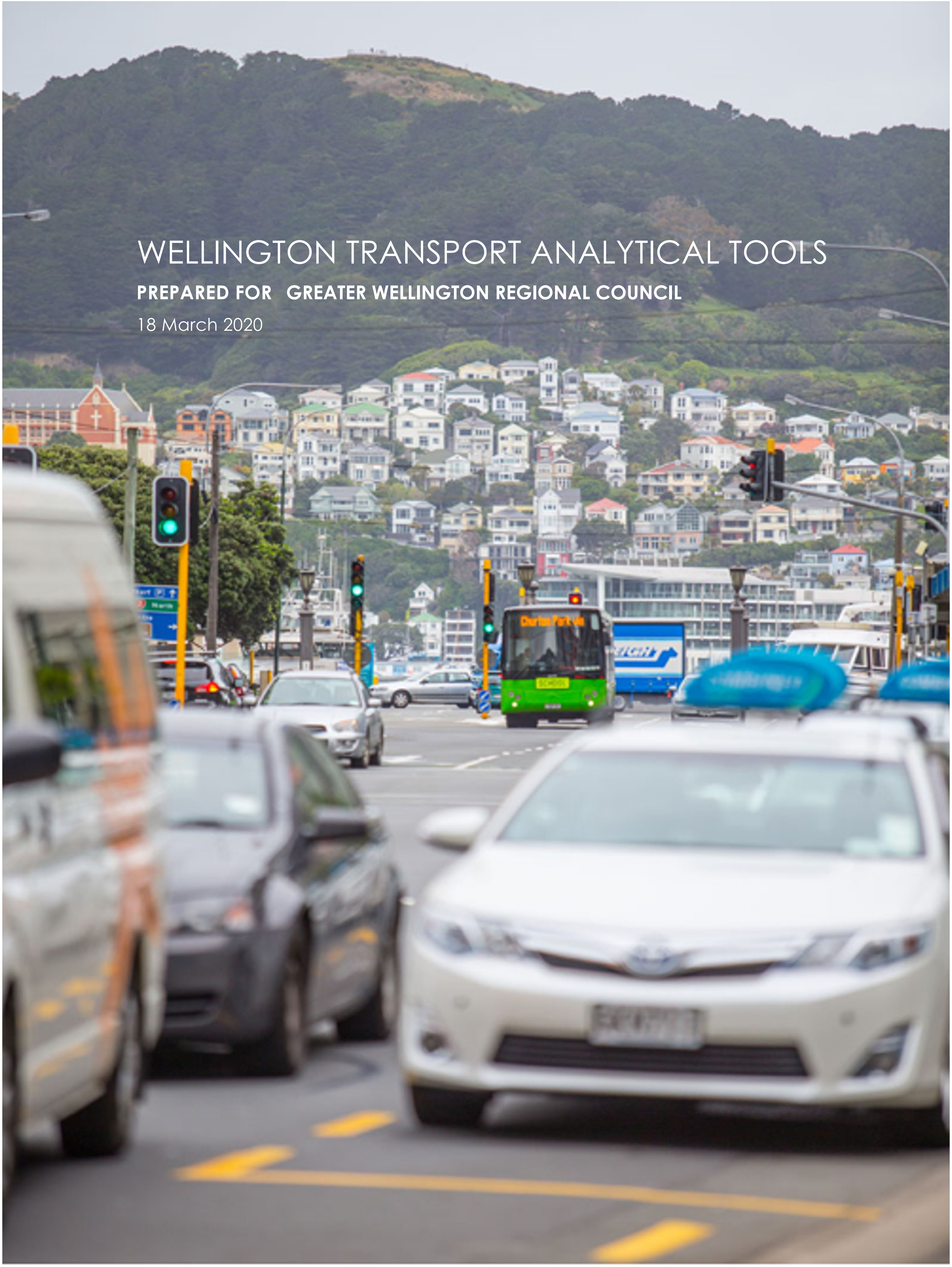
WELLINGTON TRANSPORT ANALYTICAL TOOLS

PREPARED FOR GREATER WELLINGTON REGIONAL COUNCIL

18 March 2020



Stantec | JACOBS

This document has been prepared for the benefit of Greater Wellington Regional Council. No liability is accepted by this company or any employee or sub-consultant of this company with respect to its use by any other person.

This disclaimer shall apply notwithstanding that the report may be made available to other persons for an application for permission or approval to fulfil a legal requirement.

QUALITY STATEMENT

PROJECT MANAGER	PROJECT TECHNICAL LEAD
Alan Kerr	Geoffrey Cornelis

PREPARED BY		
Geoffrey Cornelis Julie Ballantyne	....	6/11/2002
CHECKED BY		
Julie Ballantyne	....	6/11/2002
REVIEWED BY		
Daniel Harney Steven Piotrowski	....	6/11/2002
APPROVED FOR ISSUE BY		
Alan Kerr	....	6/11/2002

WELLINGTON
Level 13, 80 The Terrace
Wellington
TEL +64 4 381 6700

REVISION SCHEDULE

Rev No.	Date	Description	Signature or Typed Name (documentation on file)			
			Prepared by	Checked by	Reviewed by	Approved by
1	24-01-2020	First issue				
2	18-03-2020	Second Issue	GC	JB	DH/SP	AK
	06-11-20	Final Issue	GC	JB	DH/SP	AK

Greater Wellington Regional Council

Wellington Transport Analytical Tools

CONTENTS

LIST OF TABLES

LIST OF FIGURES

1. Introduction

This technical note is part of a series documenting the 2019-2021 update of components of the Wellington Regional Transportation Planning Analytical Tools ("Analytical Tools", "Tools"). The higher-level Analytical Tools are maintained and operated by Greater Wellington Regional Council (GWRC), who are the client for this project. This project is being primarily delivered by Stantec and Jacobs, supported by GWRC transport planners.

1.1 Objectives

The project objectives can be distilled to:

- Improve user confidence in the Analytical Tools;
- Produce a high quality, fit for purpose product;
- Ensure the updated Tools are as simple as possible and transparent, while maintaining flexibility for future changes;
- Fix identified weaknesses; and
- Plug identified functionality gaps by developing and implementing new modules.

1.2 Project Staging

The project is organised into three sequential stages, which encompass:

- Stage 1 – fix specified weaknesses and develop new modules to embed specific additional functionality. Review the current primary Tool and determine if a full rebuild of the underlying equations is necessary. This process runs in parallel with the collection of Household Travel Survey (HTS) data, which is the primary source of travel information and underpins strategic model development;
- Stage 2 – if required, rebuild the primary Analytical Tool which forecasts travel demand throughout the Region; and
- Stage 3 – incorporate income segmentation and PT crowding. During the Scoping Workshop, it was requested that PT crowding be addressed as part of Stage 2.

The project extends over 2.5 years from December 2019 and staging the implementation of updates is sought so that benefits can be realised along the way.

1.3 Purpose of this Report

The purpose of this technical note is to expand on the approach outlined in our response ("Proposal") to the Request for Proposal (RfP) and provide more detail regarding the tasks to be delivered. It summarises options and functionality discussed in the "Scoping Workshop" held 10-11 December 2019, which was attended by the Client, key stakeholders, and the senior consultant team.

To provide value for money, we will first focus on the ultimate model form which will be delivered in Stage 2. This will ensure interim updates align with the final product. Hence this document, after a presentation of the analytical tools suite, considers each task in turn with the following sections:

- The purpose of the task, outlining what is the issue to be solved, or improved or new functionality sought;
- Current functionality of the models, including their strengths and weaknesses;
- Revised ultimate functionality at the end of Stage 2; and
- Options for staged implementation as part of Stage 1.

Enhancements to be included in Stage 3 have not been considered further at this point.

2. The Analytical Tools

The full suite of the Wellington Regional Analytical Tools for transport planning is shown below. The different components have specific capability and functionality and hence are applied at different stages of the transport planning process.

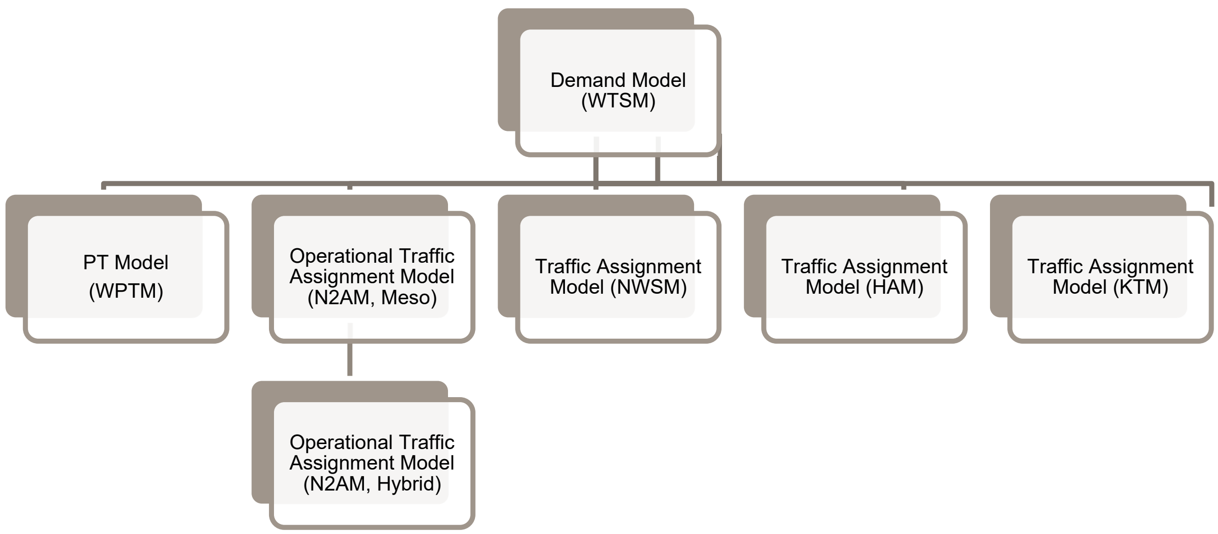


Figure 2-1: Wellington Regional Analytical Tools

The requirement of these tools is to provide a reliable basis for:

- Making informed investment decisions;
- Evaluating transport strategies;
- Evaluating the impact of transport interventions, including road and public transport improvements;
- Provide a mechanism to assess the impact of changes on mode share, including walking and cycling; and
- Providing travel demand for lower-tiered transport models.

