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Christchurch (NZ) Transportation Model Update – A Moving Feast

The Christchurch Transportation Model (CTM) is a four-stage model and is the main planning tool for the region. Forecast travel patterns are produced from input land use and the transport network. The CTM was originally calibrated to 2006 conditions.

The earthquakes in 2010/11 produced a substantial shift in the land use pattern and significantly impacted the transport system. The City Centre is still being rebuilt, with increased business activity in the west. There has been a permanent shift in residential distribution with some suburbs in the east no longer viable. Roads are still being repaired and roadworks dominate the landscape.

This paper summarises the 2013 validation of the CTM and the challenges faced. Obtaining representative observed data was difficult; the road network was in a state of flux due to repairs; and the land use distribution was quite different compared to when the model was originally built. The combination of these factors meant that checking the model was somewhat of a moving feast.

1. Introduction and Background

Christchurch is the third largest city in New Zealand, located about half way down the east coast of the South Island. Approximately 425,000 people reside in Christchurch and the two key drivers of its economy are industry, including dairy, and tourism. Being approximately one eighth of New Zealand's population, the major gateway to the offerings of the South Island and also home to drawcards such as its three major tertiary education institutions, an international airport and Antarctic research programs run by several different countries, Canterbury is an integral part of New Zealand.

The Canterbury plains lie to the west, stretching from the north to the southwest, and there are many developing satellite towns in these areas which interact with Christchurch City. To the north lies the Waimakariri River which has two major vehicle crossing points to access Christchurch. The Pacific Ocean is to the east and Banks Peninsula over the Port Hills to the southeast. The Lyttleton tunnel burrows through the Port Hills and connects Christchurch with Lyttleton which contains the South Island's largest port handling 370,000 twenty-foot equivalent units of containerised cargo a year. Christchurch International Airport is located on the western fringe of Christchurch and handles over 6 million passengers per annum.

The main state highway one in New Zealand runs north to south and passes through Christchurch. The supporting state highway and local road network offers a significant amount of flexibility due to the flat terrain and grid network in the City Centre. In Christchurch, buses are the major form of public transport and the bus network has a large coverage of the region, including connecting the satellite towns to the central area. There is no passenger train service used for commuting in Christchurch, but the rail network is used primarily for freight along with two tourism lines taking passengers to the north and west of the South Island. Traditional trams run through the Central City, however, like rail, primarily cater for tourism due to their very slow speeds and high fares. Due to Christchurch's flat geography, cycling is prominent with approximately 7% of commuters choosing this method of transport, and the Christchurch City Council is in the process of delivering a $156 million major cycle routes network. However Christchurch city still has over 60% of its population using a private vehicle to work, and another 15% in a company vehicle.

The Christchurch Transportation Model (CTM) is the major planning tool used for the Greater Christchurch region, jointly owned by Christchurch City Council (CCC), Selwyn and Waimakariri District Councils (SDC and WDC), the New Zealand Transport Agency (NZTA), and Environment Canterbury (ECan). It is a four stage model of Greater Christchurch centring on Christchurch and with a boundary roughly 30km away – the same distance away from the CBD as the significant satellite towns of Rangiora in the north and Rolleston in the southwest. The model is available for general use (based on obtaining permission from the model owners) and is calibrated and validated to 2006. In normal circumstances the model is re-checked every five years in line with the New Zealand Census.

In 2010/2011, Christchurch was hit by a series of major earthquakes. These earthquakes caused significant loss of life and infrastructure and contributed to some massive changes in land use. 185 lives and up to 11,500 dwellings were lost, the CBD was ruled off limits for a period of time and must be largely rebuilt from scratch, large swathes of land throughout the city were designated 'red-zoned' and will probably never be used for residential land use again and businesses relocated to suburban centres with many operating out of residential premises for a period of time. While Christchurch is in the process of rebuilding, the landscape of Christchurch will continue to change significantly for some time to come yet.

The result of the earthquakes was that there were large changes in land use, as houses were unable to be occupied while they waited for or received repairs, were destroyed or deemed too dangerous to live in. Over 5% of the housing stock in Christchurch was permanently removed in a very short period of time, which was predominantly on the eastern side of the City. In addition to this, as many houses waited for or underwent repairs, there were many unoccupied households – this number increased by 10,000 between 2006 and 2013. There was an urgent need for accommodation and this forced rapid development ahead of schedule of planned new subdivisions. Hand in hand with the sudden reduction in supply of accommodation, the value of the available homes skyrocketed in the area. There are now at least 25 subdivisions being built around Canterbury, along with households for 25,000 people being built in higher-density apartments in the Central City.

In addition to household movement, employment patterns changed significantly. Initially many Central City businesses relocated to residential areas in the less damaged western parts of the City and worked from houses. Some were refurbished into business friendly environments, some are still being used. Suburban centres flourished as office space was hard to come by and many business parks were and are still being developed, especially in the northern and western suburbs. Only now in 2016 are we starting to see the Central City emerge as an employment destination again. The impact of the earthquakes on land use patterns resulted in dramatically altered travel patterns.

The bus network, which primarily operated radial routes serving the City Centre, experienced significant declines in patronage. A new bus network was designed that would better cater to current and future evolving land use patterns. In 2014, the Christchurch bus network changed to a hub-and-spoke system. In 2015, the central hub moved from its temporary station to a more permanent home.

