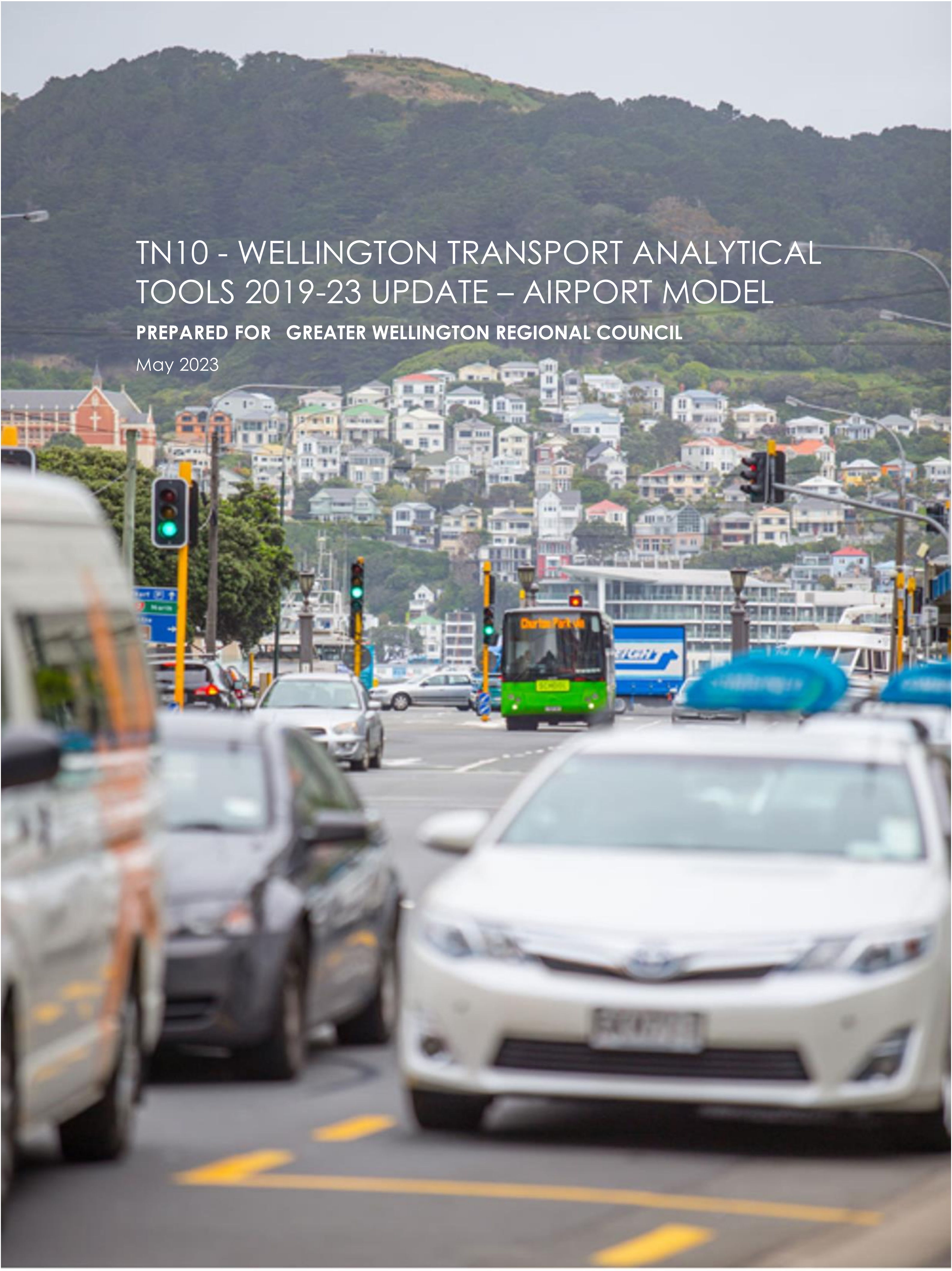

TN10 - WELLINGTON TRANSPORT ANALYTICAL TOOLS 2019-23 UPDATE – AIRPORT MODEL

PREPARED FOR GREATER WELLINGTON REGIONAL COUNCIL

May 2023

Stantec | JACOBS

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QUALITY STATEMENT

PROJECT MANAGER

Ali Siddiqui

PROJECT TECHNICAL LEAD

Julie Ballantyne

PREPARED BY

Amanda Klepper, Geoffrey Cornelis 17/05/2023

CHECKED BY

Julie Ballantyne 17/05/2023

REVIEWED BY

John Richardson 17/05/2023

APPROVED FOR ISSUE BY

Julie Ballantyne 17/05/2023

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

REVISION SCHEDULE

Rev No.	Date	Description	Signature or Typed Name (documentation on file)			
			Prepared by	Checked by	Reviewed by	Approved by
1.3	11 Sep 2020	Draft	Amanda Klepper, Geoffrey Cornelis	Julie Ballantyne	John Richardson	Julie Ballantyne
2	2 Oct 2020	Final	Geoffrey Cornelis	Julie Ballantyne	Geoffrey Cornelis	Julie Ballantyne
3	9 May 2023	Final Updated	Geoffrey Cornelis	Julie Ballantyne	Geoffrey Cornelis	Julie Ballantyne

Greater Wellington Regional Council

TN10 - Wellington Transport Analytical Tools 2019-23 update – Airport model

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1. Introduction

1.1 Project Overview

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.

1.2 Purpose of this Report

This report details the development of a new airport passenger land access module within the Wellington Transport Strategy Model (WTSM).

The previous airport model included in the WTSM was very simplistic, only considering car vehicle trips. Total number of produced trips were based on passenger movements from airport data and forecasts, with distribution based on population (whole region) and employment (CBD only). These were converted to origin-destination by time periods and assuming 50% inbound – 50% outbound.

A 4-step airport forecasting model representing person trips by car and public transport was developed as part of the 2011 WTSM update but has never been implemented in WTSM.

As quality Public Transport (PT) to the airport is of great interest, a more sophisticated airport model that includes mode choice and can model a potential shift from car to public transport is essential. Therefore, a new airport model has been developed that estimates trips made by private vehicle trips, booked services (taxi, rideshare and shuttle) and PT associated with airport flight passengers. The model development has been constrained by data availability, and has prioritised simplicity and transparency over complexity, consistent with the WTSM update project overall. However, it was also built in a way that would easily enable refining elements of the model should more data become available in the future, as well as allowing the flexibility to adjust inputs and respond to "what if" questions relating to airport access outcomes, as per the brief.

The report is organised into the following sections:

- Overall airport model structure
- Data sources and analysis
- Development of the demand matrices and mode choice model
- Validation, sensitivity testing and forecasting
- Implementation into the strategic model suite

2. Overall Airport Model Structure

The airport model has the following features:

- It is a March 2018 based model, representing weekday average, flight-related passenger demands (excluding airport staff and flight crews).
- The airport is represented in a single zone in WTSM. This is currently using the same zone for passenger-related trips as for other purposes (e.g. employment) represented in WTSM. It is anticipated that this will change in the next version of the model and this can easily be implemented then.
- Matrices of flight passengers to the airport (i.e. passengers departing on flights) and trips from the airport (i.e. passengers arriving on flights) were developed from total passenger data and flight details, and distributed in the region based on mobile phone data.
- This demand is split into 4 segments based on trip purpose and residency:
    - Business, Wellington residents
    - Business, non-Wellington residents

    - Personal, Wellington residents
    - Personal, non-Wellington residents
- Matrices are produced for each of the new WTSM time periods[1]:
    - AM peak: 6-9am
    - Interpeak (IP): 9am-3pm
    - PM peak: 3-6pm
    - Overnight (ON): 6pm-6am
- Logit mode split models allocate the trips to modes using generalised costs developed from WTSM time and distance skim matrices, as well as other costs specific to airport access. A nested logit model is used, which first separates total demand into car and public transport, and then splits car matrices into private (including vehicles parking at the airport and pick-up/drop-off) and booked services (taxi, rideshare and shuttle).
- Matrices by mode are added to the WTSM vehicle or PT matrices prior to assignment in WTSM.

