - There are 4 rails lines within the Greater Wellington Region on which rail intercept surveys were undertaken. The lines and dates between which the surveys were undertaken are as follows:

- Hutt Valley Line – 18 stations, surveyed between Wednesday 26th and Thursday 27th October 2011;
- Kapiti Line – 15 stations, surveyed between Wednesday 26th and Thursday 27th October 2011;
- Melling Line – 6 stations, surveyed between 15th – 19th August 2011; and
- Johnsonville Line – 9 stations, AM peak services surveyed in June 2011, Inter peak services surveyed between 15th and 19th August 2011.

With the exception of the Johnsonville Line, which was surveyed in June 2011 (in the AM peak only), all lines were originally surveyed between the 15th and 19th August 2011. There was, however, severe inclement weather (a snow storm) during the survey period which affected both reliability and patronage. Analysis of the data collected during this period showed that whilst the Johnsonville and Melling lines remained relatively unaffected by the snow, the Kapiti and Hutt Valley lines were significantly affected. As a result both the Hutt Valley and Kapiti lines were re-surveyed on the 26th and 27th October 2011.

In total 4,420 completed survey records were returned. Survey data was collected in order to coincide as neatly as possible with the modelled time periods:

- AM peak period – 7am to 9am; and
- Inter peak period – 11am to 1pm.

For the purpose of this survey the following definitions were employed to determine the time period:

- For inbound trips towards Wellington, the time period was allocated according to the scheduled arrival time of the train at Wellington Station; and
- For outbound trips, the time period was allocated according to the departure time of the train from Wellington.

Using this method the majority of passengers using rail services during both modelled time periods should be recorded. Analysis undertaken by TDG and Research NZ suggested that this was the case.

Further Documentation: *Ref TN5a Bus intercept Survey Analysis and TN5b Rail Intercept Survey Analysis.*

3.7 Highway Journey Times Survey

Observed travel time data was sourced from NZTA. NZTA's consultants undertake bi-annual travel time surveys along the State Highway network nationally in March and November. This results in 6 northbound and southbound routes in the WTSM area. Initially the March data was used for model calibration until the November 2011 data became available..

This data collection exercise has a standard specification developed by NZTA to capture journey times on strategic links and these results have been utilised and documented in TN18.

Further Documentation: *Ref TN18 WTSM Calibration and Validation*

3.8 Base Observed PT Matrices

This section summarises the creation of the base year Public Transport (PT) demand matrices for the Wellington Public Transport Model (WPTM). The methodology for preparing the PT matrices is detailed in TN7, and outlined below:

- Base public transport demand matrices were developed from observed data sources: rail on-board surveys, rail boarding and alighting counts, bus on-board surveys, and bus electronic ticket machine (ETM) data;
- Travel on the minor modes of cable car and ferry was derived from patronage counts;
- Demand was created for the 2 hour AM peak (0700–0900) and the 2 hour Inter peak (2 hour average of 0900–1500);
- A trip was included if the boarding time (first boarding time where linked trips can be identified) was within the time period;
- An exception was made for long distance trips which were included if they enter the study area inside the time period – this rule applies to Wairarapa and Capital Connection (Palmerston North) train services;
- The trip volumes were controlled to the annual average weekday, 2011;
- Separate matrices were developed for adults and children; for trip purposes: work, education and other; and for car availability status; and
- Total public transport travel between WPTM zones was determined by adding together the observed bus, rail, ferry and cable car demand, ensuring in the process that any double-counting was removed.

TN7 provides more detail on the development of the matrices for each of the individual nodes – bus, rail, ferry and cable car and how they were each combined to develop the full PT matrices. TN7 also discusses the validation bus and rail trips across screenlines and at cordons.

Further Documentation: *Ref TN7 PT Matrix Development*

4 Model Development, Calibration and Validation

4.1 Base WTSM Development

The updated EMME network has been formed using road centreline GIS shape files and the information contained in the General Transit Feed Specification (GTFS) of the Wellington region. The GTFS contains information on all bus services and stop locations and is created from the Greater Wellington Regional Council (GWRC) Public Transport Database.

The transit times for rail, cable car and ferry are 'hard coded' in both WTSM and WPTM according to the published timetable. The actual performance of these modes is understood to largely match the timetable, although some unreliability is inevitable. This 'hard coding' approach would be possible for bus but this would limit the model in two ways (1) it is known from ETM data that buses frequently fail to adhere to timetables, particularly in peak periods and (2) increasing highway congestion in future years is expected to affect bus run times. Based on these arguments, an approach was selected that seeks to replicate actual (not the timetabled) bus run times in the base year, and using the WTSM highway (car) times as an explanatory variable. This enables the model to capture the impact of increasing or reducing congestion in future years as Wellington grows and as the highway network changes.

Figure 4-1 below display the difference between the 2006 and 2011 networks for Wellington City and the additional links and definition included in the model. A similar exercise occurred throughout the region.