The tools should reflect observed behaviour in the base year to an appropriate level of accuracy. They should be capable of forecasting future year conditions given specified inputs, and should enable (potentially through "what if" testing) the assessment of emerging trends.

A short description of the models illustrated in Figure 2-1 is provided in the following sections.

2.1 Demand Model

The overarching tool is the demand model, the Wellington Transport Strategy Model (WTSM). WTSM is the primary tool used by for strategic transport demand analysis. It is used to investigate infrastructure investment options, public transport provision, transport policy and land use scenarios.

WTSM is a multi-modal four step strategic transportation model that outputs travel by mode based on input assumptions on the transport network, population and related demographics, policies (such as travel demand management initiatives, parking costs, fuel prices, etc), and other metrics. WTSM currently accounts for traditional mechanised travel on the road network (private vehicles and light/heavy commercial vehicles), and people using public transport (rail, bus, ferry and the cable car). Bicycle and walk trips are not explicitly represented at present but are accounted for as a proportion of either car or PT (which varies by trip purpose).

A diagram of the model framework is shown below.

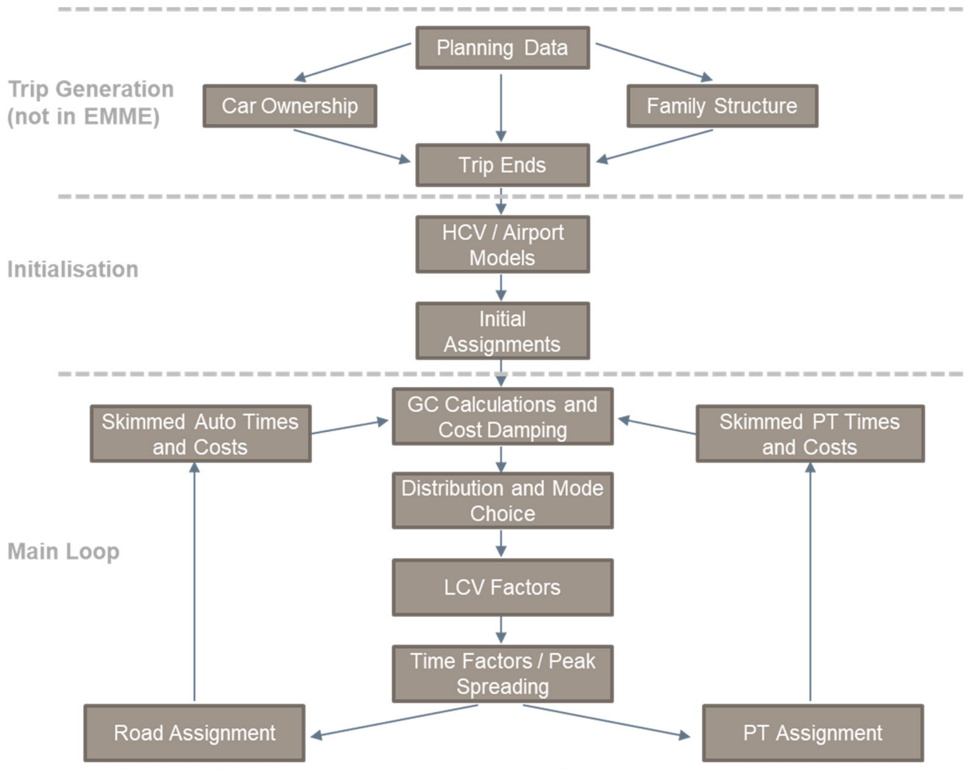


Figure 2-2: WTSM Schematic[1]

The model estimates demand for an average weekday. Prior to assignment, this daily demand is broken down into time periods: a two-hour AM peak (7-9am), a two-hour interpeak (two hours between 9am-4pm), and a two-hour PM peak (4pm-6pm). These demand matrices are subsequently assigned to the road and public transport networks.

The primary purpose of the WTSM is to estimate travel demand by mode for medium to long-term horizons (i.e. 20, 30, 40 years beyond the base year). It produces first order estimates of transport system performance including travel distances and congested travel times, enabling high-level quantification of indicative benefits for strategic-level interventions. The model is appropriately strategic with 225 internal zones.

This generation of WTSM was first created in 1996 when the model was converted into the current software platform. The WTSM was then fully calibrated and validated using a Household Travel Survey for the base year of 2001. Since then, it was revalidated to the years 2006, 2011 and 2013. The years 2001, 2006 and 2013 coincided with the National Census. The 2011 revalidation should also have coincided with Census, but because of the Canterbury earthquakes, the 2011 Census was postponed to 2013. The 2011 review continued, however, to support a high-profile project, followed by a check in 2013 when Census data was available.

WTSM is now 18 years old, and it is appropriate to consider if the underlying travel behaviour still holds. If significant change has occurred, then the model must be re-calibrated and model processes reviewed and enhanced where appropriate.

[1] Trip generation in WTSM currently carried out in Excel

2.2 Public Transport Model

The Wellington Public Transport Model (WPTM) equips the Region with enhanced capability for public transport planning. WPTM recalculates sub-mode choice and then route choice for public transport trips using more refined processes. It has an incremental mechanism to estimate future travel patterns based on changes forecast by the WTSM. The model outputs are at a greater level of detail, with 780 internal zones to capture walk-in versus ride-in catchments.

A diagram of the model process is shown below.

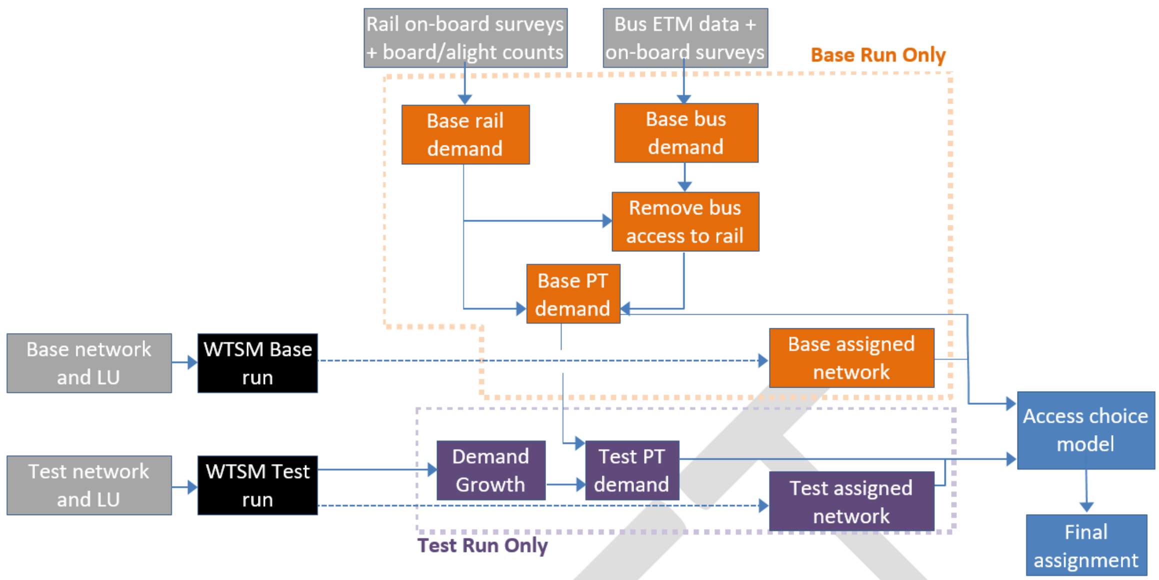


Figure 2-3: WPTM Schematic

WPTM currently has two-hour AM peak (7-9am) and two-hour interpeak assignments (2-hour average of 9am-3am) that were developed from comprehensive observed data. There is also a two-hour PM peak assignment (4-6pm) that was developed as a factored transpose of the morning period.

Obtaining reasonable public transport trip matrices from a mode choice model embedded in a strategic model can be extremely challenging. The purpose of the WPTM is to produce a more refined estimate of public transport (PT) patronage by mode and route using observed PT matrices and a pivoting approach. Public transport system performance and benefits of PT interventions can be better estimated using this approach. It is noted that bus travel times are a function of the WTSM forecast of congested travel times on roads, which are strategic in nature (i.e. turning delays at intersections and bottlenecks are reflected simply).

WPTM (AM and interpeak periods models) was developed as part of the 2011 update and was calibrated and validated to 2011. The demands were developed from observed data – including rail and bus origin-destination interview surveys. The observed matrix was modified in 2013, applying minor sector-based factoring to reflect 2013 demand. In 2016, the PM peak period was added by transposing the AM peak demands with factoring of the outputs to better reflect observed patterns.