More than half the road network, which formed the backbone of the transport system, experienced some sort of damage. This effected all modes of travel, including cyclists, buses, cars, and freight. Repairs and rebuilds have been ongoing since 2011 and are rolled out on a suburb-by-suburb basis. This geographic clustering maximises efficiency and minimises costs for the repair teams, but has a greater impact on localised transport. The road repairs and rebuilds have included complete road closures for significant periods of time (6 months to several years), temporary road closures, and lane closures resulting in restricted road widths. At the time of writing this paper in 2016, there were still 840 different projects in place on the roads in the Greater Christchurch area, and 128 road closures.

One further outcome of the earthquakes was that the national Census, which was planned for 2011, was postponed to 2013. This was primarily because Statistics New Zealand, who conducts the Census, is based in Christchurch.

The need to rebuild the City Centre offered significant opportunities to improve the urban form and supporting transport network. The plans are too detailed to cover in this paper, but overall in transport terms, the redesign should mean better allocation of road space to sustainable travel modes. Key changes relevant to this paper are changes to the operation of the southern pair of east-west one way streets and reducing vehicle speeds in the central core to 30kph.

2. Overview of Model Validation

The 2013 check on how the model was performing, which forms the foundation of this paper, was commissioned by the local and central Government agencies in the region, mentioned earlier. The complete 2013 model update project, which also encompassed checking an assignment model that sits beneath the CTM, was jointly delivered by consultants QTP and TDG.

The 2013 validation check involved comparing model outputs to:

- Observed traffic volumes (by light and heavy vehicles) at key locations;
- Observed vehicle travel times along specific routes;
- Actual bus boardings; and
- Journey-to-Work travel patterns from the 2013 national Census.

It is worth noting that the inputs to the model are the:

- 2013 land use derived from Census;
- 2013 road network excluding capacity reductions from long-term road repairs;
- 2015 hub-and-spoke bus system, with minor changes to reflect the direction roads were operating in the City in 2013. The 2015 bus network was modelled instead of 2013 at the request of the client; and
- 2013 temporary post-quake Central City bus exchange.

This paper describes the:

- Traffic count processing and the issues encountered;
- Observed bus boardings processing;
- Key model inputs and output metrics for context; and
- Validation in terms of comparisons to traffic counts, travel times, bus boardings, and journey to work travel patterns.

3. Traffic Count Processing

3.1 Counts Required

For the 2013 validation of the CTM, traffic counts ideally required are light and heavy vehicle counts from August 2013 at model screenline locations for the AM peak (07:00-09:00), the interpeak (09:00-16:00), the PM peak (16:00-18:00), and the overnight period (18:00-07:00).

During the original model build in 2006, 23 screenlines were formed intercepting key movements across the City. Of these, 3 screenlines represent external movements. Counting each direction separately, there were 420 individual sites forming the 23 screenlines.

3.2 Counts Supplied

Traffic counts on screenlines were requested from the three territorial authorities covering the modelled area (Waimakariri in the north, Christchurch City, and Selwyn in the south) and the NZTA who are responsible for the state highway network. The information supplied was:

- All link traffic counts collected in Christchurch during 2012, 2013, and 2014 were provided irrespective of whether the counts were on a screenline or not. The data had not been processed and was provided in raw (MetroCount) format;
- Counts in Selwyn collected from 2011 to 2014 were provided. As the Christchurch data was unprocessed, the same raw format was requested to streamline processing;
- In the north, Waimakariri provided 2013 and 2014 counts at the three local road external locations only. Again, the data was provided in raw format;
- NZTA provided counts for June and July 2013 at key locations. These counts were downloaded from the Traffic Monitoring System (TMS) and were in CSV format.

There was a significant amount of processing required to geo-locate and clean the counts, including identifying anomalies from tube failures. This processing is described below.

3.3 Converting 'Raw' Counts

The majority of counts were supplied in 'raw' format. These files were processed with MetroCount Traffic Executive, converting them into CSV format.

Only directional, classified counts were retained. Classes for the recorded data are identified with the "TNZ 1999"[1] classification system. This is a system divided into 13 unique classes

[1] http://mtehelp.tech-metrocount.com/Article.aspx?id=DB8E1AF3A2

ranging from dual axle cars to 9 axle trucks. Classes 1 and 2 are made up of cars and light commercial vehicles (LCVs) with and without trailers. Class 3 consists of medium commercial vehicles (MCVs), classes 4 to 7 heavy vehicles with 4 axles or less (HCV1) and classes 7 to 13 heavy vehicles with an excess of 4 axles (HCV2).

The CTM outputs vehicles in two classes – light and heavy vehicles. Light vehicles are cars and LCVs (TNZ classes 1 and 2) and heavies are anything larger (TNZ classes 3 to 13).

3.4 Geo-locating Counts

The traffic counts needed to be geo-located to determine if they were on a screenline. This was particularly the case for Christchurch as all counts collected over three years were provided irrespective of whether they were on a screenline or not. The geo-referencing was undertaken by firstly attempting to match each count with the count database from 2006 using the text descriptions provided, and secondly using manual inspection of text descriptions and co-ordinates.

After geo-referencing all the unique counts, the process was:

- Some counts were matched exactly to an existing screenline and were utilised;
- Of the counts that were not on existing screenlines;
  - It was determined if new, additional screenlines could be formed. It was found there were no new screenlines to be made from the data present;
  - Counts on key strategic locations were retained and utilised as link-only counts (i.e.: not on a screenline).
- Four counts were found to be close enough to existing screenlines that they could be utilised by redefining the screenline.

As noted above, the 23 screenlines were comprised of 420 individual sites (each direction separately counted) where the model performance was checked against observed. Based on the counts supplied by the territorial authorities, three screenlines (one in Waimakariri and two in south Christchurch) had no recent counts at all and were discarded. Reducing the number of screenlines to 20 dropped the total number of sites from 420 to 388. Of these 388 sites, recent counts were sourced for only 234 locations representing 60%. Counts were sourced for 100% of roads crossing the external screenlines.