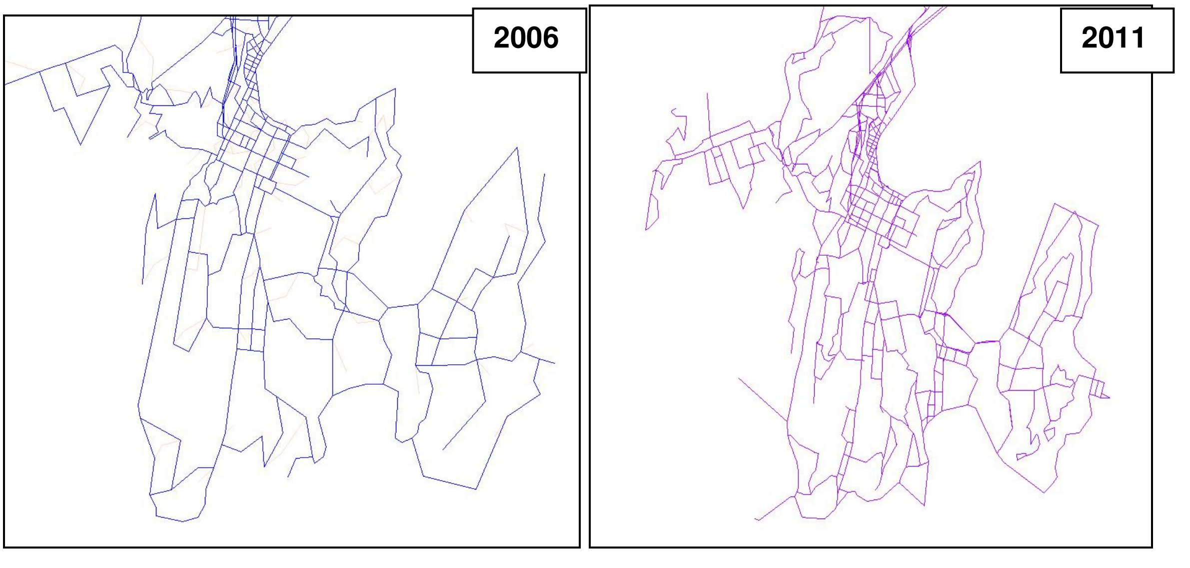


Figure 4-1 : 2006 and 2011 Network Coding for WTSM and WPTM

Further Documentation: *Ref TN1 Network Preparation and TN15 Input Parameters*

4.2 WTSM Base Model Calibration and Sensitivity Testing

WTSM Calibration - A number of key themes developed early in the model update process that affected how the project proceeded and the type of analysis undertaken. The following issues presented the team with the following opportunities and challenges:

- New networks and services;
- Estimated land-use (and cancellation of the 2011 NZ Census);
- Economic recession and government policy changes;
- Disruption to data collection programmes;
- Better public transport data availability;
- New PT assignment module in EMME software; and
- Undocumented model run macros and updates to macros.

The team met these challenges through a series of thorough investigations which benefited substantially from involvement of the peer reviewer via weekly update meetings. Those investigations included:

- Trip generation & aggregate demand;
- HCV demand re-estimation;
- Network and matrix model convergence;
- Mode choice model adjustments;
- Assignment routing issues; and
- Testing and implementation of new Transit Assignment EMME Module.

Testing of Model Parameters – TN15 documents the tests undertaken to assess the impact of various changes to input parameters on percentage trip increases between 2011 and 2021. The tests were as follows:

- Test 1: PT fares increased by 10% by 2021;
- Test 2: PT fares increased by 10% and Vehicle Operating Costs increased by 29%;
- Test 3: PT fares increased by 10%, Vehicle Operating Costs increased by 29%; and Parking increased by 23%; and
- Test 4: PT fares increased by 10%, Vehicle Operating Costs increased by 29%, Parking increased by 23%, and Value of Time increased by 23%.

WTSM Sensitivity Testing – TN18 documents the tests that were run to establish whether the overall sensitivity of the model to changes in network level-of-service is reasonable. These tests were:

- Public transport fares: +20% changes in all PT fares;
- Public transport in-vehicle times: +20% changes in all PT times;
- Public transport frequencies: +20% changes for all PT;
- Car operating costs or fuel costs: +20%; and
- Car in-vehicle times: +20%.

For information the following additional tests were completed:

- CBD parking charges: 100% increase on average CBD charges; and
- CBD pricing cordon: $2 peak, $1 off peak.

Further Documentation: *Ref TN15 Input Parameters and TN18 WTSM Calibration and Validation.*

4.3 Airport Model Calibration

Survey of vehicle movements entering and exiting the Airport was undertaken on Tuesday 4th October 2011 as outlined in TN8. Data was collected across all three peak periods and, in conjunction with flight passenger information, was used to form the basis of the calibration of the airport model.

Analysis of the survey data allowed modal capability to be updated from that within the 2006 model, which only accounted for car trips to and from the airport. Two key changes with respect to modal choice in the airport model are as follows:

- Market segmentation has been abandoned. The purpose of this segmentation in the 2006 model had been to determine alternative mode preference arrangements for different market segments. However, as these segments have not been based on any sort of survey data it is difficult to support the approach i.e. it adds complexity to the model but is not supported by any verifiable data.
- Mode choice, which had previously been fixed, has been converted into a logit model with 'park-and-fly', 'drop-off / pick-up', taxi and car hire being rolled up into 'car'. While the logit model is not particularly sophisticated it does succeed in meeting the goals of introducing a mode response for airport passenger related demand.

Time of day period conversion factors were developed using a combination of airport passenger arrival and departure information for initial factors which were then calibrated to match the observed traffic data.

As discussed in TN9 (to remain in draft form and not part of the core model documentation) there were a number of options recommended in the literature regarding mode choice model forms. The most common included nested logit, multinomial logit and binomial models. The first two require significantly more data concerning both market segmentation and mode choice preferences than what was available for this study. The approach therefore was to adopt a relatively simple synthetic binomial choice model for a single market segment: air passengers.