2.3 Traffic Assignment Models

Alongside the WPTM are a series of traffic assignment models covering different geographic areas of the Region. These models produce more refined estimates of vehicle route choice with smaller zones and have a more detailed calculation of congested travel times taking intersection delays and cumulative queues explicitly into account. They have a base year vehicle demand matrix derived initially from WTSM and then adjusted and improved using observed data. Their respective base years vary depending on when and why the models were originally developed. These models all focus on vehicles, so while buses are represented as part of the traffic flow, people on the buses are not considered. Forecast vehicle demand is produced by applying the changes forecast by WTSM between the base and future years.

Each of these models was developed for the purpose of producing a more robust estimate of travel benefits (congested vehicle travel times and travel distances) for a specific scheme. Given their large scale, however, they have subsequently been applied to evaluate other projects (after appropriate checks and updates were undertaken).

The newest of the suite is the Ngauranga to Airport (N2A) operational traffic model. Taking advantage of modern software functionality, this model assesses the build-up and dissipation of traffic throughout the congested peak periods. There is an AM peak (6-10am), an interpeak (10am-2pm), and a PM peak (3-7pm) model. Only the middle two-hours of each of the three periods were validated, with the first and last hour a warm-up and cool-down periods typical with simulation modelling.

3. Current Model Structure Improvements

3.1 Task Purpose

The purpose of this task is to streamline performance of WTSM and WPTM without any changes to the model functionality and form. This task is about "quick wins" and improving efficiency.

3.2 Current Model Functionality

WTSM is implemented within INRO's Emme software package and scripted in the Emme macro language. The model has 225 zones (excluding external, port and park-and-ride zones). A Modeller version of the model exists but has never been used and is not up to date with the latest version of the model. The highway assignment uses Emme's standard (equilibrium) assignment methodology.

WPTM is scripted in Emme Modeller, with 780 zones, excluding external and park-and-ride zones (which are common with WTSM). Matrix calculations and convolution (triple-index operations) are implemented using Emme Modeller tools.

Strengths:

- Current WTSM model is stable and well understood. Model run-time is considered good at about 1 hour 15 minutes;
- Emme Modeller version of WPTM has been extensively used and is stable;
- 780 zones is a suitable level of zonal disaggregation for the WPTM.

Weaknesses:

- The Emme macro language used in current WTSM is not being actively developed by INRO anymore and some new functionalities are now only implemented in Emme Modeller. The conversion of Emme macros to Emme Modeller for WTSM would bring more flexibility with Python as the chosen scripting language, including access to extensive programming libraries, interfaces with Microsoft Excel, DBF files, spatial (GIS) files, graphics and plotting, version control systems, fast manipulation of large matrices through the "NumPy" library and the potential for improved run-times;
- The current version of WPTM runs in slightly over 1 hour for all three time periods. Using python libraries (NumPy) for the newer PM peak component of the model has resulted in a reduced run-time from 20 minutes for this period to about 5 minutes, so there is significant potential for reducing total run-time if similar changes are implemented in the AM and interpeak (IP) time periods;
- WTSM's 225 zones are considered too coarse for a strategic model based on current standards, especially for representing active modes or access to PT;
- Information is passed from WTSM to WPTM, but no feedback is provided in the other direction. A different number of zones in the two models complicates data transfer and consistency of results.

3.3 Revised Model Functionality

All of the revised capability relating to improving the structure of WTSM lies within Stage 1, so there is no requirement for interim updates.

- Produce an up-to-date Emme Modeller-based version of WTSM, so that WTSM and WPTM are both based on the same language and interface. For run-time issues relating to the auto assignment, we will keep using the self-contained assignment macro at first, and investigate how to reduce run times, including by using new assignment algorithms (SOLA, Path-based) without un-validating the model;

- Improve some of the methods used in the models to reduce run-times and increase functionality, including using NumPy library for matrix convolutions or calculations in WPTM, and enhanced and multi-threaded assignment procedures (SOLA or path-based for traffic). This will better enable increasing the number of zones in WTSM as part of Stage 2;
- Review the 780 zone system in WPTM to ensure it is appropriate for use in both the PT and strategic models (including for road assignment and active modes), and consistent with new SA1 census zone boundaries. Consider special generators (including separate zones for port and ferry terminals) and zones for known future land-use developments;
- Establish a WTSM-WPTM toolbox for interactively running both models and some of their individual components.

4. Updated Demand Model

4.1 Task Purpose

The first purpose of this task is to evaluate if the demand model is still reflecting current travel trends using the latest Household Travel Survey and conclude if a partial or full model rebuild is required.

If a full model rebuild is deemed necessary, then a new demand model will be developed, calibrated and validated. A comprehensive update opens the door for considering a wider range of possibilities for the model form and functionality. A partial update of some sub-models will be more limited in potential scope, but considerably more cost effective.

4.2 Current Model Framework

WTSM is a standard 4-step trip-based model with 225 internal zones, forecasting demand for an average weekday (24 hours), then splitting it into three two-hour time periods for assignment. Time periods are shown in the following table.

Table 4-1: Current Time Period Definiton

Period	Hours
AM	7-9am
Interpeak (IP)	Seems to have changed over time 2001 and 2006 models had a two-hour average of the seven hours from 9am-4pm 2011 model used 11am-1pm
PM	4-6pm

Strengths:

- Relatively simple, well understood and widely used model form;
- Fast run-times at 225 zones, although run-times will increase if the number of zones is increased to circa 780 zones using the same zone system as the WPTM.

Weaknesses:

- Simple model with limited explanatory variables, and all trips modelled independently of each other. It is noted that all model forms have limitations;
- Dated, as built from 2001 Household Travel Survey data. There is evidence from US and Australian capital cities that suggests that trip generation rates for some trip purposes have decreased significantly since 2005;
- Relatively coarse geographic resolution (225 zones) compared with other cities in New Zealand;
- Limited possibilities of modelling time-of-day choice, travel demand management, active / AVs / ride-hailing modes;
- Large share of Home-Based Other and Non-Home-Based (NHB) trips, which are not well represented. NHB trips, in particular, are the weakest part of any 4-step model as they are difficult to forecast reliably.

4.3 Revised Model Framework

4.3.1 Model Form

Options for revised model form include:

- Retain trip-based model, either keeping the current 4-step model or moving to 5-step, with the fifth step being time-of-day choice (model currently has fixed proportions for period-to-day which vary by trip purpose and origin-destination area);
- Move to a tour-based model;

- Move to an Activity Based Model (ABM).

There was no recommendation or appetite to consider an ABM, which are primarily used in the US. ABM's have the strongest explanatory power but are substantially more complex than both trip and tour-based models requiring considerable investment to develop and apply. It is noted that the Ministry of Transport has just awarded a research study to scope, and potentially then develop, a national agent-based Activity-Based Model.

The key challenges with ABM's are as follows:

- Extremely complex - understood by very few;
- Nearly impossible to explain the process to others;
- Run-times orders of magnitude greater, for example, potentially 24-72 hours;
- A number of the existing ABMs in application takes more than a week to run a single scenario even with expensive hardware and multiprocessing and can have a high degree of variability in results produced between model runs using the same input parameters;
- Extremely significant development time and cost, e.g. It normally takes 3-6 years and costs $2~$5m USD for an ABM base model development;
- Agreement that "we don't need to make the black box any darker".

The form of the model, focused on trip-based versus simplified tour-based, was discussed at the Scoping Workshop but there was insufficient information on the benefits of moving to tours to reach a conclusion on the way forward. The form of model (trip-based, tour-based, simplified tour-based) will therefore be agreed early in Stage 1 following research into any benefits/disbenefits experienced by cities that have made the change. Implementation will be carried out during Stage 2.

Advantages and disadvantages of trip vs tour-based models discussed at the Scoping Workshop are documented below. These are based on a literature review and are therefore not proven to the team.

Table 4-2: Pros and Cons of Trip vs Tour-Based Models

	Trip Based	Tour Based
Advantages	• Relatively simple • Standard software • Costs less to develop (although this is debatable) • Relatively fast run-times (dependant on the number of zones, CPU speed, and software) • User-community and technical industry are more familiar, so more easily understood • Calibration and validation processes are well understood and widely applied • Modularity allows for incremental improvements to model processes in most cases • Estimation processes are relatively simple and implementable	• Interactions between journeys that occur across the day are taken into account • Ability to model departure time choice better • Able to model some demand management (but ABMs are better) • Better potential to model AVs and ride-hailing • Could be better for analysis of intangible PT amenities • Improved ability to model walking and cycling • Model choice more accurately reflected by accounting for linked trips • More information and analysis can be produced to inform decision making • The number of productions (the home end of a journey) and attractions (the out-of-home activities) are implicitly balanced
Disadvantages	• Simple statistical models with limited explanatory variables • All trips modelled independently of one another • Can't model peak spreading as easily	• No advantages over trip-based models for highway assignment (except carbon pricing)

	Trip Based	Tour Based
	• Less capable in evaluating TDM • Struggles to model walking / cycling • Can't easily model AVs or ride-hailing • Large number of Non-Home-Based trips ("rubbish bin") which are inaccurate to forecast • Doesn't retain Household attributes • Consistency is not maintained between the characteristics of outbound and return trips (for example, consistent travel modes, traveller demographics and geographic locations of home and activity locations)	• No existing evidence of significant difference in forecasting accuracy • More complex models are more difficult to calibrate, hence costs more • May have longer run-times, but not as long as ABMs • Less industry knowledge - understood by fewer people

Key points on one particular form of simplified tour-based model were discussed, which are as follows:

- Uses the discrete tour-based approach throughout;
- Uses logit models and Monte Carlo simulation;
- Has a Household synthesizer, rather than a population synthesizer that ABM's require. Household synthesizer is simpler to produce although compromises some detail;
- Easier to understand than ABM's;
- Runs faster than ABM's;
- More complete usage of household attributes in all steps compared with trip-based models;
- Discrete process avoids aggregation error;
- Round trip tours are more accurate than disjointed trips;
- Better reflection of the way people travel compared with trip-based models;
- Requires standard HTS data; and
- Calibration takes slightly longer than trip-based models.

