CALIBRATION OF THE 1995 TRANS MODEL

Summary:

TRANS, a joint technical committee on transportation systems planning in the National Capital Region, (NCR) consists of representatives of the regional, provincial and federal governments having jurisdiction in the greater Ottawa-Hull area, as well as the two public operators. One of the key responsibilities of TRANS is the development and maintenance of the TRANS travel demand model.

The objective of this study is the calibration of the existing TRANS model to 1995 PM peak hour travel in the National Capital Region. The transportation demand model currently used by TRANS was calibrated on the 1986 OD survey and reflects 1986 travel behavior. In large metropolitan centers as the National Capital Region, transportation models are updated, or re-calibrated every 10 years to take into account current travel behavior characteristics.

In 1995, TRANS carried out the 1995 OD survey to record 1995 travel demand on a household and individual person level. The survey was a 5 percent sample of households in urban areas and a 20 percent sample in rural areas. The information collected included details about the household, characteristics of each individual in the household as well as information about each trip made by persons aged 10 or more. The 1995 model calibration task utilizes the 1995 OD Survey database and applies the same general structure of the existing model.

The existing model is a traditional four stage travel demand model consisting of trip generation, distribution, modal split and trip assignment models. The software used to simulate travel demand is EMME2. Travel demand is simulated by inputting travel demand equations which use the demographic databank to estimate travel demand. Travel demand is in the form of matrices representing trips between traffic zones. These matrices are assigned onto the networks to obtain auto person, auto vehicle as well as transit travel on the road and transit networks respectively. The calibration to 1995 conditions involves updating the demographic databank, developing new equations to estimate travel demand matrices and auto and transit networks reflecting 1995 conditions.

This report is structured in the manner that the calibration process was carried out. Chapter 2 describes the process used to update the auto and transit networks and the volume delay functions. Chapter 3 outlines the calibration of the trip generation model. Chapter 4 describes the trip distribution model and Chapter 5 describes the development of the modal split model. Chapter 6 provides insights learned from this modeling exercise where further study can be carried out to enhance the model.

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1. INTRODUCTION

1.1 Study Objective

TRANS, a joint technical committee on transportation systems planning in the National Capital Region, (NCR) consists of representatives of the regional, provincial and federal governments having jurisdiction in the greater Ottawa-Hull area, as well as the two public transit operators. One of the key responsibilities of TRANS is the development and maintenance of the TRANS travel demand model.

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2. NETWORK CALIBRATION

2.1 Overview:

This chapter outlines the method used to develop the auto and transit networks. The approach used to obtain the 1995 networks began by developing an ultimate network containing all potential road and transit infrastructure improvements that could occur within the next 30 years. A system was then developed to “turn off” improvements until the desired 1995 network was in place. The advantage of this approach is that all networks that may be studied will have a common node and link system, making comparisons between alternatives possible using EMME2 software. The main tasks in developing the networks are:

- Converting the existing EMME2 networks to the NAD 27 coordinate system.

- Expanding the rural network to better replicate the road system in areas anticipated to develop within the 2021 time frame.

- Modifying the number and location of centroid connectors, allowing traffic to spread more uniformly throughout the network.

- Reviewing turn penalties for 1995 and 2021 networks.

- Developing new volume delay functions for the auto and transit modes.

- Revising the transit route descriptions such that transit time functions are based on congested roadway speeds.

2.2 Convert Existing EMME2 Network to NAD 27 System

The existing EMME2 network was developed by digitizing several base maps covering urban areas within National Capital Region (NCR). Roads in the auto network include highways, arterials, several collectors and local roads where transit service exists. For the rural areas, a skeleton network was developed where links were inputted to represent desired lines of travel where the road system was sparsely developed. The transit network uses the road network supplemented with route descriptions indicating where bus routes travel as well as headways, lay-over times, etc.

For the new road network, the geographic location of roads and intersections were defined based on the coordinate system contained in the Regional Municipality of Ottawa-Carleton (RMOC) Microstation database. NAD 27 was used as the base since this was the system in use at the time this study was carried out.

The existing EMME2 network was inputted into the Microstation environment and coordinates were obtained for all link's beginning and end points. The new coordinates were then fed back into the EMME2 software to re-position the network to the new coordinate system. With the EMME2 network contained in the Microstation environment, it was possible to refer to this system to determine coordinate locations for any new roads that may be required to input into the EMME2 software environment. Once this task was completed, it was possible to carry out the remaining network modifications as outlined in the remainder of this chapter.

2.3 Expanding EMME2 Network into Rural Areas.

To provide suitable travel demand simulations outside the Greenbelt, additional links were coded into the network using Microstation to obtain the appropriate x-y coordinates. In the rural areas where the Microstation road network is currently not developed, conceptual nodes and links were added to provide better replication of the highway system outside the NCR where external travel enters and leaves the network via external nodes.

2.4 Centroid Connector Modifications

A review was made of the location and number of centroid connectors to determine if they adequately distributed current and future traffic onto the network. New centroid connectors were connected between zone centroids and the road network in a manner to limit the trips on a centroid connector to under 1000 trips. In most cases, between 2 and 4 connectors are used.

2.5 Turn Penalties

A review was carried out on the 1995 turn penalties by comparing the penalties to RMOC by-laws in effect for 1995. Furthermore, modifications were made to the turn penalty files where an existing turn penalty became invalid due to a node numbering change between the new and existing networks. In the Communauté urbaine de l"Outaouais (CUO), turn penalties in the existing network were verified by field inspections.

To obtain the 2021 turn penalty file, a review was made to find turn restrictions that were in the 2021 RMOC Official Plan Review (OPR) network but not in the 1995 OPR network. These turn restrictions were then modified to conform with the new networks developed in this study combined with the new 1995 turn restrictions, giving the new 2021 turn movement file.

2.6 Macros to Convert SC5 to 2021 OP and 1995 Networks

As described previously, the approach used to obtain the new 1995 network was based on the development of a future network that has all the proposed and/or studied road and transit options examined in the RMOC and CUO. Facilities in this network were then "turned off" to such that auto and transit trips were not assigned onto these facilities. However, with this method, it is assumed that the volume delay functions remain the same unless the user goes in and manually alters them.

A special volume delay function of 10 with a high delay is used to “turn off” roads to ensure no traffic is assigned to these facilities. The 2021 and 1995 networks contain the volume delay number other than 10 if the road is assumed to be in place by 1995 or 2021. Lanes which will be widened between 1995 and 2021 maintain the same volume delay function between 1995 and 2021, with only the number of lanes changing. If it is considered important to have different volume delay functions for a link in different scenarios, the user must go in and manually make this change.

The network conversions is accomplished by using the link UL3 field containing a road improvement tag. Three networks were developed for this modeling exercise:

- **sc5** is a network containing a wide range of potential new roads, road widenings and transit facilities considered as potential network options in the recent RMOC Official Plan Review.
- **2021** network is the network reflecting the road system that is anticipated to be in place by 2021 according to the OPR.
- **1995** network is the network in place during the fall of 1995 and the spring of 1996.

To convert sc5 to 2021 network, use macro sc5to21.mac. To obtain the 1995 network, run macro sc5to95.mac. The corresponding transit route description, turn penalties, etc. are also batched into the new 1995 and 2021 networks.

2.7 Development of New Volume Delay Functions

Volume delay functions are equations used by the EMME2 software to determine travel times on roads that are sensitive to changes in roadway traffic volume. In order to provide more suitable simulation of travel demand on roadways, it was decided to develop new volume delay functions based on roadway lane capacity and posted speed limits rather than those currently used in the TRANS model. This method of using lane capacity and posted speed limits is currently in place in other cities as Regina and Vancouver.

The method developed to define a particular delay function for a road is based on the nominal capacity and posted speed used in the function equation. The first digit of the delay function name is the nominal capacity of the road divided by 200. The second digit is the first digit of the posted speed limit under 100 kph. Links with speeds of 100 kph use 0 as the second digit in the function name.

Posted speeds for the 1995 network were obtained by reviewing by-laws and with in-house knowledge of staff in the Mobility Services Division. Maps of the EMME2 network in Hull, Gatineau and Aylmer were passed on to staff in each of these communities for their input.

Speed limits were then inputted into the UL1 field and lane capacity into the UL2 field in the sc5 network. Exhibit 2.1 contains guidelines to assist in identifying nominal capacity of roads in the NCR. For future roads, a suitable posted speed and capacity were coded into the appropriate UL fields. An EMME2 macro named vdf.mac was developed to calculate the correct vdf function number into the vdf link field.

Exhibit 2.1 - Guidelines to Assign Link Nominal Capacaties to NCR Roads

Road Classification	On Street Parking	Operation	Location			Freq. Signals	Few Signals	At Grade Intersections	Raised Median	Grade Sep. Intersections	Example	Capacity per Lane
			CBD	Urban	Rural							
Centroid Con.		2 way										See note 1
Local	x	2 way						x				400
Collector	x	2 way	x	x		x		x			Percy	400
Collector	x	2 way		x	x		x	x			Jockvale Rd.	600
Arterial	x	2 way	x			x		x			Elgin (2 directions)	400
Arterial		2 way	x			x		x			Queen Street	600
Arterial		2 way	x			x		x			Bank (no left turns etc)	800
Arterial		1 way	x			x		x			Slater	800
Arterial	x	2 way		x		x		x			Wellington @ Parkdale	600
Arterial		2 way		x		x		x			Parkdale	800
Arterial		2 way		x		x		x	x		Merivale @ Baseline	1000
Arterial		2 way		x	x		x	x	x		Hunt Club (western part)	1200
Parkway		2 way		x			x	x			Q. Eliz. & Co. By Dr.	800
Parkway		2 way		x			x	x	x		Ottawa R. & Island P.	1000
Parkway		2 way		x					x	x	Airport Parkway	1200
Highway		2 way		x		x		x			Hwy 31 @Hunt Club	800
highway		2 way		x			x	x			Hwy 16 @Hunt Club	1000
Highway		2 way			x	x		x			Hwy 16 at Woodroffe	1200
Highway		2 way			x			x			Rural highways	1600
Bus lane-urban		2 way									Slater, Albert, Maisonneuve	See note 2
Bus lane-Hwy		2 way									Hwy 17, Orleans	See note 2
Transitway		2 way									Transitway	See note 2
Hwy 417		1 way	x	x	x				x		ramps	1200
Hwy 417		2 way	x	x					x	x	CBD - lanes - much weaving	1600
Hwy 417		2 way		x	x				x	x	lanes - little weaving	1800

Notes
1 Centriod connector capacity set to 1000.
2 Transit only facilities do not use lane capacity. To flag these facilities, a capacity of 1400 is reserved for these facilities.

The exceptions to the above rules are the following:

- Volume delay function (Fd) Fd10 is set such that the delay is infinite and no traffic is assigned to a link (used to turn new roads “on” or “off”).
- Centroid connectors are reserved for functions fd11-19.
- FD 70-79 are reserved for future use and are presently used to flag transit bus only lanes and transitways.

An advantage of the new delay functions is that they are user friendly. The number describing the function allows the coder to quickly identify which function to use once the posted speed and lane capacity are established. The graphic capabilities of EMME2 can be used to do quick checks to ensure speeds, capacities and delay functions are suitable on a link and network basis.

Exhibit 2.2 tabulates the volume delay (FD) functions for easy reference and contains samples of the functions to clarify the relationship of how the equations alter given different posted speeds and lane capacities.

Exhibit 2.2 - Methodology of Naming Volume Delay Functions (FD)

	Nominal Capacity (vehicles per hour / lane)								
Posted Speed (kph)	See Note 1	400	600	800	1000	1200	See Note 2	1600	1800
20	12	22	32	42	52	62	72	82	92
30	13	23	33	43	53	63	73	83	93
40	14	24	34	44	54	64	74	84	94
50	15	25	35	45	55	65	75	85	95
60	16	26	36	46	56	66	76	86	96
70	17	27	37	47	57	67	77	87	97
80	18	28	38	48	58	68	78	88	98
90	19	29	39	49	59	69	79	89	99
100	10	20	30	40	50	60	70	80	90

General Comments: Areas not shaded areas reflect DF functions frequently used in the TRANS model on roadways.
FD numbering is determined as follows:
The first number is the nominal capacity divided by 200
The second number is the first digit of the posted speed limit under 100 kph.
For example, FD45 is a road with a nominal capacity of 800 and posted speed of 50 kph.

Notes: 1 - FD10 has infinite delay and is used to switch off links in the network
FD11 not used
FD12 used for CBD centriods
FD13 used for centriods just outside CBD
FD14 not used
FD15 for zones inside the Greenbelt
FD16 for centriods just outside the Greenbelt
FD17 not used
FD18 for rural centriods
FD19 for external zone centriods
FD 70 -79 reserved for future use. At present they are used to flag transit only facilities.

Sample of Volume Delay Function Formulas

Function	Formula
fd10	100000
fd11	1.1 * (length / 10) * (1+.6 * ((volau + volad) / (lanes * 1000)) ^4) * 60
fd35	1.4 * (length / 50) * (1+.6 * ((volau + volad) / (lanes * 600)) ^4) * 60
fd46	1.3 * (length / 60) * (1+.6 * ((volau + volad) / (lanes * 800)) ^4) * 60
fd57	1.2 * (length / 70) * (1+.6 * ((volau + volad) / (lanes * 1000)) ^4) * 60
fd89	1.1* (length / 90) * (1+.6 * ((volau + volad) / (lanes * 1600)) ^4) * 60
fd90	1.1* (length / 100) * (1+.6 * ((volau + volad) / (lanes * 1800)) ^4) * 60

2.7.1 Calibration of Auto Volume Delay Functions

Volume delay functions traditionally used in the EMME2 model are based on functions developed by the US Bureau of Public Roads (BPR). In the function, travel time along the road section is based on characteristics as free flow travel time and lane capacity. The form of the auto volume delay function is:

Volume delay = (free flow travel time on road section)+(travel time due to congestion)

In mathematical form this amount to:

*((length/free flow speed)*60 min./hour)*(1+**A***(road volume/(#lanes*lane capacity)))^4*

The congested delay time is estimated using the function to the power of 4. The steepness of the delay time curve is primarily governed by “A” which typically has values ranging form .2 to 1. The greater the value of “A”, the steeper the curve and the more delay occurs as traffic volumes increase.

In the functions developed by the BPW for highway facilities, free flow speed is approximately equal to the posted speed limit. However, in urban areas, free flow speed is much slower than the free flow speed (assumed equal to the speed limit in our case) since significant time is spent stopped at traffic signals. For this reason, it was decided to insert a new coefficient “B” into the equation to reduce the free flow speed for a signalized urban street system.

B*((length/free flow speed)*60 min./hour)*(1+**A***(link volume/(#lanes*lane capacity))^4*

This implies that two coefficients require calibration, “B “ to adjust for free flow speeds in the urban signalized street system and “A” to adjust for delay as traffic congestion increases. Calibration of the volume delay functions is an iterative process where trips are assigned to the network and the volume delay coefficients are modified such that travel speeds along roads approach those observed on the road system and at the same time simulated traffic volumes have values close to screenline counts.

Coefficient “A”

It was decided to estimate coefficient “A” first by setting coefficient B to 1.0. Coefficient “A” was calibrated by comparing screenline counts to simulated volumes on the network. Assignments to the 1995 auto network were carried out by assigning the PM peak hour auto vehicle matrix. This matrix was obtained by adding the 95 OD Survey observed auto vehicle trip table (excluding external-internal trips) to a 1995 matrix consisting of the auto vehicle trips to and from the NCR not captured by the 95 OD Survey which gives total auto vehicle travel demand. After doing a systematic analysis, the values for coefficient “A” were .6 for lower volumes roads with lane capacities between 400 to 1400,.8 for lane capacities of 1600 and 1.0 for lanes capacities of 1800.

During the calibration process, it was found necessary to increase the posted speed limit of NCC roads by 10 kph. This was necessary to compensate for their unique design compared to other roads in the NCR. NCC roadways are scenic routes aligned along attractions as waterfronts and tend to be non-linear routes with longer origin-destination distances than routes utilizing other public roadways. These roadways have few traffic signals and no private accesses. By increasing the posted speed limit in the model, it assumes traffic flows faster on these routes due to their unique design.