It also became apparent during model calibration that the importation of constants and parameters from other models was not going to be appropriate. This was due to differences in characteristics of the Wellington International Airport and its proximity to demand sources e.g. a large part of the demand comes from the Wellington CBD where the choice is more car versus taxi.

A possible improvement to the airport model could be to develop a hierarchical mode choice model where the first decision point is car versus bus and a second tier which splits the car trips across taxi, park and fly, drop off and hire car.

While this airport model was developed as part of the project, due to timeframes and the very low PT demands from the Wellington Airport it was decided that the model would not form part of the validation process or core modelling system at this time.

Further Documentation: *Ref TN8 Airport Survey Methodology and TN9 Draft Airport Model WTSM (delivered to GWRC but not part of the core model documentation at this time)*

4.4 WTSM Validation

The criteria agreed with the peer reviewer and client has been detailed in TN17.

The WTSM process, being an update only, suggests that in general, the validation will be carried out against the same criteria and levels as the previous update of the model undertaken in 2008. WPTM is an entirely new model, with trip demand from observed data sources. This has some implications for validation, and a method and criteria appropriate to this type of model is set out in TN17.

As emphasised in the Model Investigation Report, both WTSM and WPTM have been validated together. The following summarises the approach being taken.

1. **Initial Network Development.** This task covers the initial development of networks and PT services from GIS files and GWRC's Public Transport Database. Basic model assignment algorithms are developed and unitary matrices are assigned to the network to check for coding deficiencies. These networks and services form the basis for both WTSM and WPTM assignment and aside from the different zone system (and centroid connectors) sizes will remain identical.

2. **Initial WTSM Calibration.** The purpose of this task is to get WTSM into a reliable and stable enough state to provide initial data for WPTM development. This step will provide robust highway travel times for the bus assignments and allow skimming of the network for development of the access choice model.

3. **Initial WPTM Calibration.** The purpose of this task (which overlaps with stage 4 described below) is to use the WTSM networks and services (with highway speeds) in the calibration of PT services and PT related parameters (new walk connectors may also be added).

4. **WTSM – WPTM Validation Iteration.** This stage involve iterating between the WTSM and WPTM calibration i.e. any changes in the following elements will be brought back into WTSM to maintain consistency between the models[*]:

    - Networks e.g. walk links;
    - PT services e.g. if services are disaggregated; and
    - PT assignment parameters.

TN18 describes the calibration and validation procedures carried out on the 2011 WTSM model update and covers:

- **Vehicle screenline validation process** - Validation of vehicle trips has been carried out in a similar method to that used for the 2006 WTSM validation such that comparison can be made between the two models. Vehicle assignment has been compared against observed data and 2006 values using GEH statistical values for

[*] Any exceptions will be described & documented in TN18

private vehicles and HCVs separately. Additionally, individual counts have been presented as scatterplots for the calculation of the coefficient of determination (R^2) and root mean square error (RMSE).

- **Vehicle journey time validation** - Journey time surveys carried out on behalf of NZTA along strategic routes within the Wellington region across the AM, IP and PM periods have been utilised. Summary tables comparing observed averages against modelled times are presented in the main body of TN18 along with notes with further explanation.
- **Bus passenger count validation** - Observed values were sourced from the WPTM bus assignment which assigned observed ETM records. Validation of bus patronage has been carried out in a similar method to vehicle screenline validation. They differ in terms of the period reported (data was only collected for AM and IP periods) and in the measures they assessed against (GEH is combined with % difference in line with international best practice).
- **Rail count validation** - Observed values were obtained from rail counts at the end of 2011. Rail count validation was been reported as a comparison of observed and modelled cumulative loading profiles down the Kapiti and Hutt lines for the AM and IP peak periods.
- **Demand and assignment model convergence** - Demand model convergence has been measured by calculating the RMSE for each final demand matrix (car and public transport for each period - i.e. 6 matrices). Highway assignment convergence has been measured using relative gaps of total vehicle kilometres and vehicle minutes travelled between successive updates of intersection capacities during the highway assignment.
- **Sensitivity tests** - Tests were run to establish whether the overall sensitivity of the model to changes in network level-of-service are reasonable. These tests included changes to public transport fares, public transport in-vehicle times, public transport frequencies, car operating costs or fuel costs, car in-vehicle times and CBD parking charges.

The 2011 model update process concluded with a model that achieved validation goals and, as such, is considered suitable for the purpose of policy studies, strategy studies, corridors studies and providing demand to project models in the Wellington Region. However, as with any strategic model, local area validation may be required if it is to be used for project studies where WTSM is the sole source of economic evaluation data.

The key WTSM validation outcomes resulted in the following:

- Highway validation similar to the 2006 model and better than the 2001 model; and
- Rail and bus validation better than 2006 due to the significant data collection exercise for WPTM and the improvements to the model (especially in the AM peak).

Further Documentation*: Ref TN17 Validation Guidelines and Criteria – WTSM and WPTM and TN18 WTSM Calibration and Validation*

4.5 WPTM Base Model Development

As part of the project, the team reviewed the proposed 780 zone system and determined that this would be implemented for WPTM, this significant increase in zone definition is displayed in Figure 4-2 below which presents the difference between the 228 zones definition in WTSM and the 780 zones definition in WPTM for the Wellington area. The increased zone definition has allowed for better representation of bus stop and rail station access and locations. The zone disaggregation process and the growth demand forecasting between WTSM and WPTM has been documented in TN20.