4.3.2 PT Crowding

PT crowding is the process of representing capacity on public transport services in destination choice, modal choice, and route choice. In particular, it is important to consider capacity when the overall demand exceeds the supply.

The inclusion of PT crowding was specified as a Stage 3 deliverable in the RfP. During the Scoping Workshop, it was requested and agreed that PT crowding be implemented as part of Stage 2, which is likely to be more cost-effective.

No further investigation has been undertaken, and options to implement PT crowding will be considered during the detailed specification of the model form for Stage 2.

4.3.3 Zonal Definition

Irrespective of the model form, the number of zones in WTSM (225 internal zones) is considered coarse by modern standards. It was agreed that the zonal resolution will be increased, with the current zone system from the WPTM (780 internal zones) being used as a starting point. However the final number of zones to be used in all three models will likely differ slightly to ensure that the zone system is appropriate for demand modelling as well as car and PT assignments, and compatible with the new SA1 census units. Increasing the number of zones will ensure the following benefits:

- Better representation of traffic volumes, especially in urban areas as the current large zones in WTSM result in significant amounts of traffic loaded at a limited number of locations on the network;
- Better representation of short trips and trip legs for active modes and access to public transport;

- Using the same zone system as WPTM and WTAM will allow for easier analysis and passing of information between models, including potential feedback loops. The same Emme database may be used for all three models, with the possibility for WTSM assignment to be ultimately replaced by the more detailed assignment models.

There is an aspiration that demand model run-times will not increase significantly, although it was noted that increasing computer power will offset this issue. Run-times of 4-6 hours are considered a maximum, which enables multiple options to be assessed overnight. It is noted that run-times cannot be guaranteed, and that many of the aspirations for enhanced functionality will come at the cost of increasing run-times. Any zonal refinement for the demand model needs to take account of the WPTM and N2A zone boundaries, as well as changes required from Census moving from Area Units/Meshblocks to SA2/SA1 units.

Considerations that effect, and do not effect, the choice of the number of zones include:

- Not significantly increasing run-times, as discussed above;
- The finer the zone system in terms of dividing Census SA2 units (unit of future year land use prediction), the greater level of uncertainty regarding input land use;
- The Household Travel Survey is not a constraint on the number of zones;
- More zones could improve the potential to calibrate/validate the model to observed data.

4.3.4 Time Periods

In the Scoping Workshop, deciding on the time periods to be modelled was a hot topic of discussion and we did not reach a final consensus. One key challenge is that congestion occurs at different parts of the network at quite different times, with the CBD experiencing the worst morning peak congestion between 8 and 9am while on the motorway at Ngauranga, morning peak delays occur much earlier at either 6 to 7am or 7 to 8am. The time period must be selected considering the entire Region. It is acknowledged that the longer the time period modelled, the more likely that lower travel benefits will be indicated by the demand model from providing additional road or PT capacity. However, the purpose of the demand model is to forecast demand, as well as enabling the calculation of first order estimates of travel benefits.

The second challenge is that the metrics available to check the outputs of the demand model are traffic counts which, for congested periods, measure supply and not demand. So it is not advisable to select a peak period which is too short, which would mean the demand model could underestimate travel. The consultant recommendation was therefore to extend the current two hour peak periods to three or even four hours in duration. This suggestion was not confirmed during the Scoping Workshop.

It was agreed that the demand model should reflect 24 hours of travel, divided into four time periods representing the AM peak, interpeak, PM peak, and overnight periods. The summation of the four time periods should equal 24 hours without any further factoring.

It was also deemed preferable to specify whole hours (i.e. not half past an hour) to maximise use of existing traffic counts.

Options for revised peak periods are shown in the following table. Traffic counts and PT boardings will be reviewed and a recommendation made early in Stage 1 on assignment period durations.

There are implications for the WTSM-WPTM interaction of significantly changing the time periods in WTSM. One solution would be to forecast longer time periods in WTSM, incorporate factors to subsequently factor the WTSM demands into "peak period" and "shoulder period". As an example, WTSM AM peak demand would represent 6-10am, which would then be divided into a matrix representing 7-9am and the two shoulder peaks (6-7am plus 9-10am).

Having different time periods in the demand model (WTSM) and assignment models (WPTM and WTAM) was not seen as being detrimental provided appropriate factoring is applied to demand passed to the lower tiered models. This is even viewed as potentially being the more suitable approach as these models are more likely to be used for assessment of options, in which case the shorter time periods will reduce the risk of under-estimation of economic benefits.

Table 4-3: Options for Time Period Definiton

Period	Current Hours	Revised Hours
AM	• 7-9am	• Retain 7-9am • Expand to 6-9am • Expand to 6-10am to match N2A Model and future-proof the model for further peak spreading and ensure that the period incorporates the build-up and dissipation of peak demand by including the shoulder peak period
Interpeak (IP)	• Seems to have changed over time • 2001 and 2006 models had a two-hour average of the seven hours from 9am-4pm • 2011 model used 11am-1pm	• Will cover all hours between selected AM and PM peak periods. Not necessary to model a two-hour average. • Apply a demand multiplier to represent "average" conditions experienced during the period
PM	• 4-6pm	• Retain 4-6pm • Expand to 3-6pm to include after school peak • Expand to 3-7pm to match N2A Model and future-proof the model for further peak spreading
Overnight/Off Peak (ON/OP)	• N/A	• Will cover all hours between selected PM and AM peak periods. Not necessary to model a two-hour average. • Apply a demand multiplier to represent "average" conditions experienced during the period

4.4 Staged Implementation

The updated model form is a Stage 2 delivery, so any earlier deliverables relate to research and preparation. Actions regarding model form include:

- **Model Form Actions:**
  - Investigate examples of tour-based models in operation overseas to inform the decision. We are particularly interested in cities that have moved from a trip-based to tour-based model, and their experience in terms of benefits and disbenefits;
  - Liaise with INRO to research current and upcoming Emme functionality for tour-based modelling;
  - Analyse current traffic counts and traffic speeds, as well as PT patronage to ascertain temporal variability and the optimal duration of morning and evening peak periods. As an example, extending the current AM peak from 7-9am to 6-10am would improve confidence in the ability of the demand model to forecast demand, as current comparisons against 7-9am traffic counts have the issue of supply-constraint (i.e. we are comparing a traffic demand against supply and not the true demand). Furthermore, aligning with the N2A model periods negates the uncertainty of factoring different durations;
  - Once a decision on the updated model form is reached, more detailed scoping on functionality will be undertaken in Stage 1.
- **Decide on Need for Model Rebuild:** Utilising the available sample of Household Travel Survey data from the Ministry of Transport, refine the expansion of this dataset to represent the 2018 Wellington Region. Depending on Census availability, it may be that 2018 Census control totals are used with other information from the 2013 Census. Compare WTSM's forecast of 2013 and 2021 travel patterns with observed and conclude if an update is required. Given the age of WTSM, we are expecting a full recalibration will be required.
- **Household Travel Survey:** Undertake statistical calculations to confirm required sample size. Confirm sampling approach with the Ministry of Transport and impact of additional sample funded

by Waka Kotahi NZ Transport Agency. Monitor geographic coverage and representativeness of data collected, because targeted sampling may be subsequently required to ensure the HTS is representative particularly for some demographic segments that may be under-represented but important to demand estimation.

5. 2018 Network and Parameter Updates

5.1 Task Purpose

The purpose of this task is to update all year specific files and parameters to 2018. This includes networks (road and public transport), vehicle occupancy and other key parameters.

5.2 Current Status

Road and PT networks have been developed for the base year 2013, at both 225 and 780 zones. Parameter files also currently represent 2013.

Vehicle occupancy parameters are defined per purpose and for different geographical sectors (e.g. trips to CBD, intra-TA), calibrated on 2001 values.

5.3 Revised Status

The road and public transport networks will be updated from 2013 to 2018 and maintained at both 225 and 780+ zones initially to ensure flexibility. The centroid connectors and loading points for the 780+ zones will be reviewed and updated to ensure they are appropriate for both highway and public transport assignments. Any required data that is missing will be coded.

Parameter values (value of time, vehicle operating costs, etc) will be updated to 2018 values. Fully revising parking inputs (cost, capacity, etc) will be undertaken as part of the Parking or Park-and-Ride tasks.

If the 2018 Census data is going to be available within the next 4-6 weeks, the current unchanged version of WTSM will be run for the year 2018 at 225 zones. If 2018 Census is not available in time, 2013 land use will be simply factored to a quasi-2018 (factoring to replicate either population or dwellings total by Territorial Authority). The (quasi) 2018 assignment validation (road and PT) will be tabulated. This will be a benchmark to determine if changes made to the model in Stage 1 are adversely affecting the outputs. It is stressed that this is not a validation exercise – it is benchmarking.

For vehicle occupancy, as an interim measure before parameters are fully updated as part of the model development in Stage 2, a mechanism to manually adjust these values for forecasting for each segment will be added to WTSM.

The updated model is to represent an average March weekday 2018, rather than an annual average weekday.

5.4 Staged Implementation

This task will be delivered as part of Stage 1.