Coefficient "B "

With the coefficient "A" established, it was possible to obtain coefficient "B". Simulated travel times on the auto network was compared to travel time and speeds from two sources of information:

- RMOC, STO and MTQ in house travel time survey.

  This in house survey was carried out in April 1997 to obtain information on auto travel times in the NCR area during the PM peak period. The participants consisted of staff from the RMOC, NCC, and CUO who were asked to record in-vehicle trip start and end times to the nearest minute. Over 170 origin-destination auto and transit trip times were obtained from this survey.

- OC Transpo Bus Travel Speed (with and without stopping for passengers).

  OC Transpo has facilities to record bus speeds while in active service. Information is collected on the time and speed of travel which can be separated into two components:
  - Average moving speed, which includes the time moving between bus stops.
  - Average total speed, which includes the time moving between stops, stop and go time, idle time, dwell time and excess time.

It was assumed the average moving speeds of autos along arterial roads would be marginally slower than the average moving speeds observed by OC Transpo. No additional surveys were carried to determine the difference between the average operating speed of buses and cars.

The numerical value of the "B" coefficient is multiplied by the length of the link, thereby calculating the free flow travel time based on a link set artificially longer. Therefore, a factor of 2 would cause a posted speed of 50 kph to have a maximum operating speed of 25 kph.

Estimates of the "B" coefficient were obtained by comparing a sample of posted speed limits to OC Transpo average moving speeds. It was found that the most suitable approach was to use one factor for each set of volume delay curves for a given lane capacity. Therefore, roads with a low capacity of 400 vehicles/hour which are used on roadways in the CBD and residential streets was given a factor of 1.7, changing the posted speed limit of 50 kph to a free flow operating speed of about 30 kph.

High capacity roadways as the Queensway and rural highways were given a factor of 1.1. This factor was obtained partly using judgment since OC Transpo operating speeds on these facilities is not available and/or not applicable and by observing that longer trips in the RMOC in house survey were too fast unless this adjustment was made.

An auto assignment was carried out to obtain auto link speeds which were compared to the operating speeds on a random sample of links where OC Transpo speeds were recorded, see Exhibit 2.3. The results indicate that the mean simulated auto speed was 36 kph while the OC Transpo speed was 31 kph. The other statistical indicators indicate that the OC Transpo speeds are generally slower and less dispersed compared to the simulated auto speeds. It was concluded that the auto speeds obtained provided a satisfactory estimate of auto speeds.

Exhibit 2.3 - Link Speeds Simulated vs OC Transpo

Data Source	Mean	Minimum	Maximum	Standard Deviation
Simulated	36	20	46	6.1
OC Transpo	31	18	42	4.9

Exhibit 2.4 illustrates the fit of estimated zonal travel times using the new volume delay functions to auto travel times 10 minutes and over reported in the in-house survey. For this comparison, EMME2 zone access time was set to 0 since the survey recorded in-vehicle travel times.

Exhibit 2.4 - Auto Time (Simulated Versus In - House Survey)

Data Source	Mean	Minimum	Maximum	Standard Deviation
Simulated	18	1	61	11.1
In - House Survey	20	10	60	9.3

The results indicate that there is a good fit for trips over 10 minutes recorded in the in-house survey. Trips under 10 minutes are difficult to predict since the trip travel time are heavily reliant on centroid length. The model estimated average trip time was 18 minutes while the survey average time as 20 minutes.

2.7.2 *Centroid Connector Volume Delay Functions*

Centroid connectors are imaginary links from which all trips from a zone enter or exit the auto and transit networks. A systematic method was chosen to select a suitable speed for centroid connectors. The method is based on choosing a speed based on geographical location where the speed is assumed representative of auto travel along minor roadways in PM peak hour congested traffic. The speed on these links was assigned for RMOC links as follows:

- 20 kph for areas within the CBD
- 30 kph for areas just outside the CBD
- 50 kph for the remainder of the links within the greenbelt
- 60 kph for areas just outside the greenbelt
- 80 kph for the remainder of internal zones
- 90 kph for external zones

A similar approach was used to assign speeds to CUO centroid connectors. Centroid link connector capacity was set to 1000.

2.8 Transit Network Calibration

The first task in calibrating the 1995 transit network was to review transit routing to ensure they reflect transit operation during the fall of 1995. The transit route descriptions used in the 1995 network for the Official Plan Review (OPR) were reviewed using September 1995 OC Transpo route map supplemented with individual route maps when necessary. 1995 CUO transit routes were reviewed to ensure that the routes maintained the paths as coded by CUO staff before the network was refined as discussed previously.

For roadways where buses operate on a lane designated for transit, the auto network was modified to reflect the number of lanes actually available for cars on roads as Albert and Slater. For Maisonneuve Boulevard in Hull which has a HOV lane used by cars and buses, the number of lanes per direction was set to 2.5 rather than 3 lanes.

2.8.1 Transit Volume Delay Functions

A key concept in the model calibration was to have transit in-vehicle travel times sensitive to auto traffic when operating in mixed traffic. This would allow transit travel times to alter as roadway traffic increases. The existing TRANS model assumed that transit speeds would remain unaffected by changes to roadway congestion. The method used in the 1995 model calibration utilized transit travel time functions coded into the transit route descriptions. Two type of transit functions were developed:

- One type being sensitive to auto traffic congestion
- Another type having a constant transit operating speed (transitway and bus lanes).

Where the bus route operates in mixed traffic, the bus travel time function is based on the congested auto time multiplied by a factor to account for frequent stopping to load and unload passengers. The factors were estimated based on OC Transpo data by dividing average moving speed by average total speed. Where buses operate on transitways and roadway lanes restricted for buses, a speed of 48 kph was used for all transitways and 15 kph for bus only lanes.

EMME2 1995 route travel times were verified using route schedules and bus average running speeds. The transit travel time functions were considered calibrated once the scheduled time and speeds along the links sampled were considered to be acceptability close to one another. Exhibit 2.5 contains a sample of 143 routes with travel times obtained from EMME2 and transit schedules. The results indicate that the model estimates an average transit route travel time of 55 minutes while bus schedules give a mean time of 58 minutes. Much of the variance between the two samples occurs for routes with travel times over one hour which are usually regular service routes which carry a small proportion of peak hour transit users.

Exhibit 2.5 - Transit Route Travel Time Comparison

Data Source	Mean	Minimum	Maximum	Standard Deviation
Simulated	55	6	150	31
Observed	58	13	183	35

The following transit time functions were found to simulate transit satisfactorily:

- ttf70= auto time on link * 1.6 -> this function is used where the transit route uses roads shared with private vehicles.

- ttf71 = (length/15) * 60 -> this function is used on bus only lanes where it is assumed the bus travels at 15 kph along the roadway.

- ttf72= (length/48) *60 -> this function is used for transitway links where it is assumed the bus travels at a constant speed of 48 kph.

- ttf73= auto time on link * 2.5 -> this function is used where the transit route uses Bank Street from Wellington Street to Riverside Drive.

- ttf74= (length/70) *60 -> this function is used for bus only lanes along the Queensway where buses travel at 70 kph.

2.8.2 2021 Transit Routes

The development of the 2021 transit routes based on the new 2021 network and transit time functions was developed at this time such that both an auto and transit networks were available for both 1995 and 2021. The 2021 routes were obtained as follows:

Using the 1995 OPR and 2021 OPR transit routes, they were divided into five categories:

- Routes that were identical in both the 1995 OPR and 2021OPR networks.
- Routes that had minor changes between the 1995 OPR and 2021 OPR route descriptions.
- Routes that had major changes between the 1995 OPR and 2021 OPR route descriptions.
- New routes- that is routes that are in 2021 OPR but not in the 1995 OPR route descriptions.
- Deleted routes- routes that are in 1995 OPR file and not in the 2021 OPR file.

Once it was clear how the two route descriptions differed, it was possible to build the new 2021 routes as follows:

- Substitute the new 1995 route descriptions where the 1995 OPR and 2021 OPR routes were identical.
- If the route was slightly different the nodes would be analyzed to see where changes were required. If the route was extended or shortened to enter a transit station or a shopping center, or if the error was a result of updates in the network, the routes from the 1995 OPR file would be used.
- If the route in the 2021 OPR route description was significantly different from the 1995 OPR route descriptions, the 2021 OPR file would be used. These routes were updated to include the new volume delay functions.

If the route was not in the 1995 OPR route description but was in the 2021 OPR description, then the data from the 2021 OPR was used. These routes were updated to include the new volume delay functions.

- If the route was in the 1995 OPR route description but not in the 2021 OPR , the route was omitted from the 2021 route descriptions.

2.9 Assignment Results

Exhibit 2.6 compares screenline counts with assigned auto volumes of the 1995 OD Survey on to the new 1995 network. The screenline volumes for RMOC facilities are an average of 1995 and 1996 summer counts. This is because the 1995 count program was sparse while the 1996 counts contained information at all screenline locations. In house studies at the RMOC indicate that summer counts are approximately equal to fall counts and therefore no adjustments were made to convert the RMOC data to fall. For the STO area, 1995 counts carried out in the fall were used.

The results indicate that the OD survey differ from the counts in a pattern whereby Ontario screenlines have the survey higher than the counts, while in Quebec, the survey is lower than the counts. The OD survey was carried out in a manner that did not bias the method to collect trip information between the two provinces. The differences between the survey and the counts is likely due more to differences in the way traffic counts were conducted.

2.10 Further Work on Networks

The new 1995 network developed as outlined above could be further refined in the CUO network, particularly in the Hull area. A detailed review was not carried out to verify if additional turn penalties are warranted and should be coded into the networks.

For the 2021 network, it will be necessary to review the network in the area around the bridgeheads across the Ottawa River and the Rideau Canal. The new network does not take into account the new HOV lane on Portage Bridge, changes to the operation of MacKenzie King Bridge and traffic operational changes around the Rideau Centre and Ottawa University area. For the 2021 transit system, a review should be carried out to verify that the proposed east-west rail corridor is being simulated to the conditions seen appropriate for the study.

Exhibit 2.6 1995 Auto and Transit PM Peak Hour Screenline Results

OUTBOUND

Screenline	TOTAL PERSONS			AUTO PERSONS			AUTO VEHICLES			TRANSIT		
	Observed Counts	Survey Assigned	Survey / Counts	Observed Counts	Survey Assigned	Survey / Counts	Observed Counts	Survey Assigned	Survey / Counts	Observed Counts	Survey Assigned	Survey / Counts
Ottawa River (LN2,3,4)	15,574	16,642	1.07	13,168	13,931	1.06	10,180	10,886	1.07	2,406	2,711	1.13
Rideau River (LN19,20,32,33)	28,284	30,970	1.09	21,792	22,008	1.01	16,509	17,521	1.06	6,492	8,962	1.38
CPR (LN27, 28, 29)	19,880	21,224	1.07	14,931	14,443	0.97	11,236	11,720	1.04	4,949	6,781	1.37
Ottawa Central Area (LN35-38)	35,356	36,488	1.03	19,495	19,907	1.02	13,523	14,822	1.10	15,861	16,581	1.05
Rideau Canal (LN34, 39)	29,370	26,903	0.92	20,707	19,252	0.93	15,301	15,009	0.98	8,663	7,651	0.88
Fallowfield (LN9, 43)	7,777	7,823	1.01	7,039	6,667	0.95	5,551	5,514	0.99	738	1,156	1.57
Eagleson (LN10)	8,897	10,263	1.15	7,897	8,961	1.13	6,049	7,116	1.18	1,000	1,302	1.30
Green Creek (LN16)	11,319	13,215	1.17	8,189	9,515	1.16	6,607	7,703	1.17	3,130	3,700	1.18
CNR West / Acres (LN11,12)	18,982	19,701	1.04	16,245	16,255	1.00	12,678	13,362	1.05	2,737	3,446	1.26
CNR East (LN13,14,15)	13,555	13,998	1.03	12,274	12,680	1.03	10,595	10,383	0.98	1,281	1,318	1.03
Western Parkway (LN24,25)	18,528	20,159	1.09	15,683	16,483	1.05	12,339	13,355	1.08	2,845	3,676	1.29
Leitrim / Ramsayville (LN7,8)	6,114	5,956	0.97	6,099	5,934	0.97	4,669	5,035	1.08	15	22	1.47
Ile de Hull (LN60)	21,061	22,020	1.05	17,551	18,644	1.06	12,896	14,273	1.11	3,510	3,376	0.96
Boul. Gamelin (LN 61)	14,297	10,418	0.73	13,003	9,661	0.74	9,853	7,496	0.76	1,294	757	0.59
Ch. de la Montagne (LN62)	5,058	3,601	0.71	3,638	2,633	0.72	2,805	2,095	0.75	1,420	968	0.68
Deschenes (LN63)	5,211	4,099	0.79	4,041	3,185	0.79	2,959	2,457	0.83	1,170	914	0.78
Q64	3,546	3,203	0.90	3,146	3,012	0.96	2,425	2,357	0.97	400	191	0.48
Q65	13,577	13,963	1.03	11,885	12,308	1.04	8,370	9,518	1.14	1,692	1,655	0.98
Q66	2,698	2,167	0.80	2,668	2,167	0.81	1,953	1,782	0.91	30	-	0.00
Montee Paiement (LN67)	9,171	8,587	0.94	8,081	7,770	0.96	5,953	5,994	1.01	1,090	817	0.75
Q68	4,834	4,465	0.92	4,514	4,209	0.93	3,371	3,152	0.93	320	256	0.80

INBOUND

Screenline	TOTAL PERSONS			AUTO PERSONS			AUTO VEHICLES			TRANSIT		
	Observed Counts	Survey Assigned	Survey / Counts	Observed Counts	Survey Assigned	Survey / Counts	Observed Counts	Survey Assigned	Survey / Counts	Observed Counts	Survey Assigned	Survey / Counts
Ottawa River (LN2,3,4)	9,212	7,097	0.77	7,344	5,141	0.70	5,596	4,376	0.78	1,868	1,956	1.05
Rideau River (LN19,20,32,33)	22,151	19,825	0.89	19,662	17,639	0.90	14,774	14,655	0.99	2,489	2,186	0.88
CPR (LN27, 28, 29)	12,467	12,543	1.01	10,422	10,905	1.05	8,294	9,019	1.09	2,045	1,638	0.80
Ottawa Central Area (LN35-38)	19,517	16,024	0.82	13,921	10,162	0.73	10,338	8,217	0.79	5,596	5,862	1.05
Rideau Canal (LN34, 39)	20,575	18,267	0.89	15,562	14,075	0.90	11,893	11,841	1.00	5,013	4,192	0.84
Fallowfield (LN9, 43)	3,312	2,036	0.61	3,242	1,971	0.61	2,448	1,640	0.67	70	65	0.93
Eagleson (LN10)	4,803	5,074	1.06	4,643	4,902	1.06	3,834	4,166	1.09	160	172	1.08
Green Creek (LN16)	3,805	3,501	0.92	3,551	3,296	0.93	2,609	2,567	0.98	254	205	0.81
CNR West / Acres (LN11,12)	13,180	10,498	0.80	12,510	9,914	0.79	9,830	8,478	0.86	670	584	0.87
CNR East (LN13,14,15)	8,442	6,235	0.74	8,016	6,082	0.76	6,570	5,076	0.77	426	153	0.36
Western Parkway (LN24,25)	11,548	10,703	0.93	10,596	9,831	0.93	8,246	8,199	0.99	952	872	0.92
Leitrim / Ramsayville (LN7,8)	3,028	1,924	0.64	3,017	1,907	0.63	2,180	1,609	0.74	11	17	1.55
Ile de Hull (LN60)	7,236	6,796	0.94	6,486	6,298	0.97	5,166	5,211	1.01	750	498	0.66
Boul. Gamelin (LN 61)	7,580	4,095	0.54	6,800	3,695	0.54	5,310	3,068	0.58	780	400	0.51
Ch. de la Montagne (LN62)	2,280	1,175	0.52	1,960	1,113	0.57	1,537	842	0.55	320	62	0.19
Deschenes (LN63)	1,758	1,115	0.63	1,732	1,096	0.63	1,343	879	0.65	26	19	0.73
Q64	986	576	0.58	941	551	0.59	742	492	0.66	45	25	0.56
Q65	4,727	3,265	0.69	4,547	3,072	0.68	3,456	2,554	0.74	180	193	1.07
Q66	1,239	908	0.73	1,239	908	0.73	870	740	0.85	0	-	0.00
Montee Paiement (LN67)	5,311	2,404	0.45	5,236	2,343	0.45	3,777	1,913	0.51	75	61	0.81
Q68	2,374	1,864	0.79	2,294	1,847	0.81	1,657	1,414	0.85	80	17	0.21

3. TRIP GENERATION MODEL CALIBRATION

3.1 Overview

This chapter outlines the development of the trip generation equations based on the 1995 OD survey. The study began by reviewing demographic and travel demand trends by trip purpose and mode as reported in the 1986 and 1995 OD surveys. A review was also carried out of the existing trip generation model. From this exercise, it was possible to gain insight into the style the new model would take and the key variables to include in the trip generation equations.