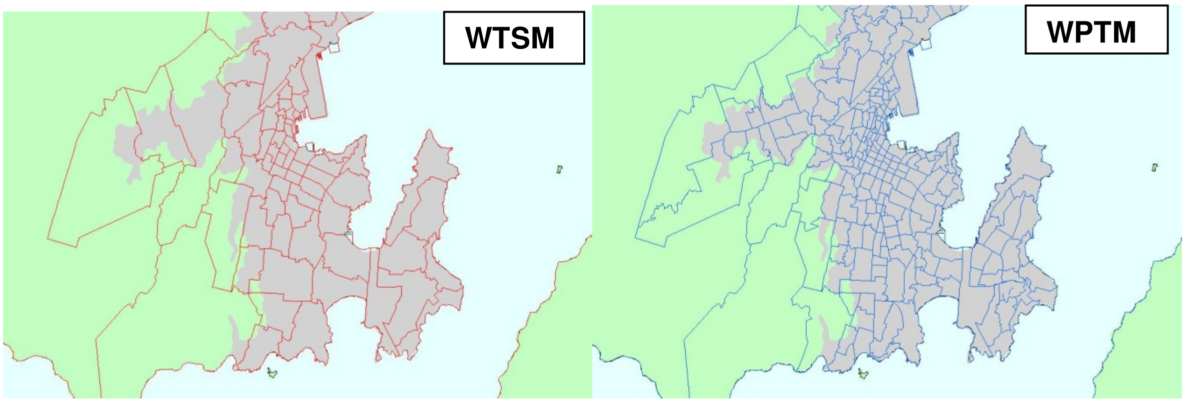


Figure 4-2: WTSM and WPTM Zone System

There were four options considered for the model structure of WPTM and discussed in detail in TN6. Option 4 was selected as the preferred method for WPTM. It is simple and takes advantage of the relative strengths of the two approaches – an assignment model to allocate demand to modes and routes, and logit models for access choice that is unsuited to assignment (access choices being influenced by non-modelled personal circumstances as much as the travel times and costs).

Mode-specific preferences of bus, rail and other modes will be captured in the assignment model through use of variable weights applied to in-vehicle time, boarding or wait time.

Some different assignment methods were trialled in EMME: standard, optimal strategies and strategies with variants. It was decided to use the strategies with variants, as this method closely replicates the results of the other two assignment methods, while giving more flexibility in options. Details on this topic are provided in TN19.

A key feature of WPTM is that demand matrices are developed from observed data, rather than being synthesised by the model. This ensures that demand is as accurate as it reasonably can be (modelling errors being minimised), and making WPTM particularly well suited for application to corridor projects, operational studies and projects in the later stages of design.

Further Documentation: *Ref TN6 WPTM Specification and TN19 WPTM Calibration and Validation*

4.6 WPTM Base Model Calibration and Sensitivity Testing

WPTM Calibration - The key results that were checked with each set of new parameters were the CBD cordon survey, bus vs. rail splits in key corridors, rail boarding and alighting graphs, and screenlines.

Some of the parameters changes that were trialled to improve the results (but not necessarily adopted) were:

- Changing the method of distributing flow between attractive lines from “frequency” to “frequency and transit time”;
- Changing the effective headway calculation (and hence perceived wait time), both overall and for different modes;
- Changing the wait time perception factor;
- Changing the walk time weight;
- Changing the in-vehicle time factors;
- Increasing the VoT (value of time) parameters by 50%, 100% and 70% from the base values;
- Changing the line boarding penalties; and
- Changing the boarding fares.

Many of these parameter changes made little difference to the mode split and other key results. This is perhaps not so surprising considering that for many of the main movements in the Wellington region there are no mode options, hence the model is insensitive to small changes. However several of the parameter changes were effective, these are discussed in more detail in TN19.

WPTM Sensitivity Testing - The additional zones in the WPTM, compared to WTSM, allow for more accurate calculation of access times between stops / stations and trip origins / destinations. The base year demand in WPTM is also highly accurate as it has been built up from observed data rather than from a trip generation / distribution / mode split model as in WTSM. However, WPTM has no functionality to forecast changes in the total public transport (PT) demand for future years. For this reason, WPTM is linked to WTSM to apply the forecast growth rates in PT demand from the WTSM to the WPTM base year matrices.

For the testing of the model system, combined model runs of WTSM and WPTM were undertaken: WTSM provides growth rates in PT demand; WPTM determines the division of PT demand among possible access modes, PT modes, PT routes, stations and stops.

A total of seven sensitivity tests were undertaken using the transport modelling system. These are listed in Table 4-1 below.

Table 4-1: List of Sensitivity Tests Undertaken

Sensitivity Test	Description
Test 1	PT Fares +20%
Test 2	Car Fuel Cost +20%
Test 3	New P&R site at Ava Station
Test 4	Equal behavioural weights
Test 5	Route 3 frequency +25%
Test 6	Route 3 to Bus Rapid Transit (BRT). No mode preference.
Test 7	Route 3 to BRT. With mode preference.

Further Documentation: *Ref TN22 WPTM Sensitivity Testing*

4.7 2011 WPTM Validation

The guidelines for validation have been summarised above in Section 4.4 WTSM Validation and are detailed in TN17 for the WPTM validation.

TN19 documents the calibration and validation of the Wellington Public Transport Model (WPTM). Whilst there are a lot of comparisons of modelled versus observed undertaken and reported on in this document, the aim is to ensure that the agreed upon validation criteria (documented in TN17 – Validation Guidelines and Criteria) has been achieved.

A high-level summary of the validation guidelines and criteria reported in TN17 and the summary results highlighting how well each criterion has been met as reported in TN19 is given below for reference. A column indicating references where further information can be found has also been included.