3. Supporting Data

3.1 Data Sources

The data available for developing and testing the airport model was limited. The data collection at the airport originally planned for the WTSM model update was not carried out, and a survey of vehicle numbers and occupancy planned to be undertaken in March 2020 was cancelled because of COVID -19 already having a clear impact on travelling patterns at this stage.

No survey data was available, current or historical, regarding demand segmentation, purpose or access/egress mode (such as an intercept survey) at Wellington airport, resulting in a lack of information regarding individual mode choice behaviours.

However, a number of other data sources were used, including high-level mobile phone data, a database of parking gate transactions provided by Wellington International Airport Limited (WIAL), monthly total of taxis, bus and rideshare (i.e. Uber, Lyft) patronage, and the vehicle and occupancy survey carried out for the model developed during the 2011 update, and therefore dating from 2012.

Table 3-1 shows the data that has been used for developing, calibrating, and validating the airport model, its source, and how it was used.

Table 3-1: Available data for the new WTSM airport model development

Data Type	Source	Use
Passengers per day	WIAL	Trip generation, domestic and international proportions
Details of flights per day	WIAL	Time of day for passengers
Mobile phone trip data	Qrious mobility data	Trip distribution
Parking gate transactions	WIAL	Number of vehicles entering/leaving airport for general public, buses, shuttles, and taxis Duration of stay used to derive pick-up/drop-off vs short-term and long-term parking
Monthly transport movements	WIAL	Used to factor general traffic, taxis, rideshare and bus patronage

[1] It is anticipated that the airport model will in the interim be used with the current 2013 version of WTSM, and temporary factors have been calculated to convert output from the model to the time periods used in this version of WTSM (7-9am for AM peak, 11am-1pm for Interpeak, 4-6pm for PM Peak).

Data Type	Source	Use
2011 airport model development survey	GWRC	Occupancy, bus patronage daily profiles

The data available for the development of the new airport model has a number of gaps which were filled by relying on older sources of information and assumptions. The main gaps include:

- No detailed or recent information on bus patronage data (2012 observed patronage, and 2018 monthly totals)
- No detailed information on rideshare use (monthly totals only)
- Vehicle occupancy from 2012 survey
- No detailed information on origin / destination of airport users in the Wellington region (although the mobile phone data does provide some of this information)
- Particularly, no intercept survey providing information on individual behaviours and how they might differ depending on trip types (Wellington residents or non-residents), purpose, mode used and origin or destination.

The limited availability of data and inability to conduct surveys has had a direct impact on the structure of the model. In order to provide a complete picture of average weekday land-based trips at the airport, a number of simplifications and assumptions were necessary which are detailed in the following sections to ensure transparency of the model and highlight its limitations.

Methodology and parameters from the Auckland, Sydney and Melbourne airport models were also investigated to inform these assumptions.

Finally, it is intended for the airport model to represent March 2018 average weekday travel patterns. Data for this period was used whenever possible, and factored accordingly otherwise.

3.2 Data Analysis

3.2.1 Flight Schedules and Patronage Data

Information provided by WIAL includes total number of passengers per day, for arrivals and departures and for both domestic and international flights, between January 2017 and August 2019.

Total number of passengers per flight or time period was however not available. To address this, flight schedules, including number of seats per flights, were used to derive total capacity per time of day, direction and type of flight (domestic and international). Using data from March 2018 weekdays, the average totals of daily number of seats and daily passengers were used to derive average flight occupancy.

In the absence of more detailed data, this occupancy was then applied throughout the day for each flight type and time period (this assumption could be revised if more data on number of passengers per time period was to be made available). The resulting flight capacity, passenger totals and occupancy rates are shown in the following table.

Table 3-2: Daily passengers and seat totals, flights occupancy

	DOMESTIC		INTERNATIONAL		Total
	Arrival	Departure	Arrival	Departure	
Seats	10,030	10,086	1,516	1,516	23,149
Passengers	8,181	8,432	1,281	1,358	19,251
Occupancy	82%	84%	84%	90%	83%

3.2.2 Parking Gates Transactions

Airport parking gates data was provided by WIAL for March 2018, that includes all transactions for vehicles entering or exiting the airport car park, as well as through gates separating different areas within the car park.

Each record includes the entry and exit transactions, including:

- Date and time for both entry and exit

- 'Device' for both entry and exit, i.e. gate ID
- 'Article', which is a categorisation of vehicles based on entry and exit devices, as well as special parking badges when applicable. These include: public, taxis, staff, contractors, rentals, access to golf club, etc
- Car park, which identifies the main car park area entered through this transaction (e.g. Uncovered, Long term, Taxi pen, etc)

The database was processed based on the following steps:

- Transaction for weekends were removed, as well as Good Friday.
- Transactions were 'linked' for vehicles going through more than a single Entry and Exit gates. For example, a vehicle using the Covered Car Park would involve three records:
    - Entry main entrance gates to uncovered car park – Exit into Covered
    - Entry Covered Car Park – Exit into uncovered
    - Entry Uncovered – Exit through main exit gates

  As there is no identifier attribute for a single vehicle, dates, times and devices were used to match any exit matching entrance values in another record. This then allowed consideration of characteristics (i.e. stay duration, purpose) for the whole trip for these vehicles.
- A new 'Purpose' field was added to classify the trip into a group of main purposes, these being: Public, Taxi, Shuttle, Bus, Golf, Rental, Staff and Other. In most cases this was based on the gate devices first (e.g. vehicles going through Golf, Staff or Taxi gates were classified as such), with the Article attribute then used to classify remaining records.
- Taxis records were separated into 'pick-up' and 'drop-off' depending on their exit gates: any taxi exiting through exit gates 16 and 17 were classified as pick-up, with the remainder classified as drop-off. It must be noted that due to the layout of the airport car park, any taxi dropping off a passenger and then going back to the taxi pen to pick up their next customer needs to exit and re-enter the car park.
- A new attribute was added to group the transactions by duration stay, which was then used to separate them into pick-up/drop-off (including short stay where the accompanying driver does use short-term parking) and passengers parking at the airport.
- Time periods in and out were added, based on the same time periods used in the new WTSM.
- Some transactions were finally removed which included staff and access to golf club records, a number of records showing stays of 30 days caused by vehicles for which the exit was not properly recorded, and vehicles transiting through Stewart Stuff Drive but not linked to the airport, These were identified as vehicles not being taxis or shuttle, exiting through exits 16 and 17 and with stay duration less than 10 minutes.

While this car park data is a very rich dataset and proved very valuable for the development of the airport model, the following assumptions had to be made:

- While the dataset identifies rental vehicles in the 'Article' attribute, this was found to be difficult to use and somewhat unreliable, as depending on the assumptions made to identify them it led to either unrealistically high or low number of rental vehicles. Given that this represents a small proportion of total demand, and there is no data to support treating this segment differently from general private vehicle users in terms of trip distribution and modal choice, rentals were grouped together with public vehicles, mitigating this issue.
- The parking data does not identify rideshare vehicles, and they are therefore included in the 'Public' segment. The only data available was monthly number of rideshare and taxi vehicles drop-off and pick-up. This was used to evaluate the proportion of rideshare vehicles compared with taxis. These proportions were then applied for each time period and direction to estimate the corresponding number of vehicles in the Rideshare category, which were then removed from the Public segment.