The RMOC and CUO Planning Department demographic data for 1995 as well as the 1995 OD survey data were the two data sources used for developing the new trip generation model. Analysis was carried out by comparing common data between the two data sources to identify, and if possible correct for biases in the 1995 OD survey that may influence the trip generation equations.

Based on the above study, the new 1995 trip generation equations were developed using auto person and public transit trips and the same trip purpose definitions as the existing model as listed below:

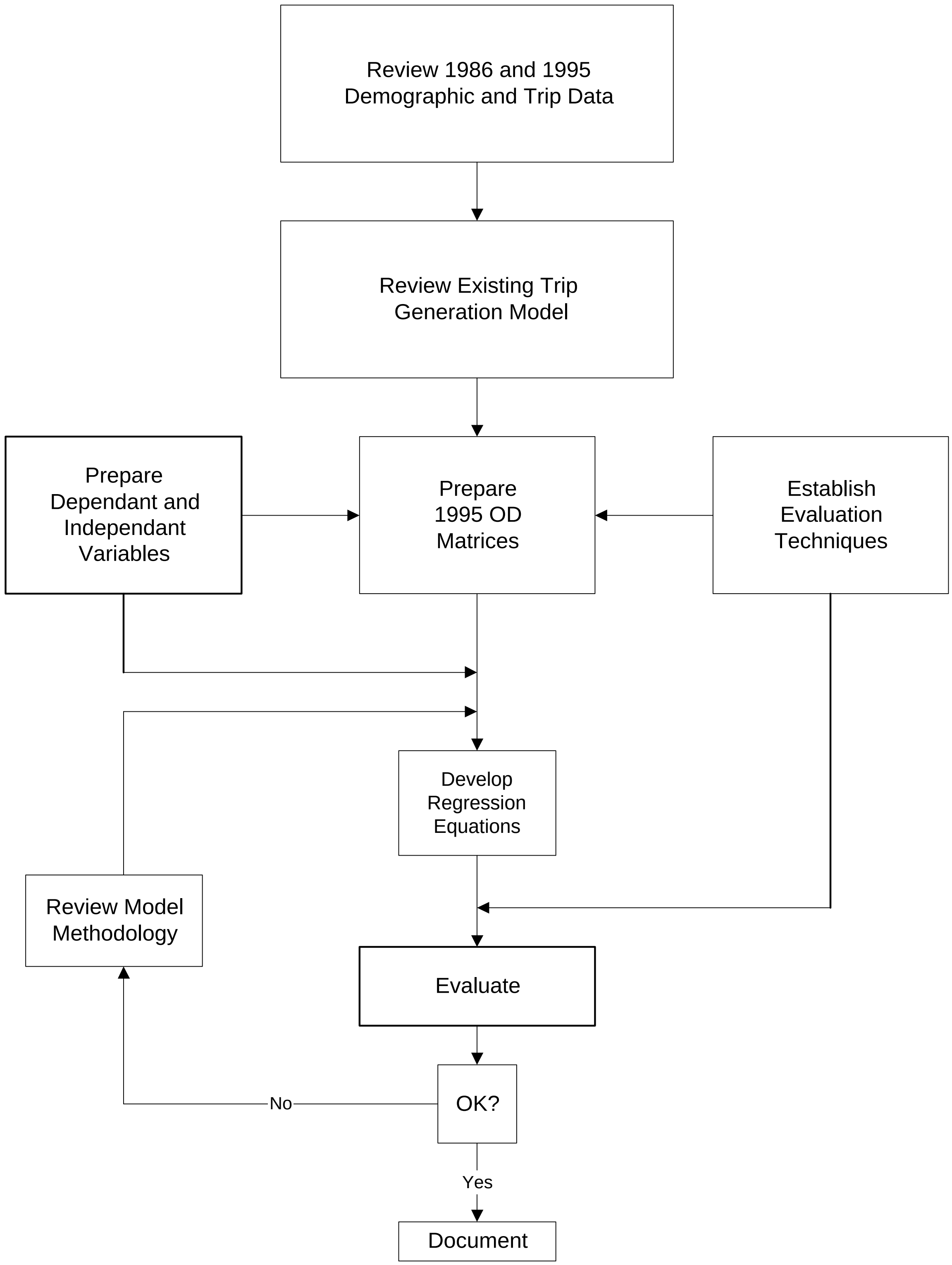
- Work to home
- School to home
- Other to home
- Leave home
- Non-home based

In most cases, the new trip generation model uses the same independent variables as the existing model. However, alternative equations were tested in an attempt to obtain equations that provided a more suitable fit to the data.

As with the existing model, the trip generation equations were developed for PM Peak period defined by the time interval 3:30 PM and 5:59 PM. However, in the new model, factors are applied to the outputs of the trip generation equations to convert to the PM peak hour of the auto mode (4:16 PM to 5:15 PM). In the existing model, factoring from the peak period to the peak hour was done after mode split. This new approach has the advantage of utilizing a large sample for developing the trip generation model and at the same time allows the rest of the model to reflect peak hour conditions that provides a more accurate simulation of trip distribution, mode split and ultimately PM peak hour trip assignment.

The process used for developing the trip generation model is summarized in Exhibit 3.1.

Exhibit 3.1
Trip Generation Process



3.2 Comparison of Demographic Data (1986 and 1995)

The key demographic variables for 1986 and 1995 that influence trip generation are illustrated in Exhibit 3.2. Note that total population increased 19 percent from 806,600 to 960,400 while the numbers in the individual age cohorts fluctuated. The 15-24 age group declined to 90 percent of the 1986 amount while the 45-64 and 5-14 groups increased by close to 30 percent over the 1986 figure. 1995 post secondary students are over twice the 1986 amount. A detailed explanation of how demographics changed between 1986 to 1995 is provided in the TRANS report "1995 NCR OD Survey- Highlights of the Demographic and Travel Patterns", May 1997.

Exhibit 3.2 - Demographics, 1986 and1995

Variable	Variable name	1986	1995	Increase over 1986
Total Population	POP	806,600	960,400	1.19
Popul. aged 5-14	POP5-14	105,300	134,400	1.28
Popul. aged 15-24	POP15-24	139,800	126,500	0.90
Popul. aged 25-44	POP25-44	284,800	344,700	1.21
Popul. aged 45-64	POP45-65	151,500	195,100	1.29
Popul. aged 65 & over	POP65+	70,700	85,200	1.21
Dwelling units	DWEL	298,300	374,400	1.26
Total Employment	EMP	409,300	454,900	1.11
Total Employment less Retail Employment	EMP (other)	357,900	393,900	1.10
School Enrollment				
Primary & Secondary	SCHS	93,000	117,100	1.26
Post Secondary	SCHP	30,000	78,400	2.61
GLA (gross leasible floor area in 1000 sq ft.)	GLA	12,060	13,150	1.09

Source: 1986 data from 1986 emme2ban databank, except school enrollement from a query of the 1986 OD Survey database.
1995 data from 1995 OD Survey with the exception of
- GLA which was supplied from the Planning Deptment.
- Employment less retail derrived from the Planning Dept. estimate of the ratio of total employment to total employment less retail employment.

N/A - the 1986 value contained in the 1986 databank is for secondary school enrollement and excludes primary school enrollement.

3.3 Comparison of Person Trips (1986 and 1995)

The existing TRANS model includes transit and auto persons consisting of the sum of auto drivers and auto passengers. Exhibit 3.3 compares the number of trips by mode and purpose for the PM peak period for 1986 and 1995. As illustrated, work trips, post secondary and non-home based trips increased slightly between 1986 to 1995, leave home trips increased substantially, primary and secondary trips remained the same, while other to home trips decreased. Total trips increased 1 percent from 478,200 to 482,900 in the PM peak period between 1986 and 1995. This suggests that the PM peak period person trip rates were lower in 1995 compared to 1986 since both population and employment grew substantially more than total PM peak period travel demand.

PM. peak period transit modal share dropped from 22% in 1986 trips to 15% in 1995. The only trip purpose showing an increase in transit use over 1986 conditions is post secondary school to home.

Exhibit 3.3 Person Trips (1986 & 1995), Peak Period

Purpose	Mode	1986 OD Survey		1995 Od Survey	
		Trips	%	Trips	%
Work to Home	Auto Person	104,500	68	121,100	76
	Transit	49,000	32	37,500	24
	Total	153,500	100	158,600	100
Primary & Secondary School to Home	Auto Person	5,100	31	6,700	41
	Transit	11,100	69	9,500	59
	Total	16,200	100	16,200	100
Post-Secondary School to Home	Auto Person	4,900	54	5,300	49
	Transit	4,200	46	5,600	51
	Total	9,100	100	10,900	100
Other to Home	Auto Person	116,300	87	103,800	94
	Transit	17,600	13	7,200	6
	Total	133,900	100	111,000	100
Leave Home	Auto Person	51,400	90	67,200	94
	Transit	5,500	10	4,500	6
	Total	56,900	100	71,700	100
Non-Home Based	Auto Person	90,900	84	105,600	92
	Transit	17,700	16	8,900	8
	Total	108,600	100	114,500	100
Total trips	Auto Person	373,100	78	409,700	85
	Transit	105,100	22	73,200	15
	Total	478,200	100	482,900	100

3.4 Analysis of 1995 OD Survey

The 1995 OD Survey data and Planning Department demographic data were input into SPSS files and aggregated by traffic zone. Trip records were filtered to include peak period trips which began between 3:30 PM to 5:59 PM, with origins and destinations within the National Capital Region made by auto users and public transit passengers. The exception was secondary school trips where trips made between 2:29 to 5:59 were included in the regression equations to increase the number of observations since poor regression results were found using the two and one half hour peak period. A factor was applied to the secondary school equations to convert to the 3:30 to 5:59pm period.

The data used to develop the trip generation models was derived from the 1995 OD Survey with the exception of GLA which was obtained from the Planning Department The following demographic variables used in the existing TRANS model equations were indirectly derived using 95 OD survey and Planning Department data:

- Total employment - obtained by counting the number of occurrences of reported place of work zone contained in the 95 OD survey person trip file.

- Employment (other) - obtained from the Planning Department estimate of the percent of employment (other) to total employment.

- School enrollment - derived by summing the number of occurrences of reported “school zone” contained in the 95 OD survey person trip file. The data was stratified by student age to separate between secondary, post secondary, Ontario and Quebec school trips.

Exhibit 3.4 contains a statistical summary of the variables from the Planning Department and the 95 OD Survey data. In this table the means of the variables on a zonal level are compared. With the exception of school enrollment, the means between the two samples are quite similar, with

Exhibit 3.4 - Comparison of 1995 Demographics

	Mean		Standard Deviation		Correlation
Variable	Planning Dept.	OD Survey	Planning Dept.	OD Survey	
Population, Age15 to 24	721	677	584	591	0.907
Population, Age 25 to 44	1,802	1,789	1,499	1,517	0.946
Population, Age 45_64	1,100	1,032	898	892	0.938
Total Population	4,755	4,855	4,162	4,222	0.98
Dwelling Units	1,855	1,853	1,610	1,602	0.987
Total Employment	1,923	1,880	3,244	2,800	0.951
Other Employment	1,684	1,628	3,109	2,676	0.959
Sec. School Enrollment	746	388	859	687	0.829
Post Sec. School Enrollment	603	5,156	2,363	2,702	0.971

Note: Above means are based on traffic zonal averages.

their mean values within 6 percent. The difference in the means for the school enrollment variable is partly due to the Planning Department estimates neglecting private schools. Furthermore, the OD Survey includes part time students making school trips in the peak period while the Planning Department estimate of 1995 school enrollment only includes full time students.

The standard deviation is used to measure the dispersion of the data. The data for all variables in the two samples is quite dispersed. This is indicated in the high values of the standard deviation when compared to their mean. The standard deviation for each variable between the two samples are also similar, indicating that both samples have similar dispersion of the values for each variable.

The correlation coefficient is a factor measuring the degree to which two variables are related. If the variables contained in the two samples were identical, the correlation coefficient would be one. Dwelling units has the highest correlation while secondary school enrollment has the lowest value of .829. This suggests that significant differences exist for secondary school enrollment between the 1995 OD Survey and the Planning Department estimate extrapolated from 1991 data. Since the OD survey did not collect information on gross leaseable area, no comparison of this variable was possible. It is possible that significant error occurs with this variable since it does not account for space in shopping centers with unoccupied space nor does it include strip development or large single centers as Price Club and stand alone super stores.

In conclusion, this analysis found that the 1995 OD survey provided an acceptable match to the Planning Department data in most instances. As more current data become available for 1995 employment, school enrollment and GLA, they should be compared with the 1995 OD survey to determine if adjustments to the trip generation equations are warranted. It is also recommended that the methodology used to quantify GLA be more inclusive of stand alone developments or that another variable be developed as an indicator to quantify retail draw to travelers.

3.5 Trip Generation Equations

Trip generation equations were developed for each trip purpose currently used in the TRANS model. Equations selected for the 1995 calibration are highlighted in Exhibit 3.5. For comparison purposes, the existing TRANS model equations are also shown.

Several criteria were used to evaluate the trip generation equations:

- Goodness of fit measures, primarily the goodness of fit statistic R^2; the closer this indicator is to 1, the more reliable the equation.
- Comparison of the trip generation equations in the existing model.
- Reasonableness, which provided a balance between the statistical explanation of a relationship, and reasonable expectations.

With the exception of the leave home attraction equation, the new equations have higher R^2 values, indicating that they should provide a more reliable estimate of trip attractions and productions than the 1986 model. A main difference between the new trip generation equations and the existing equations is that the new equations do not contain constants. This was done to ensure traffic zones containing no demographic data would not generate traffic.

The calibration of the work trip model involved developing six equations, three for the production model and three for the attraction model. Separate equations were developed for Ontario, Quebec and the central business district. It was found that this geographic area breakdown had unique rates for trip attraction and production for workers and therefore provided the most satisfactory fit to the 95 OD survey data. This was considered critical since this trip purpose significantly impacts on modal split. Therefore, if the work trip demand could be simulated appropriately, then it would also allow for a more reliable estimate of modal split.

