1. INTRODUCTION

The purpose of this note is to document the Goods Vehicle Model for internal travel by medium and heavy commercial vehicles.

Medium and heavy vehicles, the definitions of which are shown in Table A2.1 of the NZ Transport Agency (NZTA) Economic Evaluation Manual (EEM), include any vehicle over 3.5 tonnes in gross laden weight. In this technical note, these are referred to as “heavy” vehicles for simplicity, although medium commercial vehicles are included.

The main data sources for model development were the Household Interview Survey (HIS) and the Roadside Interview (RSI) Surveys. The HIS by definition was household-based, and although some heavy vehicle trips by household residents were collected, the data were sparse and did not constitute a representative sample. The HIS was not designed for development of the heavy vehicle model and is not an appropriate source.

The roadside interview surveys collected data on travel by all vehicles across specified screenlines. While these provide information on travel by heavy vehicles, they are focused on particular areas and do not represent all internal travel. This data source is therefore most valuable as a validation check of average trip length across the surveyed screenlines.

The approach adopted was therefore to apply the Commercial Vehicle Model developed for Christchurch and ascertain whether this was appropriate for the Waikato.

In this technical note, the Christchurch model is initially summarised including the model components and relevant statistical indicators that demonstrate the model calibration. This is followed by the results of applying the Christchurch model to the Waikato in terms of comparing modelled with observed traffic volumes.

2. CHRISTCHURCH HEAVY VEHICLE MODEL

2.1 Overview

The Christchurch Model was produced by combining two key data sources to develop an observed base year matrix from which the model was then fitted.

The data sources were the roadside interview surveys conducted at 22 locations (three internal screenlines and the external cordon) supplemented by NAVMAN GPS data. Significant processing of the GPS data was required to identify trip ends and eliminate false observations, which included slow moving vehicles approaching traffic signals, GPS drift near the Port Hills, and movements within yards. The cleaned GPS dataset was spliced with the roadside interview survey, and matrix estimation techniques applied to produce a daily origin-destination matrix of heavy vehicle travel.

The model components developed included:

- Trip end model;
- Trip distribution model.

Each of the model components is described in turn in the following text.

2.2 Trip End Model

The trip end model is where the daily origins and destinations of internal-to-internal trips are estimated. Analysis was undertaken to determine linear relationships between the observed base year internal trip ends (for Christchurch internal-to-internal trips only) and land use parameters such as employment and numbers of households. Both the observed and explanatory land use data were aggregated from zones to sectors to resolve the lumpiness of the data associated with the sampling.

The internal trip end model was linear in form and developed using regression techniques. The procedure for calibrating the model was:

- Internal trip origins and trip destinations were averaged, to produce a single value for the internal trip end. This further assisted with smoothing out the data;
- All explanatory land use variables were initially included;
- SPSS was used to regress the independent and dependent datasets with a zero constant;
- Variables were then omitted from each model in a stepwise fashion. Variables were omitted if they had a negative coefficient, should not be present from a planning perspective, or the t-statistics were low. A t-statistic of two or greater indicated that the variable was statistically significant;

- This exclusion of variables continued until a satisfactory model was obtained. A satisfactory model must be logically acceptable from a transportation planning point of view as well as statistically significant.

The model finally adopted is shown in the following table with the adjusted R square which demonstrates a robust correlation.

Heavy Vehicle Internal Trip End Model			Table 1
Land Use	**Coefficient**	**T-statistic**	**Adjusted r^2**
Primary Employment	0.563	17.712	0.812
Household	0.031	2.016	

That is, the adopted model is:

$$TE_i = 0.563 PE_i + 0.031 HH_i$$

where: TEi is the trip end value for zone i; PE is the primary employment in zone i; and HHi is the number of households in zone i.

The types of land use that constitute "primary employment" are shown in the following table. Note that at the time of development of the Christchurch Model, the classification was only available in 1996 Australian and New Zealand Standard Industry Classification (ANZSIC) categories.

Primary Land Use Data	Table 2
	ANZSIC (1996) DIVISION
A	Agriculture, Forestry and Fishing
B	Mining
C	Manufacturing
D	Electricity, Gas and Water Supply
E	Construction

The source of employment data for Christchurch was the Annual Business Frame survey, conducted in February of each year by Statistics New Zealand to collect business demographic information. This introduces a definitional difference between the employment data used for Christchurch and Waikato. In Christchurch, Business Frame employment data were used, whereas in Waikato, Census employment data have been adopted. It is unlikely that this definitional difference in input employment land use will significantly affect the output of the model.

2.3 Trip Distribution Model

The internal trip distribution is where the internal trip origins are linked to the internal trip destinations to form a matrix of daily commercial vehicle trips.