While these are simplifications that were necessary due to the unavailability of more detailed data, we recommend these assumptions are refined if the data becomes available.

The resulting number of vehicle trips averaged for a March 2018 weekday are shown in the following table.

Table 3-3: Airport passengers-related vehicles movements

Period	ENTRY					EXIT				
	Bus	Taxis	Public	Rideshare	Shuttle	Bus	Taxis	Public	Rideshare	Shuttle
AM	9	774	701	203	34	9	777	502	206	34
IP	14	1,013	1,487	265	68	14	1,010	1,400	263	68
PM	11	743	864	210	43	11	747	975	212	43
ON	8	719	1,137	186	51	8	715	1,273	184	51
24hr	42	3,249	4,190	865	196	42	3,249	4,150	865	196
Total	**8,541**					**8,501**				

3.2.3 2012 Survey

A vehicle number and occupancy survey were carried out in 2012 for the development of a revised airport model. While this survey is outdated in terms of vehicle numbers, especially given the growth in airport patronage and emergence of rideshare services since, vehicles occupancy results were used as occupancies are unlikely to have varied as much since.

Passenger occupancies for private vehicles, taxis, shuttles and buses are shown in the following table.

Table 3-4: Vehicle passenger occupancy at airport

Period	Taxi	Public	Shuttle	Bus
AM	1.84	1.75	3.60	15.57
IP	1.97	1.98	3.24	13.79
PM	1.99	2.08	3.74	15.64
Other	1.97	1.98	3.24	14.95

The following observations can be made regarding vehicle occupancies and their use in the model:

- Taxi and Public passenger occupancies (i.e. travelling group size) are generally high compared with other models. As an example, the Auckland model has occupancy ranging from 1.26 to 1.67 for drop-offs and 1.17 to 1.77 for taxis, depending on trip purpose. Similarly, the Sydney Airport Landside Transport Model shows group sizes ranging between 1.24 and 1.89. These surveyed values were used in the absence of alternative data, but we recommend that the model be revised once new surveyed occupancies are available.
- The same occupancies as Taxi were also used for Rideshare vehicles as these were not operating when the survey was carried out in 2012.
- Occupancies for buses were factored to match 2018 monthly patronage.
- Overnight period was not surveyed and values from the Interpeak were therefore used.

3.2.4 Mobile Phone Data

Mobile phone mobility data was provided by Qrious to GWRC. This data shows trips between the airport and the rest of the Wellington region using a 55-sector system. Movements are provided for 24hr and per time period, and the dataset covers one week from the 25th to the 31st of March 2019.

While this dataset was valuable in providing information on origin and destination of land-based trips respectively to and from the airport, a number of caveats apply:

- Data is provided for 2019 whereas the airport represents March 2018. As this dataset will be used to derive trip distribution but not the amount of trips, this is not considered critical as trip patterns are unlikely to have changed significantly in a year.
- Time periods are different to the ones used in the model, being 7-10am for the AM peak, 10am-4pm for the Interpeak and 4-6pm for the PM peak. No information is available for the Overnight period.

- The 55 sector system is coarser than the anticipated 820 zone system used in the updated version of WTSM, or even the 225 zones used in the current model. This was not considered to be an issue as due to the sparsity of trips to/from the airport some level of aggregation would likely have been required.
- The dataset only provides aggregate number of trips and does not differentiate passenger-related trips to other purposes, including employment at the airport. Similarly it does not provide any information on demand segment or transport mode.
- Trips between the airport and two sectors directly next to it (Kilbirnie and Miramar) seem over-represented. This is likely caused by issues with allocating trip ends, possibly due to signals switching between nearby towers in these zones. These two sectors were therefore removed from the dataset.
- There may be a bias between the sample of domestic and international passengers, particularly arrivals.
- There is generally no knowledge as to how this dataset was produced, including what expansion factors were used.

Despite these limitations, this dataset represents the only available information on airport-related trip origin and destination in the Wellington region and was therefore used as a base to develop the distribution component of the airport model.

4. Model Segments and Modes

While data availability has constricted the level of detail including segmentation into different trip purposes and types and the number of modes that can be explicitly represented, the model has been developed with a reasonably high level of resolution, nonetheless. The purpose of this is first to enable more flexibility in varying different assumptions in forecasting, but also to allow plugging some of the gaps if the required data were to be available in the future without having to significantly alter the model form. This has some implications in terms of detailed validation per segment and mode, as detailed further in this section.

4.1.1 Demand Segments

Based on data availability and investigation of other airport models, demand has been divided into Business vs Personal purposes, and Wellington resident vs non-residents. Given the lower number of international flights compared with other international airport, overseas residents are included in the non-Wellington resident's category due to the lack of data regarding how their behaviours might differ from domestic passengers. This classification therefore results in the four following trip types:

- Personal, resident
- Personal, non-resident
- Business, resident
- Business, non-resident

Domestic and international flights passengers (whether Wellington residents or non-residents) are treated separately at the trip generation stage to allow applying different lead and lag times (see section 5.1)and different forecasted growth but are then combined in later stages in the model, as no data was available to differentiate their behaviours.

4.1.2 Transport Modes

The following modes are represented in the model:

- Public transport (bus only in the base year scenario)
- Private vehicles, including:
  - Pick-up / drop-off, including with accompanying driver parking short term
  - Passenger parking at the airport
- Booked services, including:
  - Taxi
  - Rideshare

- Shuttle

Only public transport, private vehicles and booked services are explicitly represented in the modal choice model, with the further disaggregation into pick-up & drop-off / parked vehicles, or taxi / rideshare / shuttle based on fixed factoring.

4.1.3 Limitations

To reiterate, this level of segmentation is provided in the airport model to increase flexibility in use of the model and future-proof it by allowing refinement of various components without altering its structure should more detailed data become available. However, the data available often did not allow calibrating or validating the model at this level of detail.

The model was therefore validated at an aggregated level only, looking at total number of passengers for public transport and observed vehicles for private and booked services vehicles, and this was based on a number of assumptions which are detailed in the remainder of this report. The same parameters were often used for different segments as no data was available to differentiate them.

5. Development of Matrices by Segment

5.1 Trip Generation

Total land-based trip generation for passengers is based on the number of air passengers daily and per time period. Using flight passengers to generate trips ensures that the total number of land-based trips is driven by airport activity and allows forecasting changes in trips based on airport growth forecasts rather than regional changes in population or employment.

The number of air passengers per day was based on daily passenger counts and flight schedules provided by WIAL, using the calculations described in section 3.2.1. A reduction of 3% was applied to account for transit passengers, although this assumption should be confirmed or adjusted should this data become available.

Time period factoring occurs before trip distribution and mode choice. This is because generalised costs and other parameters have been estimated separately for each time period, consistent with the 2011 airport model.

Ideally, time period factors would be applied by mode and market segment, however the proportions by time period are not available, as a result each time period has the same passenger composition and trip distribution. In reality, there may be a higher share of business trips in the AM peak which could cause (for example) higher taxi usage for trips to the CBD during this time period. However, in the absence of supporting information, this had to be represented through the use of varying trip rates and mode choice constants per time period.

To split demand by time period, passengers were split into AM, IP, PM, and ON based on the profile of flights and seat capacity throughout the day. The split also accounted for the fact that passengers arrive in advance of their flight time and leave the airport later than their arrival time by applying adjustments for lead and lag times. These adjustments were adopted from the Auckland airport model, and are shown in the following table.

Table 5-1: Lead and lag times

	Departures	Arrivals
International	-2.5 hrs	+40 min
Domestic	-45 min	+20 min

Lead time for international flight departures may potentially be shorter at Wellington airport, possibly due to it being smaller and less busy than Auckland. However no data was available to support applying a change, and testing of reduced lead times showed little impact due to the duration of time periods modelled.