Exhibit 3.5 - Summary of Trip Generation Regression Formulations

Trip Purpose	Regression Details	SPSS File	Regression Equation	R^2
Work to Home	Production, 1986 Existing Model		.4645*EMP(other) - 50	0.86
	***Production, 1995 Calib.**	**odp_wh.sps**	**.446 * EMP(other) - for Ottawa and Hull central areas**	**0.97**
			.390 * EMP(other) - for Ontario	**0.94**
			.433 * EMP(other) - for Quebec	**0.91**
	Attraction, 1986 Existing Model		.3235*POP15-24 + .2755* POP25-44 + .1847* POP45-64	0.94
	Attraction, 1995 Calib. (1)		-.098 * POP15-24 + .336 * POP25-44 + .321* POP45-64	0.97
	***Attraction, 1995 Calib. (2)**	**oda3_wh.sps**	**.178 * POP 25-44 + .192 * POP45-64 for Ottawa and Hull central areas**	**0.97**
			.348* POP 25-44 + .258 * POP45-64 - for Ontario	**0.98**
			.405 * POP 25-44 + .117 * POP45-64 - for Quebec	**0.99**
Sec_ Sch to home	Production, 1986 Existing Model		(.3059 * SCHS + .0691 * POP25-44 + 29)*.365	0.61
	Production, 1995 Calib. (1)		(.231 * SCHS - .014 * POP25-44) * .6	0.68
	***Production, 1995 Calib. (2)**	**odp_ss3.sps**	**** (.171 * SCHS) * .6**	**0.7**
	Attraction, 1986 Existing Model		(.2684 * POP5-14 + .0422 * POP15-24 + .0337 * POP25-44 + 2) * .365	0.81
	Attraction, 1995 Calib. (1)		(0.102 * POP10-14 + .08123 * POP15-24 .0046 * POP25-44) * .6	0.78
	Attraction, 1995 Calib. (2)		(0.08555 * POP15-24 + .02249 * POP25-45) * .6	0.77
	***Attraction, 1995 Calib. (3)**	**oda_ss2.sps**	**** (0.142 * POP15-24) * .6**	**0.75**
Post Sec_ Sch to home	Production, 1986 Existing Model		.1861 * SCHP + 8	0.95
	***Production, 1995 Calib.**	**odp_su.sps**	**.117 * SCHP**	**0.96**
	Attraction, 1986 Existing Model		.0396 * POP15-24 + .0246 * POP45-64	0.53
	Attraction, 1995 Calib. (1)		.103 * POP15-24 - .01 * POP45-64	0.83
	***Attraction, 1995 Calib. (2)**	**oda_su2.sps**	**.074 * POP15-24 + .0059 * POP25-44**	**0.83**
Other to Home	Production, 1986 Existing Model		.044 * POP + .0978 * EMP + 3.164 * GLA + 72	0.8
	***Production, 1995 Calib.**	**odp_hbo.sps**	**.052 * POP + .0711 * EMP + 1.947 * GLA**	**0.85**
	Attraction, 1986 Existing Model		.159 * POP + 21	0.87
	***Attraction, 1995 Calib.**	**oda_hbo.sps**	**.115 * POP**	**0.96**
Non Home Based	Production, 1986 Existing Model		.0478 * DWEL + .1576 * EMP + .9515 * GLA + 72	0.79
	***Production, 1995 Calib.**	**odp_lh.sps**	**.0542 * DWEL + .176 * EMP + .578 * GLA**	**0.93**
	Attraction, 1986 Existing Model		.064 * EMP + .1024 * DWEL + 2.824 * GLA + 70	0.77
	***Attraction, 1995 Calib.**	**oda_lh.sps**	**.0902 * EMP + .128 * DWEL + 1.69 * GLA**	**0.89**
Leave Home	Production, 1986 Existing Model		.1697 * DWEL + 24	0.73
	***Production, 1995 Calib.**		**.187 * DWEL**	**0.9**
	Attraction, 1986 Existing Model		.026 * EMP + 1.387 * GLA + 114	0.61
	***Attraction, 1995 Calib.**		**.062 * EMP + 1.06 * GLA**	**0.57**

Notes: * **Equations underlined and bold printed were sellected for new model calibration.**
The SPSS files contains the records used to carry out the regressions. The files are in c:\temp\tripgen directory
contain the appropriate zonal demographac data as well as trip attractions/ productions per zone.
** Secondary school trips multiplied by .6 to convert trips from a 2:29-5:59 period to 3:29-5:59 period.
The existing TRANS model scondary school trip equation was multiplied by .365 to correct for an error in the origional model equation.

Some of the differences in the regression coefficients between the 1986 model and those obtained from the 1995 survey can be explained by the economic conditions in each of the two years. In 1986, the economy was much more robust than it was in 1995. The unemployment rate was lower, people felt more financially secure and were likely to make more shopping, social and personal business trips. These type of conditions alter the trip making habits of people and therefore alter trip generation rates as well. This is reflected in some of the higher values of the 1986 coefficients in the equations than those contained in the 1995 equations.

3.6 Comparison of Models using 1995 Data

To gain insight into the differences between the existing trip generation equations and the new equations, they were inputted into EMME2 macros and run using 1995 zonal demographic data obtained or derived from the 1995 OD survey as described earlier in this report. The results are illustrated in Exhibit 3.6.

Exhibit 3.6 - Trip Generation Results (PM Peak Period)

Trip Purpose	Production or Attraction	Existing Model	New Model	New Model (PM Peak Hour)	
		PM Peak Period Trips	PM Peak Period Trips	PM Peak Hour Factor	Trips
Work to Home	Production	171,300	163,000	0.502	81,800
	Attraction	171,900	162,000	0.502	81,300
Sec_ Sch to home	Production	8,900	12,000	0.238	2,900
	Attraction	6,700	11,000	0.238	2,600
Post Sec_ Sch to home	Production	16,700	9,000	0.347	3,100
	Attraction	9,800	11,000	0.347	3,800
Other to Home	Production	146,900	108,000	0.433	46,800
	Attraction	158,100	110,000	0.433	47,600
Non Home Based	Production	120,700	108,000	0.440	47,500
	Attraction	122,600	111,000	0.440	48,800
Leave Home	Production	69,700	70,000	0.400	28,000
	Attraction	59,500	42,000	0.400	16,800
Total	Production	534,200	470,000		210,100
	Attraction	528,600	447,000		200,900

A comparison between the existing and new regression models indicate that:

- The existing model formulation over estimates 1995 work to home, other to home and non-home based trips - the largest discrepancy occurs in the other to home trips.
- There is an error in the existing trip generation model for estimating secondary school trips. An attempt was made to correct this error by factoring these trips by .365 (.365 was a factor derived while carrying out the RMOC Transportation Master Plan Study) , giving the value shown in the table above.

The number of PM peak period trips based on the 1995 regression equations is about 15% less than that obtained from the existing model formulation. The total number of peak period trips reported by ADI (the consulting firm that carried out the 1995 OD Survey) in their report “1995 NCR OD Survey Database Validation and User Guide” was in the order of 495,000 trips. The difference between the ADI estimate of total trips and that obtained from the regressions were primarily due to the ADI data containing trips that were not applicable for the model development exercise such as:

- 2,500 trips with invalid traffic zone numbers,
- 9,600 internal-external trips
- and about 100 trips with incomplete information to carry out the regressions with missing data as the person’s age, etc.

3.7 Conversion to Peak Hour

As illustrated in Exhibit 3.6, factors were applied to the outputs of the new trip generation equations to obtain PM peak hour results. The factors were developed based on the ratio of peak hour trips to peak period trips for each trip purpose.

4. TRIP DISTRIBUTION

4.1 Overview

This chapter outlines the calibration of the trip distribution model to the 1995 OD Survey. The study began by reviewing traditional trip distribution methods including those used in the existing model. Limitations of the existing model were identified and by testing alternate trip distribution approaches, the form of the new model evolved.

In the existing model, the gravity model was originally used only for the work trip purpose. During the Official Plan modeling work, it was decided to use the gravity model for the non-home based trip purpose rather than the Fratar method. For the remaining trip purposes, the Fratar method was used. The gravity models used a separate trip generation equation for trips with an origin in Ontario and a destination in Quebec and another equation for the remaining trips. When the existing model was first developed, the trip distribution equations were three dimensional, with the first dimension being origin totals, the second dimension being destination totals and the third dimension being forty trip length distribution intervals. The third dimension had the effect of fixing the proportion of total trips in each of the forty intervals. This third dimension was removed from the TRANS model for the Official Plan modeling work, making the model two dimensional. In the disutility equations, both auto and transit travel times were included.

In the 1995 model calibration, the gravity model was used for all trip purposes. The model uses four separate equations to reflect travel within and between Ontario and Quebec. Furthermore, the models are two dimensional. The disutility equations use both auto and transit travel times.

4.2 Methodology

The basic premise of the gravity model is that the number of trips between zones is directly proportional to the number of trips produced by a zone, the number of trips attracted to a zone, and inversely proportional to a function quantifying the spatial separation between zones. The function quantifying the spatial separation between zones is usually a function of auto and transit travel time. The advantage of this type of model is that the trip distribution model is sensitive to the level of service of the transportation modes.

The formulation of the gravity model used in the 1995 model is:

$$Tij = OiDj(f(Cij)) / \sum_j Aj(f(Cij))$$

Where Tij = Total trips between origin i and destination j

Oi = Total trips produced by origin zone i

Dj = Total trips attracted by destination zone j

$f(Cij)$ = a measure of the spatial separation between zones i and j, or impedance.

Aj = proportionality factor

The style of the impedance function used in the 1995 model is:

$$f(Cij) = (autotime^{C1} \exp(-C2 * autotime)) + (transittime^{C1} \exp(-C3 * transittime))$$

The new trip distribution models are two dimensional, with balancing being carried out to origin and destination totals. With the third dimension omitted (trip length frequency distribution), the model will be sensitive to changes in demographic patterns where trip length can fluctuate under different land use scenarios. Furthermore, auto and transit travel times are included in the impedance equations. This insures that the model is sensitive to level of service changes in both modes.

Each trip purpose uses separate impedance functions for trips from Ontario to Ontario, Quebec to Quebec, Ontario to Quebec and Quebec to Ontario. This was done to account for the impedance imposed on travel as a result of the limited road and transit capacity across the Ottawa River as well as infrastructure and socio-economic differences between the provinces.

Calibration of the trip distribution model involves quantifying coefficients in the impedance function. The desired result is to have coefficients that provides a distribution of trips between traffic zones similar to those observed in the 1995 OD survey for each trip purpose. The coefficients obtained for the 1995 model calibration are illustrated in Exhibit 4.1.

Exhibit 4.1 - Trip Distribution Equations

Trip Purpose	Area	Coefficient C1	Coefficient C2	Coefficient C3
Work to Home	1	0.75	-0.12	-0.12
	2	0.75	-0.06	-0.06
	3	0.5	-0.11	-0.11
	4	0.5	-0.08	-0.08
Leave Home	1	0.75	-0.25	-0.25
	2	0.75	-0.25	-0.25
	3	0.5	-0.1	-0.1
	4	0.5	-1	-1
Non-Home Based	1	0.5	-0.15	-0.15
	2	0.5	-0.2	-0.2
	3	0.5	-0.15	-0.15
	4	0.5	-0.3	-0.3
Other	1	0.5	-0.2	-0.2
	2	0.5	-0.2	-0.2
	3	0.5	-0.3	-0.3
	4	0.5	-0.2	-0.2
Secondary School	1	0.5	-0.15	-0.15
	2	0.5	-0.15	-0.15
	3	0.5	-0.15	-0.15
	4	0.5	-0.25	-0.25
Post Secondary School	1	0.5	-0.15	-0.15
	2	0.5	-0.15	-0.15
	3	0.5	-0.25	-0.25
	4	0.5	-0.2	-0.2

Notes: Impedance =(Auto Time^C1 * Exp(-C2 * Auto Time)) + (Transit Time^C1 * Exp(-C3 * Transit Time))
Area 1 is Ontario to Ontario, Area 2 is Quebec to Quebec
Area 3 is Ontario to Quebec, Area 4 is Quebec to Ontario

Two approaches were used in the model calibration for each trip purpose:

1. comparing modeled versus survey trip totals between clearly defined geographic areas. In this study, the Ottawa River was used to distinguish trips between Ontario and Quebec and also within each province, see Exhibit 4.2

2. Analyzing travel times by mode using histogram plots of auto and transit travel time weighted by the demand matrix.

   Travel time used for auto is what the EMME2 model estimates as the zone to zone travel time. For transit, total travel time is used which includes access, egress, transfer and wait times. These out of vehicle times can cause transit travel time to vary significantly from observed travel times for short trips. This is because the EMME2 model may simulate longer access/egress times or the time waiting for the bus to arrive.

   The histograms provide insight into the match of the total number of trips as well as where the simulated demand matrix differs from the observed demand matrix in terms of trip travel time by auto and transit. It is desirable to have the mean and standard deviation of the travel times of the model close as possible to the survey results, see Exhibit 4.3.

Exhibit 4.2 - Trip Distribution Results- Origin-Destination Patterns

Trip Purpose	Source	From Ontario To Ontario	From Ontario To Quebec	From Quebec to Ontario	From Quebec To Quebec	Total	Model / Survey
Work to Home	Model	55,892	10,157	2,320	11,124	79,493	
	Survey	54,607	9,906	3,197	9,737	77,447	1.03
Sec. School to Home	Model	1,686	104	57	494	2,341	
	Survey	2,408	147	10	927	3,492	0.67
Post Sec. School	Model	2,870	417	10	805	4,102	
to Home	Survey	2,537	338	10	945	3,830	1.07
Other to Home	Model	32,001	2,107	371	8,667	43,146	
	Survey	28,185	2,016	355	8,964	39,520	1.09
Leave Home	Model	21,028	9	988	4,563	26,588	
	Survey	18,541	318	1,066	5,398	25,323	1.05
Non-Home Based	Model	33,893	3,144	2,265	6,898	46,200	
	Survey	34,900	3,307	1,975	6,690	46,872	0.99
Total	Model	147,370	15,938	6,011	32,551	201,870	
	Survey	141,178	16,032	6,613	32,661	196,484	1.03
	Model/Survey	1.04	0.99	0.91	1.00	1.03	

Exhibit 4.3 - Trip Distribution Results- Travel Times

Trip Purpose	Source	Auto Time		Transit Time	
		Mean	Standard Dev.	Mean	Standard Dev.
Work to Home	Model	18.58	10.65	39.28	25.60
	Survey	18.50	10.71	38.60	24.92
Sec. School to Home	Model	12.70	8.39	29.48	21.45
	Survey	13.83	9.17	30.67	20.70
Post Sec. School to Home	Model	16.59	10.28	34.07	24.15
	Survey	16.21	9.16	32.68	20.17
Other to Home	Model	11.60	7.70	25.80	18.98
	Survey	12.32	9.95	27.93	24.02
Leave Home	Model	10.00	6.54	24.83	20.56
	Survey	11.25	8.28	27.18	22.53
Non-Home Based	Model	12.06	8.37	26.51	20.89
	Survey	12.72	8.94	26.95	20.36

4.3 Simulation Results

A review of the estimated trip demand within and between the provinces in Exhibit 4.2 illustrates that:

- Modeled compared to survey total trips crossing from Ontario to Quebec are within 1 percent
- Trips from Quebec to Ontario are under estimated by 600 trips by the model, 9% lower than the survey.
- Trips within Ontario are over-estimated by 6000 trips, implying the model is high by 4%.
- Simulated compared to survey trips within Quebec are within 1%.
- The model to survey ratio for secondary school trips of .67 is a result of the difficulty of estimating the attraction and productions amounts of these in the trip generation model.

An analysis of the average travel times in Exhibit 4.3 indicate the following:

- Home Based Work Trips

  The auto and transit travel times are a close match between the simulated and survey trip demand for this trip purpose. This trip purpose accounts for about 30% of the total peak hour auto trip demand and over 60 percent of the transit demand, implying that it is particularly important to have a good fit of the travel times for both modes.

- Secondary School to Home

The auto and transit travel times are quite different between the survey and the survey. This is partly due to the significantly lower number of model trips compared to the survey. The school trips account for only about 1 percent of the PM peak hour total person demand and according to the OD survey, about 10 percent of PM peak hour transit demand. This implies that this modeling error will have little impact on auto trip demand but will tend to have the model underestimate transit trip demand. The model appears to estimate shorter trip lengths based on auto trip time of 13.8 for the survey compared to 12.7 for the model; for transit the trip time mean is 30.7 compared to 29.5 for the model).

- Post Secondary School to Home
  For this trip purpose, the model over-estimates both the auto and transit trip length. The standard deviation of the model travel times are higher than the survey, indicating that the modeled results are more dispersed.

- Other to Home
  The auto and transit trip times of the model are a little lower with less dispersion compared to the survey

- Leave Home
  The auto and transit times of the model are lower and less dispersed than the survey

- Non-Home Based
  The auto travel times predicted by the model is lower than that compared to the survey. The transit time is slightly lower for the model compared to the survey.