The form of the trip distribution was a gravity model, which was estimated using self-calibrating gravity model functionality. A gravity model distributes trips according to the number of trips at each origin and at each destination and a deterrence function, which is negatively related to the spatial separation between origin and destination pairs.

Generalised cost is the main input to the deterrence function, which was calculated from parameters in the EEM. For heavy vehicles, generalised cost was calculated as travel time (in minutes) plus travel distance (in kilometres) multiplied by 2.26. This coefficient is obtained from the ratio between 0.3273 $/min and 0.7400 $/km, derivations of which are provided in Tables 3 and 4 respectively. Generalised cost is expressed in units of equivalent minutes.

Value of Time Derivation			Table 3	
Quantity	**Work**	**Commuting**	**Other**	**Source**
Base Value of Time	20.1 $/hr	7.8 $/hr	6.9 $/hr	EEM Table A4.1
Conversion from 2002 to 2006 values	1.11	1.11	1.11	EEM Table A12.2
Conversion from resource to perceived cost	1.00	1.15	1.15	EEM Table A11.1
Proportion of traffic	80%	8%	11%	Christchurch RSI Data
Final Value of Time	19.64 $/hr ie 0.3273 $/min			

Vehicle Operating Cost Derivation		Table 4		
Quantity	**Mcv**	**Hcvi**	**Hcvii**	**Source**
Base Vehicle Operating Cost	0.267 $/km	0.506 $/km	0.871 $/km	EEM Table A5.3/4/5
Conversion from 2002 to 2006 values	1.30	1.30	1.30	EEM Table A12.2
Conversion from resource to perceived cost	1.20	1.20	1.20	EEM Table A11.1
Proportion of traffic	51%	25%	25%	Christchurch Screenline ATC
Final Vehicle Operating Cost	0.7400 $/km			

The format of the gravity model is:

$$T_{ij} = a_i b_j P_i A_j F(C_{ij}),$$

where

T_{ij} = trips estimated from zone I to zone j

P_i = productions from zone i

A_j = attractions to zone j

a_i, b_j = row/column balancing factors

$F(C_{ij})$ = cost deterrence from zone I to zone j, and is represented mathematically by:

$$F(C_{ij}) = \exp(-\lambda C_{ij}),$$

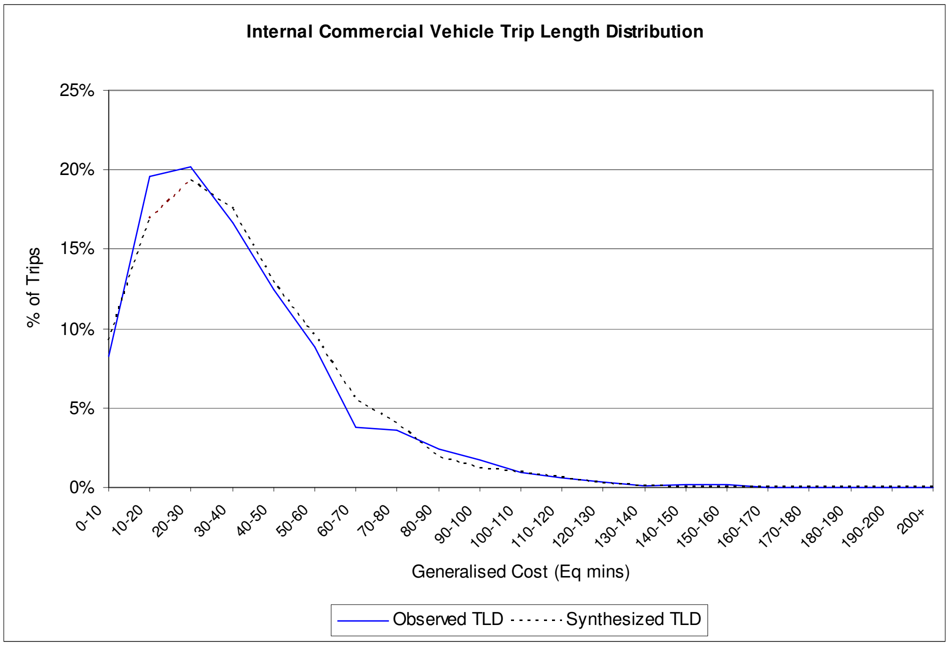
where

Cij = generalised cost of travel from zone i to zone j

λ = calibrated coefficient

The calibrated coefficient in the cost deterrence function shown above was 0.0184 for Christchurch.

The calibration of the model is demonstrated by plotting the observed heavy vehicle trips with the synthesized, or modelled, by generalised cost. These are shown below for Christchurch data.



The gravity model estimated for internal commercial vehicle movements was concluded to be acceptable.