Criterion	Measurement	Acceptable?	Reference
Bus Demand			
Scatter-gram of boardings by route: modelled vs. reference	R2 > 85% cf. ETM	Acceptable	TN19 (Section 5.4.9)
Maximum load vs. seated/standing capacity, by route	load <= capacity	Acceptable	TN19 (Section 5.4.10)
Passenger volume between fare-zones, adult and child	±15% cf. ETM	Appears reasonable – see TA to TA section for a similar check.	TN19 (Section 3.4.7)
CBD inbound volume	±15% cf. ETM	Acceptable (-6% demand only / -4% full model)	TN19 (Section 3.4.1 and 5.4.4)
Adult journey purposes	= on-board survey	Acceptable	TN19 (Section 3.4.5)
Distribution of bus access / egress trip lengths	cf. on-board survey: judgement	Acceptable	TN19 (Section 3.4.6)
Rail Demand			
Passenger volumes between TA sectors	±15% cf. expanded on-board survey data	Acceptable	TN19 (Section 3.4.7)
Boardings and alightings by station group	±10% cf. Boarding & Alighting data	**Demand** – acceptable - AM max 2%, IP max 11%. **Full model** – acceptable in AM except JVL. IP % differences high, although actual differences comparatively low.	TN19 (Section 3.4.2 and 5.4.6)
Maximum load by line/direction, compared against seated/standing capacities	load <= capacity	Acceptable	TN19 (Section 3.4.2 and 5.4.6)
Adult journey purposes and car availability	=on-board survey	Acceptable	TN19 (Section 3.4.5)

Criterion	Measurement	Acceptable?	Reference
Distribution of rail access / egress trip lengths by access mode	cf on-board survey – judgement	Acceptable	TN19 (Section 4.5.1)
CBD inbound volume	cf. survey of arrivals at Wellington – report only	Acceptable (+4% demand only / -2% full model)	TN19 (Section 3.4.1 and 5.4.4)
Access Choice			
Demand by access mode by station	±20% cf. on-board survey data	Acceptable	TN19 (Section 4.5.1)
Demand by access mode by station group	±10% cf. on-board survey data	Acceptable	TN19 (Section 4.5.1)
Network			
Check list of coded services against definitive list	matching	Acceptable – checked against General Transit Feed	n/a
Scatter-gram of end-to-end running times by route	R^2 > 85% cf. combined reference data created from combination of ETM & timetabled data	Acceptable	TN19 (Section 5.4.1)
Scatter-gram of sectional running times in the critical Wellington Station – Courtenay Place – Newtown corridor	R^2 > 90% cf. reference data created from combination of ETM & timetabled data	Differences – see TN1 for a further discussion	TN19 (Section 5.4.2)
Scattergram of adult and child fares by fare-zone movement	R^2 > 80% cf. Metlink fare table	See TN1 for discussion	TN1
Assignment			
Bus and rail volumes at screenlines	±15%	Majority of screenlines meet this criterion, some do not.	TN19 (Section 5.4.5 and 5.4.8)
Bus/rail shares in competition corridors: Ngauranga Gorge, Ngaio Gorge, SH2 south of Petone	±10%	Acceptable in key competition corridors.	TN19 (Section 5.4.11)
O to D comparisons: Metlink journey planner	reasonable match of alternative route options and travel times – judgement	Acceptable – bus, rail, ferry split appears ok for a selection of trips.	TN19 (Section 5.4.3)

The detailed calibration/validation of the WPTM was finalised in early June 2012. Following the completion of the calibration/validation, several minor edits were made to the WTSM and WPTM requiring documentation and confirmation that the changes have not adversely affected the validation of the WPTM.

The changes made to WTSM and WPTM post-validation and the impacts on base year results have been documented in the report *Addendum to TN19.* The results showed that the changes made to the validated WPTM documented in TN19 did not materially affect the validation of the final version of the model but did result in some localised differences.

Further Documentation: *Ref TN17 Validation Guidelines and Criteria – WTSM and WPTM,TN19 WPTM Calibration and Validation and Addendum to TN19.*

4.8 WTSM – WPTM Transit Assignment Comparison

WTSM and WPTM have been developed such that both models can be used as part of one 'Transport Model System' when it comes to future forecasting. Whilst there are subtle differences between both models, primarily due to WTSM being a strategic model and WPTM a more detailed public transport project model, both models use the same software package and operate using similar macros and assignment algorithms.

The purpose of TN16 is to demonstrate that both models display similarities in their representation of travel times (perceived and actual) by selecting 11 'sample' journeys, for which origin-destination (O-D) travel times are obtained from both WPTM and WTSM. The travel times are broken down into their constituent components, namely:

- Access Time;
- Total Wait Time;
- Total Board Time;
- Total In-Vehicle Time;
- Transfer Time; and
- Egress Time

Such comparisons are important as WTSM will be used in forecasting mode to derive factors that will be applied to the Base WPTM PT matrices in order to create future year WPTM demand. If both models represent travel costs / times in radically different ways this could lead to difficulties when applying WTSM growth to WPTM. A situation could potentially arise where the impact of a certain policy change (e.g integrated ticketing) could vary between WTSM and WPTM.

Therefore by comparing sample journey times between WTSM and WPTM, differences and similarities regarding how certain components of a typical journey are modelled can be identified, quantified and documented, thus allowing users to take appropriate action if required in the future.