The potential for applying separate adjustments to the 'Meet and Greet' trips, i.e. the additional trip for people welcoming or farewelling travellers was investigated. However this was not adopted due both to the unavailability of supporting data, and the fact that the length of the time periods meant that it did not make a material difference.

Passengers were also divided into the four demand segments described in Section 4.1.1. The assumptions used are as follows, but these could be varied easily in the model if more supporting data was available:

- Residency is assumed to be 50% local and 50% non-resident (of Wellington)
- Trip Purpose is assumed to be 40% business for domestic flights during peak periods and 27% off-peak, based on the previous Wellington airport model, and 19% business for international flights, based on data from the WIAL website[2]

Table 5-2 shows the resulting factors after aggregation of international and domestic trips, applied to divide the daily number of arrivals and departures into time periods and demand segments.

Table 5-2: Time period and segment factors

	ARRIVAL				DEPARTURE			
	Resident		Non-Resident		Resident		Non-Resident	
	Personal	Business	Personal	Business	Personal	Business	Personal	Business
6am to 9am	4%	3%	4%	3%	7%	4%	7%	4%
9am to 3pm	11%	4%	11%	4%	13%	4%	13%	4%
3pm to 6pm	8%	4%	8%	4%	7%	4%	7%	4%
6pm to 6am	11%	4%	11%	4%	8%	3%	8%	3%
24hr	35%	15%	35%	15%	35%	15%	35%	15%
Total	100%				100%			

5.2 Trip Distribution

WTSM includes 813 internal zones, as well as two road-based external zones in the north of the region but airport trips from/to these externals would be very small.

The previous airport model estimated distribution of passenger trips between the airport and the Wellington region based on factors on employment (CBD only) and population (whole region). A similar approach was used for the new model, using the mobile phone trips data described in section 3.2.4 and census estimated resident population and employment data aggregated at the 55 sector system.

Distribution factors were derived by analysing the relationship between demography/employment and airport related trips through linear regression analysis. This was done for each time period and per direction, in order to capture different trip patterns throughout the day (e.g. more trips inbound to the CBD in the AM peak) without detailed representation of varying trip behaviours.

A number of variables were tested including population, households and various employment categories but the best results were obtained using total population and employment. Trip rates were found to be consistently higher for Wellington than for other Territorial Authorities (TA), and separate rates were therefore estimated for Wellington City and the rest of the region. The Wairarapa was not included in the analysis as it is a single sector and showed few observed trips. Trips rates for the rest of the region are therefore applied to the Wairarapa instead.

The resulting trip rates are shown in the following table. All coefficients have a p-value lower than 0.05 (except population for AM trips from the airport which is 0.06) and they lead to r^2 ranging between 0.81 and 0.97.

[2] Monthly report March 2018, rolling 12 months. https://www.wellingtonairport.co.nz/documents/415/12_March_2018.pdf

Table 5-3: Trip rates (x1000)

Time Period	Direction	WELLINGTON		OTHER TAS	
		Population	Employment	Population	Employment
AM	To airport	3.096	1.257	0.900	0.950
	From airport	0.560	2.180	0.103	0.609
IP / ON	To airport	1.599	8.839	0.365	3.783
	From airport	3.380	4.802	0.835	3.570
PM	To airport	0.278	3.122	0.149	0.856
	From airport	1.606	1.053	0.609	0.501

These trip rates were then applied to the WTSM land use per zone.

The following table shows a comparison of observed and modelled distribution (24hr and two-way), aggregated to TA, with Wellington separated into CBD and rest of the city. Distribution using the current WTSM airport model (also representing flight-related trips only) is also shown.

Table 5-4: Trip distribution by TA

Area	Observed	Modelled	Current WTSM
Wellington CBD	32%	33%	10%
Rest of Wellington	41%	39%	39%
Lower Hutt City	14%	10%	21%
Upper Hutt City	3%	3%	9%
Porirua City	5%	5%	12%
Kapiti Coast District	3%	4%	10%
Wairarapa	2%	5%	0%

The matrices of trips calculated using these factors are then factored to match the total number of trips calculated in Section 5.1, for each time period and direction.

This means that trip distribution is identical for all four trip purposes, again this should be refined if more data was to become available.

6. Mode Choice

6.1 Model Form

A number of mode choice model forms where tested, including binomial logit for PT and car, with car then split into sub-modes using fixed factors, or multinomial logit between PT, private cars and booked services. In the end, the mode choice model is based on a nested logit. While it was anticipated that the limited data available would preclude using this form of model, it was found to return the best results in representing observed mode use, and will also provide a good structure for potential model update and refinement.

The mode choice model form is represented in Figure 6-1.

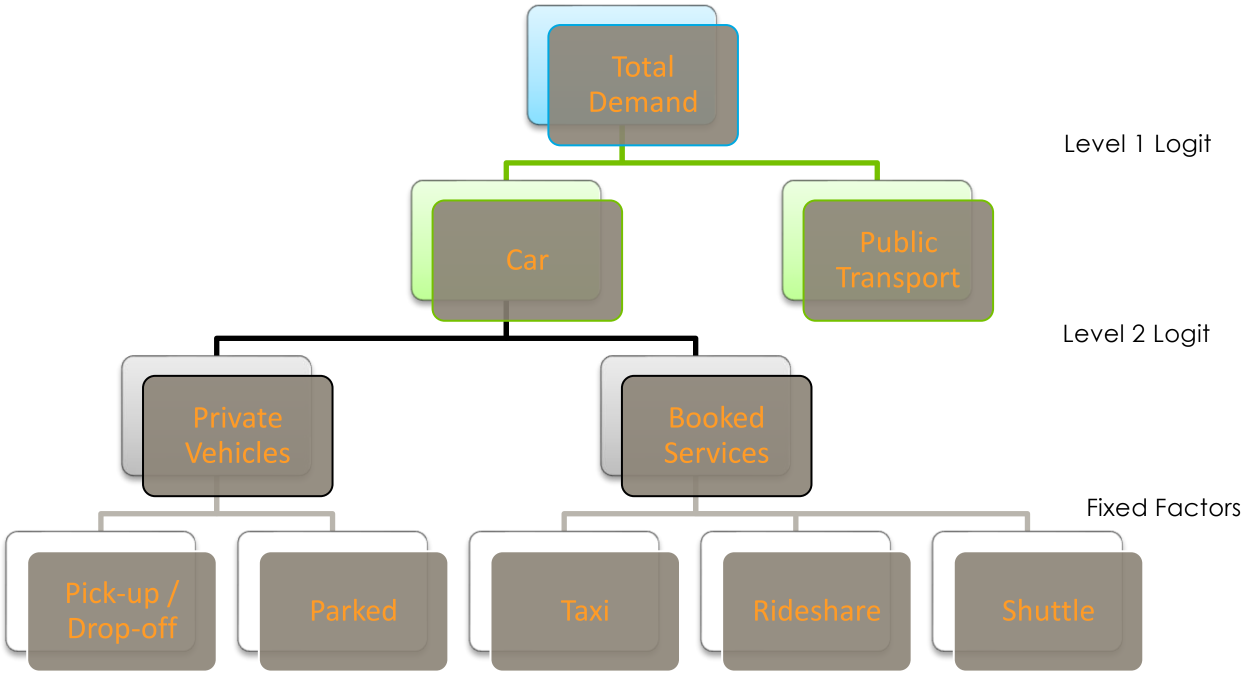


Figure 6-1: Mode choice model structure

First, demand is split into car access and public transport, then car access demand is split into private vehicles and booked services.

Private vehicles are further divided into passengers parking at the airport and pick-up/drop-off (including short stay parking) based on fixed factors from the parking duration data. One of the reasons why they were grouped together in the logit model is that the amount of vehicles parking at Wellington airport is comparatively small.