5. MODAL SPLIT

5.1 Overview

An objective of the 1995 modal split model re-calibration project was to develop a model based on the 1995 OD survey similar in style to the existing model based on the 1986 OD Survey. However, as re-calibration work progressed, it became clear that the style of the 1995 model would differ in several key areas. In particular, it was found that the logit model could be used successfully for both home based work and home based school inter-zonal trips (trips where the trip origin and destination are located in different zones) within the Urban Transit Area (UTA). Furthermore, the new logit models includes the modes auto person and transit rather than auto driver, auto passenger and transit. This mode choice selection was based on the logit model results for the home based work trips where it was found that unacceptable simulation results were obtained if the auto mode was separated into two modes. A car occupancy model was developed outside of the logit model to convert auto persons to auto vehicles in the new model.

For the remaining inter-zonal trip purposes inside the UTA, modal split was based on equations relating mode choice to ratios of transit to auto travel times. Different equations are provided based on whether auto travel times fall within specified auto travel time ranges. This differs from the existing model where one equation was used for all auto times within the UTA for non-work trips.

For all inter-zonal trips outside the UTA, equations were developed to estimate auto vehicle trips from auto person trips.

For intra-zonal trips (i.e., trips for which the origin and destination points are located in the same zone), modal split for each zone was based on observed mode choice in the 1995 OD survey.

Exhibit 5.1 highlights the main differences between the 1986 model and those developed based on the current study.

Exhibit 5.1 - Comparision of 1986 and 1995 Models

Model	Details	Description
1986 Model	3 modes	Auto Diver, Auto Passenger, Transit
	Logit Model	Work to Home (UTA)
	Diversion Curves	All Other Trips
1995 Model	3 modes	Auto Vehicle, Auto Person, Transit
		(Auto Vehicle by Regression)
	Logit Model	Work to Home (UTA)
		School to Home (UTA)
	Diversion Curves	All Other Trips

The first section of this chapter presents the methodology used to build, select and aggregate the most appropriate logit models for home based work and home based school trip purposes. A description follows the method used to develop the modal split models for the remaining trip purposes and the approach used to simulate intra-zonal mode split. The final section of the chapter is a comparison of observed versus simulated travel demand by mode.

5.2 Logit Model Preparation

In practice, variables which are most suitable to include in the logit model equation is not known at the beginning of the model building process. At best, the person developing the model will have a list of variables they feel are suitable candidates for inclusion into the model. They must then go through the process of developing a databank containing all potential variables that could be used in the model. This process of fitting a model to the data is the calibration process. This is a process of estimating the values of the numerical coefficients in the models and testing different models to determine which one best explains the available data.

5.2.1 *Data Preparation, Logit Models*

Because a modal split model attempts to replicate the mode choice decision of individuals, it is desirable to know as many factors as possible that influence their decision making behavior. Disaggregate logit models have been used successfully to perform this task. Logit models are mathematical techniques that reproduces the decisions of individuals, based on personal considerations of two types of factors: socio-economic characteristics of the individual and level of service variables describing the mode. To develop the model, a database is required which describes all the travel choices of a large number of people, and provides information about the specific conditions considered by each individual.

In this study, the primary data source to support the development of the modal split models was the 1995 TRANS OD Survey. The survey database contains the response information for each person included in the survey sample. From the survey, 12,000 trips by auto and transit were obtained in the PM peak hour by auto and transit. From this file, information was available about each person and their household such as household location, number of vehicles in the household, each person’s employment or student status as well as their sex and age.

The OD survey also contains information about their PM peak hour trip such as trip purpose, the location of the trip origin and destination, trip start time (but not trip end time), mode used to make the trip, and whether a parking cost was incurred (but not the amount paid to park). Level-of-service variables as travel time and cost were not collected in the survey.

In the development of logit models, you require detailed information about all modes available to the traveler. To obtain this information, the EMME2 model was used to assign observed PM peak hour travel demand onto the auto and transit networks to estimate mode attributes such as time and travel cost. Furthermore, the theory of logit models make it necessary that the individuals being modeled have access to all modes under consideration. It was assumed that the auto mode was available to all users, since anyone could be an auto passenger if they were unable to be an auto driver. Transit was assumed available to all trip makers provided their trip began and ended within the UTA.

Since the cost of travel was not collected in the survey, a method was developed to estimate this variable. Transit fare for 1995 was estimated by developing a fare matrix system, see Exhibit 5.2. Areas were identified where regular and premium transit serviced specific geographic areas in the National Capital Region. The transit fare required to travel between the areas in the matrix is a function of cash fares and monthly passes, taking into account the dual OC Transpo and STO fare structure for regular and express service.

Exhibit 5.2 - Transit Fare Matrix

Origin Area		Destination Area								
Area No.	Description	1	2	3	4	5	6	7	8	9
1	RMOC inner UTA	1.35	1.73	1.73	3.1	3.1	3.1	1.35	1.73	3.1
2	RMOC outer UTA West& South	1.35	1.35	1.73	1.35	3.1	3.1	1.35	1.73	3.1
3	RMOC outer UTA -east	1.35	1.73	1.35	3.1	3.1	3.1	1.35	1.73	3.1
4	RMOC Stitsville	1.35	1.35	1.73	1.35	3.1	3.1	1.35	1.73	3.1
5	RMOC Richmond	1.35	1.35	1.73	3.1	1.35	3.1	1.35	1.73	3.1
6	RMOC Rockland	1.35	1.73	1.73	3.1	3.1	1.35	1.35	1.73	3.1
7	CUO West of Gatineau River	1.35	1.73	1.73	3.1	3.1	3.1	1.35	1.73	3.1
8	CUO East of Gatineau River	1.35	1.73	1.73	3.1	3.1	3.1	1.35	1.35	3.1
9	CUO, Rural East Quebec	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	1.35

area No.	emme2 traffic zones in areas
1	1-45, 57-104, 106, 110-122, 201, 232-234
2	46-56, 123-133, 135-138, 140, 206 - 215, 220-231
3	105, 107-109, 139, 141 -144, 202-205, 235-247
4	216-219
5	134
6	145
7	146-164, 182-184, 254-258
8	165-177, 248-253
9	178 - 180

Concept: The high fares of $1.73 are for accessing green express buses. It is assumed that the green fare of $1.73 is for outbound trips, while inbound trips have the regular fare of $1.35. For across region service as from Orleans to area 2, the $1.73 fare is assumed, since they would have to go to the central area and then transfer to a green route to complete their trip.

emme2 zones assumed outside of the UTA for 1995 are:
132, 133, 135, 137 - 141, 146, 147, 177, 181-185, 186-200, 212-215, 227-230

Travel costs for auto work trips consisted of an operating cost assumed to be the cost of fuel consumed and a parking cost. Fuel consumption costs were based on averages across Canada as reported by Canadian Automobile Association for 1995. For the model calibration, 5 cents per kilometer was used as the fuel cost based on an average fuel consumption rate of 9.2 liters /100km and a fuel price of 55 cents/liter. The parking cost was estimated by contacting major parking suppliers and finding out what the monthly cost was for parking all day. This amount was then divided by 20 to get a daily rate. This amount was then multiplied by the proportion of auto drivers who paid for parking at the work place as recorded from the 1995 OD survey. This factoring process was necessary in order to be consistent with the approach used to aggregate this variable to a zonal level as discussed later in the section. The auto cost was then divided by auto occupancy as reported by the auto driver, giving the desired auto cost. If auto occupancy was not available, it was estimated based on analysis of vehicle occupancy rates.

Number of vehicles per household was recorded in the survey. This variable was re-coded to take on three values: 0 for a trip maker with no vehicles in the household, 1 when there is one vehicle in their household, and 2 when there is more than 1 vehicle in the household.

Total travel time was estimated using the EMME2 model to obtain the time in minutes to go from the trip origin to the trip destination. Out-of-vehicle travel time was also estimated. Transit out-of-vehicle travel time was assumed to include the time to walk to the bus stop, wait for the bus, access the bus, transfer if necessary to another bus, egress the bus and then travel to the destination. For the auto mode, out-of-vehicle travel time was assumed as 0.

Several other variables were developed using the TRANS 1995 Survey data. Referred to as dummy variables, and based on geographic location of a trip's origin or destination zone, they reflect potentially significant differences in transportation service which may not be fully captured by more tangible service attributes such as travel time or cost. For this study a "Province" variable was developed to distinguish between residents by province. If the person resided in Ontario, the variable had a value of 0, if they lived in Quebec, the value was 1.

Intra-zonal trips were excluded from the logit model databases since these trips are accounted for separately as discussed later in this section.

For short trips under 2 km in length, the database was adjusted to provide a more appropriate estimate of trip time, distance and cost. This was done using the UTM coordinates from the 95 OD survey database and applying an appropriate factor to convert from a straight line distance to a distance likely traveled by car or transit. Once the corrected distance was estimated, an appropriate travel time and cost were developed.

5.2.2 Specifying Logit Models

The model building exercise began by developing a priori model formulation which included a large number of variables considered to be of potential use. This model was much more elaborate than the final model obtained. However, it served to illustrate expectations regarding the anticipated role individual variables may have with influencing modal choice in the study area.

Application of the logit software was both an incremental and iterative process. The approach taken was to begin with a model containing the most essential level-of-service variables and to successfully add other variables or attempt variations on a previous model structure incorporating beneficial changes and discarding others.

5.2.3 *Model Evaluation*

The outputs of logit estimation software include, along with the estimated values of the coefficients, a set of statistical indicators used to judge the quality of the models. The value of individual variables may be investigated through an examination of the coefficients of the modal utility equations, the t-statistics of those coefficients and the correlation among variables.

- Sign of the coefficients should reflect expected human behavior, based on intuition, common sense and experience. For example, an increase in travel time should be expected to decrease the perceived attractiveness of a mode.

- The t-statistic of a coefficient is the estimated value of the coefficient divided by the standard error of the estimate. The t-statistic is useful for deciding whether the variable associated with that coefficient contributes significantly to the ability of the model to explain the data. Experience suggests that it is a good policy to retain variables whose coefficients have a t-statistic greater than 1.0 or less than -1.0.

- Correlation between variables- Correlation between a pair of variables greater than 0.8 indicates that a particular effect is being accounted for twice, and that the model should be re-specified.

- Goodness-of-fit indicator “Rho-bar squared”. This statistic provides a single measure to rank the goodness-of-fit of the model to the sample. In theory, the value ranges between 0.0 (no fit) and 1 (perfect fit). A small sample size or inclusion of additional modal alternatives will decrease the “rho-bar squared”, while inclusion of highly descriptive socio-economic variables will cause this indicator to increase.

- “Expected percent right” statistic reflects the estimated proportion of observed (or surveyed) choices which would be reproduced by the specified model. While a high “expected percent right” value is generally desirable, such high values may result from a high degree of modal uniformity despite a poorly specified model.

In conclusion, one should look at all the statistical measures and how they may inter-relate to one another to gain insight at the potential predictive powers of the logit model under study.

5.3 Final Logit Formulations

As outlined above, statistical procedures are used to guide the selection of variables for selecting and testing the logit models. The statistical procedures are invaluable aids in model developments, but it is important to understand that the use of statistical methods alone cannot guarantee the development of a satisfactory model. Judgment and experience to identify likely sources of error in the model and to formulate modifications of the model that might remove the errors. The modified models can then be subjected to statistical tests to determine whether they are seriously erroneous. Thus, practical model development always involves alternating between statistical analysis and judgmental activities.

5.3.1 Work to Home Logit Model

Exhibit 5.3 illustrates the model utility equations. The variables included in the equation are cost, total travel time and number of vehicles per household. No coefficients are shown in the auto mode equation for number of vehicles per household and Province since these variables are normalized to 0 based on the transit mode. Several notes should be made regarding these equations.

Exhibit 5.3 - Home Based Work Trip Logit Model

Mode	Trip Cost	Total Travel Time	Number of Vehicles per Household	Province	Constant
Auto Person	-0.8641 (-27.9)	-0.0096 (-2.14)			
Transit	-0.8641 (-27.9)	-0.0096 (-2.14)	-1.738 (-15.6)	-0.8367 (-5.64)	0.9091 (-5.41)

Note: Numbers in brackets are t-statistic for the variable's coefficient.

Other Infromat	Rho bar squared	0.57
	Mode split(model)	23%
	Mode split sample	26%
	% predicted correct	89%

auto cost -- Consists of vehicle fuel consumption cost of 5 cents/km. and a parking cost in cents.
Transit fare -- Based on fare scheme illustrated in Exhibit 4.2.
veh/hh -- (vehicles/household): =0 if veh/hh is 0, =1 if veh/hh is1, =2 if veh/hh more than 1.
Province -- Has a value of 0 for Ontario and 1 for Quebec residents.
Travel Time -- Time in minutes to travel from trip origin to trip destination.

Mode Split Sensivity Analysis

Variable	% Change in auto person mode split resulting from the following canges in the variables:
Auto Time +10%	-1.18%
Auto Cost +10%	-2.65%
Veh/HH from 1 to 2	3.48%
Ontario rather than Quebec resident	-5.07%
Transit Fare 10%	6.53%
Transit Time 10%	0.12%

The value of the t-statistics are all significant, having values less than -1 or greater than +1.0. The goodness of fit statistics of the model are as follows:

rho-bar squared = .57

expected percent right = 89%

The rho-bar squared value is dependent on the sample proportion selecting the auto mode (74%), implying that the minimum rho-squared value of about .25. The .57 value is significantly greater

than .25, indicating that the model provides a good fit to the observed mode choice as further indicated by the expected percent right value of 89%.

The values of the coefficients can be used to show the sensitivity of each variable on mode choice (see Exhibit 5.3) as outlined below:

- A 10 percent increase in auto travel time causes a 1.18 percent reduction in auto person mode split.
- A 10 percent increase in auto cost results in a 2.65 percent increase in transit mode choice.
- If the number of vehicles in the workers household increases from 1 to 2 or more, auto mode choice increases by 3.48 percent.
- The impact of place of residence is that Ontario residents tend to use transit about 5 percent more overall than Quebec residents.
- A 10 percent increase in transit fare will increase auto person mode split by 6.5 percent.
- A 10 percent increase in transit travel time increases auto person mode split by only 0.12 percent.

5.3.2 Aggregation

The logit model developed was based on an individual person basis where each record in the sample was used to build the model representing a single trip made by each individual. In order to use the model within a traffic zone system, an aggregation process was required to combine the behavior of all the trip makers in a particular traffic zone into a homogenous unit representing all trip makers in that zone.

The estimates of travel time and Province do not require aggregation since they are already in a style that can be used on a zonal basis. However, cost and number of vehicles per household required aggregation, which was carried out as follows:

- Cost- parking cost was estimated at a zonal level by taking the parking cost at the place of work and multiplying by the percent of auto drivers who paid for parking at the work zone as reported in the 1995 OD Survey. This amount was added to the cost of fuel consumed. The auto cost was then divided by an estimate of vehicle occupancy.

- Vehicles per household. A market segmentation approach was used for this aggregation. Using the databank, the percent of PM peak hour work trip makers with no car, one car and more than 1 car in their household was obtained for each destination traffic zone. This percentage was then used to weight mode choice dependent on car ownership.

5.4 School to Home Logit Model

Exhibit 5.4 illustrates the equations for the school to home logit model. The variables included in the equations are Province, out-of-vehicle travel time and vehicles per household. No coefficients are shown for the auto person mode since the auto person coefficients are normalized to 0 based on the transit mode.

Exhibit 5.4 - School to Home Trip Logit Model

Mode	Out of Vehicle Travel time	Number of Vehicles per Household	Province	Constant
Auto Person				
Transit	-0.0926 (-2.87)	-1.083 (-5.59)	-0.527 (-1.95)	2.85 (-6.05)

Note: Numbers in brackets are t-statistic for the variable's coefficient.

Other Infromation:	Rho bar squared	0.16
	Auto Mode split (model)	50%
	Auro Mode split (sample)	48%
	% predicted correct	67%

Out of vehicle -- Is 0 for auto mode. For transit it is total travel time less in vehicle travel time.

veh/household -- Has three groups, 0 for no vehicle/household, 1 for 1 vehicle/household, 2 for more than 1 vehicle per household.

Province -- Has a value of 0 for Ontario and 1 for Quebec residents.

Mode Split Sensivity Analysis

Variable	% Change in auto person mode split resulting from the following changes in the variables:
Veh/HH from 1 to 2+	2.60%
Ontario rather than Quebec resident	-2.60%
Transit Out of Vehicle Travel time 10% Increase	1.00%

The definition of Province and number of vehicles per household is the same as for the work to home logit model. Out-of-vehicle travel time was assumed to be 0 for auto trips. For transit trips, vehicle travel time includes access and egress time as well as wait and transfer time.