Further Documentation*: Ref TN16 WTSM and WPTM PT Assignment Comparison*

4.9 WTSM – WPTM Interface

WTSM is a 4-step regional travel demand model whilst the WPTM is an incremental public transport model that is linked to WTSM by the sharing of a common network with the distinction of the zone systems in the two respective models:

- WTSM comprises 228 zones, including 3 external zones (+50 park and ride station zones); and

- WPTM comprises 780 zones (+50 park and ride station zones).

The additional zones in the WPTM allow for more accurate calculation of access between stops / stations and trip origin / destinations. The base year demand in WPTM is also highly accurate as it has been built up from observed data rather than using a synthetic demand model as in WTSM. However, WPTM has no functionality to forecast changes in public transport demand for future year scenarios. For this reason, WPTM is linked to WTSM to apply the forecast growth in PT demand from the WTSM to the WPTM base year matrices.

TN21 describes the structure / operation of the two models and the linkages between the two models and how the two models work together as a system.

The interface between the models can be broken down into two main streams; model *interaction* and model *integration.*

Model Interaction

Model interaction refers to the passing of information between the WTSM and WPTM. The interaction of the WTSM and WPTM is documented in Section 6 of TN21 and covers two key areas:

- Network information (road network, public transport supply and network related attributes); and
- Matrix information (used to calculate growth factors that are applied to the base WPTM public transport matrices).

These processes are represented diagrammatically in Figure 4-3 below.

It is important to note that 'Base' refers to the 2011 validated WTSM scenario whilst 'Test' implies any deviation from this. This refers to any run in which changes to the base networks, public transport service supply, travel demand and/or model parameters were made. Changes to public transport supply include travel time changes to on-road public transport caused by highway assignment changes that affect link travel times.

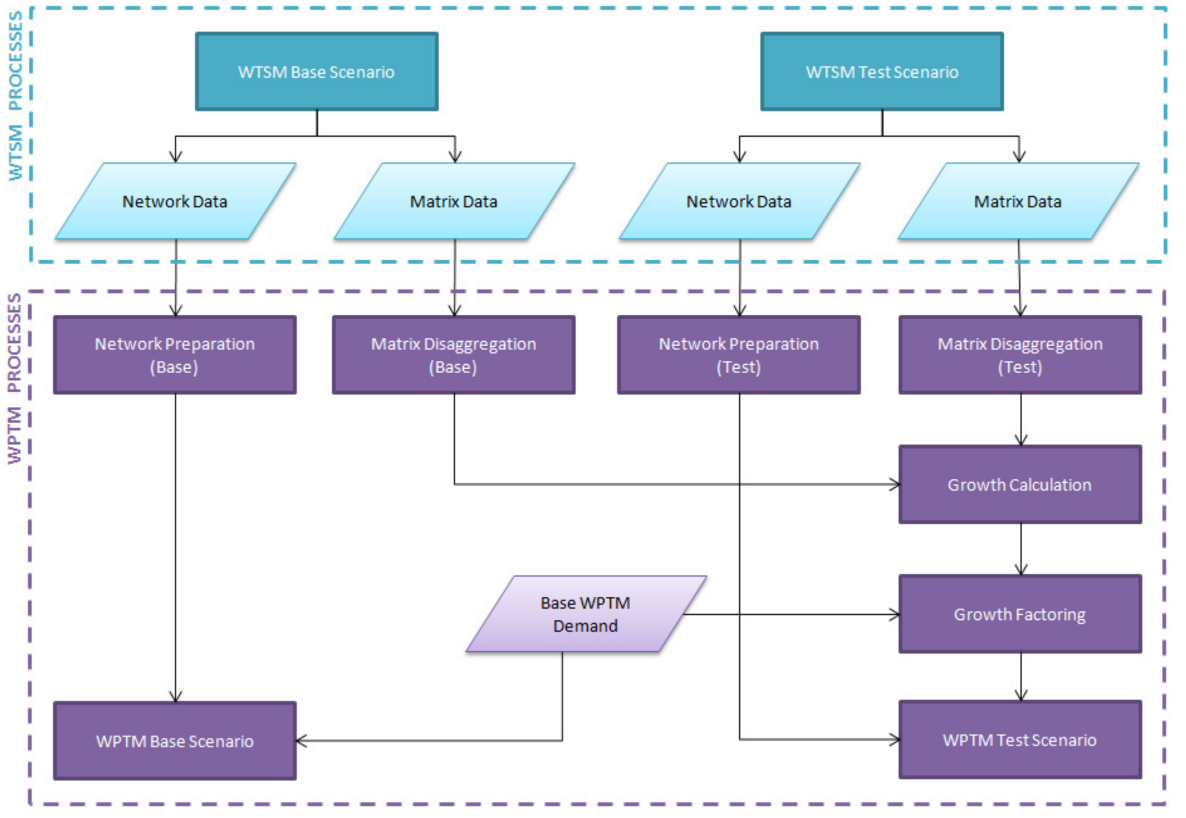


Figure 4-3: Model Interaction Flowchart

Model Integration

Model integration relates to the combining of the WTSM and WPTM into one coherent and integrated modelling system i.e. the model interactions are still taking place in the same manner but are housed and controlled within one modelling system rather than two separate systems.

Further Documentation: *Ref TN21 Models User Guide and WTSM – WPTM Interface (note that this TN has been developed for GWRC to be used internal and will be a live document not forming part of the core external model documentation).*

5 Model Forecasting

5.1 Future Baseline Networks and PT Services

A baseline forecasting report is one of the key outputs from the 2011 WTSM / WPTM model update programme. TN23 presents model outputs from the future year scenarios that are to be tested, whilst also documenting forecasting assumptions. TN23 discusses in more detail:

1. The infrastructure projects that have been assumed as 'committed' (likely to take place over the course of the next 10 years) and also lists 'other significant activities expected to commence within the next 10 years'.