Similarly booked services are split between taxi, rideshare and shuttle using factors based on observed data and assumptions outlined in section 3.2.2. This split is also based on fixed factors partly due to limited information, but also because potential shifts in demand between taxi and rideshare is more likely to be caused by changing behaviours and increased uptake in rideshare services rather than actual change in generalised costs, and is therefore best used as an input into the model.

This last level split based on fixed factor is mostly used for generalised costs calculations, as explained in the next section.

At either level, the probability for a mode m being used is:

$$P(m) = \frac{e^{(U_m)}}{\sum_{j=1}^{J} e^{(U_j)}}$$

Where J is the set of available modes and U_m is the Utility of mode m:

$$U_m = \beta * GC_m + ASC_m$$

β = Sensitivity parameter (β_1 for level 1, β_2 for level 2)

GC_m = Generalised cost for mode m

ASCm = alternative specific constant for mode m

More detail on β and ASC values can be found in section 6.3.

For level 1, the logsum composite utility of 'Car' mode needs to be calculated from Private Cars and Booked Services utilities. This is based on the following equation:

$$U(car) = \frac{\beta_1}{\beta_2} * \ln\left(e^{U_{Private}} + e^{U_{Booked}}\right)$$

6.2 Generalised Cost

The generalised costs used for the mode choice model have been calculated from standard WTSM network skim matrices:

- For public transport: in-vehicle time, auxiliary time (access and egress to PT), waiting time, boarding numbers, and fare (including additional fare for the Airport Flyer).
- For cars: distance, time, and tolls (there are no tolls currently in Wellington, but this allows testing tolls in forecasting)

In addition, the following prices factor into the generalised cost calculations, and the following sections describe how these prices were calculated:

- Airport parking charge
- Fares for taxi, shuttle, and rideshare
- Values of time
- Vehicle operating costs

All prices used for the generalised cost calculation are expressed in 2018 NZ dollars.

6.2.1 Parking Charge

Private vehicles that park at the airport incur the parking charges. The airport has various rates for different parking locations, whether they are short term, long term, covered, premium, etc. Additionally, the price structure sets different prices for different lengths of stay in a non-linear fashion.

To find a single average price for passengers parking, the parking data was used to get the average length of stay for each differently-priced parking area and assigning the price that a visitor would pay to stay in that parking area for that length of time. Those values were then averaged, weighted by the number of people parking in each area.

The average cost of parking for vehicles staying longer than 4 hours (assumed to be passengers parking at the airport) is $69.92.

Parking for pick-up and drop-off was estimated similarly based on the average charge paid by vehicles staying less than 4 hours at the uncovered car park. This returned an average charge of $1.54, highlighting the fact that most vehicles stay for less than 10 minutes (using the pick-up/drop-off bays) and do not incur a charge.

6.2.2 Taxi, Shuttle, and Rideshare Fares

Taxi fares were based on an investigation of a number of taxi operators, which were found to charge similar rates, in terms of flagfall and per kilometre fare. In addition, most operators apply a fixed fare of $30 between the airport and the CBD. The resulting costs are shown in the table below.

Table 6-1: Taxi fares

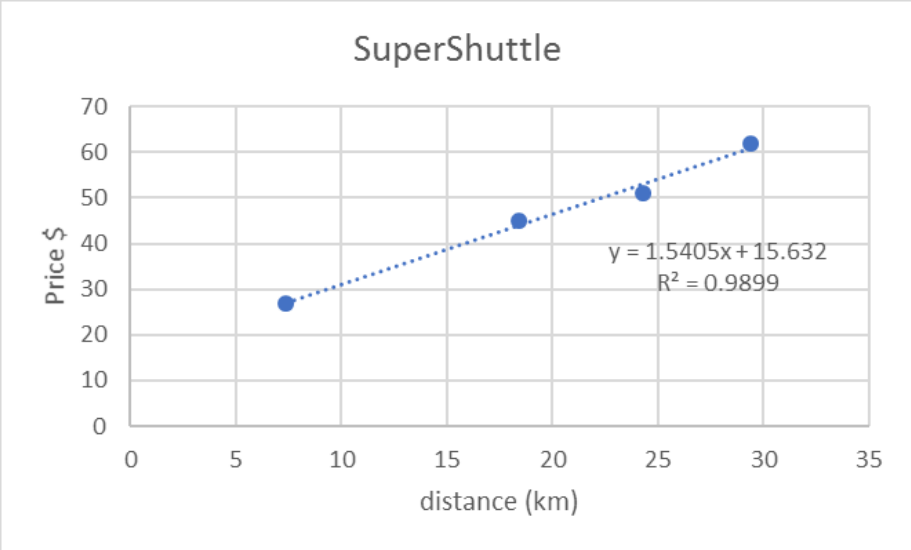
Fare Component	Price
Flagfall	$3.50
Per km	$2.70
Airport Fee (pick-up and drop-off)	$5.00[3]
Fixed fare to CBD	$30.00

For shuttle and rideshare fares, quotes were requested for several locations around Wellington to and from the airport (the CBD, Island Bay, Lower Hutt, Johnsonville, Porirua). These rates were plotted against the distance between the airport and those locations, and a line was fitted to the plot. The equation of the line provided the flagfall fare (the constant) and a per km cost (the gradient). Shuttle fares came from the SuperShuttle website (https://www.supershuttle.co.nz/Booking/). Rideshare fares came from the Uber

[3] Comprises $3 fee charged by the airport and $2 on-charge added by taxi companies.

website (https://www.uber.com/nz/en/price-estimate/). Although not explicit on the website, SuperShuttle appears to have a $15 flat fare between the airport and the CBD, which was applied in the model.

The plotted fares and resulting costs for Shuttle and Rideshare are shown in Figure 6-2 and Table 6-2.



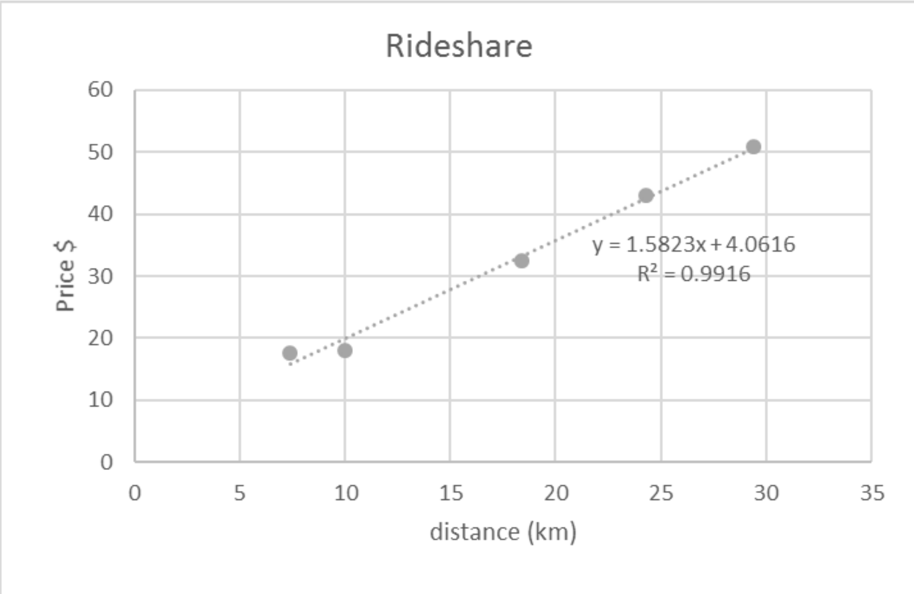


Figure 6-2: Shuttle and Rideshare fares vs distance

Table 6-2: Shuttle and Rideshare fares

Mode	Fixed to CBD	Airport Fee	Flag Fall	Per km
Shuttle	$15	N/A	$15.63	$1.54
Rideshare	N/A	N/A	$4.06	$1.58

6.2.3 Vehicle Operating Costs

Vehicle operating costs (VOC) are used for private vehicles and are consistent with the overall values used in WTSM (see TN9 – Economic Parameters), themselves based on the Waka Kotahi Economic Evaluation Manual.