3. APPLICATION FOR WAIKATO

The Christchurch trip end and trip distribution model were applied across the full Waikato model zone system.

The trip end model documented in Section 2.2 of this note was applied to Census employment and household data by Waikato Model zone to produce the estimated daily commercial vehicle trip ends.

The gravity model was then applied to these synthesized trip ends. At this preliminary stage of model development, matrices of travel time and distance produced from a daily assignment of light vehicle drivers (from the Household Interview Survey) were used. During the model validation, these will be replaced by travel time and distance matrices for heavy vehicles extracted from a multiple user class assignment.

The resulting daily matrix of heavy vehicles was assigned in the TRACKS model. The objective of this exercise was to determine whether the Christchurch model produced trips in the correct order of magnitude for the Waikato. The assignment therefore excluded light vehicles, which meant that the routeing did not consider existing congestion, and hence is not accurate to individual road level.

In the following table, the modelled flows are compared with observed for two screenlines: the bridges across the Waikato River, and the Hamilton/Waikato boundary. The modelled and observed flows represent both directions of travel combined.

Comparison of modelled with Observed – Heavy Vehicles – Screenline Volumes					Table 5
Site	**Count**	**Modelled**	**Change**	**%**	**Geh**
Fairfield Bridge	225	432	207	92.0	2.3
Boundary Rd Bridge	657	592	-65	-9.9	0.5
Claudelands Rd Bridge	92	407	315	342.4	4.1
Bridge St Bridge	363	916	553	152.3	4.5
Cobham Dr Bridge	2010	996	-1014	-50.4	5.3
Total Screenline 1	**3347**	**3343**	**-4**	**-0.1**	**0.0**
SH1 south of Shakespeare Cambridge	3747	2946	-801	-21.4	2.8
SH3 north of Tuere Te Awamutu	1788	1804	16	0.9	0.1
SH39 south of Hanning Piongia	882	634	-248	-28.1	1.8
SH23 west of Heddon Raglan	345	728	383	111.0	3.4
SH1 south of Tregoweth Huntly	4483	2496	-1987	-44.3	6.9
SH26 west of Harbottle	1123	1186	63	5.6	0.4
Total Screenline 2	**12368**	**9794**	**-2574**	**-20.8**	**5.0**

In total, the modelled heavy vehicle trips replicate observed almost exactly with a 0.1% difference for the first screenline, and are 20.8% lower than observed for the second screenline. The observed counts by definition include both internal and external travel whereas the modelled flows (in this case) only represent internal travel. The model should therefore estimate trip making lower than observed. At this stage, the comparison indicates that the model estimates heavy vehicle trips of the expected order of magnitude.

The comparisons between observed and modelled total screenline traffic are a measure of the combined generation and distribution models. Predicted traffic flows at individual locations on the screenline do not closely match observed counts at the daily level, due to the limitations of this preliminary heavy vehicle-only assignment in uncongested conditions, however all GEH values are less than seven when calculated from hourly flows.

The average trip length across the Waikato River estimated by the model was compared with the data in the roadside interview surveys. The average time, distance and generalised cost is shown below for modelled compared with observed.

Comparison of Modelled with Observed – Heavy Vehicles - Average Trip Length				Table 6
	Observed	**Modelled**	**Change**	**%**
Time (mins)	27.43	23.49	-3.94	-14.4
Distance	25.41	22.98	-2.43	-9.6
Cost (equiv mins)	85.87	76.34	-9.53	-11.1

This indicates that the model performs well, with a slightly shorter trip length compared with the internal heavy vehicle trips collected during the roadside interview surveys. The coefficient in the cost deterrence function calibrated for Christchurch could be adjusted to increase the average trip length. This will be considered during the model validation.

4. ALTERNATIVE DATA SOURCES

Discussions are ongoing to obtain data on freight generators within the region. This information will be used to supplement the model reported in this technical note. Depending on the quality and form of raw data provided, options are to extend the database of travel movements with which to calibrate and validate the model, or to assimilate selected inferred trip rates directly.

5. CONCLUSIONS

Overall, the heavy vehicle internal trip model calibrated for Christchurch was concluded to be applicable for the Waikato. The estimated number of trips across the Waikato River is comparable with observed, although marginally high. The modelled average trip length is also similar to that observed during the roadside interview surveys, although the model slightly underestimates the trip length.

Based on these indicators, the preliminary Waikato model for heavy vehicles performs satisfactorily, and is fit for incorporation into the full all-vehicle model.

Validation of road assignment will address comparison of modelled versus observed volumes for heavy vehicles in the context of a fully developed model and on a fully loaded road network. Methodology and parameters for the heavy vehicle model may be readdressed at that time if the heavy vehicle component of the modelled traffic volumes do not meet EEM validation criteria with respect to heavy vehicle counts.