The value of the t-statistics are all significant, having values less than -1.0. The goodness of fit statistics of the model are as follows:

Rho-bar squared = .16

expected percent right = 67%

The minimum value of Rho-bar squared for the sample with the observed mode split of 46 and 54 percent is about 0, indicating that the value of .16 is good with an expected percent correct of 67%.

The mode split sensitivity analysis results illustrated in Exhibit 5.4 indicate the following:

- If vehicles per household goes from 1 to “2 or more”, auto use increases by 2.6%.
- If you live in Ontario, the province variable indicates auto use decreases by 2.6 %.
- A 10% increase in transit out of vehicle travel time will cause a 1 percent increase in auto mode choice.

5.4.1 Aggregation

The approach to aggregate the variables contained in the school to home logit model is the same as outlined in the work to home model.

5.5 All Other Trip Purposes, Inside the UTA Model

The remaining trip purposes of “home based other”, “other to home” and “non-home based” were grouped together to build a modal split model using a relationship based on the ratio of transit to auto travel time rather than a logit model. This is because the trip making behavior of these trip makers do not follow a distinguishable pattern of behavior, a key requirement for the use of a logit model.

It was found that two equations provided the best model. One equation is used to estimate model split when the auto trip time is under 15 minutes and another equation for trips that could be made by auto in 15 minutes or more. A plot of the observed model split is illustrated in Exhibits 5.5 & Exhibit 5.6. A linear regression was carried out on the observed data giving the two equations illustrated in Exhibit 5.7.

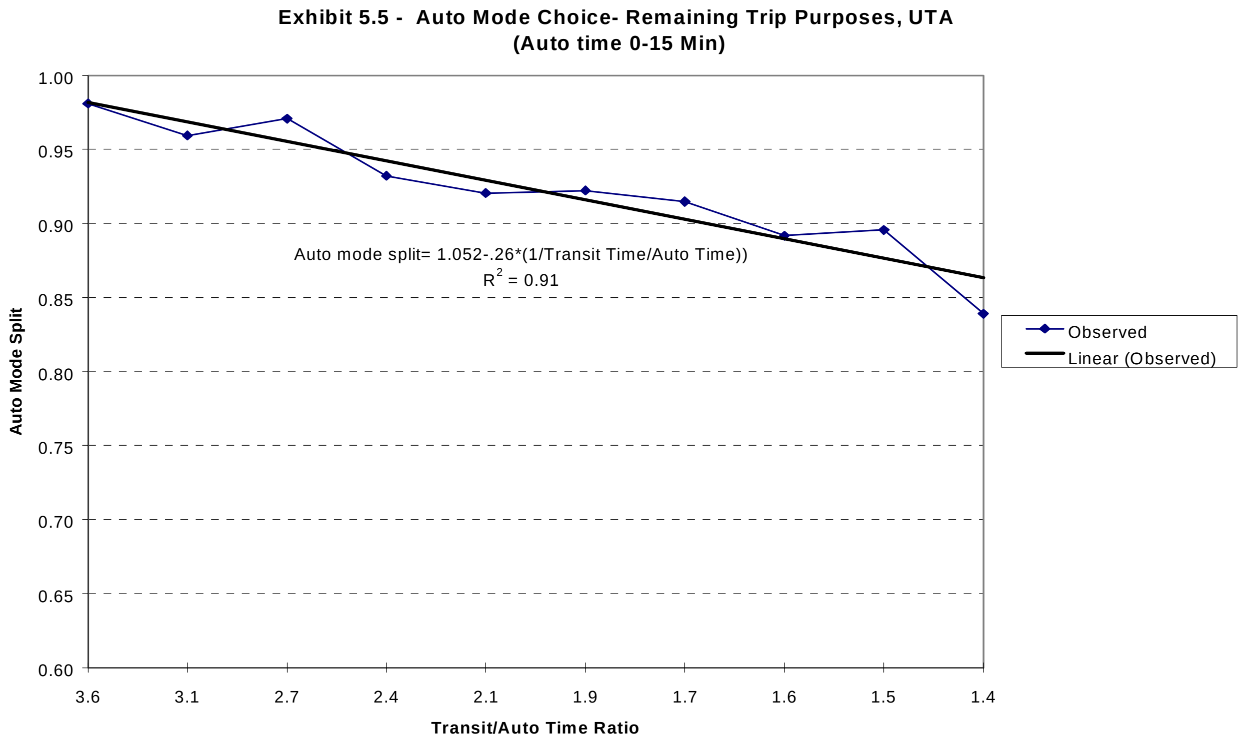


Exhibit 5.5 - Auto Mode Choice- Remaining Trip Purposes, UTA
(Auto time 0-15 Min)
1.00
0.95
0.90
0.85
0.80
0.75
0.70
0.65
0.60
Auto Mode Split
Auto mode split= 1.052-.26*(1/Transit Time/Auto Time))
R2 = 0.91
3.6
3.1
2.7
2.4
2.1
1.9
1.7
1.6
1.5
1.4
Transit/Auto Time Ratio
Observed
Linear (Observed)

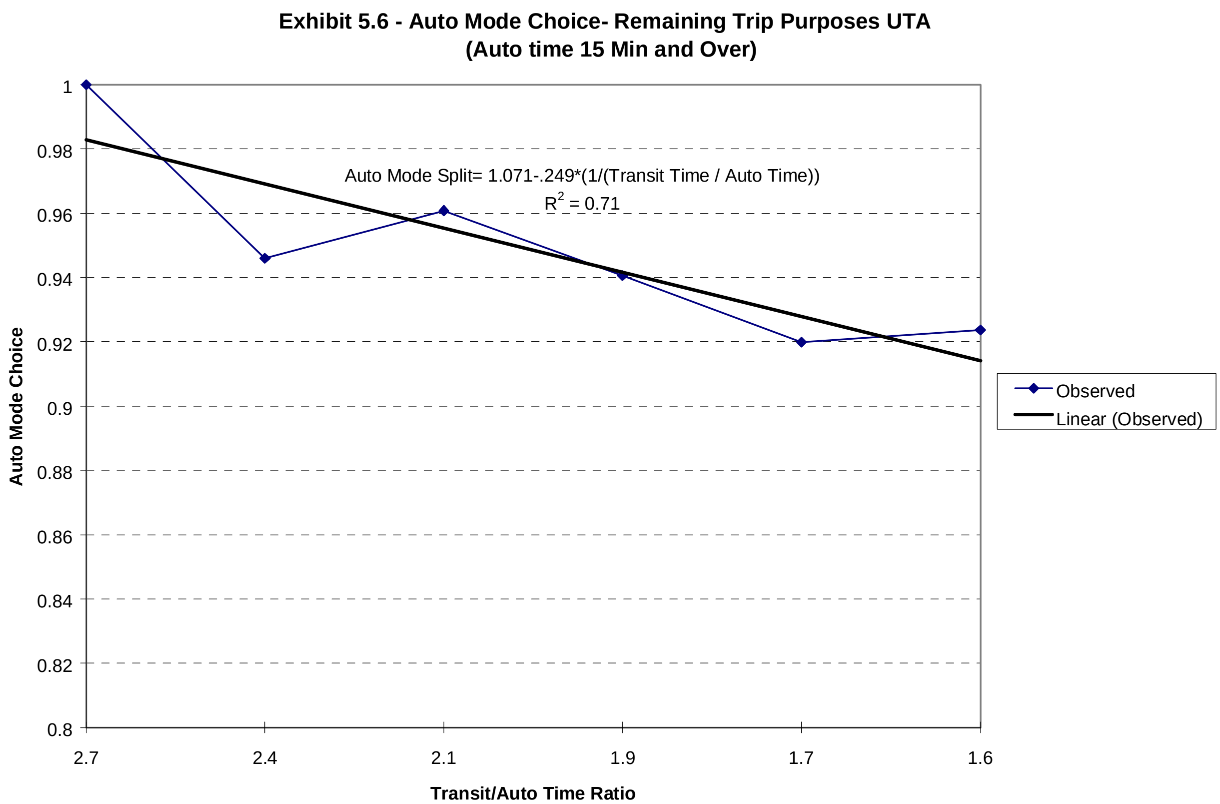


Exhibit 5.6 - Auto Mode Choice- Remaining Trip Purposes UTA
(Auto time 15 Min and Over)
1
0.98
0.96
0.94
0.92
0.9
0.88
0.86
0.84
0.82
0.8
Auto Mode Choice
Auto Mode Split= 1.071-.249*(1/(Transit Time / Auto Time))
R2 = 0.71
2.7
2.4
2.1
1.9
1.7
1.6
Transit/Auto Time Ratio
Observed
Linear (Observed)

Exhibit 5.7-- Model Equations- Other Trip Purposes Inside UTA

Auto Time Interval	Equation	R Squared
Auto Time 0-15 Minutes	auto mode split=1.052-.26*(1/(TransitTime/Auto Time))	0.91
Auto Time over 15 Minutes	auto mode split=1.071-.249*(1/(TransitTime/Auto Time))	0.71

Seventy-five percent of the trip makers in this combined trip purpose definition have an auto time in the interval of 0 to 15 minutes. This model has an R squared of .91, indicating that the equation explains 91% of the variability of the mode choice. Of the remaining 25 percent of the trip makers, they have an auto time of 15 minutes and over. The equation for these observations has an R squared statistic of .71. The two equations combined estimate auto person mode choice of 92.5% compared to 91.8% as contained in the survey.

5.5.1 Trips Outside the UTA

By definition, trips outside the UTA do not have access to OC Transpo or STO public transit and therefore transit mode split should be zero. In actuality, some trips are reported as being made by transit outside the UTA. This is because there are several private companies providing bus service to residents in some of the smaller rural towns within the study area. No attempt was made to include these transit trips within the model framework.

Since public transit is not considered available in the model for the trips outside the UTA, the model only estimates auto occupancy. Regression equations were developed to estimate auto occupancy based on trip length, see Exhibit 5.8. The regressions are based on the 1995 OD Survey matrices of auto person and auto vehicles for the PM peak hour and not the auto occupancy variable recorded in the 1995 OD Survey. It was found that the auto occupancy question in the survey was not reliable since it could contain persons under 10 years of age in the vehicle while the trip data from which the model is based includes trips by persons aged 10 and over. The matrices from which the equations were built are based on the observed auto driver and auto person trip matrices.

Exhibit 5.8-- Auto Occupancy Equations

Trips being Modelled	Equation	R Squared
Work UTA	Auto Occupancy = 1.249-.00259*distance	0.251
Work Outside UTA	Auto Occupancy = 1.071+.00275* distance	0.55
Other UTA	Auto Occupancy = 1.25+.001186*distance	0.127
Other Outside UTA	Auto Occupancy = 1.296-.00187*distance	0.18
School UTA	Auto Occupancy = 3.67-.7481*ln(distance)	0.84
School Outside UTA	Auto Occupancy = 3	estimated

As can be seen with the low R squared values in the equations, the models have limited ability to predict auto occupancy based on distance. During the calibration process, it was found that the equations resulted in too many auto vehicle trips and as a result all of the auto occupancies were reduced by 4 percent.

5.5.2 Intra-Zonal Trips

Intra-zonal trips are not assigned onto the road and transit network and therefore are insignificant from the perspective of their impact on the auto and transit networks. Since these trips are not assigned onto the network, the model does not provide estimates of modal attributes as travel time or distance. However, intra-zonal trips are included in the demand estimates for auto and transit and have to be estimated. For this reason, it was decided to estimate modal split for these trips based on the observed mode split by zone as contained in the 1995 OD Survey.

5.5.3 External Trips

External trips have a trip origin and/or a trip destination outside the area included in the 95 OD Survey. The travel demand was estimated from a 1993 study carried out by TRANS and expanded to a 1995 amount. The demand is in the form of a matrix and was ultimately added to the travel demand estimates outlined above.

5.6 Modal Split Model Results

Exhibit 5.9 contains a comparison of the number of trips by mode and purpose as reported in the OD survey and estimated by the complete model run of the model (trip generation, distribution and mode split). The main findings from the comparison are the following:

- Total transit trips predicted by the model (30,404) is close to the values as reported in the 1995 OD survey (30,850). Transit modal choice estimated that the model is 13.5 percent compared to the survey amount of 13.8 percent.

- The model tends to underestimate intra-zonal trips which is a result of the trip distribution model. However, the model does provide a close estimate of inter-zonal auto vehicle and transit trips, but overestimates inter-zonal auto person trips. Once the inter-zonal trips are added to the intra-zonal trips, the total number of auto person and transit trips are close to the OD survey amounts. It is important to realize that the OD Survey inter-zonal auto vehicle trips are close to the model estimates which are the trips that are assigned onto the network.

- The number of total person school trips is low. This is in part due to the lower number of school trips obtained from the trip generation and the trip distribution balancing process resulting in 5658 trips compared to 7392 in the OD Survey.

Exhibit 5.9 - New Model Versus OD Survey Travel by Purpose and Mode

Trip Purpose	Source	Total Trips				Inside UTA (Interzonal)			Outside UTA (Interzonal)			Intrazonal Trips		
		Total Persons	Auto Person	Auto Veh.	Transit	Auto Person	Auto Veh.	Transit	Auto Person	Auto Veh.	Transit	Auto Person	Auto Veh.	Transit
Work	OD Survey	78,780	59,551	49,238	19,229	49754	40685	18717	7800	6780	449	1,997	1,773	63
	Model	81,348	61,455	48,968	19,893	50819	40179	19847	9346	7844	0	1,290	945	46
School	OD Survey	7,392	3,727	1,712	3,665	3125	1509	3623	415	197	21	187	6	21
	Model	5,658	2,754	1,298	2,904	2115	1122	2889	518	173	0	121	3	15
Other	OD Survey	124,905	116,949	93,353	7,956	94032	74953	7754	8766	7066	56	14,151	11,334	146
	Model	125,989	118,383	89,484	7,607	100260	76564	7500	8984	6882	0	9,139	6,038	107
Total	OD Survey	223,898	193,048	155,167	30,850	146911	117147	30094	16981	14043	526	16,335	13,113	230
(see note)	Model	225,816	195,412	150,614	30,404	153194	117865	30236	18848	14899	0	10,549	6,986	168

Note: Total trips includes external travel demand of 12,821 auto persons and 10,864 auto vehicle trips. These trips are from a 1995 external trip matrix.

Exhibits 5.10 illustrates assigned average travel time by mode for the new model and the OD survey demands. For auto vehicles, the OD survey average trip time is 13.6 minutes while the model estimates an average time of 13.4 minutes. For auto person trips, the survey average trip time is 13.57 minutes while the model estimate is 13.38 minutes. For transit, the survey estimate is 29.16 minutes while the model estimate is 26.83 minutes. This difference of transit travel times implies the model has difficulty distinguishing between modes for some longer trips. It can also be a result of simulation errors in the trip distribution model where longer trips are underestimated in areas where transit is an attractive alternative to auto, primarily for work to home trips.

Exhibit 5.10 - Trip Assignment Results- Average Travel Times

Mode	Source	Auto Time	
		Mean	Standard Dev.
Auto Vehicle	Model	13.42	10.38
	Survey	13.61	10.91
Auto Persons	Model	13.39	10.29
	Survey	13.57	10.83
Transit	Model	26.83	15.65
	Survey	29.16	15.80

5.7 Trip Assignment

With the modal split model developed, it was possible to do a complete model run and assign the estimated 1995 PM peak hour trip tables for auto persons, auto vehicles and transit passengers to the auto and transit networks. The results of the assignment and a comparison of the model to traffic counts are illustrated in Exhibit 5.11. A comparison of outbound trips of the model and observed counts reveal the following:

Total person trip estimates on screenlines in the RMOC are for the most part within 10 percent of the counts for outbound trips. Person trips in the CUO appear to be underestimated, with model estimates closer to the range of 80 to 100 percent of the counts.

The model overestimates auto vehicle trips heading outbound to the east areas outside the greenbelt by about 17% (i.e., Orleans) and underestimates auto vehicle trips 12 to 15 percent to the south areas outside the greenbelt as the South Urban Communities of Nepean and Gloucester.