6. Park and Ride

6.1 Task Purpose

The purpose of this task to improve the representation of modal choice associated with park-and-ride facilities in terms of access mode, as well as accounting for the impact if a charge is added for parking.

6.2 Current Model Capability

WTSM has a coarse representation of Park and Ride access and costs, through the use of P-connectors linking centroids to rail station nodes. The cost of travelling on the P-connector is obtained through assignment during model development but is not recalculated as part of a scenario run. The resulting auto trips to rail access get added to total car demand. "Costs" means generalised cost and does not include specific parking charges at present.

WPTM has a detailed PT access logit choice model (including park-and-ride, kiss-and-ride and non-car) which is applied to railway stations only (i.e. no park-and-ride for buses).

Strengths:

- The WTSM process is simple and is assessed through the assignment, run-times are minimised;
- The WPTM access choice model is detailed and is therefore more representative of real access choices.

Weaknesses:

- P-connectors in WTSM are only a crude representation, with no accounting for capacity, price2, etc. Choice between car (through P-connector) and non-car (through regular connector and walk or bus access) is done through the assignment;
- WPTM access choice model does not feed back into WTSM. Therefore, improvements in park-and-ride can impact on car vs non-car access to PT and share of bus vs rail, but not on total PT demand. The more accurate representation of park-and-ride use and associated generalised costs also does not feed back into the WTSM which would also impact on distribution, mode choice and overall public transport demand;
- Representation of car access to bus in WPTM might be limited (to be tested, see below);
- There is no functionality for charging for parking at park-and-ride sites in either model;
- There is no enforced representation of capacity constraint, although WPTM does use formal and informal parking capacity as an attractiveness variable in the logit model. So in both models, parking demand can exceed supply.

6.3 Revised Model Capability

Access mode choice for park-and-ride sites in WTSM will be improved during the model rebuild in Stage 2 through the following modifications:

- Include a rail access choice calculation within the modal choice logit model (similar to WPTM) in WTSM. This will consider park-and-ride, kiss-and-ride, and other (walk in or bus ride in). The objective of this is to improve the assessment of modal choice relating to car access to public transport. It is noted this will increase complexity and run-times, both at odds with a project objective;
- Consider adding access choice calculation for key bus interchanges within the model choice logit model in WTSM. This would only be for a small number of significant bus interchange locations. The functionality should be flexible to enable extension to other bus stops in the future. The decision on whether this functionality is implemented will depend on the additional complexity that needs to be incorporated, as maintaining transparency and simplicity are key project objectives;

[2] Price as understood by the Users and not the true price of providing the parking

- Add car access leg to PT to the road assignment;
- Add functionality to represent parking capacity (with formal/informal to be represented either as absolute or as a ratio). Implement a module which can be switched on or off that enforces parking capacity at park-and-ride sites so that demand cannot exceed supply. It is noted that this could increase run-times, however ensuring the module can be switched off mitigates this issue;
- Incorporate park-and-ride charging to WTSM, with the ability to add parking charges that can vary by park-and-ride sites. For sites with both formal and informal parking capacity, a weighted average parking cost would be calculated with zero cost for the informal parking spaces and the specified charge for the formal spaces. Sites with significant availability of informal parking spaces will therefore dilute the impact of adding parking charging.

For the WPTM, access mode choice will be amended to allow charging for formal parking (flexible to be varied by site) and improve representation of parking constraints, using a similar methodology as the approach proposed for WTSM.

Data collected from the 2011 development of WPTM and the more recent 2017 Rail survey will be used for calibration.

6.4 Staged Implementation

The park-and-ride enhancements for WTSM described above will likely change composite travel costs and would therefore un-calibrate the model, for this reason they will be implemented as part of the model redevelopment in Stage 2. For Stage 1, interim implementation in WTSM will include:

- Recalculating costs on P-connectors by extracting costs from the car assignment. This retains the current model structure but produces an interim improvement and improved internal consistency in the model;
- Adding parking costs to the generalised cost. This would be a weighted average of the cost for formal spaces and the number of informal spaces.

In WPTM, the following changes will be made as part of Stage 1:

- Investigating adding bus P&R in WPTM. Implement if possible and practical, while meeting project objectives of transparency and simplicity;
- Investigating adding charging and capacity constraints in WPTM. Implement if possible, while meeting project objectives of transparency and simplicity.

7. Parking

7.1 Task Purpose

The purpose of this task is to improve the representation of modal choice associated with parking facilities in terms of parking capacity, cost, and in the CBD, time spent circulating to find a space.

7.2 Current Model Capability

The cost of car parking is represented in WTSM through matrix-based costs for zones in Wellington CBD. Different costs are applied to Upper and Lower CBD, as well as Home-Based Work (HBW) versus other purposes.

Strengths:

- Simple implementation – transparent and no impact on run-times.

Weaknesses:

- Wellington CBD only, although this is where the majority of parking constraints exist;
- No parking capacity constraint, so demand can exceed supply;
- Assumes the parking zone is the same as the destination zone in terms of door-to-door travel times;
- No representation of additional time spent searching for a parking space, or additional delay for traffic caused by vehicles circulating to find a park;
- Source of the parking costs applied in the model unknown. Last two model updates have only applied the observed relative increase to modelled costs.

7.3 Revised Model Capability

Changes to the representation of parking costs in WTSM will include the following:

- Add cost to park to WTSM:
  - Re-calculate wider Wellington CBD parking costs (to include coupon parking areas and informal parking supply using a similar approach as for the park-and-ride module) based on current prices, high-level summary of parking in the CBD by type and data about parking use from the HTS (including duration of stay and trip purpose);
  - Differentiate parking costs and use by trip purposes (commuting, employer provided, and other). This will be dependent on sufficient data availability;
  - Implement procedure to apply parking costs at sector levels but with functionality to apply per zone when required. Sectors will cover the entire modelled area, but costs and capacities will only be specified for the wider Wellington CBD area and set to zero for the rest of the region initially. These parameters can however be filled in for later analysis with the model, for example, for areas such as Porirua and Hutt City CBDs.
- Implement module to enforce parking capacity restraint in WTSM:
  - Parking capacity constraints will be applied through an additional function returning additional costs as demand increases. Capacity both formal and informal will be a variable in the cost function;
  - This module will be able to be switched on or off. It is noted that switching it on will significantly increase run-times as the model iterates towards convergence;
  - Initially, parking capacity restraint will only be tested for the wider CBD (at a sector level), but again the ability to apply anywhere in the model including in other regional centres will be incorporated.
- Parking zone will be assumed to be the same as destination zone. While it is recognised that this is a simplification, estimating the choice of parking destination and resulting parking circulation would lead to significant increase in complexity and run times. Circulation between parking and

destination can be addressed in lower tiered models and the application of sector-based parking costs partially addresses the cost disconnect between parking location and final destination;

- Add "terminal time" to mimic extra circulation time and walking time between the parking location and destination in WTSM, which will mitigate the limitation described in the previous point:
  - Fixed times, specified by sector, will be added to the generalised cost of vehicle trips to reflect the ease of getting a park in terms of circulation and walking distance;
  - These times will vary by purpose, with higher values in the CBD;
  - The times will be specified on a sector-basis, which can be easily changed;
  - The terminal times are not dynamic – they are a simple representation of ease of locating a parking space.
- Cost parameters, parking capacity, and terminal times will be stored in an easily editable input file;
- These elements (parking costs, parking capacity restraint, terminal times) will not be added to WTAM. This is because WTAM is a vehicle assignment model and not a demand model. The objective of improving the representation of parking is to improve the demand calculation.

7.4 Staged Implementation

Terminal time and enabling parking costs to be specified (by redefinable sector) across the whole model can be implemented in WTSM in Stage 1. It is worth noting that this may un-calibrate/un-validate the model if the outputs change substantially. Implementation of this aspect in Stage 1 is therefore subject to discussion/agreement.

The recalculated parking costs could also be incorporated in WTSM in Stage 1. However, this is subject to the same issue as noted above regarding maintaining WTSM calibration/validation.

8. Vehicle Delay Representation

8.1 Task Purpose

The purpose of revisiting the estimation of congested vehicle travel times is to improve the assessment of modal choice, particularly car versus public transport.

8.2 Current Model Capability

Vehicle travel times in WTSM are represented through link and simple intersection delays and are both based on Akcelik functions. Intersection delay is approach-based, not turn-based.

Approach capacity is recalculated based on opposing volumes during the assignment (not a standard Emme approach and INRO advises against the current approach). This was developed to better represent congestion in areas such as the CBD, but convergence issues led to capacities being fixed (imported from a SATURN model) in the CBD.

Bus travel times are a function of general traffic travel times, with a factor applied to account for slower speed for buses and acceleration/deceleration time. This factor varies by type of link (normal road, bus lane, bus only link), location (CBD and non-CBD) and time period. Dwell times are then added that vary by location (CBD and non-CBD) and time period. Public transport travel times use the same function in both WTSM and WPTM.

Assignment is based on vehicles and not PCUs (Passenger Car Units).

Strengths:

- Akcelik functions for links and intersections are widely used and generally performs acceptably;
- Approach-based intersection delays are used, and it is not considered necessary to fully model intersection delays in a strategic model (refined versions of approach-based intersection delays used in Sydney and Brisbane models);
- WTSM is a demand model, therefore no stringent capacity constraints recommended. This can be handled by lower tiered models.

