Urban transport modelling in New Zealand – data, practice and resourcing

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An important note for the reader

Erratum

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Table 2.6 page 17 and tables 2.8 and 2.9 page 18 corrected. Text revised in first and second paragraphs under table 2.9.

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Abbreviations and acronyms

ABM	activity-based model(s)
AFC	Auckland Forecasting Centre
AMETI	Auckland Manukau Eastern Transport Initiative
APT3	Auckland Passenger Transport Model (version 3)
ART3	Auckland Regional Transport Model (version 3)
CAST	Christchurch Assignment Simulation Traffic Model
CD	compact disc
CTM	Christchurch Transport Model
GPS	global positioning system
HPTM	Heretaunga Plains Transport Model
HTS	Household Travel Survey
KTM	Kapiti Traffic Model
MOT	Ministry of Transport
N2A	Ngauranga to Airport model
NUTS	National Urban Transport Survey
NWSM	North Wellington Saturn Model
PNATM	Palmerston North Area Transport Model
S3M	Southern Sector Saturn Model
Transport Agency	New Zealand Transport Agency
WPTM	Wellington Public Transport Model
WRTM	Waikato Regional Transport Model
WTSM	Wellington Transport Strategy Model

Contents

Executive summary

This project had its genesis as a result of the decision by the Ministry of Transport (MOT) to alter the basis of the Household Travel Survey (HTS) with a new contract, which came into effect in the 2015/16 financial year.

The travel survey contract was set up with provisions for sample expansion for particular purposes, and it was thought the MOT survey could be used this way to form the basis of data from which transport models could be calibrated.

From this the scope widened to include a review and comparison of HTS already undertaken in New Zealand and a stocktake of the existing models used throughout the country. From this beginning, the research project was developed to address two knowledge gaps: one specifically around the HTS and its use in regional/local government transport modelling, and the other more generally about the transport modelling situation in New Zealand.

The new HTS is a continuous survey that uses global positioning system (GPS) technology and the internet to provide detailed information on participant travel patterns and behaviours. The survey's base sample is designed to provide national- and regional-level data over multiple years, but the contract also offers local authorities the ability to obtain meaningful data at a more local level through purchasing additional 'over samples' in local areas where they require more detailed information.

In order for local government to make informed decisions about oversampling in their area, especially for modelling purposes, they need to know that the HTS is sufficient for their transport modelling needs and/or what changes might need to be made to make it sufficient. It is also useful to know the suitability/adaptability of the HTS data to future generations of transport models, which may incorporate different scale needs, interpretations of travel behaviours and the like.

More generally, the research identified a knowledge gap around the status of the transport modelling systems employed by the government. Disparate models are held or commissioned by different agencies, with different assumptions and data sources. A basic understanding of what the transport system models undertaken by the government are, what they are for, how they are used and how they might interact, would help to better inform discussion about future models.

This study is in seven parts. Chapter 2 reviews the Ministry of Transport HTS, with an emphasis on the questions included in the survey, and quality checks on the data obtained. It makes a number of recommendations, all of which have been incorporated in the 2017 and 2018 surveys.

Chapter 3 summarises the household interview surveys that have been undertaken in New Zealand from 1967 to 2018 and makes a detailed comparison of trip-making characteristics for those surveys undertaken since 2001. The study concludes that there is a high degree of consistency in daily trip rates per person across all surveys at 4.2 daily trips per person with a standard deviation of 0.48. Equally, daily trips per household are also relatively constant at 11.64 trips per household with a standard deviation of 0.86. The study also found a strong relationship between trips per person and age band, concluding that the relationship has the potential to be an important method in controlling total trip generation within a model.

Chapter 4 is a stocktake of the models currently used in New Zealand. There are three- or four-step models in almost all New Zealand cities, with detail ranging from very coarse strategic models in Auckland, Wellington and Christchurch to detailed models incorporating sophisticated junction modelling in most provincial centres. The coarse nature of the models in the three main centres has necessitated the development of more detailed 'project models' and public transport models that sit beneath or alongside the strategic models

Chapter 5 takes the MOT data and confirms that it is suitable for building the variety of three and four-step models that are currently being used in New Zealand. It does make the point that, in the early years of the MOT rolling surveys, sample size in any particular model area might be an issue. There is also a brief discussion on the utility of the data if the current set of trip-based models are to be transitioned into tour-based or activity-based models.

Chapter 6 provides a discussion on a modelling hierarchy, including the NZ Transport Agency's model category definitions, current model forms drawing on the model stocktake discussed in chapter 4, and concludes with a theoretical hierarchy including four levels of modelling – strategic, tactical, operational and design.

Chapter 7 contains a description and the results of a survey of the modelling skills, experience and resources currently available within the New Zealand public sector.

Chapter 8 contains a summary of conclusions reached from the research.

Chapter 9 includes recommendations for future research.

Abstract

Household Travel Survey data is an essential component of building a transportation model. The New Zealand Ministry of Transport (MOT) has recently embarked on a rolling programme of annual surveys. This research project confirmed that, with some changes, the data collected in the surveys was adequate to build existing model forms currently being used and would be suitable if tour-based or activity-based transportation models were to be built in the future, noting that sample sizes in the MOT survey would need augmenting for this purpose.

As part of the project a stocktake of current models was undertaken, as was a short survey of the public sector transport modelling resource in New Zealand. The study concludes with suggestions for topics of future research.

1 Introduction

1.1 Background

This project had its genesis as a result of the decision by the Ministry of Transport (MOT) to alter the basis of the Household Travel Survey/s (HTS) with a new contract, which came into effect in the 2015/16 financial year. The travel survey contract was set up with provisions for sample expansion for particular purposes, and it was thought that the MOT survey could be used this way to form the basis of data from which transport models could be calibrated.

From this, the scope widened to include a review and comparison of HTS already undertaken in New Zealand and a stocktake of the existing models used throughout the country. From this beginning, the research project was developed to address two knowledge gaps: one specifically around the HTS and its use in regional/local government transport modelling, and the other more generally about the transport modelling situation in New Zealand.

The new HTS is a continuous survey that uses global positioning system (GPS) technology and the internet to provide detailed information on participant travel patterns and behaviours. The survey's base sample is designed to provide national- and regional-level data over multiple years, but the contract also offers local authorities the ability to obtain meaningful data at a more local level through purchasing additional 'over samples' in local areas where they require more detailed information.

In order for local government to make informed decisions about oversampling in their area, especially for modelling purposes, they need to know that the HTS is sufficient for their transport modelling needs and/or what changes might need to be made to make it sufficient. It is also useful to know the suitability/adaptability of the HTS data to future generations of transport models, which may incorporate different scale needs, interpretations of travel behaviours and the like.

More generally, a knowledge gap around the status of the transport modelling systems employed by government has been identified. Disparate models are held or commissioned by different agencies, with different assumptions and data sources. A basic understanding of what the transport system models undertaken by government are, what they are for, how they are used and how they might interact, would help to better inform discussion about future models.

1.2 Objectives

The research project had 10 objectives:

- Review the new HTS and confirm the questions are sufficient to build transport models.
- Confirm that the new MOT data can be used to derive the underlying relationships as in the current set of models.
- Recommend any changes to the survey that might be required as a result of this analysis.

- Review the current models in New Zealand and document the parameters and equations (including, for three- and four-step models[1], trip rates, attraction equations, distribution functions and mode split equations) that have been used in their calibration.
- Determine differences in trip making from available HTS since 1971.
- Demonstrate that the data in the MOT HTS can be used to calibrate models.
- Determine similarities and differences in travel behaviour between geographic areas.
- Investigate the linkages in a hierarchy of models.
- Recommend the desirable frequency of updating the travel data underpinning the models.
- Investigate the capability and resourcing of New Zealand modellers.

The project was split into two stages. Stage one was the primary analytical stage, including a review of MOT HTS data, confirmation that it was suitable as the basis for calibrating current model forms, and a comparison of the more recent HTS.

It also included a stocktake of the models currently used around the country.

Stage 2 of the project was intended to cover the more general discursive topics of the structure of New Zealand models including the way in which a hierarchy of models fits together, and the capability and resourcing of the New Zealand models and modellers.

The output from the research is this report covering both stages of the project. It should be noted that the initial objectives were modified slightly as the project proceeded and as priorities altered. For example, at the outset, the survey was intended to cover both the private and public sector, but for reasons of commercial sensitivity, only the public sector was approached

1.3 Structure

The report is structured as follows:

Chapter 2 is a review of the MOT HTS, with emphasis on the questions included in the survey and quality checks on the data obtained. It makes a number of recommendations, all of which have been incorporated in the 2017 and 2018 surveys.

Chapter 3 summarises the household interview surveys that have been undertaken in New Zealand from 1967 to 2018 and makes a detailed comparison of trip-making characteristics for surveys undertaken since 2001. The study concludes there is a high degree of consistency in daily trip rates per person across all surveys at 4.2 daily trips per person with a standard deviation of 0.48. Equally daily trips per household are also relatively constant at 11.64 trips per household with a standard deviation of 0.86. The study also found a strong relationship between trips per person and age band, concluding that the relationship has the potential to be an important method in controlling total trip generation within a model.

Chapter 4 is a stocktake of the models currently in use in New Zealand. There are three- or four-step models in almost all New Zealand cities, with detail ranging from very coarse strategic models in Auckland, Wellington and Christchurch to detailed models incorporating sophisticated junction modelling

[1] A three-step model has generation, distribution and assignment – with vehicle driver trips and flows as outputs. A four-step model includes a mode split phase, and will normally output car driver, car passenger, public transport and active mode trips and flows.

in most provincial centres. The coarse nature of the models in the three main centres has necessitated the development of more detailed ‘project models’ that sit beneath the strategic models.

Chapter 5 takes the MOT data and confirms that it is suitable for building the variety of three- and four-step models currently being used in New Zealand. It does make the point that, in the early years of the MOT rolling surveys, sample size in any particular model area might be an issue. There is also a brief discussion on the utility of the data if the current set of trip-based models are to be transitioned into tour-based or activity-based models.

Chapter 6 provides a discussion on a modelling hierarchy, including four levels of modelling – strategic, tactical, operational and design.

Chapter 7 contains the results of a survey of the modelling skills, experience and resources currently available within the New Zealand public sector.

Chapter 8 sets out the conclusions drawn from the research.

Chapter 9 includes recommendations for future research.

2 Ministry of Transport Household Travel Survey

2.1 Introduction

The first question addressed in this research project was:

> *Is the current New Zealand Household Travel Survey (HTS) asking suitable questions for use as a basis for transport modelling at a regional/territorial local authority level? Is there any key information missing and/or what would need to be changed in the questions to get this information?*

This chapter covers:

- a description of the data
- data quality
- data checking
- GPS pulse data
- sample representation and weighting
- initial trip rate analysis
- recommendations for change.

2.2 Data description

The data supplied covered surveys from October 2015 to December 2016, although there were no survey days in January 2016. It was supplied as 'comma separated variable' files (as requested), with one each for household, person and trip data, plus an Excel spreadsheet containing the 'data dictionary', which described the fields and coding of each field in the data files.

The files were:

- A **household** file containing information about all households in the sample, whether or not they participated in the survey, including person and vehicle information. There were 53 data fields in the file.
- A **person** file containing information about each person in the household, again whether or not they participated in the survey. There were 188 data fields in the file.
- A file containing information about the **trips** made by each person on each of the survey days. There were 60 data fields in this file.
- A file containing the **addresses** and co-ordinates of each address used by each trip. There were 12 data fields in this file.
- Three files containing the **GPS pulses**.

At the time of writing, the data has not been finalised, but it is understood that after each year's data is finalised, summary reports (in the short term) and confidential unit record file data at the household, person and trip level (in the longer term) will be made available via the MOT website –

www.transport.govt.nz/research/travelsurvey/. Researchers are recommended to contact MOT to discuss access to further details.

2.3 Data quality

2.3.1 Identifying fields

Overall, the quality of the data is very good. It seems that the combination of GPS and interviews produces good data. There were some issues, which are discussed below. In most cases with a degree of effort, the data can be 'cleaned'.

One of the conventions of the HTS is that the household, person and trip records share a common set of initial fields so that each trip is uniquely identified by the trip number within a survey day, and by a person within a household. These four fields are common to each of the files, and by convention would normally occur in the same order in each file.

In this data the common identifying fields are:

- household file:
  - year number
  - survey year name
  - sample number.
- person file:
  - year number
  - survey year name
  - sample number
  - person number
- trip file:
  - year number
  - survey year name
  - sample number
  - person number
  - trip day
  - trip number for that day.

2.4 Data checking

Since 1975, TDG (now Stantec) has been involved in the collection and/or analysis of a number of HTS and over the years has developed range and logic checking software that will throw up errors and inconsistencies in a dataset. All surveys are different, and the software is customised each time to suit the survey.

The software checks the data range for each variable, undertakes a series of logic checks and is a tool to check that the key data needed for model building is present and correct.

Table 2.1 summarises the 2016 sample data. For this survey, 3,912 household were selected to be contacted and invited to participate in the study.

Table 2.1 Summary of surveyed households

Response code	Code description	Number	Percentage
1	Full response of all eligible people	1,553	39.7%
3	Not occupied	267	6.8%
5	Not a dwelling (NDE)	116	3.0%
9	Not contacted	411	10.5%
10, 11, 12	Refused, or health/safety issues	586	15.0%
14	No travel interviews completed	356	9.1%
15	Partial – 1 or more travel interviews	623	15.9%

In this process, only those households with a response code of 1 (all persons in the household responded for every travel day) were examined. Of the 3,913 households in the initial sample, 1,531 (39.1%) were included in the checking and subsequent analysis for this project.

The checking threw up a number of issues in the initial data delivery, although only a small percentage of the 72,280 trips were affected.

- 54 trips (0.07%) had a trip start or end time missing, or the start time of a trip was earlier than the end time of the last trip.
- 76 trips (0.15%) had no address coded, or the start address was not the same as the end address of the last trip.
- 3,009 trips (4.16%) had a zero duration of stay at the destination – in other words the start time of a trips was the same as the end time of the last trips. While this may be a result of the seconds not being included, it may also mean that a single trip was incorrectly coded as two trips.
- As well as these, 2,094 (2.89%) trips did not have either the first trip of the day starting at home, or the last trip of the day ending at home. While these may be correct, it seems to be a relatively high number and should be checked.
- Household 2240 has two addresses coded as home in the address file. That is incorrect – one should be coded as O (other).
- Household 2349 has the home address coded twice, one as address no.1 and the other as address no.23. In the trip file, trips going to address 23 were incorrectly coded as 'Social Rec'. They need to be recoded as 'Going home', and address 23 recoded as 1 for both origin and destination.
- In the address file, the address field has this comment '*Error: We can't get address from selected data, You have exceeded your daily request quota for this API.'*
- The activity of every destination was recorded. The assumption could be made that the origin of the next trip was the same as the destination of the last trip, and the combination of the start and end activity gave trip purpose – an essential component of model building.

However, one important piece of information, the origin activity of the first trip of each day, was not collected. For the 1,283 trips that did not start at home, trip purpose cannot easily be determined, although it may be possible to infer it if the start address is a destination on one of the travel days. It is noted that this has been rectified in subsequent years of data collection.

The transport models are normally built for an average weekday, when schools and universities are in session. The analysis reported below includes all survey days, but the school holidays should be filtered out in later stages of the project. To facilitate this, although it can be derived from the household data, it would be useful for the survey date to be included on every trip in the trip file.

2.5 GPS pulse data

There were significant problems with the relationship between the GPS pulse data, and the way this was converted into trips. The GPS pulses were out of order and needed to be sorted chronologically (by GPS ID) before they could be used. Taking a person day[2] at random (household 159, person 1, day 1) the raw GPS pulse data was compared with the trips in the trip data file. The last three pulses of each trip were the same as the first three pulses of the next trip and should be ignored in one or the other.

In the GPS data the trips have been identified as:

Table 2.2 Sample GPS data

Trip	Trip start	Trip end
1	06NOV2015:08:28:37.000	06NOV2015:08:43:58.000
2	06NOV2015:08:43:58.000	06NOV2015:09:02:56.000
3	06NOV2015:09:02:16.000	06NOV2015:16:32:00.000
4	06NOV2015:16:31:00.000	06NOV2015:16:37:21.000
6	06NOV2015:20:59:06.000	06NOV2015:21:00:47.000

In this example, the break between trip 1 and 2 is not a stop, but the others are. However, the same trips in the trip file are coded as:

Table 2.3 Sample trip data as coded

Trip	Data start	Data end
1	8:28	8:43
2	8:43	9:02
3	9:02	16:31
4	16:31	16:38
5	20:59	21:00

In this data, with the exception of trip 5, there was no time spent at the end of each trip and the start of the next. The way in which the data was coded gives a false picture of the number of trips made, the time they were made, the duration of the trip and the geographic location of the trip ends. That said, the data is there; it is the way in which it is interpreted that requires attention.