3.5 Adjustments/Corrections to Counts

In reviewing the 2013 counts, some corrections were required to account for:

- Likely directionality disparities, where the count direction appeared to be incorrect;
- Tube count failures, where certain days had to be discarded;
- Annual and seasonal adjustments to reflect August 2013; and
- Infilling missing traffic counts.

3.5.1 *Directionality Issues*

There were several cases where the tidality of traffic in the morning and evening peaks seemed to have reversed between 2006 and 2013. Given the dramatic shift in land use since the earthquakes, a reversal in tidality was entirely possible. However a similar issue was encountered in 2006 during the model build, when counts were also supplied with incorrect directions appended, so each count where the tidality had reversed between 2006 and 2013 was manually inspected. Tidality on adjoining roads was considered and local knowledge used to decide which direction reflected the real-world peak. For all but two of these suspect counts, the tidality was concluded as being incorrect and these two counts retained tidality different to 2006, while the remaining directions were reversed.

The final scenario encountered was counts recorded as north-south, where in fact they were running east-west (and vice versa). To address this, local knowledge was again applied to determine the appropriate direction and apply consistent labels.

3.5.2 *Tube Count Failures*

There were counts where suspiciously low volumes were recorded on some weekdays and a basic filter was used to determine these. These were determined to be a result of tube failure. The following figure shows daily light vehicles at a sample of locations by day of the week. The days with zero flows are shaded orange, while days with suspiciously low flows relative to other days are shaded pink. Both instances were excluded from the calculation of the average weekday volume.

Figure 1: Sample Daily Light Vehicle Counts by Location and Weekday

Location	Ref	Year	Monday	Tuesday	Wednesday	Thursday	Friday	Average	Graph
Cones Rd S Ashley Bridge	A01-N	2014	5298	5232	5506	5528	5825	5478	
Cones Rd S Ashley Bridge	A01-S	2014	4972	4862	5113	5163	5318	5086	
Burwood N Travis	F07-N	2013	3494	3484	3604	3756	3792	3626	
Burwood N Travis	F07-S	2013	0	9	33	4116	4130	4123	
Riccarton at Rail Xing	G19-E	2013	10449	11058	11234	11905	12339	11397	
Riccarton at Rail Xing	G19-W	2013	10710	11402	11488	12064	12239	11581	
[297] Moorhouse W Lincoln EAST at #	G30-E	2013	14706	14259	167	15443	16067	15119	
[297] Moorhouse W Lincoln EAST at #	G30-W	2013	13554	14373	14388	14498	15237	14410	
Marshland Road S Prestons	H13-N	2014	0	0	0	8741	9483	9112	
Marshland Road S Prestons	H13-S	2014	0	0	0	9363	9879	9621	
Wairakei Road W Russley	J05-E	2013	3944	4117	0	0	4455	4172	
Wairakei Road W Russley	J05-W	2013	4480	4685	0	0	4987	4717	
Roydvale S Memorial	K03-N	2012	3851	5149	3189	4800	5273	5074	
Roydvale S Memorial	K03-S	2012	3168	4239	2492	3718	4209	3834	
Sherborne St N Bealey	K30-N	2014	4544	6308	6334	4277	6304	6315	
Sherborne St N Bealey	K30-S	2014	6153	7737	7803	7947	8115	7551	
Gloucester E Fitzgerald (OS No415)	L23-W	2014	2622	3570	3550	3750	3806	3669	
Gloucester E Fitzgerald (OS No415)	L23-E	2014	2934	3942	3940	3944	3987	3953	
Worcester Street E Fitzgerald	L24-E	2012	1311	1418	1411	111	1425	1391	
Worcester Street E Fitzgerald	L24-W	2012	1125	1354	1389	109	1352	1305	
Tuam E Fitzgerald	L29-E	2013	3438	3524	3596	3530	3498	3517	
Tuam E Fitzgerald	L29-W	2013	58	53	78	61	1694	1694	

3.5.3 *Annual and Seasonal Adjustment*

The cleaned traffic counts were then factored to account for yearly and seasonal variation. For the time series adjustment, counts collected in other years were factored to represent 2013. For the monthly adjustment, the original 2006 model build used traffic counts collected in August – the same neutral month was therefore adopted for 2013.

The monthly factors were calculated by using counts from the NZTA TMS. Data from each month for the past five years for every telemetry site around Canterbury was downloaded. The weighted average was calculated to factor counts by month to an August equivalent. These factors were separately calculated for light and heavy vehicles.

The calculation of annual adjustment factors followed a similar method. Counts for telemetry sites around Canterbury were downloaded from the NZTA TMS. Data for 2011 (the earliest count) to 2015 (the latest count) was used to calculate factors adjust to 2013. In general, as traffic movements have grown over time more recent counts need to be scaled down, and earlier counts scaled up. This does not incorporate the shift in traffic from the land use changes in the City associated with the damage caused by the earthquakes, and a more refined adjustment would require significantly more data than was available.

3.5.4 *Infilling of Missing Counts*

There were many locations where recent traffic counts were not available and where traffic volumes have changed considerably between 2006 and 2013 due to red-zoning of residential areas and relocation of business activities. In these locations, it was considered particularly important to check the model and hence an estimate of observed flows was essential.

At several key locations without a recent count, the 2006 count for all four time periods from the original model build was used and factored based on recent turning count data. This turning count data could not be used in isolation for the validation of CTM as observations did not exist for every time period (e.g.: interpeak and overnight periods).