   Each scheme has been categorised as follows:

   - Not to be modelled;
   - To be modelled, coding exists; and
   - To be modelled, further information collected from NZTA and WCC.

   The key changes to the network involve the implementation of the RoNS projects between 2021 and 2031.

2. The Wellington Regional Rail Plan which comprises a series of infrastructure and timetabling improvements over the course of the next 10 years, designed to improve the capacity, frequency and reliability of the Wellington rail network.

3. The "Wellington City Bus Review (WCBR)" which forms part of the revised bus networks and constitutes the Baseline bus network for the Baseline Forecasting process. The WCBR is comprised of two phases. The first phase includes Wellington City and Southern Suburbs. The second phase is for Northern Suburbs. Each phase consists of:

   - Bus services with high frequencies "frequent core network";
   - Bus services with relatively low frequencies "secondary services": and
   - Bus services only available on peak hours "peak-only services".

Further Documentation: *Ref TN23 Future Base Networks and Services*

5.2 Forecast Parameters

TN15 has documented the development of the forecast parameters. A summary of the results is provided here:

- **Values of time**. The approach taken in the 2011 update was to adjust all inputs to nominal values in 2011 before making an inflation adjustment to 2001. Real GDP per capita forecasts from NZ Government Treasury Department were used to adjust values of time, with an elasticity of 1 on work travel and 0.8 for non-work travel. This corresponds with advice in the UK's Department for Transport Webtag.
- **Vehicle operating costs**. Vehicle operating costs covered two main elements – fuel related vehicle operating cost (VoC) and non-fuel related VoC. The two sets of data

inputted from the model were guided by the EEM (2008 prices). Fuel related costs were affected by congestion, stoppage costs and change in speed costs whereas non-fuel costs related to road surface condition costs i.e. the rougher the road, the faster the tyres, suspension wears out. Fuel related costs were then adjusted to 2011 values using fuel price data from Statistics NZ while non-fuel prices were adjusted using CPI data from Statistics NZ. Both fuel and non-fuel costs were adjusted to 2001 levels using CPI.

  The forecasting approach was to use both Ministry of Economic Development (MED) fuel price forecasts and vehicle efficiency changes from the Ministry of Transport Fleet Emissions Model to forecast VoC for 2021, 2031, and 2041.

- **Parking Costs**. Parking charges were applied in WTSM but only in the CBD. The 2011 update of parking charges were complicated by the fact that the 2001 parking charges were not corroborated by data collection. Similar problems were encountered in the 2006 update resulting in an estimation of parking cost changes in the future. After collecting parking charge information from parking management companies in Wellington the conclusion was reached that the same adjustment applied in 2006 would be applied to 2011 (before being adjusted back to 2001 prices).

  While there was substantial debate around this approach amongst industry representatives it was decided to accept David Young's recommendation which was to use the real GDP per capita forecasts from the NZ Treasury to forecast parking costs.
- **PT Fares**. There are two components to the PT fares in WTSM – assignment based fares and matrix based fares (used in the trip distribution and mode split models). The update approach is summarised below:
  - *Assignment based PT fares* are incorporated into the @board penalty attribute. These are used in the calibration of routing so relate more to the perceived penalty of boarding buses and trains rather than 'actual' PT fares i.e. these values are not passed back into the trip distribution and mode choice models.
  - *Matrix based PT fares* are values used in the calculation of PT generalised costs so are used in the trip distribution and mode choice models. The 2011 update used PT assignment macros to count the number of fare-zone boundary crossings. These were updated using a PT assignment macro which:
    - Identified boarding and distance based components separately; and
    - Counted the number of fare-zone boundary crossings.

  Two approaches to forecasting PT fares were considered – one was to follow a policy based increase of 1% a year (in real terms) while the other was to apply real GDP per capita forecasts with an elasticity of 0.25. The second approach was used.
- **Travel Demand Management Parameters**. The effects of workplace travel initiatives in WTSM is an assumed removal of 3% of HBW trips by car to the Wellington CBD with 90% of these trips transferred to the same trip by PT modes and the remaining 10% not allocated.

Further Documentation: *Ref TN15 Input Parameters.*

5.3 Demographic Forecasting

As discussed earlier in Section 1.1, the initial plan was to update the 2006 base to a 2011 base using 2011 Census data, but due to the Canterbury earthquakes of 2010 and 2011 the Census planned for March 2011 was cancelled and has been re-scheduled to 2013.

Despite the lack of Census data to update the model to 2011 the 2006 WTSM was considered somewhat out of date and needing updating. Therefore, Russell Jones of Prism Consulting was engaged to develop a new 2011 base. Russell Jones' work is documented in Appendix B of TN29. He used changes in population from 2006 to 2011, Statistics NZ projections and other demographic trends to influence his work.

A number of checks were completed on the new 2011 base including comparisons to the 2006 base and comparisons between the 2011 base for WTSM and the Statistics NZ 2011 estimates.

In conjunction with the update of the base to 2011 the future year forecasts have been updated. This includes the low, medium and high growth scenarios for 2021, 2031 and 2041. The new forecasts were developed by using the new 2011 base and scaling the previous future year forecast.

The expansion land-use scenarios were formed by putting all WTSM zones within an identified growth area at the high growth forecast while keeping all other zones at the medium growth level. Therefore the totals for the region for population, employment, households and education do not correspond to the high growth or medium growth scenario. Rather the totals are somewhere between the medium and high growth scenario depending upon the specific land-use scenario.