Using GIS, the GPS pulses were plotted for this person's trips, and the paths are shown in figure 2.1. The trip data is not accurate. In fact, there were six, or seven trips, but the start and end times and positions

[2] The issue here has been identified using one person from household only, by inspection. A more rigorous check could be carried out if the software is changed, but for the moment one example will suffice.

are not correct as shown in the table below. Trip 1 is from home to school 1 to drop off a child, and the start and end times are essentially coincident. Trip 2 is from school 1 to another school 2. Trip 3 is from school 2 back home. There are some random very close spaced pulses around 1400 hours with the GPS essentially moving around the house. Trip 4 (and possibly trip 5) is from home to school 1 and school 2, but there is no way to determine whether there was a stop at school 1. Trip 5 is from school to shopping, and the trip back home is missing. There are a few close-spaced pulses around home at 2100 hours which have been coded as trip 5 but are irrelevant.

Table 2.4 Probable trips

Trip	Data start	Data end
1	8:28	8:44
2	8:44	9:02
3	9:02	9:15
4	16:15	16:31
5	16:31	16:37
6	missing	

The algorithm that converts the GPS pulses into trips is one of the more critical parts of the data collection and this example highlights the difficulties of analysing GPS data using algorithms.

While the GPS data is acting as a 'memory jogger' for the respondents, the more accurate the algorithm the less time it will take for errors to be corrected with manual coding. The GPS data also provides a wealth of information on routes and delays that is not available with non-GPS data collection methods[3].

One final comment is that New Zealand summertime began on Sunday 25 September. A check should be made that the times for any subsequent days have been adjusted, particularly when the survey week spanned that Sunday.

2.6 Sampling and weighting

A total of 3,913 households were identified in the 2015/16 data set. Of these, 1,531 were coded as fully responding. Weights were calculated by geographic sampling, with a range varying between 82.3 and 31,654.

A person correction factor was also calculated that removed age bias by correcting the sample to match 2013 census totals by age group.

When HTS data is used for modelling, additional weights are normally calculated to correct for bias by:

- household category
- gender and age
- car ownership.

These corrections should be applied to the data before it is used for model calibration.

[3] Note that a random check of the data in the year 15 dataset (collected after this report was written) indicates that there is now a good match between the GPS data and the trip data

Typically, past HTS used to provide data for a local authority model build would cover about 2% of the households for one travel day. The 2016 data covers 0.1% of the New Zealand households but over five weekdays[4].

In general, New Zealand models have used a household category model stratified by five household size categories and four car ownership categories. Recent model builds have attempted to stratify by life cycle categories, but for the purpose of this research project the simpler 20 category model was accepted. This means the data should be corrected so that each of the 20 categories has the right weight.

Table 2.5 shows the number of households in each of the categories, taken from the 2013 Census. The total is 1,471,758, as some of the census responses did not specify car ownership, and these have been excluded. Note that the weighting in the HTS was calculated using the Department of Statistics estimates of households for each survey year – not the census number.

Table 2.5 Number of houses in each household category (census)

Census households by household category (percent)							
		Persons per household					
		1	2	3	4	5	Total
Car ownership	0	68,208	24,855	11,088	6,288	5,934	**116,373**
	1	227,364	170,532	70,392	49,713	34,818	**552,819**
	2	29,664	249,144	100,572	112,548	73,170	**565,098**
	3+	6,483	60,342	60,261	56,481	53,901	**237,468**
Total		**331,719**	**504,873**	**242,313**	**225,030**	**167,823**	**1,471,758**

Table 2.6 converts each cell into a percentage of the responding households.

Table 2.6 Percentage of households in each category (census)

Census households by household category (percent)							
		Persons per household					
		1	2	3	4	5	Total
Car ownership	0	4.63%	1.69%	0.75%	0.43%	0.40%	**7.91%**
	1	15.45%	11.59%	4.78%	3.38%	2.37%	**37.56%**
	2	2.02%	16.93%	6.83%	7.65%	4.97%	**38.40%**
	3+	0.44%	4.10%	4.09%	3.84%	3.66%	**16.13%**
Total		**22.54%**	**34.31%**	**16.46%**	**15.29%**	**11.40%**	**100.00%**

Tables 2.7 and 2.8 are the equivalent tables taken from the 2015/16 sample.

[4] Note that the models would normally be built for a March weekday while schools and universities were in session. Non-school days have yet to be removed.

Table 2.7 Number of houses in each household category (HTS sample)

Sample households by household category (number)							
		Persons per household					
		1	**2**	**3**	**4**	**5**	**Total**
Car ownership	0	69	17	4	2	1	**93**
	1	403	209	49	33	15	**709**
	2	55	350	62	75	39	**581**
	3+	5	55	36	30	22	**148**
Total		**532**	**631**	**151**	**140**	**79**	**1,531**

Table 2.8 Percentage of household in each category (HTS) sample)

Sample households by household category (percent)							
		Persons per household					
		1	**2**	**3**	**4**	**5**	**Total**
Car ownership	0	4.51%	1.11%	0.26%	0.13%	0.06%	**6.07%**
	1	26.32%	13.65%	3.20%	2.16%	0.98%	**46.31%**
	2	3.59%	22.86%	4.05%	4.90%	2.55%	**37.95%**
	3+	0.33%	3.59%	2.35%	1.96%	1.44%	**9.67%**
Total		**34.75%**	**41.21%**	**9.86%**	**9.15%**	**5.03%**	**100.00%**

The correction factors for each category are then calculated by dividing the census percentages by the sample percentages, as shown in table 2.9.

Table 2.9 Household correction factors

Household category correction factors							
		Persons per household					
		1	**2**	**3**	**4**	**5**	**Total**
Car ownership	0	1.03	1.52	2.88	3.27	6.17	**1.30**
	1	0.59	0.85	1.49	1.57	2.41	**0.81**
	2	0.56	0.74	1.69	1.56	1.95	**1.01**
	3+	1.35	1.14	1.74	1.96	2.55	**1.67**
Total		**0.65**	**0.83**	**1.67**	**1.67**	**2.27**	**1.00**

Households with 2 cars have been representatively sampled, but the 1 and 3+ car ownership categories are significantly under sampled and 1 car households oversampled. There is a significant over sampling of the smaller households, and larger households significantly under sampled.

It means that some of the expansion factors would be over 6,000 (6.17 x 998.06) whereas typically they should be between 100 and 200. As the sample increases with the subsequent year's data, and the sample is more representative, these should decrease.

When the additional samples for specific local authorities are drawn, a reasonable target expansion factor for each category should be in the order of 150 to 200 or better.

2.7 Initial analysis

For the purposes of this chapter, it is sufficient to check the trip rates are consistent with other surveys. Again, they have been calculated from the 1,531 households, with no distinction made between urban and rural households. Only weekday travel days have been used, and all days (school days and holidays) have been included.

Table 2.10 contains the unexpanded trips for each category. This produces 13,242 trips per day, or 8.65 (standard deviation =7.0) person trips per household.

Table 2.10 Trips per week (5 days) by category

Trips per week							
		Persons per household					
		1	**2**	**3**	**4**	**5**	**Total**
Car ownership	0	886	472	150	112	80	**1,700**
	1	8173	8578	2604	2345	1453	**23,153**
	2	1476	15567	3863	6080	4182	**31,168**
	3+	111	2630	2359	2856	2234	**10,190**
Total		**10,646**	**27,247**	**8,976**	**11,393**	**7,949**	**66,211**

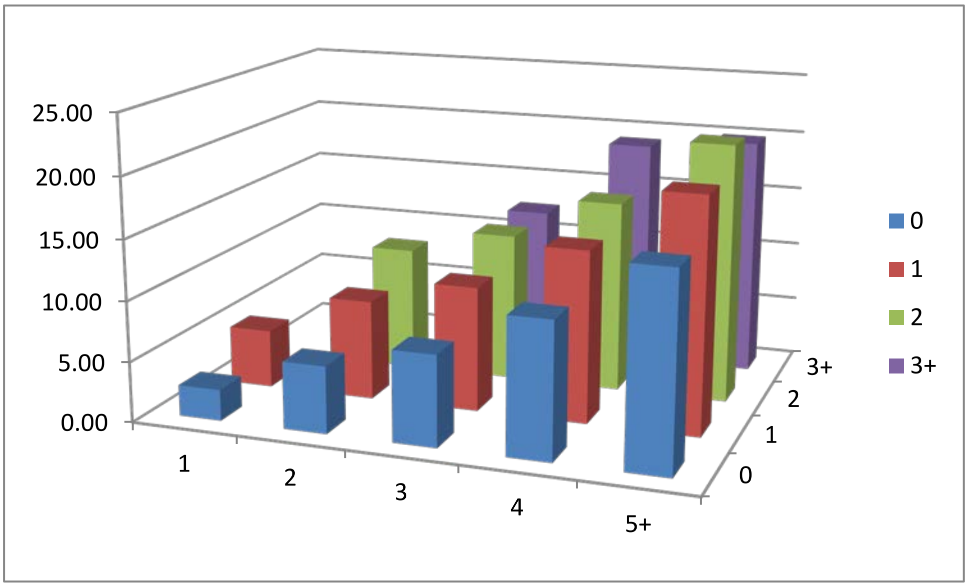
And finally, table 2.11 contains the trip rates per day by category. In this table, the 1 person, 2 and 3+ cars categories have been combined with the 1 person and 1 car category, and 2 person 3+ cars category has been combined with 2 person 2 car households category.

Table 2.11 Unweighted trip rates by category

Total trips per day per household							
		Persons per household					
		1	**2**	**3**	**4**	**5**	**Total**
Car ownership	0	2.57	5.55	7.50	11.20	16.00	**3.66**
	1	4.21	8.21	10.63	14.21	19.37	**6.52**
	2	-	8.98	12.46	16.21	21.45	**10.69**
	3+	-	-	13.11	19.04	20.31	**13.58**
Total		**4.00**	**8.64**	**11.89**	**16.28**	**20.65**	**8.65**

These numbers are displayed graphically in figure 2.1. In general, the trip rates should increase with increasing household size, and with increasing car ownership.

Figure 2.1 Unweighted trip rates by category



In most past HTS surveys where the data was collected for model building purposes, the daily person trips rates overall were between 11 and 13 trips per household. The unweighted trip rates in the 2016 data are very low by comparison, but when the weighting is applied, the household trip rate is 10.99 (standard deviation = 10.8) trips per household per day.

2.8 Recommendations

A number of recommendations can be made in relation to the data. They are, in no particular order:

- The errors in the data identified above should be corrected. These checks should be made as the ‘travel diary’ is being completed by the respondent. In other words, the data should be error free at the end of the data entry process. The errors identified to date, and checks which should be carried out include:
    - Ensure that the identifier fields are in the same position in each file.
    - Each trip has a start and end time and the start time should be after the end time of the last trip.
    - There is a clear length of time between the end of one trip and the start of the next. This should also be identifiable from the GPS pulses.
    - The first and last trip of each day starts and ends at home.
    - The GPS pulse data is consistent with the trip data.
    - A trip that has a start or end address at home or at work has a trip end activity that is consistent with the address.
    - Every valid trip end has an activity coded (not -98, or -99).
    - There is only one home address (which is the address of the household being surveyed), although there could be several work or education addresses.

- The start and finish times include seconds. This will avoid issues where the start time of a trip is earlier than the end time of the last trip, unless it is a genuine error. It will also identify whether a zero time spent at a destination is correct – in which case it is not a trip end.
- The activity at the origin of the first trip of the day is explicitly identified.
- For modelling purposes, the data needs to be supplemented in order to get a better representative sample of household categories. The sample should be such that the expansion factor for trips is in the 100 to 200 range.
- A sample of trips where the first trip does not start at home or where the last trip does not end at home should be checked to see if these are genuine.

3 Trip making comparisons from recent travel surveys

3.1 Introduction

The scope for this project included the following task:

> *It [the project] will test the data to see if it is similar or different to the findings from other/historical HTS data (Dunedin/Auckland/Waikato/Wellington/Christchurch), and see if the relationships developed for one area are applicable to other areas.*

This section of the report describes the analysis undertaken to address this scope.

3.2 Historical background

Over the years a number of HTS have been undertaken in New Zealand. Table 3.1 summarises the locations and years of survey.

Table 3.1 Household travel surveys in New Zealand

City	Years surveyed					
Auckland		1973	1978	1992	2006	
Hamilton/Waikato	1968		1978		2008	
Tauranga				1996		
Heretaunga			1978			
Wellington	1963	1971	1978	1988	2001	
Christchurch	1969		1978	1990	2006	
Waimakariri					2001	
Dunedin			1978	1990		2014
Invercargill	1967					
NUTS			1978			
Ministry of Transport (MOT)			1988–89	1998–99	2003–14	2016–17

The data for the surveys up to 1995 was brought together in a Transfund NZ research project by Transportation and Traffic Systems Ltd (2000). With the exception of Hamilton, Heretaunga and NUTS[5] (where the data has been lost), the final report and that early data are planned to be available in a Microsoft Access database on the MOT website at the conclusion of this research project.

The key conclusions from that 1995 project were:

- *Too few household interview surveys have been carried out in New Zealand from which rigorous statistical analysis could be carried out. The findings of this study are therefore more indicative than conclusive. That said, the analysis in the report suggests the following:*
  - *Person trip rates vary only slightly between cities.*

[5] National Urban Transport Survey

- *Person trip rates vary only slightly over time*
- *Vehicle driver trip rates vary slightly between cities*
- *Vehicle driver trip rates increase over time as vehicle ownership increases*
- *If public transport trip rates are low, vehicle driver trip rates are high*
- *Vehicle passenger trip rates do not vary*
- *Vehicle driver trip rates for household categories of vehicles by employees and vehicles by persons vary only slightly over time*

The report went on to recommend:

- *More home interview surveys should be carried out in New Zealand. They should be timed to coincide with census years at 5, 10, 15 or 20 year intervals*
- *Further research should be undertaken to produce guidelines for a standardised home interview survey for New Zealand cities. This will ensure all necessary data are collected and are in a useful format*
- *The format would need to be flexible, and the standardised survey could be expected to evolve over time with the changes in the country's transportation system and society*
- *The possibility that home interview surveys could be conducted as part of the Department of Statistics census*[6] *should be investigated. This would help minimise the cost associated with home interview surveys*
- *Further research should be directed at establishing generation, distribution and mode choice models that are best suited to New Zealand*
- *A research project should be undertaken to correlate trip making with:*
  - *level of public transport*
  - *standard of roading provided*
  - *geographical environment*
  - *presence of tertiary institutes*
  - *presence of bulk transport facilities (air, sea)*
  - *economic activity (agricultural, industrial, available commercial, retail)*
- *A research project should be undertaken to retrieve, document, and analyse the external traffic data surveys that were carried out with each home interview survey*
- *A research project should be undertaken to retrieve, document, and analyse the commercial vehicle traffic data surveys that were carried out with and without each home interview survey, where such data exists.*

In general, several of the recommendations have been acted on. Since 2001, there has been one HTS carried out in each of the five main centres. Also, the MOT undertook nation-wide surveys from 2003 to 2014. A new national series began in 2016 with a revised set of questions that is planned to continue into

[6] At the time, there was some thought that the travel data could be included as part of the five-year census.

the future, potentially with additional samples collected in some areas to assist with model calibration/re-calibration.

The MOT rolling surveys that have been analysed in this research project, and the extension of these into targeted additional samples in other cities, have covered the first two bullet points, and later stages of this research project will go some way into covering the fourth point.

The remainder of this report takes the five recent surveys in Auckland, Waikato, Wellington, Christchurch and Dunedin, and compares key trip-making variables with the 2016 MOT data. Where applicable the historic data contained in Transportation & Traffic Systems Ltd (2000) will be compared against the recent surveys.

The survey reports are included with the pre-1995 data. However, they have been converted into a format that requires a reader that will only run on a Windows 95 or NT operating system, and may not now be readable.

3.3 Description of the analysis

The analysis in this stage of the project has three primary objectives:

- To continue the comparisons described in Transportation & Traffic Systems Ltd (2000) for a further 20 years of data collection
- To identify the extent to which trip rates in one area can be transferred to others
- To 'sanity check' the results coming from the MOT surveys to give confidence that the methodology now being used will produce data that can be used for model building in the years to come

The key variables as to whether data might be transferable from one area to another are those used to calibrate the trip generation equations. There are almost as many ways of doing this as there are modellers undertaking such analyses, but the methodology adopted for this project is as follows.

- A household-based category model has been assumed, with a cross classification of five household size categories with four vehicle ownership categories.
- The trip generation analysis has been confined to daily person trips.
- Where possible, trip making by mode as a comparison of mode share has been included, although not by household type.