Weaknesses:

- Recalculating intersection approach capacity mid-assignment is not recommended by INRO.
- Current method extends run-times and, more importantly, led to convergence issues. To fix the convergence issues, most intersections in the CBD were set to fixed capacities which are rarely updated, and the SATURN model used to provide them is not used anymore.
- Merge and bottleneck delays are currently not well represented.
- For bus travel times, dwell times do not explicitly vary with demand although the higher input values used for the CBD and peak periods do account for more boardings/alightings. Also, the factors applied to general traffic travel times have occasionally resulted in slower speed on bus lanes and bus only links than on normal roads.

8.3 Revised Model Capability

Options for modelling congested vehicle travel times, which were discussed at the Scoping Workshop, include:

- Retain current approach-based intersection delay methodology but review the shape of the speed-flow curve and the input parameters;
- Adopt a simpler approach with (for example) fixed intersection capacities and delays with sufficient detail to produce robust demand estimation. Detailed intersection modelling would then be considered in lower tiered models;
- Implement HCM methodology, possibly in addition to current delays at targeted location (e.g. merges, motorways). Upcoming junction capacity assignment being developed by INRO will be investigated;

- Move to a turn-based delay function (rather than the current approach-based).

It is recommended to keep approach-based intersection delays but review values for friction factors, capacities and J-parameters, add extra delay calculation at targeted locations (such as merges), and test removing fixed intersection capacities. The latter would require some additional network coding as some required information needs to be added to allow calculation of capacity per approach.

There was discussion on the impact of high volumes of Heavy Commercial Vehicles (HCVs) on overall traffic speeds. It was agreed that HCVs (and buses) will be modelled as PCUs in the traffic assignment.

Steep gradients and the impact on overall traffic speeds were also discussed. Although the information is included in the current network, it was concluded that this is best considered in lower tiered traffic models or specific project-based models.

Calculation of bus travel times will be reviewed and modified to solve the issue with buses occasionally running slower on new bus lanes or links than on general roads. We are not proposing to add the calculation of dwell times as a function of demand within the model as this would add to the complexity and run-times of the Tools. It is recommended that input dwell times would be manually edited for forecasting to account for significant patronage growth or improved boarding/ticketing facilities, which is already done for new modes (LRT, BRT) assessed with the Analytical Tools.

8.4 Staged Implementation

This task will be carried out as part of Stage 1.

An initial validation check will be carried out, with modelled travel times to be compared with observed, particularly through congested parts of the network (Wellington CBD, SH1/SH2 merges) and the ability of the current speed-flow curves to replicate observed travel times to be evaluated. The friction factors and the allocation of these to each link in the network based on road hierarchy will be reviewed and updated.

Fixed capacities in the CBD will be removed, and the implication of updating these quantified in terms of run-times and convergence.

The impact of changing the speed-flow curves on the model validation will be assessed. It may be that these changes completely un-validate the model. In which case, a decision will need to be made whether implementing these changes is deferred to Stage 2 (when validation changes can be accommodated in a most cost effective way).

We will discuss with INRO the availability of the upcoming junction capacity assignment and potential to use it to replace the current mid-assignment capacity calculations.

Vehicles will be assigned as PCUs in WTSM and the impact on the validation confirmed as acceptable.

9. Over-representation of Short Car Trips in CBD

9.1 Task Purpose

The purpose of this task is to address a known weakness in WTSM where too many short car trips are output, particularly within the CBD.

9.2 Current Issue

WTSM currently estimates too many short-distance car trips within the CBD. This could be due to under-estimating walk trips, or potentially also generating/attracting too many trips in total.

A number of reasons have been identified that could result in this issue, including (from easiest to most difficult to adjust in the model):

- Car ownership in the CBD, which returns higher car ownership than observed and faster growth in ownership than other parts of the region for future years;
- The method of a distance-based removal of active mode (walk and cycle) demand from either the car or PT mode (varies by trip purpose) may be under-estimating demand for walk and cycle;
- CBD parking associated costs being too low, and other issues such as circulation time to find a park and parking capacities not taken into account;
- Trip rates (total trips irrespective of mode) being too high in the CBD area.

9.3 Revised Capability

If the model delivered as part of Stage 2 is fully re-estimated, this issue will have been eliminated as calibration of the model will ensure that person trip rates and modal share in the CBD are an accurate representation of observed. In the case that the model is not fully recalibrated, the following steps will be followed:

- Tabulate 2013 modelled trips by mode and length from WTSM and compare to observed using the 2018 HTS data available. Quantify the problem (i.e. are there too many total trips? Are there too many car trips and not enough walk trips? Is the average car trip length too short?) Determine whether this is a trip generation, modal split, or distribution issue. Mobile phone data will also be investigated to inform analysis of short trips in the CBD, however, the level of aggregation of the data may not provide sufficient granularity;
- Adjust car ownership in the CBD (by adjusting zonal parameters) to better replicate observed, comparing against census data on captive/competition/choice household share;
- Adjustment of distance-based removal of active mode demand (carried out as part of task in section 10);
- Adjustments of CBD parking costs (carried out as part of task in Section 6);
- If required, and as a last resort, adjust trip generation rates for households in the CBD, which would need to be supported by HTS data analysis. This would depend on the HTS revealing lower total trip generation rates (i.e. including all modes of travel combined) for inner city residences compared with outer suburbs.

9.4 Staged Implementation

Adjustment of car ownership in CBD and distance-based split of active modes demand will be carried out as part of Stage 1.

CBD parking costs can also be incorporated, depending on the parking elements that are implemented in Stage 1 verses Stage 2 (see Section 6).

10. HBW Distribution and Mode Choice

10.1 Task Purpose

This task was to decouple the combined mode split-distribution for HBW and recalibrate separate distribution and mode split models. It only applies to HBW as this is the only trip purpose where these steps are integrated. As this is a significant calibration exercise that would only be relevant if undertaken in Stage 1, the need was explored in the Scoping Workshop.

The objective was to be able to test scenarios where the distribution would not change, but mode split could. The example given was a landslide that wiped out a significant road.

10.2 Current Model Capability

Trip distribution and mode choice stages are combined for the HBW trip purpose (mode choice then distribution for other trip purposes with Business Use (BU) being car-based only).

Strengths:

- This process likely performed the best during model calibration.

Weaknesses:

- Does not allow manual adjustment of modal choice independently of distribution, to assess what-if scenario such as network failure and resilience. However it has been noted by the technical advisor that holding distribution constant while testing changes on mode share is not a suitable task as some people would opt not to travel, or travel to different destinations. It is therefore best addressed through external processes.

10.3 Revised Model Capability

Manual adjustments process can be included to shift demand between car and PT on a sector to sector basis before final assignment, or as a post model run analysis with reassignment of the factored demand. It has been noted that there has been a move in the UK away from combined distribution and mode choice or pre distribution mode choice, to a hierarchy of distribution, then mode choice. If there is sufficient data, the hierarchy of choice should ideally be calibrated from first principles, which will be considered for Stage 2.

10.4 Staged Implementation

This matrix adjustment process can be implemented as part of Stage 1.

11. Active Modes

11.1 Task Purpose

Travel behaviour has changed since WTSM was developed in 2001, when car or PT were the primary modal choices. Now walking, cycling, e-Scootering/e-Biking are popular modes with increasing modal share. The purpose of improving how active modes (walking and cycling) are represented is to better reflect genuine modal choices and improve confidence in the model outcomes.

The aim of this task is not to provide a representation of active modes demand at the same level of detail as motorised modes, but rather to better reflect the potential impact of changes in active mode share on private vehicles and public transport demand and performance of the transport system.

11.2 Current Model Capability

Active mode demand is currently a by-product of total demand, removed from car or PT demand (depending on purpose and car availability segment) with factors being distance-based. This factoring is currently carried out directly after the distribution and mode choice calculations, and therefore applies to 24hr production-attraction matrices and not origin-destination matrices per time period.

Active modes demand is not intended to be used in further analysis in the current model form, only subtracted from total demand.

11.3 Revised Model Capability

Active modes will be included in the mode choice logit model. Analysis of HTS data will inform best form of model, with calibrated parameters to be sense-checked.

There will be no specific assignment of walk trips produced. Generalised costs for the distribution/mode split will be calculated in one of two ways.

- Either minimum distance/time will be skimmed from the road network, where times would be calculated based on a fixed walking speed (circa 5kph). If this approach is adopted, then key walk links would be added, for example, through the buildings linking The Terrace with Lambton Quay.
- Alternatively, straight-line distances between zones would be calculated, with an average walking speed applied.

A simple bicycle assignment could be included although there is unlikely to be sufficient observed data to validate this assignment to typically acceptable standards. As a result, it is not suggested that this assignment is used to estimate assigned volumes but simply to produce skims of generalised costs matrices to feed into the distribution and mode split models. To avoid any ambiguity as to the purpose of this assignment and since it would not be depending on capacity, a simple measure would be to assign a unit matrix instead of actual demand to derive the costs for each OD. Route choice and the resulting costs could be calculated based on relevant variables such as presence of a bicycle lane, traffic speeds, gradient, traffic volumes, presence of kerbside parking, area type (residential vs other), etc. Generalised costs for the distribution/mode split will need to be compatible with other modes so may still need to include time and distance.

Resulting 24 hours matrices of walk and cycle demands can then be factored to time periods using the same approach as other modes, which will allow validation against census journey-to-work and cordon counts (using matrix-based comparison if no assignment is carried out).

In addition to active modes being included in the mode choice logit model, an additional process will be applied to allow manually "enforcing" changes in active modes demand caused by factors that cannot be replicated by the model (e.g. changes in behaviours or uptake in new modes such as e-bikes). This could either be through manual adjustments of generalised costs for walk and/or cycle, or adjustments of demand matrices post mode choice model (this would be a similar approach to current adjustments to account for Travel Demand Management in the model, which transfers some of the Home-based work demand to the CBD from car to public transport, with parameters being manually set up as scenario input).