Table 6-3: Vehicle operating costs

Purpose	2018 c/km
Business (Employer Business in WTSM)	29.67

Purpose	2018 c/km
Personal (Non Employer Business in WTSM)	13.36

6.2.4 Values of Time (VOT)

The following values of time (VOT) were applied to convert dollar costs to minutes. These values are consistent with the values used for the overall WTSM (see TN9 – Economic Parameters) for 'Employer business' or 'Other', respectively for Business and Personal purposes. However, the value for the 'Personal' trip purpose has been multiplied by a factor of 1.5 to represent people having a higher value of time when travelling to or from the airport. This is in line with other airport models reviewed.

Table 6-4: Value of time

Purpose	2018 $/hr
Business	$71.33
Personal	$28.33

6.2.5 Calculating Generalised Cost

The generalised costs for each mode and purpose are calculated using the WTSM skimmed car time, distance, and toll matrices and the PT in-vehicle time, wait time, auxiliary time (i.e. access to and egress from PT), boarding numbers, and fare matrices. Monetary costs (parking, fares, vehicle operating costs) were converted to minutes using the relevant values of time for each purpose.

The formulas for each mode are as follows.

Private Car (parking)

GC_{park} = Time + (Toll + VOC + Parking*0.5)/Occupancy

Airport parking cost was factored by 0.5 as one half is applied to the inbound trip and one half to the outbound.

Private Car (pick up / drop off)

$GC_{PU/DO}$ = (Time + (Toll + VOC + Parking*0.5)/Occupancy) * 2 * PU/DO discount factor

The generalised costs for passengers being picked up or dropped off at the airport (including by accompanying driver parking short term) are similar to passengers parking vehicles, but the monetary costs are doubled to account for the additional 'empty' reverse trip. A pick-up/drop-off factor is however applied to represent the fact that this cost is typically not fully borne by the passengers themselves. Following a review of other airport models (including Melbourne and Auckland), a value of 0.8 was used for the PU/DO discount factor.

Taxi / Rideshare

GC_{Taxi} & $GC_{Rideshare}$ = Time + Fare/Occupancy

Shuttle

$GC_{Shuttle}$ = Time * Penalty factor + Fare

For shuttle trips which usually stop along the way to pick up or drop off passengers, a penalty factor of 1.3 was applied to travel times based on our professional judgement.

PT

GC_{PT} = 2*Auxiliary + 2*Wait + Transfer Penalty + In-vehicle time + Fare

Perception factors of 2 are applied to waiting and auxiliary times, consistent with WTSM overall. This reflects that out-of-vehicle time is perceived to take twice as long as in-vehicle travel.

Transfer penalties are estimated based on the number of boardings, with any transfer boarding incurring a penalty of 15 minutes.

Generalised Costs for 'Private Vehicles' and 'Booked Services'

Generalised costs for the two car mode groups used in the nested logit model are obtained by calculating the weighted average of each sub-mode, with the proportions obtained from the parking gates data factored by occupancies to get 'person' proportions:

$GC_{PrivateVehicle} = GC_{parked} * \%_{parked} + GC_{PU/DO} * \%_{PU/DO}$

$GC_{Booked} = GC_{Taxi} * \%_{Taxi} + GC_{Rideshare} * \%_{Rideshare} + GC_{Shuttle} * \%_{Shuttle}$

No terminal time has been added at the airport (which usually represents time between the parking or bus stop and the airport) due to its small size, and the fact that these would be captured through mode specific constants (see 6.3.2).

Generalised costs are calculated separately by time period, because costs vary depending on time of day. For example, travel times and PT fares are different in peak vs. off-peak travel. Generalised costs are also calculated separately by trip purpose to apply different values of time.

6.3 Model Calibration

6.3.1 Model Parameters

The sensitivity parameters β_1 for the first level of the nested logit (car vs PT) was initially based on value from the Sydney Airport Landside Transport Model and then adjusted through calibration, and set to:

$\beta_1 = -0.025$

β_2 was derived by applying an estimated scaling factor of 1.85 as follows:

$\beta_2 = 1.85 * \beta_1 = - 0.0462$

6.3.2 Mode Constants

Mode constants (also called alternative-specific constants or ASC) were initially based on a review of ASCs in the Auckland, Sydney and Melbourne models. However, these were found to vary significantly between models. In addition, a comparison of landside travel patterns of Wellington airport with other airports in Australasia carried out for the 2012 airport model[4] has shown that Wellington airport has quite distinct characteristics, being located close to a dense CBD and having a higher proportion of taxi mode share. This would limit the transferability of parameters from other models.

As a result, the ASCs were calibrated based on observed modal share of PT, private cars and booked services. This was done separately for each time period and direction. Different ASCs had to be calibrated for PT trips to the CBD vs rest of the region to better match observed mode shares.

In the absence of information of mode share per trip purpose, the same ASCs were generally applied to all four demand segments. The main exception is public transport ASCs for Business purposes which were set higher to represent this segment being less likely to use public transport, despite it being reasonably attractive in Wellington in terms of travel times to the CBD.

The resulting ASCs are shown in the following table.

Table 6-5: Mode choice ASCs

	AM		IP		PM		ON	
	Personal	Business	Personal	Business	Personal	Business	Personal	Business
To Airport								
PT CBD	-44	-34	-12	-12	-35	-30	-18	0
PT Other	20	20	20	20	0	20	15	15
Private Vehicles	0	0	0	0	0	0	0	0
Booked Services	-27	-27	-16	-16	-27	-27	-14	-14
From Airport								
PT CBD	-49	-40	-52	-52	-44	-20	-20	0
PT Other	-9	0	-12	-12	10	30	20	20
Private Vehicles	0	0	0	0	0	0	0	0
Booked Services	-50	-50	-46	-46	-22	-22	-27	-27

[4] TN9 Airport Model Development Draft v2, August 2012

6.4 Persons to Vehicles

For car demand, passenger person trips are converted into vehicle trips based on the observed 2012 occupancy shown in Table 3-4.

The additional 'empty' trip leg (including driver for pick-up / drop-off, taxis and rideshares) is also added for the reverse direction, for all passengers not parking at the airport.

7. Model Validation and Sensitivity Testing

7.1 Validation

Table 7-1 and Table 7-2 show a comparison of modelled and observed volumes, respectively to and from the airport. Volumes are expressed in person trips for public transport and in vehicles for car users, depending on the data available for validation.

Table 7-1: Observed vs modelled volumes – To Airport

	OBSERVED			MODELLED			% DIFFERENCE		
	Persons	Vehicles		Persons	Vehicles		Persons	Vehicles	
	PT	PV[5]	Booked	PT	PV	Booked	PT	PV	Booked
AM	142	701	1,011	146	692	1,040	3%	-1%	3%
IP	195	1,487	1,347	205	1,357	1,390	5%	-9%	3%
PM	172	864	995	187	939	1039	9%	9%	4%
ON	116	1,137	956	118	1,231	1053	2%	8%	10%
Total	625	4,189	4,309	656	4,219	4,522	5%	1%	5%

Table 7-2: Observed vs modelled volumes – From Airport

	OBSERVED			MODELLED			% DIFFERENCE		
	Persons	Vehicles		Persons	Vehicles		Persons	Vehicles	
	PT	PV	Booked	PT	PV	Booked	PT	PV	Booked
AM	104	502	1,016	109	519	1,040	5%	3%	2%
IP	230	1,400	1,341	227	1,357	1,390	-1%	-3%	4%
PM	180	975	1001	160	885	1039	-11%	-9%	4%
ON	115	1,273	950	124	1,137	1053	8%	-11%	11%
Total	629	4,150	4,308	620	3,898	4,522	-1%	-6%	5%

Comparison of volumes show that the model is generally a good fit with observed. The model over-estimates trip generation by circa 3% overall, with this trend being less marked in the interpeak but more pronounced during the overnight period.