The data provided for this study has been supplied either in terms of 'trip legs' or 'stops' – that is a 'walk-bus-walk' trip has been analysed as three 'trips' although they are technically 'trip legs'. Throughout the report the words 'trip' and 'trips' can mean 'trip legs', or it can mean trips where the access component legs of a public transport trip have been incorporated into the trip. This will depend on which dataset is being discussed. The data from Wellington 2001, Auckland 2006, Dunedin 2014 and the MOT 2016 HTS was supplied in the form of trip legs. Data from Christchurch 2006 and Waikato 2007 was supplied in the form of trips.

No attempt has been made to convert the trip leg data into trips, but the differences need to be borne in mind when comparing cities. In the surveys with high public transport trips, using trip legs will inflate the trip rate a little. In the cases of Auckland and Wellington, this could be in the order of 5–8%.

A further potential definitional issue is just what is meant by a trip. Common problems are:

- How are very short trips treated (eg is there a minimum trip length to count as a trip)?

- How are trips treated that involve a very short stop-off part way through (eg to purchase petrol or a newspaper)?
- Are recreational trips (for exercise etc) counted?
- How, if at all, is travel by babies and infants/very young children accounted for?

In the data sets that have been used in the comparisons below, there is a high degree of consistency. The MOT and the Waikato surveys have used the same definitions. The Auckland and Christchurch surveys were undertaken by the same organisation and the definitions are identical and similar to the MOT surveys. The Dunedin survey has its own issues (discussed later) and does not match the others.

3.4 Survey methodologies

There are generally four data components collected in a HTS, namely data related to:

- the household
- each person in the household
- trips made by each person in the household
- vehicles owned or available to the household.

As far as it can be established all the surveys until the Dunedin 2014 survey followed similar methodologies. The ones that seem to give the best results are where one person in the household provided the household data and identified the people who lived in the household. A survey day was allocated to the household, and each person was asked to record their trips on that day. Subsequently, each person was interviewed, and the responses recorded. This happened in Christchurch in 1969, Dunedin in 1990 and Waikato in 2008.

There are variations on this. In Auckland (1992) and Christchurch (1990), only one person in each household was asked to complete the travel log. The Christchurch survey relied totally on telephone contact – there was no face-to-face interview. Also, in many cases the trip log was self-completed, and there was no interview to check the responses.

The early MOT surveys used two travel days.

The disadvantage of this type of survey technology is that people's memories are notoriously bad. Not only are trips missed completely, but often the time of day is also completely wrong, and even with an interview, there is no way to be completely confident that all trips have been captured.

Until the MOT (2003/14) series, and the Waikato (2008) survey, the data collection was paper based, that is the data was written onto a form which was later typed into a database. In the MOT and Waikato, the survey contractor used laptops as aids to record trips, with the logic and range checking occurring when the data was entered during the interview. This minimised the degree of under-reporting as the computer checked that the correct sequence of trips was followed. No under-reporting adjustment was needed in Waikato.

The Dunedin (2014) survey was the first to use GPS tracking to record trips. Somewhat ambitiously, complete reliance was placed on the accuracy of the GPS units. While the data has been used to update the Dunedin model, there were several lessons learnt. It is worth documenting some of these as GPS based surveys are the way of the future.

Apart from the normal problems of people forgetting to carry the GPS unit with them, or not all members of a household agreeing to carry the GPS, the following issues were found.

- The units were designed to 'go to sleep' when there had been no activity for a period of time. It sometimes took two or three minutes for them to 'wake up', thereby losing, in some cases, a substantial part of a trip
- Dunedin is on the 45th parallel. It seems that the further south the less accurate is the GPS pulse. Coupled with the 'canyon effect' where the GPS is shielded from the satellite, the beginning and or ends of many trips were lost. Manual editing was required to correct for these
- The survey covered 7 days for each household, and the advice from the survey designer was that multiple days for each household statistically meant that fewer households would need to be surveyed
- Because there was no interview, mode and journey purpose had to be imputed from the data

These issues placed some limitations on the model specification. These were not necessarily significant, but the data to some extent constrained the options that were available.

With the manual checking, additional trips were often inserted in the dataset. In many cases, this coupled with the GPS start problem, start and/or end times were not known. Accordingly, a 24-hour generation and distribution model had to be built, with a subsequent factoring to the peak periods, rather than calibrating these directly.

Home, work and school locations were known for each person, and therefore home-work, home-education and non-home-based purposes were able to be determined from the trip end location. The trip purposes in the model were constrained to these purposes plus home-other.

Generally, the mode was able to be established from the speed, the pattern of the pulses and the mode of the trip before and after. It was difficult to distinguish between car driver and car passenger in many instances. A specific mode split (logit) model of car occupants was not able to be calibrated, and a simple factoring from known car occupancies was necessary.

Finally, the relatively small number of households surveyed, and the lack of fully responding households within the data meant that the generation model ended up as person trips per person within a household category, rather than person trips per household.

The current MOT surveys are also GPS based but have avoided most of these issues. The GPS data is used only as a memory jogger for the respondents, who fill in an on-line survey which confirms origins, destinations, times, mode and purpose. In other words, it is a combination of traditional survey methodology assisted by GPS, rather than relying solely on the GPS data.

The methodology used in the MOT survey has been summarised by McSaveney (2017) and given the importance of that survey, it is repeated below.

- *Households are sent an introductory letter before interviewers call to recruit those who are present in the household at the time. Once a household is recruited, all household member details are entered online, and the household is assigned seven consecutive travel days. Household members aged 12 and over are given the option of a GPS logger to record their travel, to assist with filling in the online travel diary. The household members who have agreed to participate are asked to recruit other eligible household members (third party recruitment).*

- *The travel diary itself is an online portal using maps. Data is uploaded from the GPS logger continuously and automatically. Whenever the participant logs on, they can edit trips and fill in details of travel.*
- *Text reminders are used for a variety of functions, such as to remind participants to use and charge the device. Reminders are also sent if no motion is recorded for more than a day (checking to see if the person did not travel that day) or if the battery of the GPS unit is low/flat (battery levels are remotely monitored). Notification/reminder levels can be tailored to suit respondent needs, so as to avoid annoying respondents with too many notifications. If no travel coding is detected, the participant is contacted by telephone to remind them to do so, or else the information is collected over the phone and coded by survey staff. A free-phone assistance line is also available to help anyone having issues, or for anyone who is unable/unwilling to complete the survey online.*

Issues that the surveying firm faced, and which contributed to sample loss included:

- household members not agreeing to take part
- respondents pulling out before completing the seven days
- forgetting to take the GPS unit (and the reminder text is too late)
- a tendency for a respondent to say that no travel occurred on a given day. The probability of this occurring increased toward the end of the survey week.

McSaveney concludes:

> *Overall, satisfaction for those who have completed the survey is high. However, the 7 day duration is proving to be a burden/barrier/disincentive to participating in the survey, and using 3rd party recruitment is also not proving as effective as had been hoped. Response rates are lower than the historical survey."*

At the time of writing, work was underway to modify the survey methodology to address these issues. Nevertheless, it seems to be a methodology that combines the best of the survey techniques, although it still requires a self-administered response rather than an interview – even if that response is via a web portal and is prompted by the GPS.

Interestingly, the McSaveney poster did not mention issues such as those found in the Dunedin survey on problems such as the time taken for a GPS unit to 'wake up' after being in snooze mode, the 'canyon' effect where tall buildings cause a loss of signal, and the issues with GPS reception in the southern latitudes.

The fourth bullet point above highlights a methodological problem with the MOT survey. There is no distinction made between a day where a person legitimately did not travel, and the noted tendency for a respondent just to say that no travel had occurred on a particular day as a means of avoiding completing the travel diary. This is a serious defect that needs to be remedied as it influences the data quality and model calibration.

3.5 Historic trip rates

Perhaps the best comparison among the various surveys is to extend table 3.2 from Transportation & Traffic Systems (2000), which sets out daily person trip rates per person to include the recent surveys.

Table 3.2 Daily trip rates per person for each survey

City	Years surveyed					
	Early 1970s	1978	Late 80s and early 90s	2001	Mid 2000s	Post 2010
Auckland	3.32		3.37		3.22	
Hamilton/Waikato		3.66			4.41	
Heretaunga		3.43				
Wellington	3.33		4.65	4.31		
Christchurch	4.58	3.24	5.11		4.63	
Waimakariri				2.83		
Dunedin		3.41	4.79			5.16
NUTS (6 city average)		3.36				
MOT			4.15		2.97	4.07/4.21

These trip rates need to be heavily caveated as they have been influenced by the survey methodology adopted.

The Christchurch (1969) survey was a full interview, but, even so the trip rate looks a little high. There are 12.78 trips per household and 2.79 persons per household, suggesting that trips per person should be 4.58.

In the Wellington (1971) and Auckland (1973) surveys, only motorised modes were recorded. Active modes were not. In the NUTS surveys, walk and cycle were recorded only if they were a direct trip to or from school or work. Note that the NUTS surveys included the four main centres and Hamilton and Heretaunga, all using the same methodology, and all have a very similar trip rate of 3.24 to 3.66 and a mean of 3.36. As noted above the documentation is on a CD that may prove difficult to read.

Some guidance can be taken from the Auckland and Christchurch 2006 surveys. These were undertaken by the same survey company (The Urban Transport Institute) using identical methodology, which involved a self-completed questionnaire. The person trip rates are 4.63 for Christchurch and 3.22 for Auckland. In Christchurch, significant effort was put into correcting the surveys for under-reporting and that has been reflected in the trip rate. In Auckland, the under-reporting correction was made in the model build and was about 38%. If that were to be applied to the Auckland data as opposed to the model, the trip rate would have been around 4.44 – not dissimilar to the other post-2000 surveys.

Incidentally, the NUTS surveys were also probably not corrected for under-reporting. If the Auckland rate is applied to them, they move much closer to the average.

Waimakariri and Dunedin are the outliers. Dunedin can in part be explained by the survey methodology, but the Waimakariri survey report does not indicate anything which would explain the low rate. It was reported later but excluded from the combined survey analyses.

The survey difficulties with Dunedin mean that not a lot of confidence can be placed on the accuracy of the trip rate, although the experience of the model builders suggests it does produce about the right number of trips when model flows are compared with counts during the validation process.

It is apparent that the trip rate recorded is very dependent on methodology. Under-reporting occurs with a self-completed questionnaire, but when corrected[7], there is a very consistent trip rate of 4.2 trips per person with a standard deviation of 0.48. The MOT rolling survey of 2003 to 2014 shows a very low trip rate per household and per person. With that excluded there is very little scatter on trips per person. Trips per household are also close to the average with the two 2006 surveys a little higher.

Table 3.3 Trip rate comparisons

Daily person trip rates for the recent surveys			
Survey	**Date**	**Trips per household**	**Trips per person**
Dunedin	1990	10.20	4.50
Wellington	2001	11.45	4.31
Auckland	2006	13.01	4.44
Christchurch	2006	12.65	4.63
Waikato	2008	11.23	4.20
MOT	2003–2014	9.71	2.97
MOT	2016	10.99	4.07
MOT	2017	11.45	4.21
Average		**11.34**	**4.16**

As an observation, it may be better to spend resource in ensuring the surveys capture all trips, rather than expending considerable effort in correcting for under-reporting later.

3.6 Trip rates by category

There have been six surveys undertaken since 2001 (excluding Waimakariri), and a comparison of person trip rates by household category has been included below. The categories chosen are four car ownership categories by five household size categories, as these are the most common category models in use in New Zealand at present as shown in the Model Stocktake section of this report. That is not to say that this model should always be used – it is merely a mechanism by which to compare the datasets. The results are in tables 3.4 to 3.11 below and are shown graphically in diagrams 3.1 to 3.8 which follow.

The surveys included are:

- Wellington 2001
- Auckland 2006
- Christchurch 2006
- Waikato 2008
- Dunedin 2014
- MOT 2003–2014
- MOT 2016
- MOT 2017

[7] This excludes the NUTS 1978 surveys, Waimakariri 2001 and Dunedin 2014

Table 3.4 Trip rates per person – Wellington 2001

Wellington 2001							
		Persons per household					
		1	2	3	4	5	All
Car availability	0	2.64	3.92	3.39	3.75	3.40	**3.29**
	1	5.00	4.19	3.82	3.97	3.81	**4.16**
	2	5.10	4.88	4.11	4.74	4.13	**4.49**
	3+	4.21	5.12	4.81	4.71	4.46	**4.70**
All		**4.29**	**4.52**	**4.11**	**4.45**	**4.08**	**4.31**

Table 3.5 Trip rates per person – Auckland 2006 (modified for under-reporting)

Auckland 2006							
		Persons per household					
		1	2	3	4	5	All
Car availability	0	3.35	4.18	3.66	2.93	2.94	**3.46**
	1	4.59	4.59	4.07	4.23	3.61	**4.27**
	2	5.13	4.76	4.24	4.55	4.17	**4.47**
	3+	6.94	5.62	4.79	5.00	4.18	**4.71**
All		**4.44**	**4.77**	**4.35**	**4.58**	**4.05**	**4.44**

Table 3.6 Trip rates per person – Christchurch 2006

Christchurch 2006							
		Persons per household					
		1	2	3	4	5	All
Car availability	0	1.88	2.80	3.03	2.88	3.64	**2.53**
	1	4.11	4.50	5.37	4.00	4.48	**4.50**
	2	4.67	4.81	4.66	4.74	4.51	**4.71**
	3+	6.14	3.84	4.91	4.85	6.05	**5.07**
All		**3.63**	**4.48**	**4.91**	**4.63**	**5.09**	**4.63**

Table 3.7 Trip rates per person – Waikato 2006

Waikato 2006							
		Persons per household					
		1	2	3	4	5	All
Car availability	0	2.02	3.24	2.24	3.20	1.41	**2.51**
	1	3.86	3.84	4.90	3.98	3.96	**4.09**
	2	5.10	4.04	4.70	4.77	4.52	**4.49**
	3+	5.15	5.13	4.73	4.85	4.83	**4.89**
All		**3.82**	**4.14**	**4.73**	**4.58**	**4.53**	**4.41**

Table 3.8 Trip rates per person – Dunedin 2014

Dunedin 2006							
		Persons per household					
		1	**2**	**3**	**4**	**5**	**All**
Car availability	0	3.24	2.83	4.61	3.73		**3.57**
	1	3.89	5.23	5.13	5.28	3.39	**4.44**
	2	3.16	4.48	5.47	4.71	6.72	**4.98**
	3+		4.64	4.93	9.68	9.46	**6.94**
All		**3.80**	**4.60**	**5.14**	**6.01**	**5.99**	**5.16**

Table 3.9 Trip rates per person – MOT 2003–2014

MOT 2003–2014							
		Persons per household					
		1	**2**	**3**	**4**	**5**	**All**
Car availability	0	2.00	2.16	2.47	2.32	2.08	2.16
	1	2.99	2.75	2.78	2.81	2.80	2.82
	2	3.51	3.01	3.04	3.13	2.98	3.05
	3+	3.78	3.33	3.10	3.30	3.03	3.18
All		2.85	2.93	2.96	3.09	2.94	2.97

Table 3.10 Trip rates per person – MOT 2016

MOT 2016							
		Persons per household					
		1	**2**	**3**	**4**	**5**	All
Car availability	0	2.41	2.96	2.86	2.18	2.86	**2.62**
	1	4.20	4.11	3.36	3.46	3.28	**3.90**
	2	5.10	4.54	4.02	4.04	3.75	**4.25**
	3+	4.03	5.06	4.19	4.42	3.78	**4.32**
All		**4.06**	**4.40**	**3.83**	**3.96**	**3.65**	**4.07**

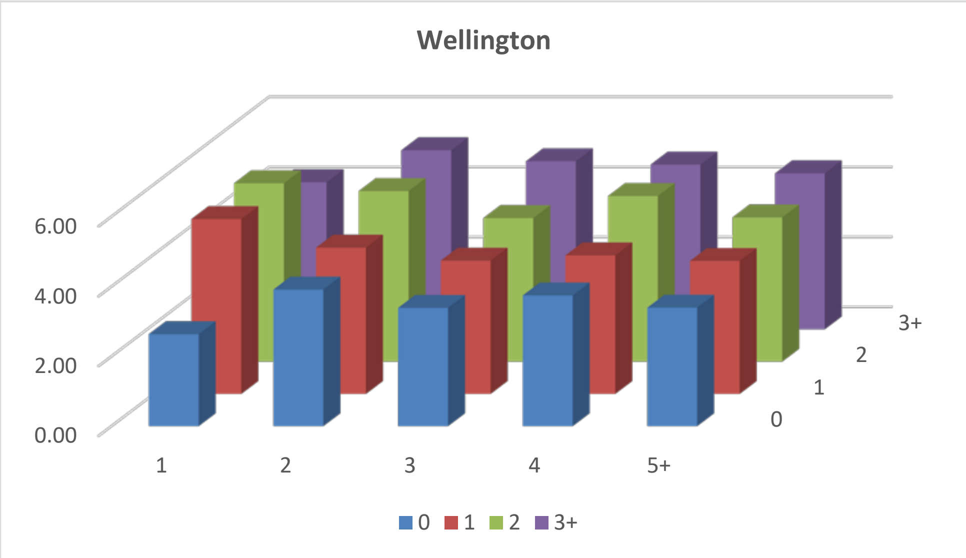
Table 3.11 Trip rates per person – MOT 2017

MOT 2017							
		Persons per household					
		1	**2**	**3**	**4**	**5**	**All**
Car availability	0	3.20	3.20	1.89	3.00	3.62	**3.16**
	1	4.52	4.03	4.02	3.60	3.12	**4.11**
	2	4.96	4.61	4.29	4.49	4.46	**4.52**
	3+	3.70	3.86	3.82	3.09	4.84	**3.98**
All		**4.26**	**4.29**	**4.04**	**4.06**	**4.36**	**4.21**

In the diagrams below, the vertical axis is the number of trips per person, the horizontal axis is the household size and the depth axis is car ownership. Each graph relates to the corresponding table. Note that the vertical scale is not necessarily the same in each diagram.