11.4 Staged Implementation

As part of Stage 1, we will:

- Review existing distance-based removal of active modes from total demand against HTS data;
- Implement process to manually adjust these factors, to test assumptions in changes in active mode demand and impact on car and PT demand.

12. Airport Model

12.1 Task Purpose

This task involved update the existing Airport Model and incorporate multi-modal capability.

12.2 Current Model Capability

The current airport model is very simplistic, only considering car trips and a single purpose. Total number of production trips are based on passenger movements from airport data and forecasts, with attraction based on distribution of population (whole region) and employment (CBD only). These are converted to origin-destination by time periods assuming 50% inbound – 50% outbound and time period factors from observed data.

A 4-step Airport forecasting model was developed as part of the 2011 update but was not used. This model will be reviewed, and discussions held with the Client regarding why the person-based Airport model was not adopted as "standard".

Strengths:

- Simple to understand, short run-times;

Weaknesses:

- Too simplistic, no business vs non-business purposes so model not aligned to drivers for air travel;
- Not multi-modal;
- Not validated.

12.3 Revised Model Capability

- The new Airport model will include a logit-based mode choice model, including vehicle and public transport modes;
- Total land-side demand for the base year will be a function of air passenger numbers, with the relationship between the two determined during the model calibration. For forecasting, air passenger growth will be either a function of GDP or based on forecasts from Wellington International Airport Limited (WIAL) if available;
- Taxis will be represented separately from cars. If distribution is undertaken before mode split, it might be possible to just represent taxis for business trips to the wider CBD only. Taxi would need to be considered for all destinations if destination choice was determined to be the more sensitive (with trip end modal split);
- Model form will ultimately be driven by the data available to build the model. There appears to be no origin-destination (OD) survey data (subject to liaison with WIAL) which includes the reason for making the trip and distinguishing meeters & greeters from air passengers, although it is understood that WIAL have processes to estimate trip purposes depending on trip direction (resident or visitor), trip time (time of day and weekday/weekend) and duration of stay. Modal choice will be calibrated against vehicle counts and occupancy survey, mobile phone data to be used for origin-destination information, supplemented by electronic ticketing machine (ETM) patronage data;
- As with active modes demand, matrix factoring processes will be included to "enforce" modal shift caused by changes that cannot be replicated by the model and assess their impact on the transport system.

12.4 Staged Implementation

The new Airport model will be implemented in Stage 1. This model will need to be developed based on the WPTM (780+) zone system. It will be complicated to incorporate in WTSM in Stage 1 while there are two different zonal resolutions, which will require separate Emme databanks. For the distribution, skims may need to be produced from WTAM in the interim (which will be 780+ zones as well). Validation will need to be checked during Stage 2, particularly with the full demand model operating at a finer zonal resolution than currently.

13. Cook Strait Ferry Passenger Model

13.1 Task Purpose

The purpose of this model is to represent Cook Strait ferry passenger (Interislander and Bluebridge) demand, particularly vehicle-related trips on the network in order to improve the balance of traffic flows between Hutt Road and the motorway.

It must be noted that this module does not include Centerport and associated HCV demand as this is included in the HCV model with the port being represented as a special generator with its own dedicated zone.

13.2 Current Model Capability

Currently there is no representation of Cook Strait ferry passenger demand. Employment-related trips are included as part of WTSM, and freight-related demand is included as part of the HCV model.

13.3 Revised Model Capability

A new ferry passenger model will be developed, with the ferry terminal treated as a special trip generator with its own zones (two zones, one for Interislander and one for Bluebridge.). Total number of trips will be based on observed and forecasted movements provided by the ferry operators.

It was noted in the Scoping Workshop that operation of the Port was compromised in 2018 due to an earthquake. This may mean 2018 observed data is atypical. Time-series analysis of ferry patronage and other economic variables will be undertaken, and if deemed necessary, the observed 2018 data will be adjusted prior to model development to ensure trips are not under-estimated.

It was also discussed that ferry trips are very seasonal. However, it was decided that the numbers were not significant enough to affect overall annualization of vehicle trips from the model.

During the Scoping Workshop, there was discussion that some people walk from CBD locations (hotels or parked cars) to access the ferry terminal. In theory, this would require a full 4-step model with mode choice to reflect travel behaviour. Given the magnitude of these trips, it was agreed that only car trips would be explicitly modelled. In addition, an adjustable input factor will be incorporated that will reduce the number of short car trips (if required), reflecting more walk-in trips. This factor can then be adjusted at any time, with the model then responding by reducing the number of short vehicle trips. The walk trips will not be explicitly modelled (i.e.: no assignment).

Limited origin-destination information is available. As a result, robust model calibration and validation is unlikely to be achievable. Instead a common-sense approach will be required. Distribution of trips will otherwise be based on regional population and employment.

For forecasting, the overall increase in demand will be based on forecasts from the Ferry operators or GDP, with flexibility to test alternative scenarios. Having separate zones for both ferry terminals as well as for Centreport will allow for assessing the impact of moving or merging terminals.

13.4 Staged Implementation

The Ferry Passenger Model will be carried out as part of Stage 1 (using the 2013 version of WTSM). Similar to the Airport Model, this model will need to be developed at 780+ zones. There may be challenges in incorporating two zonal resolutions in an Emme model.

Data on ferry activity (access mode share and numbers of people/cars) and forecasts will be sourced and analysed.

Application of the Cook Strait Ferry Passenger Model will be discussed and limitations will be clarified.

14. Heavy Commercial Vehicles Model

14.1 Task Purpose

The purpose of this task is to update the existing HCV Model using a greater sample of observed data.

14.2 Current Model Capability

The current HCV model was developed during the 2013 update. It is a synthetic demand model linking trip generation to land use, calibrated against HCV origin-destination data (eRoad and similar data from several fleet management companies), and validated against screenlines traffic volumes.

Increase in demand is indexed to GDP growth forecast with an elasticity factor applied.

Strengths:

- Synthetic, enables forecasting impact of changing land use on heavy vehicle patterns;
- Growth forecast (linked to GDP) consistent with recommended approach;
- CenterPort represented as a special generator.

Weaknesses:

- Use of eRUC in its earlier stages, so smaller sample sizes than can now be obtained;
- Sample (potentially) biased to the datasets available, with small operators less likely to be using eRUC so excluded from the sampled travel patterns;
- Information on total 'population' not available, so manual expansion was applied using screenline traffic counts. This meant there was no information to expand trips that were within sectors (i.e. not crossing any screenlines) and assumptions needed to be made and applied to intra-sector trips;
- Only one class including medium and heavy vehicles (light commercial included with cars, see next section);
- Centerport and ferry terminals are included in the same zone.

14.3 Revised Model Capability

Observed Data:

- Using eRUC origin-destination data as the sample, build an observed 2018 HCV matrix. The RfP stated that March 2019 eRUC data had already been scaled to match traffic counts, however, it appears this was relatively simplistic with a single global factor applied. So we will adjust the March 2019 sample data to match 2018 traffic counts at screenline level for each peak period (summing to 24 hours);
- It was agreed in the Scoping Workshop that a single HCV model would be developed and that medium and heavy vehicles types would not be separately distinguished. Light Commercial Vehicles (LCVs) are discussed separately;
- Ensure the HCV traffic count dataset, which will be used for sample expansion to total, does not include buses or coaches;
- Source data from Airport and Ports including forecasts for "special generators" (i.e. sites that generate atypical and substantial HCV trips);
- HCVs travel patterns are very seasonal, which was discussed in the Scoping Workshop. It was agreed that analysis would be undertaken to quantify the potential discrepancy, which would then be accounted for in the annualisaton process. It is noted that as the eRUC data has already been procured for March, changes in travel pattern throughout the year cannot be analysed. Instead, we will need to rely on an analysis of traffic counts;
- As the eRUC data has already been procured, there are challenges in that: the year is 2019 and not 2018; and while the data has been zoned to 780 zones we cannot specify different zones for CenterPort and the Ferry terminal. While these are data limitations, they are not "deal breakers", since this is sample data and will be factored to March 2018 representative totals.

Model Development:

- Rebuild the synthetic model using the same processes as during the original development (including trip generation, distribution, and sector-based factoring to peak period). It is noted that this is a 3-step model, with modal choice (road vs rail) not included;
- Separate zones for Centerport and Ferry terminals, noting this may need to be achieved using traffic counts and assumptions since the eRUC data has already been procured;
- Calibrate and validate the 2018 synthetic HCV model. It is noted that if acceptable calibration/validation cannot be achieved, the fallback position would be to adopt a pivot approach with the 2018 observed HCV matrices embedded within WTSM. The pivot approach is not preferred;
- As described previously, the assignment will be modified to represent HCVs volume in PCUs.

14.4 Staged Implementation

Update of the HCV model will be carried out as part of Stage 1 (using the 2013 version of WTSM). There may be complications in including a 780+ zone HCV model within the 225 zone WTSM due to Emme constraints. Validation will need to be verified when implemented into new 2018 version of WTSM.

15. Light Commercial Vehicles Modelling

15.1 Task Purpose

The RfP did not include a requirement to develop a Light Commercial Vehicle (LCV) model, so it was not addressed further at the proposal stage. The treatment of LCVs was, however, raised and discussed in the Scoping Workshop.

The ideal objective would be to develop an approach to ensure the unique travel patterns of LCVs are reflected, if possible. The minimal objective would be to ensure trips are not missing from the demand forecasts.