Comparison for each mode and time period is however a close match, with all values being within 10%.

The GEH statistics calculation was applied to these figures (converted to hourly) as, although it is not specifically suited for this purpose being generally used for traffic volumes, it still provides a valuable indication of goodness of fit. GEH values show a maximum of 3.9, with most values being under 2.

Given the level of uncertainty regarding inputs into the model, assumptions made and data used for validation, this was considered acceptable for its intended purpose.

7.2 Sensitivity Testing

A number of sensitivity tests were carried out by adjusting costs and parameters that feed into the generalised costs calculations, to ensure that the response of the model is realistic in terms of direction and magnitude. The airport model was run stand-alone and not as part of a full WTSM run, which ensures that

[5] PV is private vehicles

skimmed matrices were constant with only a single cost component adjusted at a time and with no impact of 'model noise'.

The following tests were carried out:

- 20% increase in PT fare
- 20% increase in taxi fare
- 20% increase in shuttle fare
- 20% increase in PT in-vehicle time
- 20% increase in PT frequencies (i.e. reduction in waiting time)
- 20% increase in airport parking costs

Guidelines to transport elasticities were investigated. It must be noted that no specific guidelines could be sourced for airport access and they apply to transport models overall. Results may vary for airport-related transport, for example, due to the typically higher value of time for passengers, what alternative modes are available, or because trip rates and lengths that might respond in a strategic model are fixed in an airport model.

In addition, these guidelines seldom clarify what definition of elasticity is used. Arc elasticity has been used for these tests, which is consistent with the approach used for the Sydney and Melbourne airport models. Relevant guidelines are included in the following table.

Table 7-3: Elasticity guidelines

Change	Guidelines
PT fare	-0.2 to -0.6 (ATAP[6], DOT[7], EEM[8]), -0.1 to -0.6 (PDFH[9])
Car in-vehicle time	-0.2 to -0.8 (DOT)
PT in-vehicle time	-0.2 to -0.8 (PDFH), -0.1 to -0.7 (EEM)
PT frequencies	0.2 to 0.7 (PDFH, EEM)

The resulting relative changes in modal share and implied elasticities were calculated and are presented in the following table, along with results from airport models for Auckland, Sydney and Melbourne for comparison. The elasticities shaded in grey represent elasticity for the mode that is directly impacted by the change in price. Unshaded values represent cross-elasticities for other modes.

Table 7-4: Sensitivity tests

	MODE SHARE CHANGE			ELASTICITY			OTHER AIRPORT MODELS		
20% Increase in:	PT	PV	Booked	PT	PV	Booked	AKL	MEL	SYD
PT fare	-2.1%	0.2%	0.1%	-0.12	0.01	0.01	-0.22	-0.5	
Taxi fare	3.3%	8.6%	-8.2%	0.18	0.45	-0.47	-1.62		-0.4
Rideshare fare	1.3%	2.6%	-2.5%	0.07	0.14	-0.14			
Car in-vehicle time (private and booked services)	9.1%	-2.9%	1.3%	0.48	-0.16	0.08		-0.34	
Car in-vehicle time (private only)	6.1%	-8.4%	6.7%	0.33	-0.48	0.36			
PT in-vehicle time	-6.7%	0.6%	0.4%	-0.38	0.03	0.02	-0.61	-0.90	-0.64
PT frequencies	4.8%	-0.4%	-0.3%	0.26	-0.02	-0.02			

[6] Australian Transport Assessment and Planning Guidelines, M1 – Public Transport, May 2018
[7] Strategic Transport Model Elasticity Guidelines, December 2015
[8] Economic Evaluation Manual, Waka Kotahi, July 2018
[9] Passenger Demand Forecasting Handbook, 2013

	MODE SHARE CHANGE			ELASTICITY			OTHER AIRPORT MODELS		
20% Increase in:	PT	PV	Booked	PT	PV	Booked	AKL	MEL	SYD
Airport parking costs	0.4%	-0.8%	0.7%	0.03	-0.04	0.04	Parking: -0.46 Drop-off: +0.2	Parking: -0.33 Drop-off: -0.02	

Results show that the model responds as expected to changes in travel costs, being generally within available guidelines and presenting similar results to other airport models. However it must be noted that the different nature of the model choice form in each airport model explains why some elasticities differ. Particularly, airport parking cost change has a small impact on car demand with the Wellington airport due to the small share of vehicles actually parking, most car trips being short term pick-up and drop-off. In addition, parking and pick-up/drop-off trips are combined in the logit model which means that there is no shift from one to the other.

8. Forecasting

In order to test the forecasting abilities of the model and assess the impact of applying forecasted input parameters including number of passengers, land use and economic parameters, a 2038 test of the model was run. This section presents the assumptions and the resulting forecasted trip numbers and modal share.

It is important to note that this is a set of assumptions and projections that is not intended to be substantiated from a transport point of view, and have simply been used for testing the response of the airport model.

8.1 Airport Projections

Airport annual patronage projections were provided by WIAL for 2035 and 2040, and these were interpolated to produce 2038 values, which are shown in the following table. These forecasts were developed prior to the onset of the Covid-19 pandemic. Subsequent discussions with WIAL indicate that they were anticipating a short term reduction in traffic followed by a return to growth in the medium/long term. Therefore, these forecasts are considered fit for the purpose of projecting long term travel patterns.

Table 8-1: 2038 Airport annual patronage projections

	2018	2038 BUSINESS AS USUAL	
	Pax	Pax	% Change
Domestic	5,249,356	8,263,840	57%
International	895,605	1,754,220	96%
Total	6,144,961	10,018,060	63%

These growth rates were applied to daily passengers for both domestic and international flights.

8.2 Land Use

No land use projections in the format used by WTSM are available yet for 2038, as a result land use for 2033 was used instead. Given that population and employment information is only used for trip distribution, this is not expected to have a significant impact.

8.3 Economic Parameters and Other Model Inputs

Economic parameters were estimated for 2038 using the approach outlined in 'TN9 – Economic Parameters'. This led to increase for each economic parameter as shown in the following table.

Table 8-2: Economic parameters 2018-2038 growth (real)

Parameter	2018 - 2038 Increase (real)
VoT Business	34%
VoT Personal	27%
VOC Personal	37%

VOC Business	37%
PT Fares	8%
Airport Parking	33%
Taxi, Rideshare, Shuttle Fares	33%

Other input parameters (share of parking vs drop-off/pick-up, share of taxi/rideshare/shuttle, occupancies, etc) were left untouched.

Finally, the base year network skims used for the airport model development were replaced with skims from a 2038 Do Minimum scenario, including the 2033 land use and additional bus lanes between the CBD and airport (leading to a roughly 10% decrease in travel times during the peak period).

8.4 Results

Resulting changes in number of trips and mode share (24hr, two way) are shown in the following table. To enable a better understanding of the cumulative contribution of each change, their individual impact is shown separately. Note that these show person trips and not vehicle trips.