The important comparison is the pattern shown in each diagram, and it is fair to say that the comparison between surveys at this level of disaggregation shows a degree of inconsistency. In Wellington (2001) there is an increase in trip making with increasing car ownership, and a generally constant trip rate with household size albeit with the odd anomaly.

Figure 3.1 Trips per person by household category – Wellington 2001



The same is true of Auckland and Christchurch (2006) and to some extent Waikato (2008) although in Waikato households with no cars show a fluctuating trip rate with household size.

Figure 3.2 Trips per person by household category – Auckland 2006

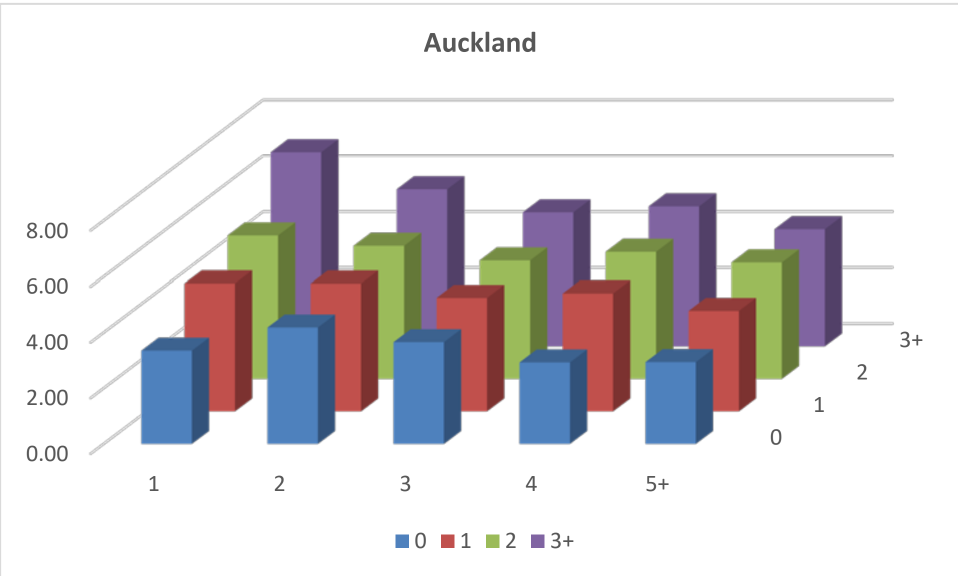


Figure 3.3 Trips per person by household category – Christchurch 2006

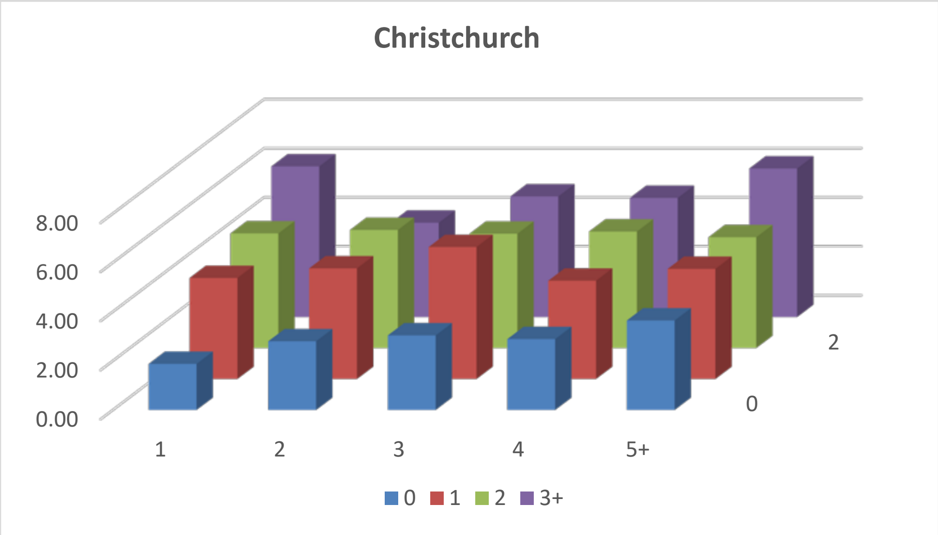


Figure 3.4 Trips per person by household category – Waikato 2008

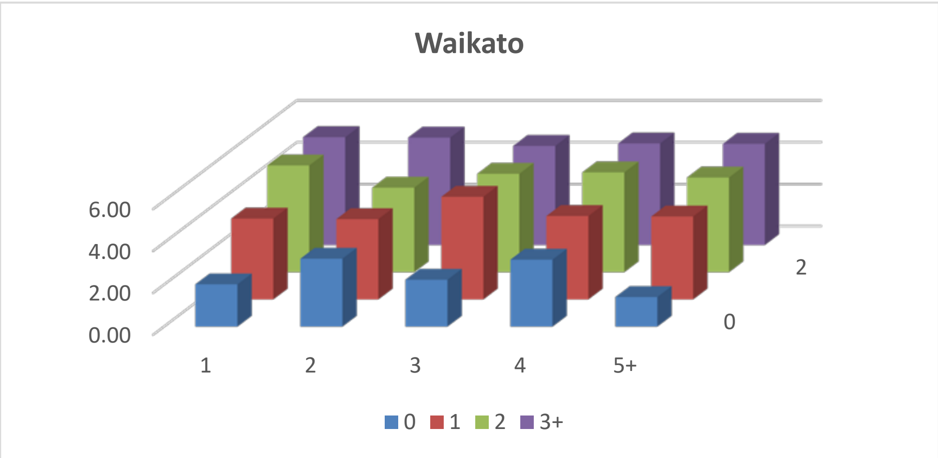
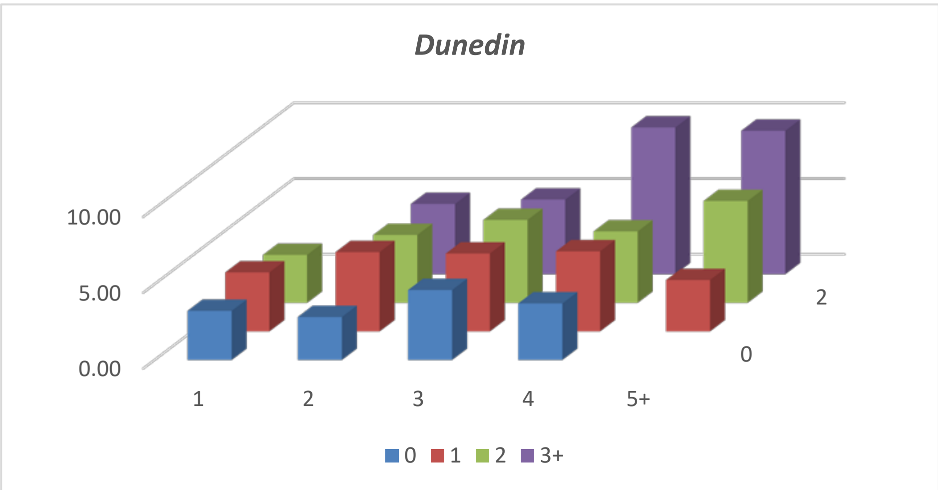
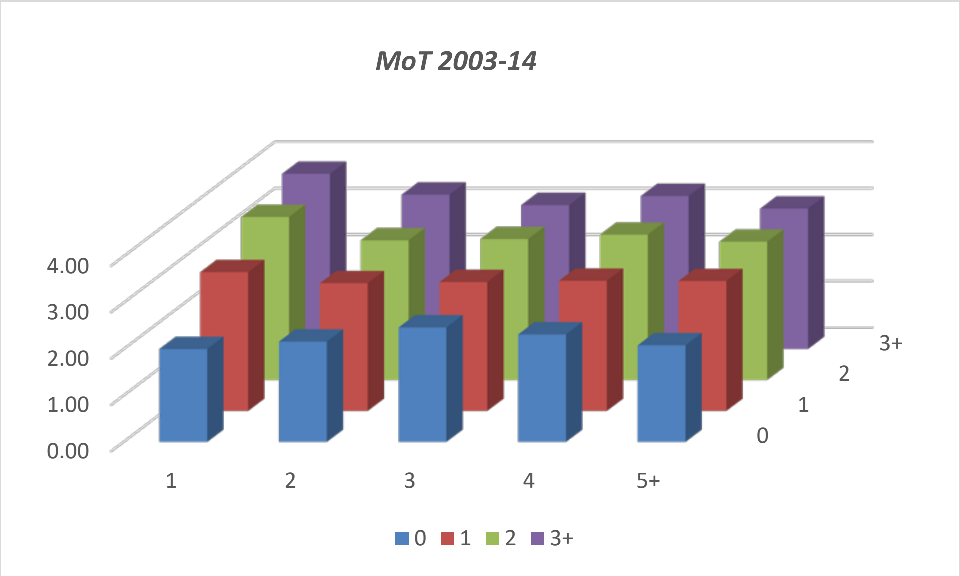


Figure 3.5 Trips per person by household category – Dunedin 2014



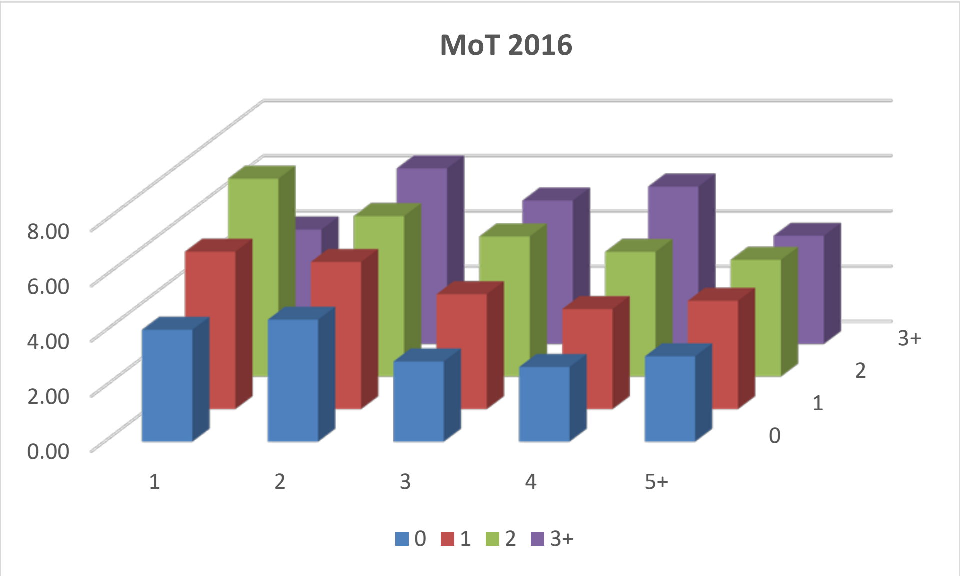
The Dunedin trip rates do not have any distinct pattern and are dominated by large households with three or more cars.

Figure 3.6 Trips per person by household category – MOT 2003–2014



This is a very large sample with all households included over the 11 years of survey – some 24,851 houses. There is very little variation by household size, but some variation with car ownership.

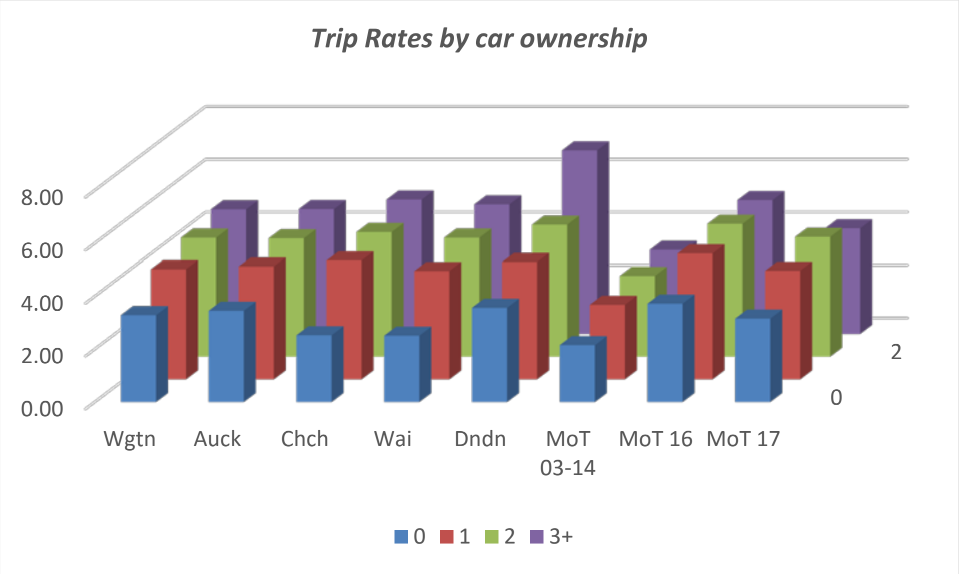
Figure 3.7 Trips per person by household category – MOT 2016



The MOT (2016) data also fluctuates with no clear pattern, but that might be a result of it being a national survey, with a very low sample rate in the first year that may correct as subsequent years' data becomes available.

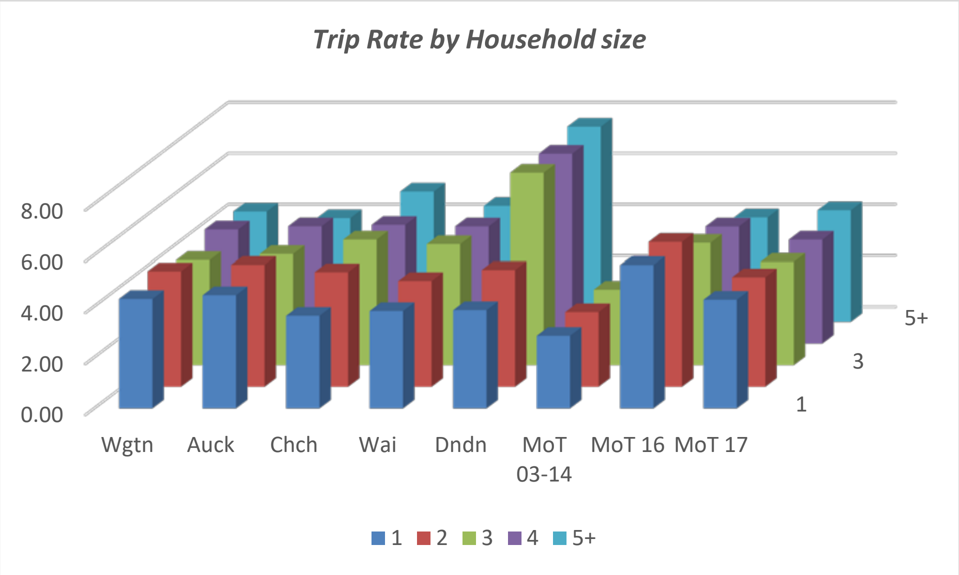
A more definite pattern occurs when the trip rate by household size or car ownership are looked at separately as totals for each survey. Figure 3.8 shows the comparison for trip rates by car ownership category.

Figure 3.8 Trips per person by household car ownership category



The rates are reasonably consistent over the surveys, with the obvious exception of the Dunedin 3+ car ownership category. Trip rates by household size are not as consistent with Dunedin showing a much higher rate for the larger households, and the MOT 03-14, and 16 data showing a decreasing rate by household size which is an opposite trend to the other surveys.