Three expansion land-use scenarios have been developed. These scenarios are:

- Scenario One: Wellington City Expansion;
- Scenario Two: Western Expansion; and
- Scenario Three: Eastern Expansion.

Further Documentation: *Ref TN29 Demographic Inputs to WTSM*

5.4 Future Baseline Model Runs and Analysis

In addition to the base 2011 scenario, a series of baseline future scenarios were developed for 2021, 2031 and 2041, which include forecasting assumptions in terms of:

- Land-use – detailed in TN29 Demographic Inputs to WTSM (the medium demographic projections were used for these forecasts);
- Infrastructure improvements – as listed below and detailed in TN23 Future Year Base Networks and Services; and
- Forecast parameters (GDP growth, fuel price increases, PT fare increases, effect of TDM etc) – detailed in TN15.

The following schemes were agreed to be included in the baseline forecast scenario, as documented in TN23:

- Adelaide Road Improvements;
- SH1 Rauhine Street Widening;
- Aotea Quay Improvements;
- SH1 Inner City Bypass Intersection Optimisation;
- SH1 (RoNs) Basin Reserve;

- Johnsonville Triangle Roading Improvements;
- SH1 Mackays to Peka Peka ;
- SH1 (RoNs) Ngauranga to Aotea Quay ATMS;
- SH1 (RoNs) Transmission Gully;
- SH1 (RoNs) Mt Victoria Tunnel Duplication;
- SH1 / SH2 Granada to Petone;
- SH1 (RoNs) Peka Peka to Otaki;
- SH1 (RoNs) Terrace Tunnel Duplication;
- SH2 / SH58 Intersection Improvements;
- Regional Rail Plan;
- Transmission Gully Link Roads;
- Bus Priority Phase 2; and
- SH1 Otaihanga to Waikanae Safety Improvements Stage 3.

TN24 presents the model outputs from these baseline future year scenarios, including key factors affecting travel demand in the region. The report focuses on just one baseline forecasting scenario, summarised above.

Further Documentation: *Ref TN15 Input Parameters, TN23 Future Year Base Networks and Services, TN24 Baseline Forecasting Report and TN29 Demographic Inputs to WTSM*

5.5 WPTM Forecast Model Design

The base year public transport (PT) demand matrix in WPTM was developed from observed data sources. As such, it is a highly reliable and accurate representation of current PT demand. This matrix would be expected to change as time goes by as the population changes and as the network develops. Therefore, for modelling future years and alternative networks, it is necessary to apply adjustments to the base PT matrix to reflect changes in trip generation, induction, suppression, redistribution and switch between car and PT. WPTM does not have any built-in functions to forecast these changes. Therefore WPTM is linked to WTSM growth rates.

TN20 discusses the proposed approach for future year application of WPTM. Linkages have been prepared between WTSM to WPTM for the transfer of:

- Nodes, links and transit routes;
- Free-flow and congested highway times; and
- Zone to zone public transport travel demands by purpose.

Validation shows this to result in growth in the WPTM matrices within 0.1% of WTSM, while retaining the essential observed demand patterns of the WPTM base matrix.

Further Documentation: *Ref TN20 WPTM Forecasting*

6 Conclusions and Recommendations:

The 2006 WSTM model had limited PT capability and was not based upon detailed survey information, while the model itself also needed to be updated with current information and revised forecast projections.

The core aim of the project has to create a more robust modelling tool for PT and it was concluded that this would be in the form of WPTM for the AM and Interpeak periods and work in parallel with WTSM.

The project has utilised a number of different data sources, advancements in EMME and network coding, and detailed modelling information for the Wellington Traffic Model to create an improved WTSM model.

An airport model has also been developed as part of the project, however due to timeframes and the very low PT demands from the Wellington Airport it was decided that the model would not form part of the validation process or core modelling system at this time.

WTSM has been successfully validated to a similar standard to other strategic 4 stage models nationally and internationally, resulting in a better level of validation that the 2001 model and a similar level to that of the 2006 model.

WPTM had a significant data source and was a new model; as a result the validation was extremely good when compared with other international models. The level of validation and model definition provides a robust tool for PT assessment, planning and decision making.

The modelling system has been designed so that WTSM can be used in isolation to WPTM or in parallel, allowing flexibility for the users and a level of detailed PT modelling which is significantly more robust to that experienced using WTSM in the past.

The model has been considered fit for purpose to be utilised for strategic assessment, transport planning and the extraction of demand matrices for more detailed project modelling for a number of key projects currently being developed in the region, these include:

- Wellington PT Spine Study;
- Wellington Regional Rail Plan;
- Wellington Bus Review; and
- The Wellington Northern Corridor Roads of National Significance (RoNS).

As with all modelling systems, there are always improvements that could be made and it is recommended that GWRC and other transport providers in the region consider the following enhancements to the model in the future:

- Improved HCV (freight) information in the base and forecast year models using developments in data collection and forecasting.

- The collection of more detailed parking information and undertaking research into future pricing projections which will allow more robust capacity constraints both now and in the future.
- Consider the use of capacity constraints on PT lines and facilities to provide a more robust assessment of modal split and service provision.
- Undertake a new household interview survey at the time of the next Census in order to capture current travel behaviours and trends, in conjunction with collection of other observed datasets for model validation purposes, such as screenline traffic counts.
- Update the modelling system to include outputs for the next Census.
- Use of updated ETM data to rebase the observed PT demand in WPTM.