Table 8-3: Projected trips and modal share

	PERSON TRIPS				MODE SHARE		
	PT	Private Vehicles	Booked Services	Total	PT	Private Vehicles	Booked Services
2018	1,276	8,117	9,044	18,437	6.9%	44.0%	49.1%
+ projected 2038 patronage	2,076	13,284	14,644	30,004	6.9%	44.3%	48.8%
+ 2038 economic parameters	2,107	13,491	14,406	30,004	7.0%	45.0%	48.0%
+ 2033 land use	2,122	13,717	14,166	30,004	7.1%	45.7%	47.2%
+ Road network skims	2,176	13,636	14,192	30,004	7.3%	45.4%	47.3%
+ PT network skims	2,291	13,560	14,152	30,004	7.6%	45.2%	47.2%

Results show that:

- The projected increase in airport patronage translates into the expected increase in person trips
- 2038 economic parameters lead to a decrease in booked services compared with other modes, likely due to fares increasing faster than PT fares, and representing a larger proportion of the total trip cost than VOC does for private vehicles (and only a small proportion of private vehicles trips using airport parking). The increase costs for car users are also mitigated by the rising values of time.
- The 2033 land use leads to another small shift from booked services toward other modes.
- 2038 road network skims lead to a slight shift to public transport as congestion increases.
- The 2038 PT network skims result in an increase in PT mode share due the reduction in travel times caused by the additional bus lanes.

Apart from the 2038 increase in patronage, the cumulated impact of these changes is modest, especially in terms of mode share. This can be expected given the assumptions made for these tests, however these results together with the sensitivity tests show that the model response in forecasting is appropriate in terms of direction and magnitude.

9. Implementation in WTSM and WPTM

9.1 Implementation in WTSM

The airport model was first developed in a spreadsheet for calibration, and was then implemented in EMME using a stand-alone python script, with an emphasis on the script being clear and readable.

The model runs during each WTSM demand loop to reflect changes in network congestion and its impact on mode choice.

All car demand including private vehicle (parking as well as pick-up / drop-off), taxis, rideshare and shuttle are added to the overall WTSM light vehicle matrices. PT demand is assigned as a separate class (called 'airppt')during the PT assignment due to its unique characteristics compared with other PT demand segments.

Finally, while the model includes a modal choice component, it also allows the user to manually input changes in mode share, to enforce expected changes in travel patterns not resulting from changes in generalised costs (such as changes in behaviours, travel demand management, etc). This flexibility allows transport analysts and planners to explore various 'what if' scenarios and their impact on the transport system.

9.2 Implementation in WPTM

No changes are required in WPTM. The airport related PT demand will be included in the 'Other' purpose matrices in WTSM, and the demand will be passed on to WPTM using existing processes.

10. Summary

This technical note has described the development of a new module to represent flight passenger landside access to the airport within WTSM, with the functionality to represent modal shift between car access and public transport.

Comparison with parking data and PT patronage at the airport shows that the model is a good fit with observed movements for the base year 2018, while sensitivity tests and baseline forecasting show that the model responds appropriately to changes in airport patronage and in travel times and costs.

The methodology and adopted form of model were however highly dependent on data availability, and this has resulted in validation to be carried out at a relatively aggregated level, and a number of assumptions having to be made that need to be considered in any usage of the model for assessment of transport policies or schemes.

It is recommended that the model is further refined when more detailed data is available, or specifically collected for this purpose, particularly the following:

- New survey of vehicles numbers and occupancies, including bus patronage and rideshare usage
- More detailed passenger's origin/destination data, potentially based on mobile phone or EftPOS data
- Although this would be a more complex and costly data collection exercise, a simple intercept survey of passenger at the airport would be extremely valuable. This could be limited to questions on flight type, landside origin/destination, mode used including for reverse journey, purpose and domicile (home/away).

Appendices

Appendix A Addendum

Please note that the comments below have been paraphrased in some places.

Question from Peer Reviewer

Firstly, I fully accept the challenges of the lack of data, and therefore the need to "make do" or sensibly interpolate.

Section 6.2. I'm interested in the parking charge of almost $70 for cars staying for longer than 4 hours for two reasons. Firstly, it may imply that some people may drive whatever the parking charge (so PT is not an option for these people), and secondly, for some business folk, they may not care about the charge, as it is not their cost. In this case, the mode choice for these people will be almost entirely about time not cost.

Response from Consultant

Correct that some people are likely to drive, and more generally to use car as it might be pick-up/drop-off or taxi/rideshare, no matter what PT improvements to the airport are made. Such improvements (for example a new mode such as MRT) most likely would mostly improve access to the CBD, and suburbs in-between such as Kilbirnie/Hataitai. People from elsewhere in the region would still need to take another bus and transfer to MRT (or MRT to MRT if there is more than one route). So this translates into more wait time and transfer penalties and these people are more likely to stick to car as a result. So it's important to recognize that any strong modal shift will likely be mostly for trips to/from the CBD.

Regarding parking, two things to note:

The fact that parking costs would be less of a disincentive for business will be captured by the higher VoT for them.

The proportion of people actually parking long term at the airport is actually pretty small, so this high cost is really not paid by many people as a proportion of total car users. Increasing parking costs would therefore have a limited impact. Proportions of people parking long term is about 4.3% throughout the day.

Question from Peer Reviewer

Section 6.4. Some of the ASCs are quite large (up to 52 minutes), and I wonder if there should be an upper limit for such factors. Alternatively, have these been set to give the right result (ie validation) and are these ASCs large to counteract my first point about parking charges and some people's high propensity to use a car?

Response from Consultant

Some ASCs are indeed quite large, especially for taxi/rideshare. They have essentially been derived through calibration as it is the main lever we have to match observed once we are satisfied with generalised costs calculations. For comparison, the Melbourne model has ASCs as high as 55 (the document provided shows only a selection of ASCs as example so others might be higher), and Sydney ranges from -131 to +105. MSM in Auckland has a narrower range but still reasonably high, basically +/-30.

Question from Peer Reviewer

Section 7. The numbers of trips by each mode appear to validate well – but as noted above, I wonder if the model is right for the wrong reasons. (I've probably put that a bit clumsily – what I am saying is I wonder if the model would also validate well with different permutations of parameters).

Response from Consultant

I suppose the question is has the model been over-calibrated through ASCs? For information, removing all ASCs lead to a PT mode share of 10% instead of 7%, so not very different. It does lead to booked services being about 20% too low however, which shows that generalised costs are not enough to represent the split with private cars, hence the large ASCs for this mode.

Question from Peer Reviewer

Section 8.3. There is a very brief comment about the effects of this new airport module on the base model validation. Presumably, it could affect both the traffic and PT validation, particularly given the figures in Table 5-4, which indicate that the current WTSM is some way away from the observed distribution (e.g. around one third of airport trips should be to the CBD, whereas the model currently suggests about 10%).

Response from Consultant

Potentially yes. This model is meant to be included in the new 2018 WTSM so impact on 2013 validation is not covered in this note. Some analysis was however carried out for specific project application.

Question from Peer Reviewer

Section 8.4. It is probably a bit disappointing that the 2038 base forecast gives almost the identical mode shares to the 2018 base, but I understand these 2038 forecasts relate to the Do Min, ie with minimal extra PT.

Response from Consultant

Yes, it is a do minimum. However testing with significant improvement of PT to the airport shows that although it leads to a reasonably large increase in patronage by WTSM and 4-step model standard, it is still not a game changer, which is to be expected with this type of model. This is where this 'what-if' approach will be more useful to force a response.

Question from Peer Reviewer

I am keen for this new module to be used to assist the LGWM project tests, but I wonder if the above points mean we need to think a bit more about the effects of a few of my comments, first, particularly:

The potential lack of mode choice for some airport users (if they are going to drive, come what may);

The perception of some users (potentially ignoring $$ costs), affecting the generalised cost;

The high level of ASCs;

The potential effects on the base validation.

Response from Consultant

All good points to keep in mind when using the model for project analysis, hopefully the explanations above have sufficiently covered these.

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

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