Figure 3.9 Trips per person by household size category



As with car availability, there is a degree of consistency across the surveys with the exception of Dunedin, which is abnormally high in the larger households, and the MOT 2003–2014 series which is significantly lower than the others.

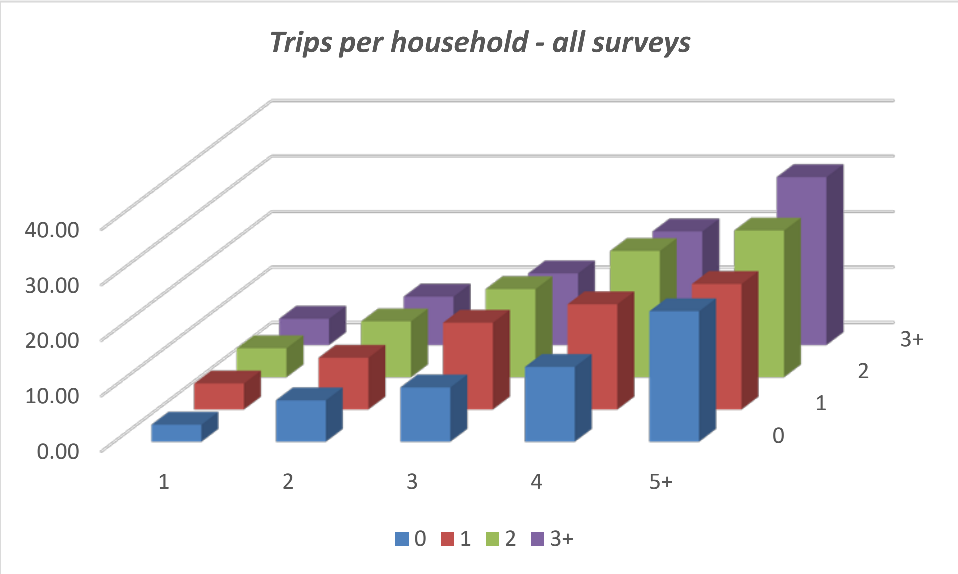
Even so, while these averages are to some extent comparable, there is substantial variation within the trip rate for each category.

To some extent, all the surveys suffer from a low sample size. When the surveys are added together a much more stable pattern can be seen, as shown in table 3.12 and its associated figure 3.10.

Table 3.12 Trips per household from the sum of the surveys

Trips per household – all surveys							
		Persons per household					
		1	**2**	**3**	**4**	**5**	**All**
Car availability	0	3.06	7.46	9.78	13.48	23.52	**4.64**
	1	4.69	9.32	15.65	18.96	22.62	**8.21**
	2	5.23	10.07	15.89	22.76	26.45	**13.76**
	3+	4.73	8.72	12.92	20.47	30.27	**15.54**
All		**4.44**	**9.59**	**14.84**	**21.28**	**26.85**	**10.85**

Figure 3.10 Trips per person by household category – all surveys combined



As expected, trips per household increase with household size, and also with increasing car ownership.

3.6 Trips by age and gender

An analysis of trip rates by age and gender for each of the six surveys has revealed some interesting results. Table 3.13 shows the results of the combined surveys.

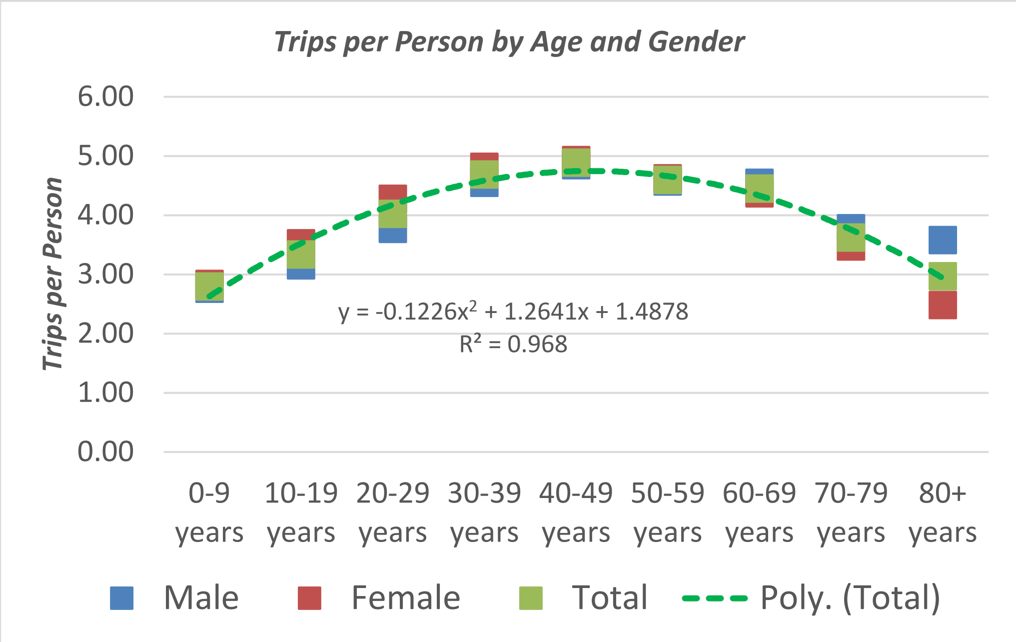
Table 3.13 Person trips rates – all surveys combined

All surveys combined							
	Persons		Trips		Trips/person		
	Male	**Female**	**Male**	**Female**	**Male**	**Female**	**Total**
0–9 years	1,095,029	992,867	3,037,190	2,838,627	2.77	2.86	**2.81**
10–19 years	1,039,416	1,028,251	3,285,555	3,631,159	3.16	3.53	**3.35**
20–24 years	1,051,077	1,051,684	3,975,812	4,522,420	3.78	4.30	**4.04**
25–34 years	1,074,376	1,161,703	4,895,434	5,614,750	4.56	4.83	**4.70**
35–44 years	975,702	1,023,893	4,745,378	5,068,219	4.86	4.95	**4.91**

All surveys combined							
	Persons		Trips		Trips/person		
	Male	Female	Male	Female	Male	Female	Total
45–54 years	972,975	1,004,616	4,451,191	4,652,895	4.57	4.63	**4.60**
55–64 years	763,733	901,913	3,479,324	3,944,805	4.56	4.37	**4.46**
65–74 years	462,068	500,006	1,748,431	1,739,746	3.78	3.48	**3.63**
75+ years	207,790	261,164	745,286	648,364	3.59	2.48	**2.97**
Total	**7,651,040**	**7,936,217**	**30,416,880**	**32,714,760**	**3.98**	**4.12**	**4.05**

When graphed, the results are shown in figure 3.11 below.

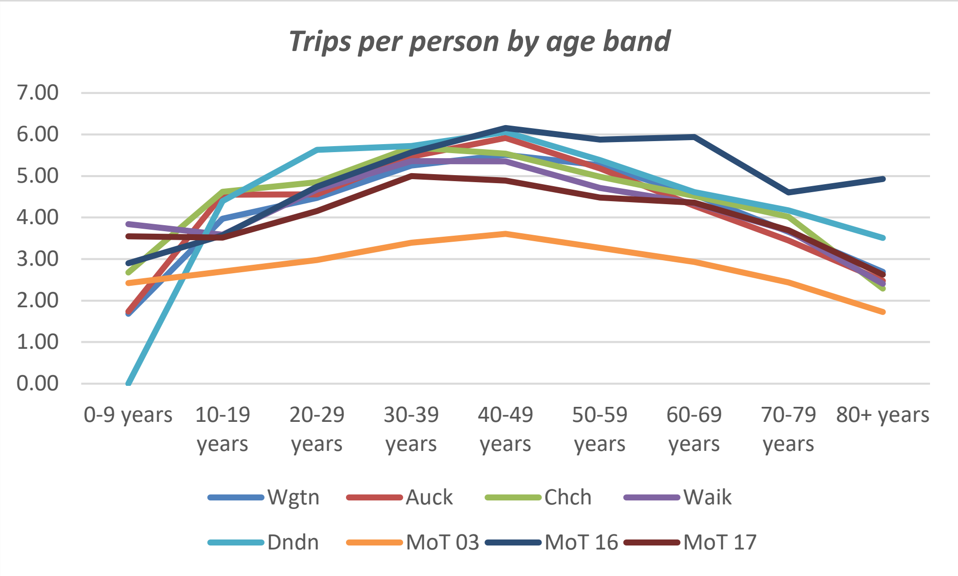
Figure 3.11 Trips per person by age



The trend line for total trips shows a solid relationship of the change in trips per person per day for the different age groups.

The individual surveys show a similar pattern as demonstrated in figure 3.12.

Figure 3.12 Trips per person by age band



There is some variation, but the shapes are similar and there is not a great degree of scatter with the exception of the MOT surveys from 2003 to 2014.

The recent MOT data shows slightly higher trip making in the older age groups, but this could be caused by the fact that no 'zero trip' days have been included in the data. Potentially, older people are more likely to have days when no trips are made.

This is an interesting and potentially significant result for the models. Traditionally, as a legacy from Roading Division of the Ministry of Works, the New Zealand provincial models have used a household category model with household size stratified by car ownership. This result suggests that a person 'age' model may well be a better descriptor. The Christchurch 2006 model used household lifestyle categories which reflects some degree of age stratification, and the Waikato model also used simplified 'life cycle' categories. The trade-off is the potentially increased predictive capability of the models offset by more uncertainty in the ability to predict future year land use by life-style category.

This would appear to be a fruitful avenue of research when building the next generation of models, perhaps with person trip rates by household size and car ownership category stratified by age group.

3.7 Trips by mode

There is a distinct difference in the mode share for Auckland and Wellington compared with the other surveys, with people in cars slightly over 70% compared with 82–85% for the others when trip legs are compared. But as noted earlier, the use of trip legs will overestimate the number of walk trips. In order to make the mode share comparisons across the recent surveys, an approximation has been applied to reduce the number of walk trips by twice the number of PT trips in Wellington, Auckland, Dunedin and for the MOT. This could slightly underestimate the walk proportion but is the only way to get a meaningful comparison of mode share using the data as supplied.

The mode share from the six recent studies (with walk trip legs removed to approximately convert to trips) has been included as table 3.14.

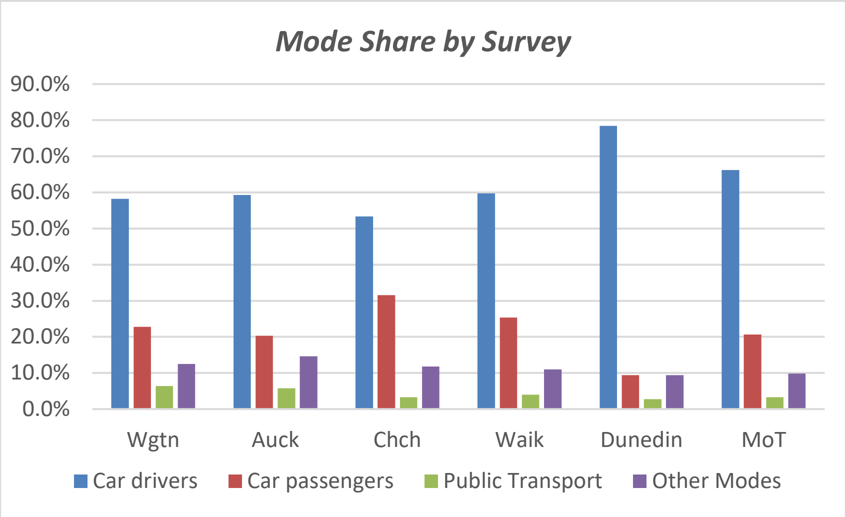
Table 3.14 Proportion of trips by mode

Mode share by city						
	Wellington	**Auckland**	**Christchurch**	**Waikato**	**Dunedin**	**MOT**
Year	**2001**	**2006**	**2006**	**2008**	**2014**	**2016**
Car drivers	58.3%	59.3%	53.4%	59.7%	78.4%	66.2%
Car passengers	22.8%	20.3%	31.6%	25.3%	9.4%	20.7%
-total persons in cars	81.1%	79.6%	84.9%	85.0%	87.8%	86.9%
-car occupancy	1.38	1.34	1.59	1.42	1.12	1.31
Public transport	6.4%	5.8%	3.3%	4.0%	2.7%	3.3%
Other modes	12.5%	14.6%	11.8%	11.0%	9.4%	9.8%

Both Wellington and Auckland have a slightly lower number of people in cars, probably as a result of the higher public transport usage, but even so, there is not a big range across the surveys. Car occupancy in Christchurch is higher than the others, and there, an occupancy correction was one element of the under-reporting adjustment using other local data sources on vehicle occupancy. Dunedin is low, but that is largely because the survey methodology made it difficult to accurately distinguish between car drivers and car passengers.

These proportions are shown graphically in figure 3.13.

Figure 3.13 Mode share by survey



3.8 Conclusions

There are a number of conclusions that can be formed from this analysis in two major groups. The first includes conclusions drawn from the data, and the second includes conclusions on survey methodology and the distribution of data.

3.8.1 Conclusions drawn from the data

There is a degree of consistency in the person trip rates per person across all the surveys, once the idiosyncrasies of each dataset are understood, and due allowances made to correct for these. The most significant of these are the adjustments needed for under-reporting trips, with a lesser but still important conversion of trip legs (or stops) to trips.

This in turn suggests that a generic set of trip generation models could be built from the national data collected by the MOT (subject to some methodological changes being made as discussed below), which would be applicable to other areas.

There is a very strong relationship between trips per person and age band. This has the potential to be an important method of controlling the total generation and is a variable that is readily forecast using cohort survival techniques.

The traditional category model applied in provincial centres in New Zealand of household size against car ownership is a useful means of comparing the datasets but could be extended to better reflect the lifestyle characteristics of people, in conjunction with the age group distributions.

Although it would still be useful to retain a household category model, consideration should be given to using trips per person in each category, rather than the more traditional trips per household. To some extent this is driven by the survey methodology issues discussed below.

3.8.2 Conclusions drawn from the survey methodology

The survey methodology is the most important determinant of data quality. There is a real danger that, in accepting the lowest cost tender from a survey company, the quality of the data is compromised, and so, in turn, is the quality of the models built from that data.

Although it is not necessarily obvious from this report, the ‘best’ data comes from the surveys where every member of the household is subjected to a face-to-face interview.

The issue of under-reporting is significant, and it is apparent that under-reporting is more likely to occur with self-completed questionnaires than when the data is collected from a face-to-face interview.

The advent of GPS units (and now mobile phone technology) has the potential to greatly improve the data quality. However, as experienced in Dunedin’s 2014 survey, total reliance on the GPS data – the cheapest survey method – compromises the data in terms of mode, journey purpose and signal interruption.

The MOT survey is a good combination of the use of GPS as a memory jogger. However, it still relies on a self-administered questionnaire, either online or on paper. It should eradicate the mode and purpose issues and should also remove under-reporting if the route prompting is accurate. The methodology must be changed so that a legitimate zero trip day for a person can be explicitly identified.

It is clear that seven survey days in the MOT survey is an imposition for respondents. For modelling purposes, a one (or sometimes two) survey day has normally been sufficient, but that means the sample size needs to be adequate. Generally, a 1–2% sample or 1,000 households, whichever is larger, is sufficient.

The sample size must be adequate. From the analysis above, the relationships were much more robust when the data from all the surveys was aggregated. The on-going MOT survey should therefore improve markedly as data from additional years is collected.

The MOT survey has defined a ‘responding household’ as one where all members of the household have completed at least one day of survey. If a generation model of trips per household is to be calibrated, this means all members of the household must complete at least one day on the same day. If a trips per person model is to be built, then the MOT acceptance criteria is adequate but the sample selection method may need to be reviewed so that the people are correctly sampled.

4 Stocktake of New Zealand models

4.1 Transport model stocktake

4.1.1 Introduction

The research brief contained a component of work, specified as:

> *The successful Proposer will undertake a model stock-take and parameter audit based on modelling approaches/models/tools used across national, regional and local government for the transport sector. It will cover all ranges of models including econometric, demand and traffic models, as well as special purpose models such as CAM/VFPM/VFEM/MBIE fuel price forecast/GDP forecasts. It will be multi-modal, including cycling. It will identify key variables and assumptions, consistencies and divergences, and suitability for use at different levels of analysis, including short term/long term, operational/infrastructure demand.*

As the project developed, it became clear that the non-transport models would be more difficult to summarise, and accordingly the task was split into two. The first became a stocktake of New Zealand transport models, and the second a stocktake of non-transport models, which would take place later as part of a separate scope. This section deals with the transport models.

The first task was to identify the current transport models in use throughout the country. These included regional models in the five main centres together with the assignment models which use the demands calculated by the regional models, and the somewhat more detailed models of the provincial towns and cities.