At other screenline count sites, where there were no recent tube or intersection counts, the 2006 count was inflated to 2013 using a global factor representing growth. These locations were then treated separately in the validation – as areas in the east most damaged by the earthquakes have declined considerably, whereas growth in the west of the City is higher. While this simple factoring of old traffic counts is accepted as being extremely simplistic given the change in traffic conditions, it was determined to be better than not checking these sites at all (i.e. leaving gaps in the screenlines).

3.6 Traffic Count Summary

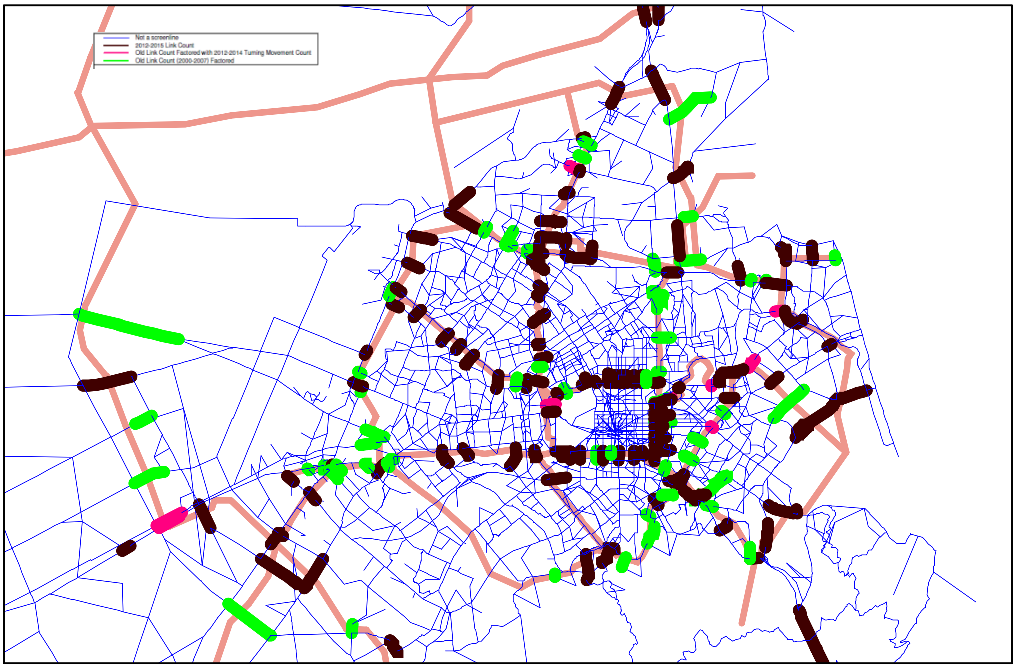
All link traffic counts provided were mapped. They were then allocated to the model screenlines and other counts reviewed to determine if new screenlines could be formed, which was found not to be possible. There were significant gaps in the screenlines which were infilled using factored 2006 counts. Traffic volumes at some of these locations had changed significantly, which was identified through the comparison of modelled with observed. In many of these cases, it was the observed (factored 2006) count that was incorrect and this was addressed by manually adjusting the link count using recent turning movement counts.

A comprehensive link count database was produced for the validation. The following figure shows Christchurch with each road on a screenline coloured based on the count data available. The colours represent:

- Dark brown shows roads with a recent (2011-2015) count;
- Lime green identifies roads where the 2006 counts were simply factored; and

- Pink are roads where 2006 counts were adjusted using recent turn counts.

Figure 2: Count Locations Colour - Coded by Count Availability – Christchurch City



4. Bus Boardings Processing

Observed bus boardings from March 2015 were provided by Environment Canterbury. This was in the form of monthly total weekday boardings for each departing service by route. From this, the average number of passengers per service was calculated by dividing the monthly total by the number of weekdays in that month. The observed bus boardings for the daytime peaks are tabulated below.

Table 1: Observed Bus Boardings by Peak Period, 2006 vs 2013

Model Period	Observed Bus Boardings by Period		
	2006, October	2015, March	Diff, 2015 – 2006
AM	8,983	9,098	115
Interpeak	9,116	10,051	935
PM	9,133	9,229	96
6 Hour Total	27,232	28,378	1,146

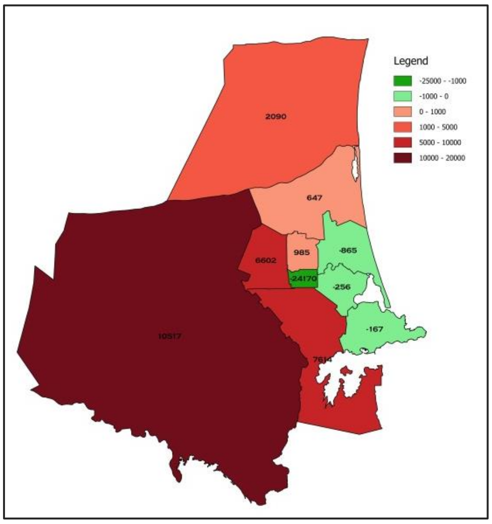
Based on March data, the total boardings in 2015 are around the same magnitude as 2006. It is worth noting that the 2015 system has a hub-and-spoke design which requires more transfers, and hence more boarding, than the system operated in 2006. The similar level of boardings in 2015 compared with 2006 would suggest a drop in person trips.

5. Forecast Change in Key Metrics, 2006 to 2013

The change in land use between 2006 and 2013, which drives the model estimates of trips made, is summarised in the following table and the corresponding graphic. Land use is an input to the model - the comparison is included to provide context to the model outputs.