In Quebec, the model appears to overestimate auto vehicles crossing screenline Q65 (Gatineau River) by 18 percent, but appears to estimate auto vehicles within 10 percent at the remaining screenlines.

Transit mode split is overestimated crossing the Rideau River by 31%, Eagleson by 19% and CNR by 26%. Green's Creek is underestimated by 19%.

In the CUO, transit appears to be underestimated for trips destined to the west and north as Aylmer and Mont Blue. Transit to the east appears to be slightly overestimated.

In general, inbound estimates of travel demand are marginally underestimated. In particular, total person trips crossing the Ottawa river is underestimated by about 30 percent.

A comparison of 1986 model calibration reveals that the re-calibrated 1995 model predicts travel demand as well as or slightly better than the 1986 model. Throughout the model re-calibration process, insight was obtained on where the current style of the model could be improved. The following chapter outlines areas where further work can be carried out to enhance the quality of the TRANS model.

Exhibit 5.11 - 1995 Auto and Transit PM Peak Hour Model Assignment Results from 1995 Calibrated Model

OUTBOUND

Screenline	TOTAL PERSONS				AUTO PERSONS				AUTO VEHICLES				TRANSIT			
	Observed Counts	Survey Assigned	Model	Model / Counts	Observed Counts	Survey Assigned	Model	Model / Counts	Observed Counts	Survey Assigned	Model	Model / Counts	Observed Counts	Survey Assigned	Model	Model / Counts
Ottawa River (LN2,3,4)	15,574	16,352	16,076	1.03	13,168	13,931	13,693	1.04	10,180	10,886	10,720	1.05	2,406	2,421	2,383	0.99
Rideau River (LN19,20,32,33)	28,284	30,945	31,473	1.11	21,792	22,008	22,966	1.05	16,509	17,521	17,897	1.08	6,492	8,937	8,507	1.31
CPR (LN27, 28, 29)	19,880	21,145	19,904	1.00	14,931	14,443	14,543	0.97	11,236	11,720	11,313	1.01	4,949	6,702	5,361	1.08
Ottawa Central Area (LN35-38)	16,185	16,395	15,218	0.94	8,637	8,624	8,542	0.99	5,927	6,545	6,638	1.12	7,548	7,771	6,676	0.88
Rideau Canal (LN34, 39)	29,370	26,656	26,630	0.91	20,707	19,252	20,247	0.98	15,301	15,009	15,820	1.03	8,663	7,404	6,383	0.74
Fallowfield (LN9, 43)	7,777	7,823	6,677	0.86	7,039	6,667	6,024	0.86	5,551	5,514	4,737	0.85	738	1,156	653	0.88
Eagleson (LN10)	8,897	10,263	8,851	0.99	7,897	8,961	7,658	0.97	6,049	7,116	6,068	1.00	1,000	1,302	1,193	1.19
Green Creek (LN16)	11,319	13,215	12,337	1.09	8,189	9,515	9,808	1.20	6,607	7,703	7,722	1.17	3,130	3,700	2,529	0.81
CNR West / Acres (LN11,12)	18,982	19,680	17,363	0.91	16,245	16,255	14,946	0.92	12,678	13,362	11,722	0.92	2,737	3,425	2,417	0.88
CNR East (LN13,14,15)	13,555	13,935	13,262	0.98	12,274	12,680	11,650	0.95	10,595	10,383	9,259	0.87	1,281	1,255	1,612	1.26
Western Parkway (LN24,25)	18,528	19,927	16,700	0.90	15,683	16,483	13,949	0.89	12,339	13,355	10,897	0.88	2,845	3,444	2,751	0.97
Leitrim / Ramsayville (LN7,8)	6,114	5,956	5,363	0.88	6,099	5,934	5,354	0.88	4,669	5,035	4,353	0.93	15	22	9	0.60
Ile de Hull (LN60)	21,061	21,859	21,944	1.04	17,551	18,644	18,519	1.06	12,896	14,273	14,530	1.13	3,510	3,215	3,425	0.98
Boul. Gamelin (LN 61)	14,297	10,418	10,599	0.74	13,003	9,661	9,696	0.75	9,853	7,496	7,602	0.77	1,294	757	903	0.70
Ch. de la Montagne (LN62)	5,058	3,601	3,998	0.79	3,638	2,633	3,307	0.91	2,805	2,095	2,582	0.92	1,420	968	691	0.49
Deschenes (LN63)	5,211	4,099	4,096	0.79	4,041	3,185	3,542	0.88	2,959	2,457	2,760	0.93	1,170	914	554	0.47
Q64	3,546	3,203	2,933	0.83	3,146	3,012	2,856	0.91	2,425	2,357	2,268	0.94	400	191	77	0.19
Q65	13,577	13,900	14,611	1.08	11,885	12,308	12,607	1.06	8,370	9,518	9,904	1.18	1,692	1,592	2,004	1.18
Q66	2,698	2,167	2,140	0.79	2,668	2,167	2,140	0.80	1,953	1,782	1,726	0.88	30	-	0	0.00
Montee Paiement (LN67)	9,171	8,587	8,530	0.93	8,081	7,770	7,414	0.92	5,953	5,994	5,843	0.98	1,090	817	1,116	1.02
Q68	4,834	4,465	4,992	1.03	4,514	4,209	4,484	0.99	3,371	3,152	3,564	1.06	320	256	508	1.59

INBOUND

Screenline	TOTAL PERSONS				AUTO PERSONS				AUTO VEHICLES				TRANSIT			
	Observed Counts	Survey Assigned	Model	Model / Counts	Observed Counts	Survey Assigned	Model	Model / Counts	Observed Counts	Survey Assigned	Model	Model / Counts	Observed Counts	Survey Assigned	Model	Model / Counts
Ottawa River (LN2,3,4)	9,212	6,643	6,374	0.69	7,344	5,141	5,686	0.77	5,596	4,376	4,436	0.79	1,868	1,502	688	0.37
Rideau River (LN19,20,32,33)	22,151	19,740	20,424	0.92	19,662	17,639	18,361	0.93	14,774	14,655	14,312	0.97	2,489	2,101	2,063	0.83
CPR (LN27, 28, 29)	12,467	12,521	12,446	1.00	10,422	10,905	11,188	1.07	8,294	9,019	8,753	1.06	2,045	1,616	1,258	0.62
Ottawa Central Area (LN35-38)	7,398	6,662	6,632	0.90	4,887	4,558	5,436	1.11	3,570	3,771	4,210	1.18	2,511	2,104	1,196	0.48
Rideau Canal (LN34, 39)	20,575	17,758	19,471	0.95	15,562	14,075	16,284	1.05	11,893	11,841	12,589	1.06	5,013	3,683	3,187	0.64
Fallowfield (LN9, 43)	3,312	2,036	2,801	0.85	3,242	1,971	2,724	0.84	2,448	1,640	2,124	0.87	70	65	77	1.10
Eagleson (LN10)	4,803	5,074	4,720	0.98	4,643	4,902	4,424	0.95	3,834	4,166	3,511	0.92	160	172	296	1.85
Green Creek (LN16)	3,805	3,501	4,188	1.10	3,551	3,296	3,905	1.10	2,609	2,567	3,048	1.17	254	205	283	1.11
CNR West / Acres (LN11,12)	13,180	10,477	10,460	0.79	12,510	9,914	9,923	0.79	9,830	8,478	7,780	0.79	670	563	537	0.80
CNR East (LN13,14,15)	8,442	6,235	6,207	0.74	8,016	6,082	5,949	0.74	6,570	5,076	4,668	0.71	426	153	258	0.61
Western Parkway (LN24,25)	11,548	10,455	9,591	0.83	10,596	9,831	9,004	0.85	8,246	8,199	7,054	0.86	952	624	587	0.62
Leitrim / Ramsayville (LN7,8)	3,028	1,924	1,866	0.62	3,017	1,907	1,845	0.61	2,180	1,609	1,483	0.68	11	17	21	1.91
Ile de Hull (LN60)	7,236	6,781	8,391	1.16	6,486	6,298	7,936	1.22	5,166	5,211	6,162	1.19	750	483	455	0.61
Boul. Gamelin (LN 61)	7,580	4,095	4,436	0.59	6,800	3,695	4,184	0.62	5,310	3,068	3,251	0.61	780	400	252	0.32
Ch. de la Montagne (LN62)	2,280	1,175	1,770	0.78	1,960	1,113	1,704	0.87	1,537	842	1,332	0.87	320	62	66	0.21
Deschenes (LN63)	1,758	1,115	1,591	0.91	1,732	1,096	1,527	0.88	1,343	879	1,190	0.89	26	19	64	2.46
Q64	986	576	1,084	1.10	941	551	1,046	1.11	742	492	819	1.10	45	25	38	0.84
Q65	4,727	3,265	4,895	1.04	4,547	3,072	4,702	1.03	3,456	2,554	3,658	1.06	180	193	193	1.07
Q66	1,239	908	1,006	0.81	1,239	908	1,006	0.81	870	740	797	0.92	0	-	0	
Montee Paiement (LN67)	5,311	2,404	2,246	0.42	5,236	2,343	2,134	0.41	3,777	1,913	1,641	0.43	75	61	112	1.49
Q68	2,374	1,864	2,292	0.97	2,294	1,847	2,253	0.98	1,657	1,414	1,770	1.07	80	17	39	0.49

6. EMME2 USER GUIDE FOR TRANS MODEL

6.1 Overview

This chapter describes the methodology used to operate the TRANS Model within the EMME2 environment. An overview is presented on how the model may be applied within EMME2 for various travel demand applications. This is followed by a description of the EMME2 operating system, the auto and transit networks, matrices, macros used to simulate travel demand and a description of annotation files developed during this model development study. Examples follow on how the model can be applied to examine a wide range of travel demand applications within EMME2.

A detailed explanation of the EMME2 software can be found in the "EMME/2 *User's Manual"*, prepared by INRO Consultants Inc. The model development work was done using Version 8. All the reports presented in this document are based on Version 8. The macros were tested in Version 9 and were found to work without error. However, based on information provided by INRO, minor differences in the modeling results will occur due to minor variations in the auto and transit assignment algorithms.

The 1995 TRANS model, databases, macros and EMME/2 software reside with the Data Modeling and Forecasting Group, Planning Department, Region of Ottawa-Carleton. TRANS staff are responsible for access to the modeling environment. A copy of a CD rom containing the EMME2 databank and macros are available to TRANS member agencies.

6.2 Environment for the TRANS Model

The EMME2 operating system includes the EMME2 databank consisting of network scenarios and matrices. Outside the EMME2 databank a number of EMME2 macros have been developed which can be used to run the TRANS model as well as annotation (i.e. street names, graphics of zone boundaries etc.) files.

6.2.1 Establishing Scenarios and Scenario Management

Scenarios refer to establishing unique road and transit networks which include related attributes such as turn penalties and transit route descriptions as a basis for analysis. Exhibit 6.1contains a listing of pre-defined network scenarios in the EMME2 databank for use by TRANS Agencies.

Exhibit 6.1 - EMME2 Scenario Descriptions

Scenario Number	Description	User Link Data		
		UL1	UL2	UL3
3	1995 Network	Screenline Tags	Lane Capacity (veh/hr)	Improvement Tag
4	2021 Network	Screenline Tags	Lane Capacity (veh/hr)	Improvement Tag
5	Ultimate Network	Posted Speed (Km/Hr)	Lane Capacity (veh/hr)	Improvement Tag
100	UL Databank 1	Screenline Tags	Link Traffic Zone Tag	

Refer to Chapter 2 for a detailed description of the background assumptions for each network and how they were developed. Each network contains specific "User Link Data" used by the macros (SC5TO95.MAC and SC5TO21.MAC) to create the 1995 and 2021 networks respectively. Appendix 1 contains a listing of the network improvements associated with the coded improvement tags in UL3. A new link traffic zone tag was developed to code which traffic zone a link is located. This tag could be useful for reporting total traffic volumes by geographic area.

Scenarios 3, 4, 5 and 100 represent the base year networks to be used by all TRANS Agencies and therefore should not be modified. The user is therefore encouraged to make a copy of these networks and then carry out the analysis on the copy. The databank as defined can accommodate an additional 16 scenarios. When this number is reached, you can either delete some of the new scenarios no longer needed or make a copy of the EMME2 databank and then delete some scenarios to allow for the development of additional scenarios.

6.2.2 Matrices and Matrices Management

Matrices are used to store data within EMME2. The data can take many forms as land use data, travel demand data as well as travel times and trip distances. Four matrix types are available:

- *ms*, refers to a scalar of dimension 1 by 1. The scalar may contain a factor, or the sum of another matrix. A typical example is the total number of trips in an *mf* matrix.

- *mo*, refers to a column vector of dimension *n* by 1. This array represents the sum of all origins, or the matrix row sum. A typical example is an array of trips for a specific purpose, originating in each zone.

- *md*, refers to a row vector of dimension 1 by *n*. This array represents the sum of all destinations, or the matrix column sum. A typical example is an array of trips for a specific purpose, destined to each zone.

- *mf*, refers to a square matrix of dimension *n* by *n*. The dimension *n* refers to the number of zones in the model. Typical examples are origin-destination trip tables.

Exhibit 6.2 to Exhibit 6.4 lists the matrices used in the TRANS model, including the matrix number, a flag indicated with a "\r" if it is protected from modification or deletion, the matrix description, how the matrix is used and the macro where the matrix is primarily used. Several matrices are required as input for the modeling process and do not change (the matrices that are flagged for protection- they are not modified or deleted). Other matrices are generated as output during model runs. The following terms describe how the matrix is used in each macro.

- Input -- matrix is input but is unchanged by the macro.

- Output – matrix is created and output by the macro.

- Information - matrix exists as information source.

Also reported in the exhibits is the specific sub-model (i.e. trip generation, distribution…) where the matrix is used. The remaining matrices shown at the bottom of the Exhibits are not used in a model run and therefore can be used to store additional information.

Matrices can be batched in and out of the databank as required. You also have the option of coping the databank and then deleting matrices to allow for the addition of new matrices.

Exhibit 6.2 - MS Matrix Description

Matrix ID	Flag	Description	How Used	Macros Used
ms02		Sum mo2 Dwelling Units	All MS matrices are used for information: they contain the sum of key MF matrices.	All MS matrices are generated within macro sum.odh.
ms03		Sum mo3 Total Population		
ms05		Sum mo5 Total Employment		
ms07		Sum mo7 Other Employment		
ms08		Sum mo8 Sec. School Enrollment		
ms09		Sum mo9 Post Sec. sch. Enrollment		
ms10		Sum mo10 GLA		
ms11		Sum mo11Popul 5-14		
ms12		Sum mo11Popul 10-14		
ms13		Sum mo13 Popul. 15-24		
ms14		Sum mo14 Popul 25-44		
ms15		Sum mo15 Popul 45-64		
ms25		Sum of ms25, work trips- gravity		
ms26		Sum of ms26, secondary school trips, Gravity		
ms27		Sum of ms27, post sec. school trips, Gravity		
ms28		Sum of ms28, other to home, Gravity		
ms29		Sum of ms29, NHB, Gravity		
ms30		Sum mf30 Leave Home Trips Gravity		
ms31		Sum mf31 Auto Person Work Trips UTA		
ms32		Sum mf32 Auto Vehicle Work Trips UTA		
ms33		Sum mf33 Transit Work Trips UTA		
ms35		Work-Home -- Attn / Prodn		
ms36		Sum mf36 Auto Person Sch. Trips UTA		
ms37		Sum mf37 Auto Vehicle Sch. Trips UTA		
ms38		Sum mf38 Transit Sch. Trips UTA		
ms39		NHB -- Attn / Prodn		
ms40		Leave-Home -- Prodn / Attn		
ms41		Sum mf41 Auto Person Other Trips UTA		
ms42		Sum mf42 Auto Veh. Other Trips UTA		
ms43		Sum mf43 Transit Other Trips UTA		
ms46		Sum mf46 Auto Per. Work Trips non-UTA		
ms47		Sum mf47 Auto Veh. Work trips Non-UTA		
ms48		Sum mf48 Auto Per. Sch. Trips Non-UTA		
ms49		Sum mf49 Auto Veh. Sch. Trips Non-UTA		
ms50		Sum mf50 Auto Per. Other Trips. Non-UTA		
ms51		Sum mf51 Auto Veh. Other Trip Non-UTA		
ms52		Sum mf52 Auto Person Trips Intrazonal		
ms53		Sum mf53 Auto Veh. Trips Intrazonal		
ms54		Sum mf54 Transit Trips Intrazonal		
ms55		Sum mf55 Ext. Vehicle Trips		
ms56		Sum mf56 External Auto Person Trips		
ms57		Sum mf57 Total Auto Person Trips		
ms58		Sum mf58 Total Auro Vehicle Trips		
ms59		Sum mf59 Total Transit Trips		
ms60-99		Free to use as desired.		