In all, the project identified 24 separate models currently active in New Zealand. Some of these have spawned 'project' models – that is models that have been developed for analysis of a specific project, but these were not investigated. The active models have been included in appendix A, with the following information recorded:

- Area: the location of the model.
- Model name: the name or acronym by which the model is known.
- Owner contact: the model owner(s) and the main point of contact.
- Description: a brief description of the model, including whether it is three- or four-step, a summary of the model form and any special features.
- Parent model: if the model takes demands from a higher level (less detailed) model, then which one?
- Child models: if the model informs lower level (more detailed) models, which ones? (These two provide the link to other models in the table.)
- Area covered: a description of the geographic area covered by the model.
- GIS based: is the network derived from a GIS centreline layer?
- NZ Transport Agency (Transport Agency) model category: which of these does the model fit into?
- Base year: the latest year the model was updated to.
- Future years: what future year land use and networks are available?
- Software platform: what software platform is the model built on?

- Modeller contact: who is technically responsible for the model?
- Peer reviewed: has the model been peer reviewed and, if so, by whom?
- Base year households, retail jobs and total jobs: these are the key land use activity variables that give a feel for the 'size' of the model.
- Precision index: this is an index taken from Foster (1994) that provides a measure of the average amount of activity in each zone. It has been used here only to provide a quick comparison between the models. Foster's definitions are:

  Three general levels of precision arise as a consequence of the detail to which delays are calculated at intersections.

  Level 1 – The traditional level of precision, whereby network supply functions occur on the links or partly on the links and at the intersection as a whole.

  Level 2 – Intersection delays are calculated on each approach to the intersection.

  Level 3 – When delays occurring in the network are calculated lane by lane on the links and according to each turn on each approach to the intersections.

  Accuracy increases with greater precision from about + or - half a lane capacity at Level 1, through 100–150 vph for Level 2, to 30–50 vph by turns for Level 3.

  The activity levels are based on a formula of:

  Households + 3 x retail jobs + 1.2 x non-retail jobs

Foster recommends the level 1 index at 1,000, level 2 at 400 and level 3 at 250.

- Base year zones, links and nodes: these provide an indication of the detail to which the network has been coded when expressed as links per zone and links per node.

4.2 Summary of models

There are essentially three different styles of model in New Zealand. These include:

- Strategic models in Auckland and Wellington where the precision level is well above Foster's recommendation of 1,000 for a strategic model without intersections specifically modelled.
- Project models that have been built sitting under the strategic models. These have been built because the strategic models lacked the detail necessary for confident scheme evaluation. This group includes the separate public transport models in Auckland and Wellington, but these are also coarser than that recommended by Foster.
- Provincial centre models, including Waikato, Christchurch and Dunedin, and every significant urban area in the country except for Wanganui and New Plymouth. With the exception of Tauranga and Christchurch, these models all have precision levels finer than that recommended by Foster for intersections modelled at the turn movement level. Christchurch also has the CAST model sitting under the CTM which performs a similar function to the project models in other cities.

All the models categorised as Transport Agency model type C – urban traffic assignment models have precision levels below 250. Having said that the Transport Agency category description is not particularly useful as all these models are three- or four-step models.

There is a degree of consistency in all models when the number of links per node is compared. The average is 2.36, but the range is 1.7 for CAST, to 2.65 for Christchurch. This is not surprising as most intersections have three or four legs, and there are often intermediate nodes that only have two links.

There is much more variation in the number of links per zone. The average is just over 15, with Rotorua having seven links per zone, Auckland 33 and Wellington 66. This suggests that Rotorua might have too many zones for the network, but Auckland and Wellington could benefit from a much finer zoning system, without significantly changing the detail included in the network.

Some 60% of the models have links per zone between 10 and 20. One inference is that the mean figure of 15 would be a good standard to target when setting up a new model.

5 Model calibration demonstration

5.1 Introduction

The research brief contained a component of work, specified as:

> *Based on the results of the HTS review and the data analysis, the successful Proposer will develop a conceptual approach to uplifting and analysing HTS data for multiple geographic areas (together or independently) for transport demand modelling. We expect the successful Proposer to demonstrate in detail how a semi-standardised next generation transport model could be built from the data, but not to actually build or calibrate the model itself.*

At the outset, it was expected that the demonstration of calibration could be undertaken using the MOT 2016 dataset, as this data and that of subsequent years is intended to be the primary source of household travel data from which the next generation of models will be built.

In the event, as described in the section of this report on historic data, the MOT 2016 data has two deficiencies. The first is that legitimate zero trip making days cannot be identified in the data. The second is that the sample size in 2016 is too small for a calibration to be carried out that has any statistical significance.

Rather than numerically demonstrate that a calibration could not be undertaken, this section of the report describes the calibration process for a typical four-step model form, details the data that would be needed to achieve this, and confirms whether or not the MOT dataset contains data adequate to the task.

5.2 The four-step model

The four-step trip-based model has been the mainstay of transport modelling in New Zealand since the first model was built in 1959. To our knowledge, no different model form has been used in a serious study in this country.

Although tour-based models could be used in the future, a HTS that meets the requirements for calibrating a four-step model will contain sufficient data to calibrate this model form. Accordingly, this chapter concentrates on the data needed to calibrate a four-step model.

For completeness the following is a summary of the four-step model. As the name suggests, it includes the four sequential processes of:

- trip end generation – the calculation of person trip ends by zone and purpose, either for 24 hours or for each time period
- distribution – conversion of person trip ends into person trip matrices by purpose by means of some function of the spatial separation of zones
- mode split – conversion of the person trip matrices into matrices for each mode
- assignment – allocation of the trip matrices by mode to the road and public transport networks.

The distribution and mode split steps rely on zone-to-zone costs.

HTS are used in the first three steps. The process and data requirements are detailed in the following sections.

5.3 Trip-end generation

Trip-end generation has two components, namely equations that calculate trip productions (trip origins) and equations that calculate trip attractions (trip destinations).

5.3.1 The trip production models

In New Zealand, most trip production models have been built using a household category model with the household type as one axis of the table and car availability as the other. Many of the so-called provincial models used household size (1, 2, 3, 4 and 5+ people) cross classified by car availability (0, 1, 2 and 3+ cars), yielding a 5x4 cross tabulation of 20 categories.

Perhaps the first question to ask is whether the data would have been sufficient to build the five most recent models used in New Zealand.

The Dunedin model has adopted the simple 5x4 category model as this project is largely a recalibration of the model first built in 1992.

The Christchurch model went a little further than the simple category model with eight household categories based on family type:

- single occupant working
- single occupant retired
- couple working
- couple retired
- solo parent
- nuclear family
- multi family
- non-family.

These were cross classified by four vehicle availability categories.

The Waikato model built on the Christchurch model, initially proposing 18 categories of household size by lifecycle status. Many of these were sparsely populated and it was reduced to 10 categories.

- one adult working
- one adult not working
- two adults both working
- two adults one working
- two adults not working
- three+ adults
- one adult with children
- multi parent with older children
- multi parent with young children
- multi parent with both.

These were also cross classified by four vehicle availability categories.

The Wellington model has a complex production component, with a different model form for each purpose. It is not appropriate to detail it here, but the variables that it needs for people are:

- work arrangement – fixed or flexible hours, rostered shifts or work from home
- employment type – paid employee, self-employed (employs others or not), family business, retired
- person ages.

For households, the Wellington model includes car availability (four categories), and 1, 2, 3+ adults, and the number of adults employed, a total of 73 categories.

The Auckland model used a number of segmentations, including:

- people by age (<5 years, 5–10 years, 11–17 years, workers and non-workers aged 26 or under, workers and non-workers aged over 26, and retired)
- employment type similar to that used in Wellington
- household category (number of adults working or not working), and by three car availability categories.

The MOT data as it stands would enable any of these production models to be calibrated.

5.3.2 The trip attraction models

Without exception the New Zealand models have calculated the attraction equations by multiple linear regression using trip attractions from the HTS data against land use activity data derived from the census. There have been variations on how these were calibrated and applied (different purposes, different equations calibrated for parts of the city for example), but the MOT HTS data would enable any of these to be calibrated.

5.4 Trip distribution and mode split

Because of the interaction between distribution and mode split, these two components need to be considered together, particularly if a simultaneous distribution and mode split model form is adopted.

The New Zealand models generally fall into two groups, those which were built as three-step models – that is car driver only, and those which were built as four-step models with the mode split step included.

For distribution, the three-step models generally adopted a gravity formulation which requires calibration of a distribution function of the cost of travel between zones. That process requires an observed trip matrix derived from the HTS data, and zone-to-zone travel costs derived from the model.

A point to note is that while the MOT data contains information on whether a parking fee was paid, and who paid it, it does not ask what the parking charge was.

The MOT HTS contains sufficient data to derive the observed matrices although the trip origin and destinations addresses will need to be geocoded to the model zone system. Latitudes and longitudes have been provided which will enable this to occur.

If the mode split step is included, then this has normally been applied using a logit model, whether that is pre-distribution, post distribution, or simultaneous. Again, the role of the HTS is to provide observed trip matrices by mode, and the MOT data will support this.

5.5 Tour and activity-based model forms

In the United States, activity-based models (ABM) are becoming more popular, although they can take about four times as long to build as a conventional four-step trip-based model. To date, there has not been an attempt to build one in New Zealand. They are designed to overcome some of the recognised problems of trip-based models. *Inter alia* these include:

- the need to aggregate trip ends into zones
- intrazonal trips not getting assigned to the network
- trip and mode decisions being treated as individual events and the effects of other related activity decisions not being considered
- the difficulty of modelling time of day and peak spreading decisions
- the static nature of the models.

A partial step from trip based conventional models to ABMs is the tour-based model, where the unit of travel is defined as the 'tour' or 'chain of trips', normally starting at home and including all component trips until the traveller is back home again. Tour based models typically take longer to build than conventional models but less time than an ABM.

It is beyond the scope of this project to attempt to develop a tour based or an ABM. However, it is sufficient to note that the data required to build them is similar to that required for the conventional mode, although ABMs require more detail, particularly for the population synthesizer. As long as every trip in a chain is captured in the data – which is the case with the MOT data – then these more recent model forms will be able to be built.

5.6 Conclusion

The MOT data would enable any of the distribution and mode split model forms used in New Zealand to be calibrated. If the GPS traces are made available, then there is the possibility that the route choice component can be better calibrated. The one caveat is that the sample size in the area of the local model must be sufficient for the model builder to have confidence on the observed matrices that are extracted from the data.

6 A hierarchy of models

6.1 Scope

The research brief contained a component of work, specified as:

> *The successful Proposer will examine the relationships and hierarchy of transport analysis tools. This will examine the strategic value in linking model inputs and outputs to answer national/regional/local policy questions. As a starting point, it will examine how the next generation of models could interact with each other, especially given a basis of common datasets and estimation approaches. It will look at top down vs bottom up approaches, including the possibility of increased benefits through linking clusters of associated transport models. It will also look at the impacts of frequency of update of underlying data sources and the possibilities of more real time data as technologies and data sources change.*

To some extent, this task for the project came about because of the current practice in the three main centres of Auckland, Wellington, and Christchurch of utilising detailed project models beneath the regional strategic models in each centre, and a potential concern over the implementation of these.

NZ Transport Agency (2014) modelling guidelines incorporate definitions of model categories which could also be considered to be hierarchical, and these are repeated below.

Model type A: Regional transport model (3, 4 or more stage or activity based) Regional models include representation of land-use activities, demographics etc. They are commonly developed to assess the strategic impacts of land-use changes, larger scale transport and public transport projects, and the effects of policy changes on wider regions	**Model type B:** Strategic network traffic assignment model A strategic network assignment model is likely to be focused on strategic links such as motorway corridors, the state highway, and/or the arterial route network across a wider geographic area. These models are commonly used to assess major transport infrastructure changes, eg large-scale motorway schemes, bridges.
Model type C: Urban area traffic assignment model An urban area model is likely to be focused on the representation of urban conurbations, city centres and other urban style environments. These models potentially have a wider range of applications which may include local authority planning, development strategy, urban traffic management and road schemes, infrastructure and policy change assessments, ITS etc.	**Model type D:** Transport Agency scheme/project model (within area of influence/focus) A model of any form and scale applied to a Transport Agency project evaluation. Where larger, eg regional, models are applied to a scheme within sub-region of the model, criteria/target levels in this guide relate to the area of influence/area of focus of the assessment. This category, and associated guidance, could be applied to any road controlling authority scheme/ project at their discretion.
Model type E: Small area with limited route choice/ corridor traffic model A small area model may represent an urban area with limited route choice, commuter corridors, smaller towns, and rural areas. These models may be used to test similar applications to larger urban area models but are likely to be focused more on traffic management testing than transport planning.	**Model type F:** Single intersection/short corridor traffic model Intersection or short corridor (around 3 intersections) models are commonly used to assess the performance of movements and approaches at intersections under different design layouts and/or traffic conditions (growth, development scenarios etc).
Model type G: Special case high-flow/high-speed/ multi-lane corridors	

Traffic models of high-flow, high-speed, and/or multi-lane corridors such as motorways may require special treatment, eg detailed data collection and higher levels of calibration and validation. These models may be used to test detailed motorway design, ITS, incident management, lane management, the effects of 'soft' policies etc.	

6.2 Current model forms

The model stocktake component of the project identified four basic model forms.

- The coarse strategic models (Fosters level 1 or coarser) of Auckland (ART) and Wellington (WTSM) – both with model precision indices larger than 2,000, and Christchurch (CTM) with an index of 893.
- There are three models at precision level 2 – Tauranga, Palmerston North and Heretaunga. They are all three-step models (Heretaunga is a partial four-step) that calculate their own demands.
- There are a number of models at precision level 3 or finer that are land use driven – Waikato, Dunedin, Nelson, Queenstown, Invercargill, Timaru, Upper Hutt, Whakatane, Napier, Rotorua, Whangarei and Taupo. These are all 'stand-alone' three- or four-step models, which calculate their own demands.
- Finally, there is a group of assignment models (generally using SATURN), which receive demands from the Auckland, Wellington or Christchurch level 1 models. Details have not been obtained for most of these, but as an example, the Christchurch CAST model has three times as many zones as the CTM model and four to five times as many links and nodes. These are generally 'project models,' that is models built for specific analysis of a particular project.

Effectively, there is the beginning of a hierarchy of models in the three main centres – with two levels, while the smaller centres only have a single level.

The Auckland, Wellington and Christchurch models have been forced to have more detailed assignment models under them because they have been built to a precision level that is far too coarse for the analysis the models have been asked to perform. Both Wellington and Auckland have models that do not include intersection delays except at a rudimentary level, which is appropriate for coarse models, but the questions being asked of them demand a more detailed assignment.

In contrast to Auckland and Wellington, where the assignment models cover areas smaller than the strategic model, the Christchurch CAST model covers the same area as the parent. Currently, only the central area is included as a simulation assignment, but there are plans to extend the simulation to the whole model area. As an observation, one wonders why.

In contrast, the Waikato model has 2,500 zones (precision index of 247) covering the whole of the Waikato region, with intersection modelling already included at the movement level. There appears to be no particular reason why future updates of the other three large area models should not follow a similar direction, provided that the household interview sample size is sufficient.

6.3 A theoretical hierarchy

So why should there be a hierarchy of models, and what are the essential characteristics of them? In the discussion above, a hierarchy was needed because the higher-level model was not appropriately specified for the analysis required of it and smaller area project models were built deriving demands from the parent model, but with no feedback of delays.

However, that is not the only way in which a hierarchy can be considered. Models can be considered in terms of function as:

- Strategic: Land use driven models of large areas with little or no detail of the road network beyond the arterial roads. This is the type of model that was built in the mid-1900s when the world was concerned with building motorways and the decisions revolved around how many lanes should be provided.
- Tactical: The most common model form used in the modern world. Land use driven three- or four-step models, with a very good representation of the road network, including intersection delays being calculated at the movement level. Good forecasting ability. Used for detailed urban planning, alternative intersection treatments, public transport modelling and parking analyses.
- Operational: Generally smaller area networks with no synthetic forecasting ability that perform the assignment step only. Demands can be surveyed or retrieved from a higher-level model and matrix estimated to better match existing flows. Suited to analysis of changed operating conditions where little or no induced demands or mode changes are expected. Forecasting relies on input from higher level models or first principles assessments.
- Design: The highest level of detail with very small networks and/or a standalone intersection. Used to establish design considerations, such as lane configurations, cycle times and phasing at signals, testing alternative controls. No forecasting ability.

Models need to have an equilibrium between supply and demand and that equilibrium needs to exist at each level of the hierarchy. Theoretically each of these models can pass demand to the next level down and each level can pass delays back, but in practice that is not so easy, and, in New Zealand at least, is seldom (if ever) done.