15.2 Current Model Capability

LCVs are notoriously difficult to model, because there is not a clear definition and it is complex and expensive to obtain observed data. An LCV could be defined as a vehicle type (e.g. utes and vans) or include their trip purpose (i.e. utes and vans undertaking commercial trips). There is likely to be a very small sample of trips made by LCVs (or MCV/HCVs) in the HTS and so sourcing travel pattern data for LCV trips is challenging.

Based on the technical notes produced for the 2001 WTSM build, it was decided to define LCVs as trips by "utes and vans" (i.e. not considering a commercial trip purpose). This was because the main concern was that the commercial utes/vans trips would be under-sampled in the HTS and the resulting modelled outputs for light vehicles (cars and utes/vans combined) would be underestimated.

The current approach in WTSM is to forecast combined "light vehicles" (cars plus utes/vans) using the traditional 4-step model. Light vehicles are then split into cars and LCVs (defined as utes/vans) using fixed proportions which vary by trip purpose. There is an under-reporting factor applied to LCVs (noting there is also a factor applied to cars but it is set to 1). Reporting states that the under-reporting factor for LCVs in the base year (2001) was set to 1, however this factor now has a different value in WTSM, which may have been a validation change at some point. There is also an additional growth factor which is applied to LCVs for forecasting. The additional growth factor is to reflect the fact that ute/van commercial trips may grow at a different rate to car trips.

The 2001 build of WTSM utilised a significant database of classified traffic counts from 1996 to enable utes/vans to be removed from "light vehicles" in the automatic traffic counts.

Strengths:

- Simple procedure, with associated fast run-times;
- No cost to collect additional representative data;
- Simple mechanism to allow for differential growth of ute/van commercial trips.

Weaknesses:

- Does not reflect different travel patterns of commercial ute/van trips.

15.3 Revised Model Capability

Model form options are as follows:

- Develop a full synthetic 3-step LCV model;
- Adopt similar approach to current WTSM. Forecast light vehicles and then separate cars and utes/vans using factors.

In determining the way forward, we need to define "LCVs", taking account of potential data sources. It would seem practical to adopt a similar approach to 2001, defining LCVs by vehicle type (utes and vans). This overcomes the challenge of separating out personal and commercial trips which can only be identified from interview data.

The key required data sources, irrespective of the model form, are origin-destination data and count data. Options are tabulated below, with their relative strengths and weaknesses.

Table 15-1: LCV Data Sources

Data Requirements	Potential Sources	Strengths	Weaknesses
OD data	Obtain tracking data from individual companies (courier companies, taxi operators, large commercial companies, etc)	• Reflects real world travel patterns	• Cost and time prohibitive
	Obtain eRUC data for vehicle class 1	• Cost effective data source • Partially representative	• Sample would be a subset of LCV trips and may not be fully representative • Data would not just relate to utes/vans and there would be an unquantifiable overlap with the HTS • Additional expense compared with budget
	eRUC data for vehicle class 2+	• Very cost effective	• Travel patterns would be for HCVs and may not be representative
	Synthesize an OD matrix using any available trips in the HTS (will be a tiny sample and relate almost completely to non-commercial trip-making) and traffic counts	• Very cost effective	• Limited evidence base which could negatively impact confidence in the model • Requires specific ute/van traffic counts
Count data	Undertake classified counts	• Robust and defendable	• Additional data collection costs compared with budget
	Assume the number of LCVs, utilising Census vehicle ownership data and proportions in the HTS	• Very cost effective	• Limited evidence base which could negatively impact confidence in the model

The recommended form is to apply a similar approach to the current WTSM. This would entail:

- Private and commercial trips by utes/vans would be combined with cars in the standard 4-step process forecasting light vehicle trips;
- The light vehicle matrices would be separated (post distribution/mode split and potentially peak period) into cars and utes/vans. A factor to allow for faster growth of light commercial vehicles would be incorporated;
- Cars and utes/vans would then be recombined for assignment;
- This process becomes more complicated in that cars needs to be segregated into SOVs and HOVs. It is likely that to maintain simplicity, a vehicle occupancy for utes/vans will need to be assumed. This could be one person per ute/van or use the same vehicle occupancy (which will vary by trip purpose) as cars.

16. WPTM – Public Transport Assignment Model

16.1 Task Purpose

The purpose of this task is to update the current Public Transport model from average weekday 2013 to March 2018.

16.2 Current Model Capability

WPTM was developed on 2011 base year, then updated to a 2013 base year. The model represents an average weekday.

16.3 Revised Model Capability

WPTM will be updated to a 2018 March base year, using observed data (ETM, rail and park-and-ride surveys, guard counts). For rail, sector-based growth will be checked and adjustments factors will be applied if necessary (using the same methodology as for the 2013 model update).

For bus demand, depending on availability and quality of the ETM data we will investigate the potential for a more refined update, especially for the PM peak which is currently a factored transposed of the AM matrices. While it is not envisaged that the ETM data will fully replace the original 2011 matrices as it would involve completely reproducing the process carried out during the model development (which necessitated intercept surveys), there is the potential for a more sophisticated approach than simple sector-based factoring.

Current time periods (7-9am, 2-hours average of 9am-3pm, 4-6pm) will be retained unchanged.

When available, 2018 Census data will be included to update the disaggregation of WTSM into WPTM zones (until WTSM changed to 780+ zones).

16.4 Staged Implementation

The update of the WPTM will be carried out as part of Stage 1. Validation will, however, need to be verified once the 2018 WTSM is finalised, which will have revised congested road travel times.

17. WTAM – Road Traffic Assignment Model

17.1 Task Purpose

A new road assignment model will be developed, achieving better levels of validation than the demand model (WTSM) by adopting a pivot approach from an observed base matrix similar to WPTM. With demand being based on observed patterns rather than synthetic equations, the WTAM will returns a level of detail more consistent with the PT assignment model (WPTM). Its main purpose will be to provide a more accurate representation of congestion on the network, leading to refined estimates of travel benefits (congested travel times and travel distances) and better differentiation between options. It will therefore provide a more suitable tool for project evaluation than the strategic model. The ultimate level of detail of the model will be governed by the capability of the software (i.e. no ability to model queuing extending back into the next intersection), the data availability (e.g. link and turning movement observed traffic counts), and the budget allocated.

17.2 Current Model Capability (WTSM Assignment)

WTSM assigns the 225-zone synthetic vehicle demand output by the distribution/mode choice modules. There are three two-hour peak period assignments, representing the AM (7-9am), the interpeak (debateable time period, but two hours between 9am and 4pm), and the PM peak (4-6pm).

The assignment is currently based on vehicles (as opposed to PCUs). WTSM uses a single class assignment during the main model loops and a multiclass assignment with light and heavy vehicles in the final iteration. The model uses the Emme Standard Assignment algorithm.

The calculation of congested travel times is discussed in a separate section.

Strengths:

- Short run-time for single class assignments at 225 zones;
- Synthetic, so strong predictive ability.

Weaknesses:

- Demand that is validated at a strategic level, hence more difference when comparing modelled flows with observed traffic counts;
- Validation too coarse when considered at a more local, project level.

17.3 Revised Model Capability (New WTAM)

A new separate (but integrated) road traffic assignment model will be developed, based on WPTM 780-zone system (including potential refinements to ensure zone system is appropriate for both road and PT, aligns with new SA1 boundaries, and differentiation of the Port and Ferry terminals).

2018 demand will be based on observed data, derived from 2013 WTSM synthetic matrices which will be adjusted using mobile phone origin-destination data and traffic counts. Forecasting will use "pivot" from WTSM base and forecast demand, similar to process used in WPTM.

The time periods for WTAM will be defined to cover the congested period on the road network considering the region as a whole. This may require extended time periods than currently in WTSM, for example, to cover both the Wellington CBD and also the motorway network. To ensure robust travel benefits are estimated for options, time-sliced or profiled assignments will likely be required. It is noted that this will likely extend run times but also increase the representativeness of the model.

As part of Stage 1 of this project, the WTSM assignment will be improved, which could include switching from vehicles to PCUs, adding a multiclass assignment for Single Occupant Vehicles (SOVs) and High Occupant Vehicles (HOVs), applying a newer assignment algorithm, and updating the calculation of delay. These changes will all be reflected in WTAM.

It is worth noting that there will be no specific turn-based intersection modelling even in WTAM. This will be handled by lower tiered models.

The new space-time assignment algorithm in Emme will be investigated, which seems to allow profiling demands over time. This could address some of the concerns over selecting a longer peak period. It is noted, however, that many new assignment algorithms are not designed to work with intersection modelling, and the current method of stopping the assignment every 20 iterations to compute capacity reductions caused by delays from opposing volumes is not a recommended approach as it results in slower convergence to a unique solution and longer assignment run-times.

17.4 Staged Implementation

WTAM will be implemented as part of Stage 1, with the observed demand matrix developed using WTSM 2013 matrices.

The transfer of demand to WTAM and model validation will need to be checked at the end of Stage 2 once the 2018 WTSM is fully operational. Note the process to derive the 2018 WTAM matrices from the 2013 WTSM will not be fully repeated once the new 2018 WTSM matrices are available. Some minor adjustment may, however, be required if there are any substantial differences between 2013 WTSM and 2018 WTSM demands.

Christchurch

Hazeldean Business Park, 6 Hazeldean Road
Addington, Christchurch 8024
PO Box 13-052, Armagh
Christchurch 8141
Tel +64 3 366 7449
Fax +64 3 366 7780

Please visit **www.stantec.com** to learn more about how Stantec design with community in mind.