Table 2: Key Input Land Use Changes, 2006 to 2013

	Population		Jobs	
	2006	**2013**	**2006**	**2013**
Christchurch City	358,700	354,000 (-1%)	188,000	186,500 (-1%)
Waimakariri	34,100	40,100 (+18%)	8,100	10,200 (+26%)
Selwyn	21,600	31,000 (+44%)	7,300	9,700 (+33%)
Total	**414,400**	**425,100 (+2.6%)**	**203,400**	**206,300 (+1.4%)**
Central City	7,900	5,100 (-35%)	52,400	28,400 (-46%)



Population has only grown by 2.6% across Christchurch between 2006 and 2013. There has been high growth in the outer areas (Waimakariri and Selwyn), although the significant percentage increases result from a low base. Employment has grown slower than population over this period. Of note, City Centre employment has dropped by 46%. This change in employment distribution means that work travel patterns will have changed considerably, much more so than over any typical seven year period. The disbursed land use also puts more pressure on the transport system – with the road and bus system designed to serve centralised employment, which is no longer the case.

Modelled daily person trips by mode are provided below for a number of scenarios. From left the scenarios represent; 2006 observed from the Household Travel Survey, 2006 modelled from the calibrated base, 2006 modelled using updated software and 2013/15 modelled.

Table 3: Modelled Daily Person Trips by Mode, 2006 and 2013

	DAILY PERSON TRIPS BY MODE						
	Observed 2006	**Modelled 2006 (Delivered)**	**Modelled 2006 (Current)**	**Diff, 2006**	**% Diff, 2006**	**Modelled 2013/15**	**% Change 2013/15 from 2006 (Current)**
Light Vehicle	1,642,799	1,641,137	1,614,159	-28,641	-1.7%	1,672,597	3.6%
Bus	42,750	42,350	46,045	3,295	7.7%	38,440	-16.5%
Bike	46,773	47,598	50,312	3,539	7.6%	47,942	-4.7%
Total	1,732,322	1,731,085	1,710,516	-21,806	-1.3%	1,758,979	2.8%

There is a significant decrease in bus patronage forecast for 2013/15 compared with 2006. It is noted that these are person trips and not boardings[2]. The bus boardings are relatively similar in 2006 and 2013 but due to the hub-and-spoke system operating in 2015, which requires more transfers than previously, the number of passengers is forecast to have declined as expected. There is no observed data to confirm this trend however it aligns with anecdotal evidence. The more dispersed employment pattern in 2013 will have affected patronage, as the bus system is focused on the Central City where employment has dropped by 46%.

6. Comparison of Forecast Traffic Flows

The following table compares observed total vehicles with modelled. For link counts, only sites with a recent count are reported (so locations with 2006 factored counts are excluded). The validation targets are from the New Zealand Transport Model Development Guideline[3], which was published in 2014 with criteria focused on the application of models and the geographic scale. This document was born to supply more suitable validation criteria for different model sizes than the criteria in the Economic Evaluation Manual (EEM), which has not been updated in 15 years and adopts a 'one size fits all' approach for model validation. The 2006 calibrated base used these EEM targets. Shaded cells indicate where the model does not achieve the target criteria.

Table 4: Total Vehicles – 2013 Modelled vs Observed Screenline and Link Flows

				TOTAL VEHICLES				
	GEH	NZ TMD Criteria		AM	IP	PM	ON	Daily
% Screenlines with GEH	< 5	>	60%	59%	55%	64%	82%	86%
	< 7.5	>	75%	73%	82%	77%	91%	91%
	< 10	>	90%	73%	91%	77%	100%	95%
% Links with GEH	< 5	>=	65%	52%	66%	49%	82%	68%
	< 7.5	>=	75%	72%	80%	66%	96%	87%
	< 10	>=	85%	83%	92%	79%	97%	94%
	< 12	>=	95%	92%	97%	88%	100%	97%
RMSE	30%			32%	30%	40%	47%	29%

The AM peak does not meet any of the validation targets, although it just fails the first two screenline checks and just fails the final three link checks. The PM peak fails most of the targets, although it exceeds the criteria for screenline flows less than 5 and 7.5. The interpeak and overnight periods achieve all but one criteria each, with the daily results exceeding all of the targets.

While it might appear that the 2013 forecasts are not performing particularly well based on observed counts and validation targets, the 2006 calibrated base results are provided in the following table for context.

[2] Observed 2015 bus patronage is not available - only observed boardings.
[3] https://www.nzta.govt.nz/assets/resources/transport-model-development-guidelines/docs/tmd.pdf

Table 5: Total Vehicles – 2006 Modelled vs Observed Screenline and Link Flows

			TOTAL VEHICLES				
	GEH	EEM Criteria	AM	IP	PM	ON	Daily
% Screenlines with GEH	< 4	= 100%	57%	78%	76%	85%	85%
% Links with GEH	< 5	>= 60%	58%	62%	52%	81%	66%
	< 10	>= 95%	86%	90%	85%	99%	94%
	< 12	= 100%	93%	96%	92%	99%	97%
RMSE	< 30%		31%	35%	30%	45%	29%

The 2006 calibrated base model did not achieve the screenline targets in any of the peak periods. Similar, the individual link validation was generally just under (albeit close to) the validation targets.