Experience has taught that the level of detail in a model should be consistent over the whole. An example of the effects that inconsistency causes occurred in an early model of Hamilton where junction delays were introduced into the model for the first time in 1981. The model builders mistakenly thought that only the central area of Hamilton needed to be coded. In the first run, because delays were higher with the junction delays, all through traffic avoided the central area completely, and the distribution was biased away from that area. Including junction delays in the full model fixed the problem.

7 Transport modelling resource in New Zealand

7.1 Introduction

The research brief asked for a review of the 'capability, resourcing and budget issues' associated with the profession, and how they relate to the options that emerge from this research. Initially the intention was to survey central and local government, and consultants, but that was modified to exclude consultants on the basis that the information could be commercially sensitive.

Of the 72 local authorities in New Zealand, 26 of the most populated were selected to take part in the survey. In addition, the seven regional councils were approached, as were four government departments (Transport Agency, MOT, Ministry of Business, Innovation and Employment and Treasury), the Auckland Forecasting Centre (AFC) and Auckland and Canterbury Universities. Auckland City was not surveyed because the modelling capability resides in AFC.

The survey asked for capability in three areas:

- whether the organisation prepared business cases
- whether the organisation undertook strategic planning studies
- whether the organisation managed road networks.

In each case the respondents were asked whether they had in-house expertise, and if not whether they wanted to have it. They were also asked whether they had the capability to manage consultants or whether they had to rely on external expertise for that role.

As well as those questions, they were asked for the number of personnel that had different levels of experience in seven areas, namely:

- intersection models
- microsimulation models
- assignment models
- strategic three- and four-step models
- database analysis
- programming skills
- GIS analytics

The survey form is included as appendix B.

7.2 The response

Two regional councils responded, as did MOT, the Transport Agency and AFC. Only 11 of the 26 councils replied.

Of the 16 responses, all but one confirmed they prepared business cases, but half did not have in-house expertise. Only two indicated they would like to have the expertise in-house.

All but two said they had the ability in house to manage consultants and these two used external agents to manage the business case consultants.

All but one council undertook strategic planning studies, but eight of the remaining 15 did not have in-house expertise, with three saying they would like to have it. Two said they did not have the ability to manage consultants, and both of these used external agents.

All the territorial councils and the Transport Agency manage road networks, but over half did not have in-house expertise. Three indicated they would like to have it. Two did not have the ability to manage consultants, but both of these used external agents.

From this part of the survey, respondents are comfortable with the resource available – either in-house or from consultants, with only two wishing to have in-house expertise that they currently do not have, and it was the same two for each of the three questions.

The number of personnel involved in modelling and data analytics was quite surprising. Table 7.1 summarises the results. Note that three councils did not provide numbers so these are from a sample of 12 organisations.

Table 7.1 Summary of personnel by skill

Summary of skilled personnel				
	Some knowledge	**Basic experience**	**Advanced experience**	**Total**
Intersection models (eg SIDRA, LINSIG, TRANSYT)	7	8	24	**39**
Microsimulation traffic models (eg Paramics, Aimsun, Vissim)	10	7	12	**29**
Other assignment models, such as strategic or mesoscopic (eg SATURN, Aimsun)	8	4	13	**25**
Demand models, such as 3-step/stage or 4-step/stage (eg EMME, Tracks, CUBE, VISUM)	10	11	11	**32**
Database (eg SQL, MS Access) or advanced Excel	23	30	42	**95**
Programming (eg Python, C++, Fortran)	17	13	22	**52**
GIS analytics	11	21	40	**72**

The numbers can only be summed across the columns as some individuals have more than one skill. It would appear that the respondents are reasonably well served with analytical staff, with all having some skill in database and GIS analytics. However, very few councils apart from the regional councils have any modelling skills, and more particularly in the demand model area. Virtually all of the programming skills lie with central government or AFC.

With such a small sample it is difficult to form any firm conclusions, but it would seem to confirm the view that there is a shortage of experienced transport modellers within the public sector.

8 Conclusions

8.1 Summary of conclusions

8.1.1 Chapter 3 – Comparison of trip making

There is a degree of consistency in the trip rates per person across all the surveys, once the idiosyncrasies of each dataset are understood, and due allowances made to correct for these. The most significant of these are the adjustments needed for under-reporting trips, with a lesser but still important conversion of trip legs (or stops) to trips.

This in turn suggests that a generic set of trip generation models could be built from the national data collected by the MOT (subject to some methodological changes being made as discussed below), which would be applicable to other areas.

There is a very strong relationship between trips per person and age band. This has the potential to be an important method for controlling the total generation and is a variable that is readily forecast using cohort survival techniques.

The traditional category model applied in provincial centres in New Zealand of household size against car ownership is a useful means of comparing the datasets but could be extended to better reflect the lifestyle characteristics of people, in conjunction with the age group distributions.

Although it would still be useful to retain a household category model, consideration should be given to using trips per person in each category, rather than the more traditional trips per household. To some extent this is driven by the survey methodology issues discussed below.

The survey methodology is the most important determinant of data quality. There is a real danger that, in accepting the lowest cost tender from a survey company, the quality of the data is compromised, and so, in turn, is the quality of the models built from that data.

Although it is not necessarily obvious from this report, the 'best' data comes from the surveys where every member of the household is subjected to a face-to-face interview.

The issue of under-reporting is significant, and it is apparent that under-reporting is more likely to occur with self-completed questionnaires than when the data is collected from a face-to-face interview.

The advent of GPS units (and now mobile phone technology) has the potential to greatly improve the data quality. However, as experienced in Dunedin's 2014 survey, total reliance on the GPS data – the cheapest survey method – compromises the data in terms of mode, journey purpose and signal interruption.

The MOT survey is a good combination of the use of GPS as a memory jogger. However, it still relies on a self-administered questionnaire, either online or on paper. It should eradicate the mode and purpose issues and should also remove under-reporting if the route prompting is accurate. The methodology must be changed so that a legitimate zero trip day for a person can be explicitly identified.

It is clear that seven survey days in the MOT survey is an imposition for respondents. For modelling purposes, a one (or sometimes two) survey day has normally been sufficient, but that means the sample size needs to be adequate. Generally, a 1–2% sample or 1,000 households, whichever is larger, is sufficient.

The sample size must be adequate. From the analysis above, the relationships were much more robust when the data from all the surveys was aggregated. The on-going MOT survey should therefore improve markedly as data from additional years is collected.

The MOT survey has defined a 'responding household' as one where all members of the household have completed at least one day of survey. If a generation model of trips per household is to be calibrated, this means all members of the household must complete at least one day on the same day. If a trips per person model is to be built, then the MOT acceptance criteria is adequate, but the sample selection method may need to be reviewed so that the people are correctly sampled.

8.1.2 Chapter 4 – Model stocktake

There are essentially three different styles of model in New Zealand. These include:

- Strategic models in Auckland and Wellington where the precision level is well above Foster's recommendation of 1,000 for a strategic model without intersections specifically modelled.
- Project models that have been built sitting under the strategic models. These have been built because the strategic models lacked the detail necessary for confident scheme evaluation. This group includes the separate public transport models in Auckland and Wellington, but these are also coarser than that recommended by Foster.
- Provincial centre models, including Waikato, Christchurch and Dunedin, and every significant urban area in the country except for Wanganui and New Plymouth. With the exception of Tauranga and Christchurch, these models all have precision levels finer than that recommended by Foster for intersections modelled at the turn movement level. Christchurch also has the CAST model sitting under the CTM which performs a similar function to the project models in other cities.

All the models categorised as Transport Agency model type C – urban traffic assignment models have precision levels below 250. Having said that the Transport Agency category description is not particularly useful as all these models are three- or four-step models.

There is a degree of consistency in all models when the number of links per node is compared. The average is 2.36, but the range is 1.7 for CAST, to 2.65 for Christchurch. This is not surprising as most intersections have three or four legs, and there are often intermediate nodes that only have two links.

There is much more variation in the number of links per zone. The average is just over 15, with Rotorua having seven links per zone, Auckland 33 and Wellington 66. This suggests that Rotorua might have too many zones for the network, but Auckland and Wellington could benefit from a much finer zoning system, without significantly changing the detail included in the network.

Some 60% of the models have links per zone between 10 and 20. One inference is that the mean figure of 15 would be a good standard to target when setting up a new model.

8.1.3 Chapter 5 – Model calibration

The MOT data would enable any of the distribution and mode split model forms used in New Zealand to be calibrated. If the GPS traces are made available, there is the possibility that the route choice component can be better calibrated. The one caveat is that the sample size in the area of the local model must be sufficient for the model builder to have confidence in the observed matrices that are extracted from the data.

8.2 Concluding comments

The project was initially intended to test whether the household travel data being collected by MOT would be sufficient to build the current set of New Zealand models, and that in turn required a stocktake of the current models, and a test as to whether models could be calibrated.

The review of the first year's data threw up a number of recommendations. All were acted upon by the MOT survey contractor, and the subsequent data is considerably more robust. In time, the year 14 data could be dropped from the sample. Along with the model stocktake, and the model calibration test, the project has achieved that objective.

The second primary objective was to compare trip-making characteristics across different cities and different years. That was achieved, but there were issues with data definitions, and the problem of trips vs trip legs that resulted in a recommendation for further work to be done on these comparisons.

However, the analysis did show a promising relationship between trip making and age that might be useful as a 'control' on total trip making.

Initially, the project sought to identify the transport modelling resource in New Zealand but given that much of that resource resides within consultancies, commercial considerations meant that this was modified to include only the public sector. The survey response was not particularly good and the results therefore are somewhat limited.

9 Recommendations for future research

During the course of this project a number of ideas for further research were identified. These are discussed below.

9.1 Further analysis of the Household Travel Survey data

9.1.1 Trips and legs

In chapter 3 a distinction is made between trips and trip legs with some of the data presented as trips, and some as trip legs. It was beyond the scope of this project to undertake the conversion of trip legs to trips, but the comparison between cities would be more rigorous if that were done.

9.1.2 Trip rates by age, purpose and mode

Chapter 3 reports a relationship between trip making and age that should be explored further with an extension into trip purpose and mode, even if the purposes must be aggregated to achieve a common definition.

9.1.3 Attraction formulae

This project only looked at the trip generation component of the data. It would be useful to investigate the development of attraction formulae between cities to see whether there is any commonality with that aspect.

The combination of the above two analyses could lead to the development of a generic model that could be applicable to many New Zealand cities.

9.1.4 Distribution and mode split

When more data is available from the MOT surveys, it would be useful to attempt to calibrate distribution and mode choice models from it, and compare the effectiveness of various model forms, for example gravity vs logit models for distribution.

9.1.5 Further statistical analysis

This project has limited statistical analysis to means and standard deviations. This analysis should be extended to include Skewness and Kurtosis (peakiness). The analysis so far suggests that the data follows a gamma distribution, is positively skewed, and highly peaked, but this should be confirmed, and the implications explained.

9.2 Processing tools

All the data sets have different variables and are in different formats. For the purposes of this project, custom-built software was written to extract the tables and undertake the statistical analysis. That software should be documented and made available to any researcher wanting to further investigate the data. At present, there are different programs for each data set, but these could be relatively easily combined into one program, including a generic table builder.

9.3 Comparison with Australian data

Most major cities in Australia have HTSs, with the Sydney survey continuous since 1997. Both Canberra and Perth have recent surveys, and the other state capitals have surveys undertaken within the last 10 years. It would be interesting to bring this data into the same comparisons as reported in chapter 3.

9.4 Long section analyses

The Sydney and MOT data are annual surveys that are amenable to analysis over time, with which to check the trip rate stability assumptions inherent in the models. A set of standard variables should be developed that can be investigated as each year's data is available.

9.5 Routing investigations

The GPS data has details of the routes drivers have taken. This should be combined with the assignment algorithms in the major software packages to confirm that the routing parameters in the assignment models are appropriate, or to calibrate new ones.

9.6 Tour-based models

As tour-based models are a part-way step toward ABMs, a demonstration tour-based model could be built, perhaps using Tauranga as the test bed as it supplemented the MOT data in that area in 2018.

9.7 Departure time choice

Incorporation of departure time choice will help to introduce peak spreading in current models. However, we need to understand the responses of travellers to congestion and crowding: whether they will first try to change mode or to depart at a different time.

10 References

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Appendix A: Model stocktake inventory

Area	Model name	Owner contact	Description	Parent model	Child models	Extent	GIS base	Transport Agency model category	Base year	Future years	Software platform	Modeller contact	Website	Peer reviewed	Base year			Precision index	Zones	Links	Nodes	Links zones	Links nodes
															Household	Retail jobs	Total jobs						
Whangarei	–	Whangarei District Council Jeff Devine	Three-step car driver model. Three periods. 5x2x4 category model calibrated from Waikato data. Separate heavy vehicle model ex Christchurch, gravity distribution, incremental assignment with intersection modelling	No	No	Whangarei District Local Government area	Yes	Model type C: Urban area traffic assignment model	2013	2023, 2033, 2043	Tracks	David Hunter (TDG)	N/a	No	29,770	3,238	27,066	68	999	8,471	3,877	8	2.18
Waikato	WRTM	LASS – Dawn Ingles Transport Agency	Four-step model for the am peak and interpeak. Three-step evening peak model. 5x2x4 household category model calibrated from Waikato HTS data (2008). Separate heavy vehicle model ex Christchurch, gravity distribution, logit mode split model, incremental assignment with intersection modelling	No	Rotorua and Taupo	Waikato Regional Council area, including Tauranga and Rotorua from Bay of Plenty	Yes	Model type C: Urban area traffic assignment model	2013	To come	Tracks	Julie Ballantyne (TDG)		Yes – Ian Clark	247,051	27,850	266,471	247	2,500	28,027	12,227	11	2.29
Auckland	ART3	JMAC – John Davies	Four-step model, with 24-hour trip generation, gravity distribution and logit mode choice, and time of day factoring to am, inter, school, off and pm peaks, calibrated on 2006 HTS. Trip generation based on zonal population, households, employment and education roll, + car ownership model. Modes include car, rail, bus, ferry, active modes (24-hour trip ends). Separate heavy vehicle model. Equilibrium assignment with simplified junction delay modelling.	No	Auckland Public Transport (APT) model, number of project specific traffic assignment models. AIMSUN-based DTA mode currently developed	Auckland region	Yes	Model type A: Regional transport model	2006 calibration, 2013 rebase	Every five years from 2016 to 2051	Emme	Jojo Valero (JMAC)	TBA	Yes – Luis Willumsen	497,416	132,862	618,152	2,621	564	18,645	7,387	33	2.52
Tauranga	Tauranga Transport model (V5.10)	Tauranga City Council – Clare Cassidy, Transport Agency – Mark Hasley, Western Bay of Plenty – Phillip Martelli, BoP Regional Council - Joe Metcalf	Three-step model for three periods. 2-hour am and pm peaks, 7-hour interpeak	No	None, numerous 'project models' forked from official Horizon year forecasts, some corridor or subarea microsim project models mostly Paramics and Aimsun	All of Tauranga and part of Western BoP	No, but can import or export shape files	Strategic planning / was also used for projects. eg TNL, TEL, B2B	2013	2016/17, 2021, 2026, 2031, 2031+ and forks are project models approx. 2046 growth areas	Cube voyager	Nyan - Beca	Yes, but limited to teamview	Yes - Ian Clark	59,000	14,000	61,000	484	325	4,000	2,100	12	1.90

Area	Mo-del name	Owner contact	Description	Parent model	Child models	Extent	GIS base	Transport Agency model category	Base year	Future years	Soft-ware plat-form	Modeller contact	Website	Peer re-viewed	Base year								
															Household	Retail jobs	Total jobs	Precision index	Zones	Links	Nodes	Links zones	Links nodes
Whaka-tane	-	Whakatane District Council – Martin Taylor	Four-step model for the three periods. 5x4 household category model imported from Auckland HTS data. Separate heavy vehicle model ex Christchurch, gravity distribution, logit mode split model, incremental assignment with intersection modelling	No	No	Whakatane District Council area	Yes	Model type C: Urban area traffic assignment model	2006	2011 2016 2021 2026 2031 2036 2041 2046	Tracks	David Hunter (TDG)	N/a	No	18,021	3,172	15,841	85	500	5,593	2,378	11	2.35
2.352.35 Rotorua	-	Rotorua District Council – Peter Dine	Three-step car driver model. Three periods. 5x2x4 category model calibrated from Waikato data. Separate heavy vehicle model ex Christchurch, gravity distribution, incremental assignment with intersection modelling	Yes – WRTM	No	Rotorua District Council area	Yes	Model type C: Urban area traffic assignment model	2013	2031	Tracks	David Hunter (TDG)	N/a	No	19,875	2,613	23,129	70	750	5,209	2,239	7	2.33
Taupo	-	Taupo District Council – Denis Lewis	Three-step car driver model. Three periods. 5x2x4 category model calibrated from Waikato data. Separate heavy vehicle model ex Christchurch, gravity distribution, incremental assignment with intersection modelling	Yes – WRTM	No	Taupo District Council Area	Yes	Model type C: Urban area traffic assignment model	2013	In prep-aration	Tracks	David Hunter (TDG)	N/a	No	9,906	1,359	10,196	53	460	4,583	2,033	10	2.25
Here-taunga	HPTM	Napier City, Hastings District, Transport Agency no current contact	Four-step model. Generation, distribution, mode split, assignment (PT and active travel skimmed off but not assigned)	No	No	Heretaunga Plains	Yes	Model type C: Urban area traffic assignment model	2013	2026, 2046	Trips	Laura Skilton (GHD)	N/a	Yes - Tony Penny	44960	5,089	44,038	292	366		44960		
Napier City	-	Napier City Council - Jon Schwass	Three-step car driver model. Three periods. 5x2x4 category model calibrated from Waikato data. Separate heavy vehicle model ex Christchurch plus special HGV matrix, gravity distribution, incremental assignment with intersection modelling. Validated in Napier City only.	No	No	Napier City Council Area plus Hasting District Council area	Yes	Model type C: Urban area traffic assignment model	2013	2015	Tracks	David Hunter (TDG)	N/a	No	47,964	5,429	46,980	76	1500	15,539	6,663	10	2.33
Palmer-ston North	PNATM (Pal-mer-ston North area traffic model)	PNCC Jon Schwass	Three-step traffic model (generation/ distribution/assignment). Reflects a base year of 2013 and covers am, pm and interpeak periods. Demand matrices have been produced for light and heavy vehicles.	No	No	PNCC area	Yes	Comment from Report: Categories A and B (regional and strategic network) are the most meaningful categories to compare against PNATM	2013	2021, 2031, 2041	Cube	Beca Nyan Aung Lin	Team view, man-aged by Beca	Yes – Tim Kelly	36,993	10,698	43,293	510	212				

Area	Model name	Owner contact	Description	Parent model	Child models	Extent	GIS base	Transport Agency model category	Base year	Future years	Software platform	Modeller contact	Website	Peer reviewed	Base year: Household	Base year: Retail jobs	Base year: Total jobs	Precision index	Zones	Links	Nodes	Links zones	Links nodes
Upper Hutt		Upper Hutt City Council – Patrick Hanaray	Three-step model for the three periods. 5x4 household category model imported from Auckland HTS data. Separate heavy vehicle model ex Christchurch, gravity distribution, incremental assignment with Intersection modelling	No	No	Upper Hutt City Council area	Yes	Model type C: Urban area traffic assignment model	2006	None	Tracks	Grant Smith (TDG)	N/a	No	14,088	2,229	9,393	98	300	3,507	1,561	12	2.25
Kapiti Coast	KTM Kapiti Traffic Model	KCDC	Highway assignment model	WTSM	No	Kapiti Coast	no	Model type C: Urban area traffic assignment model	2011	2021, 2031, 2041	Saturn	Beca	No	yes - Ian Clark									
North Welling-ton	NWSM North Welling-ton Saturn Model	NZTA		WTSM	Northern Wellington SATURN Model (NWSM)	Same size as WTSM but simulation between Aotea Quay, McKays Crossing and Upper Hutt	No, but can be exported	Model type C: Urban area traffic assignment model	2011	2021, 2031, 2041	Saturn	Kerstin Rupp (Jacobs)	No	yes - Tim Wright					650	16,917	9,786	26	1.73
Welling-ton	WTM Wellington Traffic Mode	Transport Agency/ WCC	Highway assignment model	WTSM	Basin Paramics model	Wellington City south of the Ngauranga interchange	No, but nodes are geo-coded	Model type C: Urban area traffic assignment model	2011	2021, 2031, 2041	Saturn	Opus	No	yes - Ian Clark					191	1,761	698	9	3
Welling-ton	N2A Model	Transport Agency/ GWRC/ WCC	Highway assignment model	WTSM	No	Wellington City south of the Ngauranga inter-change	Yes (WTSM net-work as base)	Model type D: Scheme/Project Model	2,016	2,026	Aim-sun	Andy Ford (GWRC) Tony Brennand (NZ Transport Agency)	No	Yes - Bruce Johnson					336	3,723	994	11	4

Area	Model name	Owner contact	Description	Parent model	Child models	Extent	GIS base	Transport Agency model category	Base year	Future years	Software platform	Modeller contact	Website	Peer reviewed	Base year: Household	Base year: Retail jobs	Base year: Total jobs	Precision index	Zones	Links	Nodes	Links zones	Links nodes
Wellington region	WTSM	Andy Ford (GWRC)	Four-step model, with 24hr trip generation, gravity distribution and mode choice, and time of day factoring to AM, inter and PM peaks, calibrated on 2001 HTS. Trip generation based on zonal population (12 categories), households (5 cat), employment (5 cat) and education roll (3 cat), + car ownership model. Modes include car, all PT, slow modes (not assigned). Separate heavy vehicle model built on fleet tracking GPS data. Equilibrium assignment with simplified intersection modelling.	No	**EMME:** WPTM (Wellington Public Transport Model) **Saturn:** WTM (Wellington Traffic Model), NWSM (North Wellington Saturn Model), KTM (Kapiti Traffic model) **AIMSUN:** N2A (Ngauranga to Airport), currently being built	Wellington Region	GIS	Model type A: Regional Transport Model	2013	2023, 2033, 2043	EMME 4	Nick Sargent (GWRC)	http://www.gw.govt.nz/wellington-transport-models-technical-reports/	Yes - John Bolland	181,405	45,788	235,760	2,430	225	14,873	6,547	66	2.27
Wellington region	WPTM (Wellington Public Transport Model)	Andy Ford (GWRC)	Public transport assignment model, including access to PT (walk, bus, park-and-ride, kiss-and-ride). Base year demand based on observed data (ETM and passenger surveys)	Yes, WTSM	No	Wellington Region	GIS	Equivalent to type B (Strategic network traffic assignment model) but for public transport	Calibrated 2011, 2013	2023, 2033, 2043	EMME 4	Nick Sargent (GWRC)			181,405	45,788	235,760	701	780	14,873	6,547	19	2.27
Nelson		Nelson City Council NZTA Andrew James	Am peak four-step model. Three-step model for interpeak and pm peak periods. 5x4 household category model imported from Auckland HTS data. Separate heavy vehicle model ex Christchurch, gravity distribution, incremental assignment with intersection modelling. Validated in Nelson City only. Updated to 2013 by Abley.	No	No	Nelson City Council and Tasman District Council	Yes	Model type C: Urban area traffic assignment model	2013	2023	Tracks	Grant Smith (TDG)	N/a	Yes - Tim Kelly	33,477	5,927	36,264	135	650	10,037	4,400	15	2.28
Blenheim												Laura Skilton (GHD)											

Area	Model name	Owner contact	Description	Parent model	Child models	Extent	GIS base	Transport Agency model category	Base year	Future years	Software platform	Modeller contact	Website	Peer reviewed	Base year								
															Household	Retail jobs	Total jobs	Precision index	Zones	Links	Nodes	Links zones	Links nodes
Christchurch	CTM	Transport Agency Stuart Woods; CCC Mark Gregory; Ecan Len Fleete	Four stage model, 24 hour generation model with time of day factoring to four peak periods, which are then assigned (4 peak periods sum to 24hrs). Model calibrated from 2006 ChCh HTS data. Logit mode split and distibution model; category trip generation 8*8*4. Volume averaging assignment with intersection modelling. Purpose-built Commercial Vehicle model from ChCh data. Employment data from Business Frame and not Census	No	CAST	Greater Christchurch	Yes	Model Type A: Regional Transport Model	Calibrated 2006. Validated 2006 and 2013	2021, 2031, 2041	CUBE	Julie Ballantyne (TDG)	N/a	Yes - Gillian Akers (PB) for first part; then John Falconer	157,181	22,278	206,331	893	498	8,504	3,208	17	2.65
Christchurch	CAST	Christchurch City Council	A detailed assignement model of Christchurch, as a sub-area of the CTM	Yes	No	Greater Christchurch	No	Model type C: Urban area traffic assignment model	2013		Saturn				157,181	22,278	206,331	312	1424	41,180	24,755	29	1.66
Timaru		Timaru District Council - Andrew Facey	Three-step model for the three periods. 5x4 household category model imported from Auckland HTS data. Separate heavy vehicle model ex Christchurch, gravity distribution, incremental assignment with intersection modelling	No	No	Timaru Urban Area	Yes	Model type C: Urban area traffic assignment model	2006	2011 2021 2041	Tracks	Grant Smith (TDG)	N/a	No	10,932	3,140	12,157	104	300	3,275	1,343	11	2.44
Dunedin		Dunedin City Council - Anja McAlevey	Four-step models for three periods. 5x4 category model, gravity distribution, logit mode split. Pm peak four-step added 2015.	No	No	Dunedin City Council Area	Yes	Model type C: Urban area traffic assignment model	2013	2016 2021	Tracks	Grant Smith (TDG)	N/a	No	45,906	6,084	48,667	177	650	13,619	5,599	21	2.43
Queenstown		Queenstown Lakes District Council	Three-step model for the three periods. 5x4 household category model imported from Auckland HTS data. Separate heavy vehicle model ex Christchurch, gravity distribution, incremental assignment with Intersection modelling	No	No	QLDC Area	Yes	Model type C: Urban area traffic assignment model	2012	2026 2041	Tracks	Dave Smith (Abley)	N/a	No	12,959	4,323	10,580	134	250	5,356	2,392	21	2.24
Southland - Gore	-	Gore District Council - Murray Hassler	Three-step model for the three periods. 5x4 household category model imported from Auckland HTS data. Separate heavy vehicle model ex Christchurch, gravity distribution, incremental assignment with intersection modelling. Built from an extension of Invercargill	No	Yes - Invercargill	Southland Regional Council Area, including parts of Dunedin City	Yes	Model type C: Urban area traffic assignment model	2006	None	Tracks	Grant Smith(TDG)	N/a	No	41,461	11,372	46,228	120	980	21,529	8,407	22	2.56

Area	Model name	Owner contact	Description	Parent model	Child models	Extent	GIS base	Transport Agency model category	Base year	Future years	Software platform	Modeller contact	Website	Peer reviewed	Base year								
															Household	Retail jobs	Total jobs	Precision index	Zones	Links	Nodes	Links zones	Links nodes
Invercargill		Invercargill City Council	Three-step model for the three periods. 5x4 household category model imported from Auckland HTS data. Separate heavy vehicle model ex Christchurch, gravity distribution, incremental assignment with intersection modelling	Yes – Southland	No	Invercargill City	Yes	Model type C: Urban area traffic assignment model	2006	2016 2026	Tracks	Grant Smith (TDG)	N/a	No	19,551	5,683	21,588	124	450	7,895	3,116	18	2.53

Auckland project models

Model name	Owner contact	Description							Software platform			Peer reviewed								
CBD Saturn 2010		Network flow model covering Auckland CBD. Network modelling to assess effects of transport and land use changes							SATURN			Da Vinci - Urie Bezuidenhout								
Auckland CBD West	ACC								SATURN											
Newmarket Model	ACC								SATURN											
Upper Harbour Area	NZTA								SATURN											
Waitemata Harbour Crossing	NZTA								SATURN											
Ellerslie Racecourse Model																				
Lunn Avenue	ACC	Test effects of future development in Mt Wellington area							SATURN											
Manukau Harbour Crossing	NZTA	Scheme assessment of MHX							SATURN			TDG								
Manukau Harbour Crossing Extension	NZTA																			
Long Bay	Landco	Assess development proposals in Long Bay area							SATURN			NSCC								
Hobsonville Peninsula	Hobsonville Land Company								SATURN											
Panmure (AMETI)	AMETI	Panmure centre. Assess AMETI Package 1							SATURN			Flow								
Puhoi to Wellsford	NZTA	SH1 north projects							SATURN			Flow								
Drury South	Stevensons Group	Investigate the proposed Drury South Business Park Development and Proposed Mill Road Corridor Study							SATURN			Flow Transport Specialists								
Flat Bush	Auckland Transport	Flat Bush Town centre and surrounds. Test Ormiston Town centre							SATURN											

Model name	Owner contact	Description							Software platform			Peer reviewed								
S3M Traffic Model	Auckland Transport	Southern Sector Saturn Model S3M. Mill Road corridor schemes, Drury South							SATURN											
CBD Saturn Extended	Auckland Transport	Network model for CBD. Test network options, CRL							SATURN			Da Vinci (2011) AT (2013)								
Newmarket Model Extend	ACC	Network model for NM, ACC							SATURN											
Papatoetoe Model	Auckland Transport	Papatoetoe Town Centre.Test rail crossing options							SATURN											
Eastern Suburbs									SATURN											
APT3	Auckland Transport	Auckland Passenger Transport model v3							Emme			SKM Daniel Brown								
AMETI (Panmure)	ACC, MCC	Panmure Busway. Panmure roundabout and busway							Vissim											

Appendix B: Skill survey questionnaire

Why are we contacting you?

The Ministry of Transport is managing an NZTA research project, with Stantec as the researchers. As part of this research, we are collating information on the resource and capability of transport analysis within our industry. This brief survey is designed for the NZ public sector.

Primarily, we are looking to establish the capability of the public sector to undertake or manage the provision of transport analytics. We have structured this around the business case model.

There are five components to the Treasury Business Case process, which is designed to systematically assess whether an investment proposal:

- Is supported by a compelling case for change - the 'strategic case';
- Optimises value for money - the 'economic case';
- Is commercially viable - the 'commercial case';
- Is financially affordable - the 'financial case'; and
- Is achievable - the 'management case'.

Transport models are useful in the development of the Strategic Case – where the set of options are evaluated for feasibility to develop a short list, and in the Economic Case to assess the likely return on investment.

Of course, there are other applications where transport analyses are required such as assessing the infrastructure requirements of strategic land use planning at one end, and operational considerations such as the setting of signal phasing at the other.

This questionnaire has been sent to a selection of Government departments, Regional and Local Authorities. Please answer the questions on behalf of your organisation.

Expertise in analytics to support business case studies

1. **Does your organisation have the need to prepare business cases** **Y/N**

   (If No go to question 2)

   a. **Does your organisation have in-house expertise in the transport analysis needed to support a Strategic or Economic Business Case** **Y/N**

   b. **If No, do you want to have that expertise in-house** **Y/N**

   c. **Does your organisation have the capability to manage consultants who have this expertise** **Y/N**

   d. **If No, can you access that capability externally** **Y/N**

Expertise in analytics to support strategic planning studies

2. **Does your organisation prepare Strategic Planning studies** **Y/N**

   (If No go to question 3)

   a. **Does your organisation have in house expertise in the transport analysis needed for strategic Planning studies?** **Y/N**

   b. **If No, do you want to have that expertise in house** **Y/N**

   c. **Does your organisation have the capability to manage consultants who have this expertise** **Y/N**

   d. **If No, can you access that capability** **Y/N**

Expertise in analytics to support operational studies

3. **Does your organisation manage road networks** **Y/N**

   (If No go to question 4)

   a. **Does your organisation have in house expertise in the transport analysis needed for strategic Planning studies?** **Y/N**

   b. **If No, do you want to have that expertise in house** **Y/N**

   c. **Does your organisation have the capability to manage consultants who have this expertise** **Y/N**

d. **If No, can you access that capability** **Y/N**

4. If you have inhouse expertise, please complete the tables below with the number of personnel in each cell

How many people do you have with experience using different transport analytics software? Please enter the number where applicable, or indicate in the box if you have none

	No experienced personal	**Some knowledge**	**Basic experience**	**Advanced experience**
Intersection models (eg SIDRA, LINSIG, TRANSYT)				
Microsimulation traffic models (eg Paramics, Aimsun, Vissim)				
Other assignment models, such as strategic or mesoscopic (eg SATURN, Aimsun, etc)				
Demand models, such as 3-step/stage or 4-step/stage (eg EMME, Tracks, CUBE,VISUM)				
Database (eg SQL, MS Access) or advanced Excel				
Programming (eg Python, C++, Fortran)				
GIS analytics				
Other: please specify				

How many people do you have with experience building or applying transport models?

		No experienced personal	**Some experience**	**Advanced experience**
Calibrated, validated, built	Assignment model (microsimulation & other)			
	Three-step demand model			
	Four-step demand model			
Applied an existing model	Assignment model (microsimulation & other)			
	Three-step demand model			
	Four-step demand model			
Extracted results from a model				
Used/interpreted results from a model provided by others				