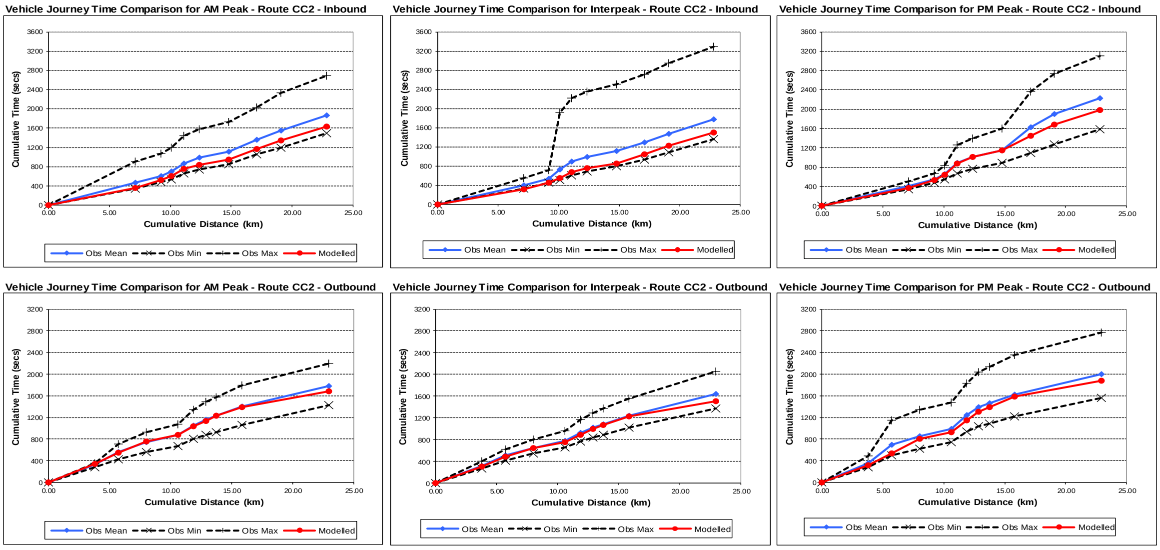
So for vehicle forecasts, the model outputs for 2013 either achieve the same, or better, replication of observed as the 2006 calibrated base. This confirms the model is performing to an acceptable standard for forecast traffic flows. This is particularly the case given the variability of actual travel patterns due to the rebuild.

7. Comparison of Vehicle Travel Times

Observed weekday travel times in March and November 2013 for the same 18 routes used in the CTM build in 2006 plus one additional route were provided by NZTA from their bi-annual floating car survey. Routes cover major strategic routes across the City.

Cumulative graphs of travel time verses distance were produced for modelled and observed for the 19 routes, by direction, and for each of the three daytime peak periods. The graphs for one route are provided below. Modelled travel times are plotted in red, with the maximum and minimum observed shown with black dotted lines, and the mean observed in blue.

Figure 3: Sample Modelled vs Observed Vehicle Travel Times for 2013



Overall, the model is slightly faster than observed in all three peak periods. The difference was not significant enough, however, to warrant altering any of the underlying relationships. This pattern is consistent with the 2006 calibrated base, where the modelled travel times were also slightly faster than observed. In terms of travel time replication, the model outputs for 2013 were determined to represent observed to an acceptable level.

8. Comparison of Bus Boardings

Observed bus boardings were compared to modelled by corridor for the AM, interpeak and PM peak periods. These are not reproduced here due to space limitations. Note that for the public transport (PT) assignment, a two hour interpeak period is modelled.

The model generally underestimated observed boardings and so further investigation was carried out. The model was originally designed to replicate boardings for October 2006. For this update, bus boardings from March 2015 were provided as October was not available at the time. Analysis of the seasonal differences between October and March was carried out using observed boardings from 2003 to 2014 (excluding 2010 and 2011 which showed an atypical pattern due to the earthquakes) to determine if the model was indeed under-reporting or whether there was a seasonal difference. The analysis confirmed that March boardings are typically higher than October. An adjustment factor was therefore calculated and applied, so the observed boardings were factored by 0.92 to approximate October.

The forecast bus boardings for 2013/15 are tabulated below compared with observed. The equivalent figures from the 2006 calibrated base are also reported for benchmarking.

Table 6: Bus Boardings Comparison, 2006 and 2013/15 Modelled vs Observed

		BOARDINGS			
		AM	IP	PM	6 Hours Summation
2006	Obs	8,983	9,116	9,133	27,231
	Mod	9,950	9,358	8,922	28,230
	% Change	11%	3%	-2%	4%
2013	Obs	8,372	9,249	8,493	26,115
	Mod	8,665	8,320	8,311	25,295
	% Change	3%	-10%	-2%	-3%

Across the network, the 2013 forecasts reproduce observed boardings well for the AM and PM periods. The modelled interpeak boardings are 10% lower than observed. No further adjustment was undertaken due to the mix of inputs (2013 land use to estimate 2015 patronage). There is more variation in the predicted bus patronage on a corridor route basis, but the variation is similar to the 2006 calibrated base and was considered acceptable.

This confirms a similar level of accuracy is produced for the forecast year of 2013 compared with the 2006 calibrated base. Given the significant changes in bus service patterns and land use distribution compared with 2006, the model is predicting patronage remarkably well.

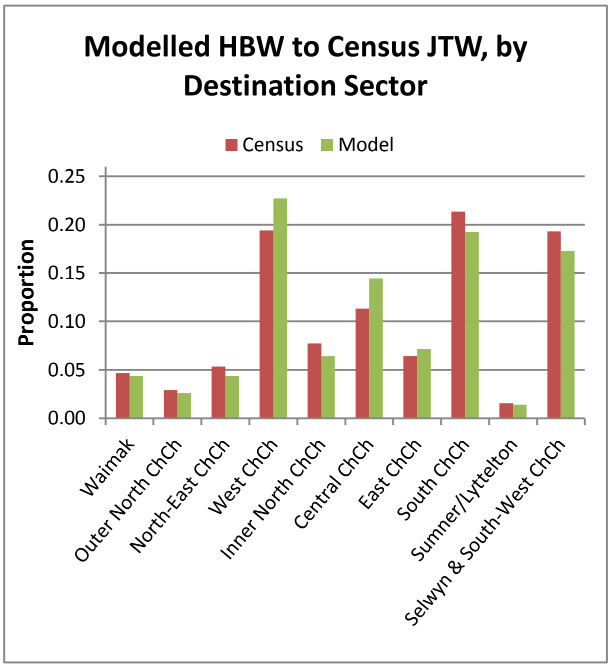
9. Comparison of Work Travel Patterns

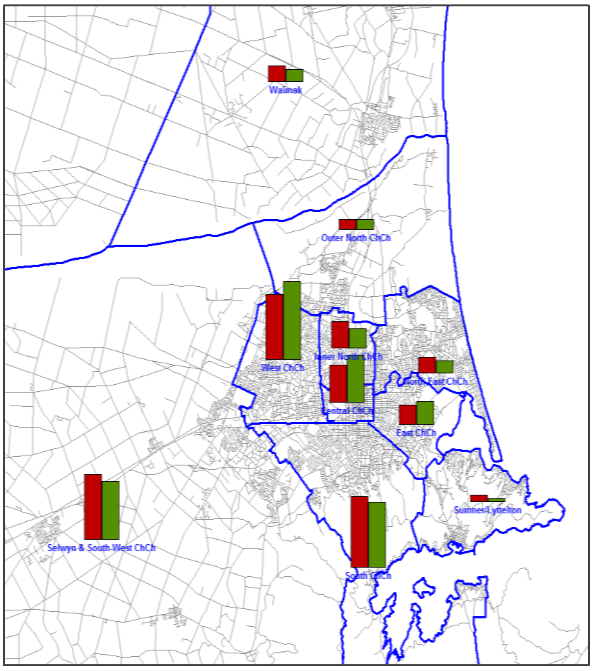
The only source of travel pattern data to check the model is the journey-to-work (JTW) data from Census. There are, however, differences in the Census JTW definition and the closest equivalent in the model, which is Home-Based Work (HBW) that must be borne in mind.

Census JTW is one direction only (i.e. to work); it includes trips with intermediate destinations, such as home → drop kids at school → work, within JTW; and it does not relate to one specific time period (although it will predominantly reflect the morning peak). The closest equivalent from the model is HBW. This includes both directions of travel (to and from work); excludes intermediate destinations (such as dropping the kids at school); is output at a daily level (although will mostly relate to morning and evening peaks); and is on a production-attraction basis rather than origin-destination.

The smallest geographic unit that JTW data is available is Census Area Units. Therefore aggregation of model zones is required. Furthermore, because of the definitional differences, the pattern of trip-making has been compared on a sector basis. The following figure compares Census JTW with modelled HBW for destinations/attractions aggregated to sectors, tabulated by proportion (i.e.: absolute numbers are not comparable). The same analysis was conducted for origins/productions, which had a slightly better correlation, but is not reported here due to space limitations.

Figure 4: Destinations of 2013 Travel to Work Trips, Modelled HBW vs Census JTW

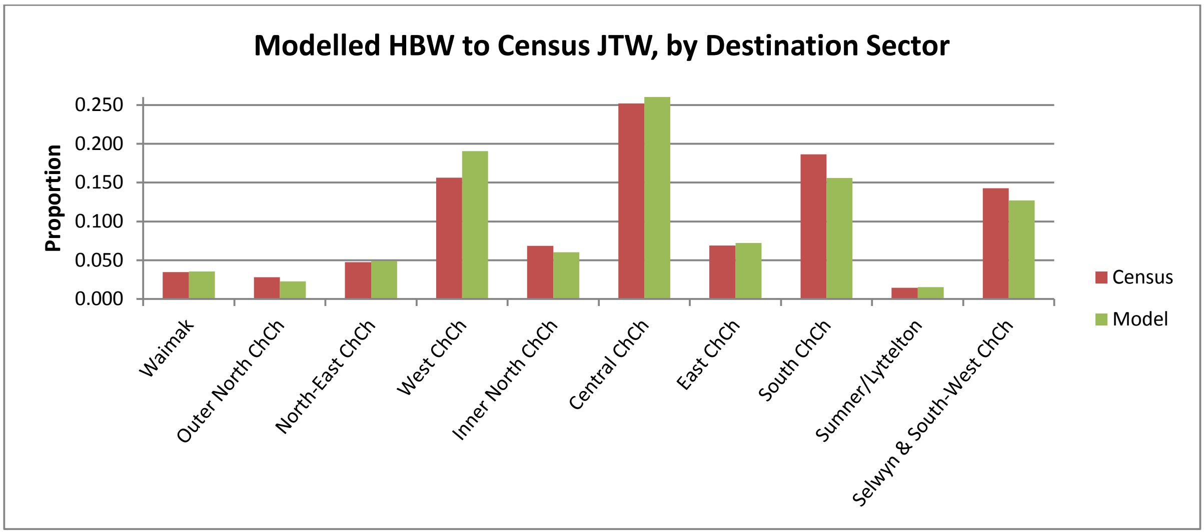




For the destination end of work trips, the model overestimates the attractiveness of West Christchurch (Census 19.4% vs model 22.7%) and Central Christchurch (Census 11.3% vs model 14.4%). Compensating for these overestimates, the model underestimates trips to South Christchurch (Census 21.4% vs model 19.2%) and South-West Christchurch/Selwyn (Census 19.3% vs model 17.3%). The difference in distribution, however, is not substantial and the model does replicate observed work trips relatively well for 2013.

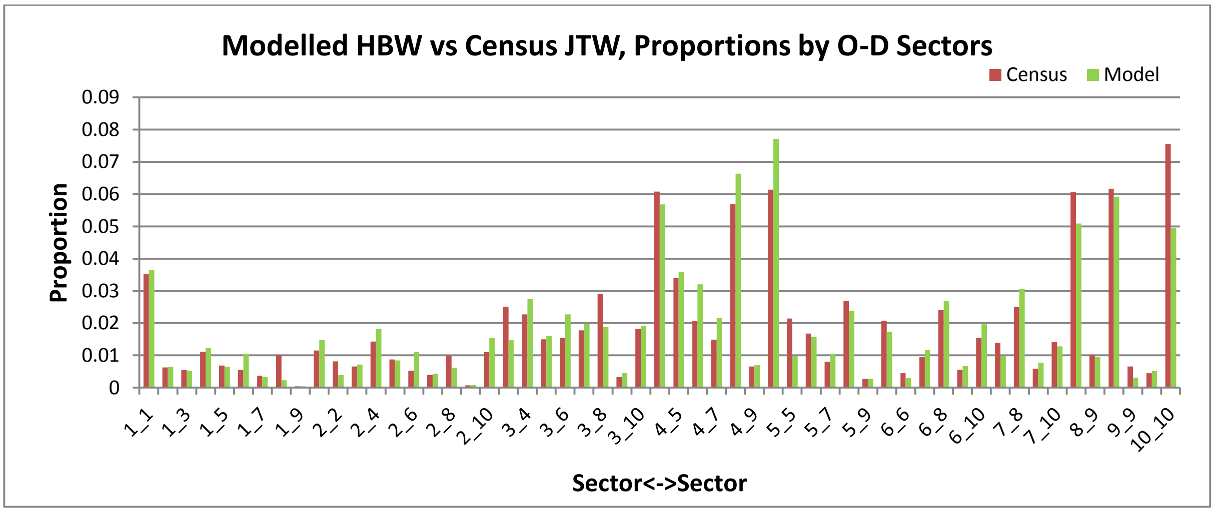
As a cross-check, the same analysis was carried out for 2006 with the proportion of destinations by sector graphed below. Of note, the difference in 2013 (West and Central Christchurch too high; South and South-West Christchurch too low) are also evident in 2006. This suggests either that the definitional differences may partly explain the discrepancies.

Figure 5: Destinations of 2006 Travel to Work Trips, Modelled HBW vs Census JTW



The following graph displays the 2013 JTW travel on a sector-to-sector basis, with the two directions combined (i.e. sector 3 to 4 summed with sector 4 to 3). The y-axis contains the proportion of the overall matrix for that movement due to the definitional differences. The x-axis sector labels are numeric rather than text in order to be readable.

Figure 6: Sector-to-Sector Movements for Work Trips, Modelled HBW vs Census JTW



The largest difference is trips internal to Sector 10 (South-West Christchurch/Selwyn), where the model underestimates the number of short distance trips. The next most significant difference is trips between West Christchurch and South-West Christchurch/ Selwyn (sectors 4-10), where the model overestimates travel. These two issues will be related. A check of the 2006 data shows the same pattern of over and underestimation in these sectors.

The next outlier is internal trips within Inner North Christchurch (sector 5), where the model underestimates shorter trips. Overall, the model slightly underestimates the number of short trips, however the difference is not considered excessive, and is influenced by the size of the sectors, which differ over the study area

Overall, the model is considered to replicate observed work travel sufficiently, particularly given the difference in definitions.

10. Summary

The performance of the four-stage Christchurch Transportation Model, which has a 2006 calibrated base, was checked by comparing 2013 model outputs with observed data.

Inputs to the model were 2013 land use from Census, the 2013 road network excluding closures and capacity restrictions associated with the rebuild, and the 2015 bus system (new hub-and-spoke system). Available observed data included traffic counts, vehicle travel times, bus boardings, and Census journey-to-work travel patterns.

In terms of traffic volumes, the model did not quite achieve the validation criteria. However, the 2006 calibrated base similarly did not quite achieve the criteria. Overall, the 2013 forecast traffic volumes achieve similar levels of accuracy as the 2006 base. This was considered more than satisfactory, given the daily variation occurring in reality and the fact that only 60% of the count database was derived from recent counts. For vehicle travel times, the model replicated observed relatively well and to a similar level as 2006.

The modelled bus boardings replicated 2015 observed well in total, with more variation by route. The differences were, however, similar to the calibrated base and not considered significant. Of note, the current bus system has a completely different operating pattern compared with 2006, and yet the model is still replicating patronage to a similar degree of accuracy.

Modelled home-based work trips follow a similar distribution pattern as Census journey-to-work. There were slightly fewer intra-sector trips produced by the model, however, the same trend could be seen in 2006 and this may be due to definitional differences rather than the model themselves. Overall, the modelled distribution for work trips was remarkably similar.

The CTM replicated 2013/15 observed travel metrics to similar levels of accuracy as the 2006 calibrated base. While there were some outliers compared with observed, the state of flux of the transport system and the fluidity of travel patterns that occur on a daily basis due to the rebuilt, means that a high degree of accuracy is just not possible. Nevertheless, with the substantial change in land use distribution across the network, the CTM successfully replicated observed 2013/15 travel patterns.

The CTM was concluded as sufficiently replicating observed trip-making to continue its role as the overarching transport forecasting tool for the region.