Exhibit 6.3---- mo and md Matrix Description

Matrix ID	Flag	Description	How Used	Macro Used
mo01 & md01	/r	1995 parking cost	Modal Split (Logit models)	ms_all95.mac, ms_all21.mac
mo02 & md02	/r	1995 od dwelling units	Input -Land Use	tripgen2.mac
mo03 & md03	/r	1995 od total population	Input -Land Use	tripgen2.mac
mo05 & md05	/r	1995 total employment	Input -Land Use	tripgen2.mac
mo07 & md07	/r	1995 Other Employment	Input -Land Use	tripgen2.mac
mo08 & md08	/r	1995 Secondary School Enrollment	Input -Land Use	tripgen2.mac
mo09 & md09	/r	1995 Post-Secondary School Enrollment	Input -Land Use	tripgen2.mac
mo10 & md10	/r	1995 Gross Leasable Area	Input -Land Use	tripgen2.mac
mo11 & md11	/r	1995 Population 5 - 14 Years	Input -Land Use	tripgen2.mac
mo12 & md12	/r	1995 Population 10 - 14 Years	Input -Land Use	tripgen2.mac
mo13 & md13	/r	1995 Population 15 - 24 Years	Input -Land Use	tripgen2.mac
mo14 & md14	/r	1995 Population 25 - 44 Years	Input -Land Use	tripgen2.mac
mo15 & md15	/r	1995 Population 45 - 64 Years	Input -Land Use	tripgen2.mac
mo20 & md20	/r	1995 (MO)del calibration res Ont=0, PQ=1	Input -Land Use	tripgen2.mac
mo25 & md25	/r	1995 OD PMPKHR work (MO) Prod., (MD) Att.	Information -95 OD Survey	
mo26 & md26	/r	1995 OD PMPKHR sec school (MO) Prod., (MD) Att.	Information -95 OD Survey	
mo27 & md27	/r	1995 OD PMPKHR post sec. (MO) Prod., (MD) Att.	Information -95 OD Survey	
mo28 & md28	/r	1995 OD PMPKHR other-home (MO) Prod., (MD) Att.	Information -95 OD Survey	
mo29 & md29	/r	1995 OD PMPKHR nhb (MO) Prod., (MD) Att.	Information -95 OD Survey	
mo30 & md30	/r	1995 OD PMPKHR leave home (MO) Prod., (MD) Att.	Information -95 OD Survey	
mo35 & md35		1995 - Work-Home - (MO) Prod., (MD) Att.	Output- Trip Generation	tgwork3.odh
mo36 & md36		1995 - P+SSchl-Home - (MO) Prod., (MD) Att.	Output- Trip Generation	tgpsschl.odh
mo37 & md37		1995 - PostSec-Home - (MO) Prod., (MD) Att.	Output- Trip Generation	tgpsec.odh
mo38 & md38		1995 - Other-Home - (MO) Prod., (MD) Att.	Output- Trip Generation	tgother.odh
mo39 & md39		1995 - NHB - (MO) Prod., (MD) Att.	Output- Trip Generation	tgnhb.odh
mo40 & md40		1995 - Leave-Home - (MO) Prod., (MD) Att.	Output- Trip Generation	tgleave.odh
mo45 & md45	/r	1995 - work % hh with 0 veh/hh logit	Input- Mode Split	ms_all95.mac, ms_all21.mac
mo46 & md46	/r	1995 - work % hh with 1 veh/hh logit	Input- Mode Split	ms_all95.mac, ms_all21.mac
mo47 & md47	/r	1995 - work % hh with >=2 veh/hh logit	Input- Mode Split	ms_all95.mac, ms_all21.mac
mo48 & md48	/r	1995 - sch % hh with 0 veh/hh logit	Input- Mode Split	ms_all95.mac, ms_all21.mac
mo49 & md49	/r	1995 - sch % hh with 1 veh/hh logit	Input- Mode Split	ms_all95.mac, ms_all21.mac
mo50 & md50	/r	1995 - sch % hh with >=2 veh/hh logit	Input- Mode Split	ms_all95.mac, ms_all21.mac
mo55 & md55	/r	intrazonal mode split -auto person	Input- Mode Split	ms_all95.mac, ms_all21.mac
mo56 & md56	/r	intrazonal mode split -transit	Input- Mode Split	ms_all95.mac, ms_all21.mac
mo57 & md57	/r	intrazonal car occupancy	Input- Mode Split	ms_all95.mac, ms_all21.mac
mo62 & md62	/r	intrazonal auto time	Input- Mode Split	ms_all95.mac, ms_all21.mac
mo63 & md63	/r	transit intrazonal time	Input- Mode Split	ms_all95.mac, ms_all21.mac
mo64 to mo99		Free to use as desired		
md64-md99		Free to use as desired		

Note: "/r" flag indiscates that the matrix is protected against modification and deletion.
It is possible to change this protection status using module 3.12.

Exhibit 6.4 - mf Matrix Description

Matrix ID	Flag	Description	How Used	Macros Used
mf01	/r	od intrazonal a_t, t_t,a_d,t_d	See note 1	ms_all95.mac, ms_all21.mac
mf02		auto time	Output- Auto Assignment	assign.mac
mf03		auto distance simulated	Output- Auto Assignment	assign.mac
mf05		transit ivtt	Output- Transit Assignment	assign.mac
mf06		transit aux time	Output- Transit Assignment	assign.mac
mf07		Revised transit aux time	Calculated	assign.mac
mf08		transit total wait time	Output- Transit Assignment	assign.mac
mf09		first wait time	Output- Transit Assignment	assign.mac
mf10		transit boarding time	Output- Transit Assignment	assign.mac
mf11		Total number of transfers	Output- Transit Assignment	assign.mac
mf12		transit trip length	Output- Transit Assignment	assign.mac
mf13		transit distance revised	Output- Transit Assignment	assign.mac
mf14		Transit total travel time (corrected for aux.)	Calculated	assign.mac
mf15		PMPKHR Auto/Transit Time Ratio	Calculated	ms_all95.mac, ms_all21.mac
mf16	/r	Internal Zones = 1	Input	ms_all95.mac, ms_all21.mac
mf17	/r	Unit matrix, all cells = 1	Input	ms_all95.mac, ms_all21.mac
mf18	/r	PMPKHR Transit Fare	Input	ms_all95.mac, ms_all21.mac
mf19		PMPKHR Work-Trip -- Gen Impedance	Output - Mode Split	All trip distribution macros
mf20		PMPKHR Other Trips mode split factors	Output - Trip Distribution	ms_all95.mac, ms_all21.mac
mf25		PMPKHR Work Trip - Gravity (Sim)	Output - Trip Distribution	tgwork3.odh
mf26		PMPKHR Sec. School- Gravity(Sim)	Output - Trip Distribution	tgpsschl.odh
mf27		PMPKHR Post Sec. School-(Sim)	Output - Trip Distribution	tgpsec.odh
mf28		PMPKHR Other-Home- Gravity (Sim)	Output - Trip Distribution	tgother.odh
mf29		PMPKHR NHB (Sim)	Output - Trip Distribution	tgnhb.odh
mf30		PMPKHR Leave-Home - Gravity (Sim)	Output - Trip Distribution	tgleave.odh
mf31		PMPKHR Auto Person Work Trips UTA	Output - Mode Split	ms_all95.mac, ms_all21.mac
mf32		PMPKHR Auto Vehicle Work Trips UTA	Output - Mode Split	ms_all95.mac, ms_all21.mac
mf33		PMPKHR Transit Work Trips UTA	Output - Mode Split	ms_all95.mac, ms_all21.mac
mf36		PMPKHR Auto Person School trips UTA	Output - Mode Split	ms_all95.mac, ms_all21.mac
mf37		PMPKHR Auto Vehicle School Trips UTA	Output - Mode Split	ms_all95.mac, ms_all21.mac
mf38		PMPKHR Transit School Trips UTA	Output - Mode Split	ms_all95.mac, ms_all21.mac
mf41		PMPKHR Auto Persons Other Trips UTA	Output - Mode Split	ms_all95.mac, ms_all21.mac
mf42		PMPKHR Auto Vehicles Other Trips UTA	Output - Mode Split	ms_all95.mac, ms_all21.mac
mf43		PMPKHR Transit Other Trips UTA	Output - Mode Split	ms_all95.mac, ms_all21.mac
mf46		PMPKHR Auto Person Work Trips Non-UTA	Output - Mode Split	ms_all95.mac, ms_all21.mac
mf47		PMPKHR Auto Veh. Work Trips Non-UTA	Output - Mode Split	ms_all95.mac, ms_all21.mac
mf48		PMPKHR Auto Person Sch. Trips NON-UTA	Output - Mode Split	ms_all95.mac, ms_all21.mac
mf49		PMPKHR Auto veh. School Trips NON-UTA	Output - Mode Split	ms_all95.mac, ms_all21.mac
mf50		PMPKHR Auto Person Other Trips NON-UTA	Output - Mode Split	ms_all95.mac, ms_all21.mac
mf51		PMPKHR Auto Vehicle Other Trip Non-UTA	Output - Mode Split	ms_all95.mac, ms_all21.mac
mf52		PMPKHR Auto Person Trips Intrazonal	Input - Mode Split	ms_all95.mac, ms_all21.mac
mf53		PMPKHR Auto Vehicle Trips- Intrazonal	Input - Mode Split	ms_all95.mac, ms_all21.mac
mf54		PMPKHR Transit Trips Intrazonal	Input - Mode Split	ms_all95.mac, ms_all21.mac
mf55	/r	1995 external auto vehicle trip matix	Input	ms_all95.mac, ms_all21.mac
mf56	/r	1993 External auto vehicle trip matrix	Input	ext93to21.mac
mf57		PMPKHR Auto Person Total Trips	Output - Mode Split	ms_all95.mac, ms_all21.mac
mf58		PMPKHR Auto Vehicles Total Trips	Output - Mode Split	ms_all95.mac, ms_all21.mac
mf59		PMPKHR Transit Total Trips	Output - Mode Split	ms_all95.mac, ms_all21.mac
mf60 to mf99		free to use as desired		

Note 1 : Intrazonal travel times and distances by mode as obtained from OD survey with the aid of Microstation. They are stored in mo62,mo63,md62,md63 (ie: a_t is auto time)

6.2.3 Annotation and Demarcation Files

The EMME2 software uses network plots to present the results of a given model run. The use of annotations such as street names and river boundaries assist the user to identify road facilities with ease. Annotation files developed for TRANS Agencies are illustrated in Exhibit 6.5.

Exhibit 6.5 - Annotation and demarcation Files

File Name	Description
annota	Street names
annotb	River boundaries
annotd	Zone boundaries
annote	Zone numbers

The user can activate each of the annotation or demarcation files by typing in the file name followed by pushing the return key after the EMME2 plot is brought up on the screen. The exception to this is in module 2.12 where you must type in g and then the file name. See the EMME2 manual for further details on operating these type of files.

6.2.4 Macros

A number of macros have been established to assist the user in carrying out EMME2 model applications. Exhibit 6.6 illustrates the macros available for use. The Exhibit lists the macro name, description and applicable user prompts.

The user should keep in mind that many possible approaches can be used to obtain the desired results of a modeling exercise. The macros contained in Exhibit 6.6 can be used to perform a wide range of modeling activities by editing the macros as required. It is strongly recommended that if the macro is altered, the macro name be altered and a description written within the macro describing changes to the original macro. It is also recommended that the user keep a record of which macros are run, as well as the date and time it was run. Monitoring the output of model runs can be done by reviewing output files and the values of the MS matrices containing the sum of key matrices. As well, the error file generated by emme2 in the working directory can also be checked.

Miscellaneous macros include those described in Chapter 2 to develop the year 1995 and 2021 networks from the "ultimate" network. Another macro used frequently is ASSIGNSM.MAC which creates two output files that are input into the Excel macro "run screenline macro" in the file SNLINE11.XLS. The user must run macro ASSIGNSM.MAC to obtain auto and transit link data text files. These text files must be modified in DOS to remove the first 14 lines of the EMME2 auto and transit output files before running SNLINE11.XLS.

Macro User Prompts

Most macros require input information following the macro name. These inputs are used to assist the user in defining information about their model run which are the primary means of documenting model results so that the user can identify and analyze model output throughout the analysis. For example, in the trip generation model, the user is requested to input %1% and %2%. The 1st input must not exceed 6 spaces- usually the year of the simulation is placed here. The 2nd input must not exceed 8 spaces and is used to provide a further description of the model run. For example, you could use PM_LUSE3 indicating a PM model run using land use option 3.

Exhibit 6.6- Macro Description

Model Process	Macro Name	Substitional Parameters	Parameter Description	Description
Trip Generation	tripgen2.mac	%1% %2%	1= Matrix Name (1 to 6 characters ie: 1995) 2=description of model run in 1-8 characters ex: PMPKHR	This is the main macro that runs the trip generation model. The user must supply %1% and %2% when running the macro. ie: tripgen2.odh 1995 PMPKHR This macro calls each of the submacros listed below: tgwork3n.odh %1% %2% is the work trip generation model tgpsschl.odh %1% %2% is the secondary school trip generation model. tgpsec.odh %1% %2% is the post secondary school trip generation model tgother.odh %1% %2% is the other home based trip generation model. tgleave.odh %1% %2% is the leave home trip generation model. tgnhd.odh %1% %2% is the non-home based trip generation model.
	factor.mac			Used to adjust 2021 Other to Home and Non-Home based trips which were under-reported in 1995 compared to 1986- see text.
Trip Distribution	tripdist.mac	%1% %2%	See TRIPGEN2.MAC parameter description.	This is the main macro that runs the trip distribution model. The user must supply %1% and %2% when running the macro. ie: tripdist.mac 1995 PMPKHR. This macro calls each of the submacros listed below: td_grwk1.odh %1% %2% is the work trip distribution model tdsch1.odh %1% %2% is the secondary and post secondary school trip distribution model. tdother1.odh %1% %2% is the other home based trip distribution model. tdleave1.odh %1% %2% is the leave home trip distribution model. tdnhb1.odh %1% %2% is the non-home based trip distribution model.
Mode Split	ms_all95.mac ma_allL21.mac	%1% %2%	See TRIPGEN2.MAC parameter description.	These macros perform the entire modal split process. The user must supply %1% %2% when running the macro. ie ms_all7.mac 1995 PMPKHR sum.odh - Macro sums key matrices and places sums in appropriate ms matrix report file called reports.sum. ms_all95 is for 1995 simulation, while ms_all21.mac is for 2021 simulation.
	sum.odh	%1%	1 = scenario number you want the summary data from.	sum.odh - Macro sums key matrices and places sums in appropriate ms matrix report file called reports.sum. (run in the modal split macro by default).

Note: **For details on how to use the macro parameters, go into the DOS editor and read the macro contents.**

Exhibit 6.6- Macro Description, continued

Model Process	Macro Name	Substitional Parameters	Parameter Description	Description
Assignment	assign.mac	%1% - %8%	1= matrix ID, max 6 characters 2= run description, max 8 characters 3 = auto vehicle matrix 4 = auto person matrix 5 = transit person matrix 6 = max. number of assig. iterations 7 = Assig. stop criteria, relative gap 8 = Assig. stop criteria, normal gap	This macro performs the auto and transit assignment. The user must supply all the parameters as indicated. This maco stores auto and transit travel time and cost matrices. For example, ~<assign.mac 1995 luse2 58 57 59 40 .3 .3 runs the assignment by saving 1995 as the matrix id, luse2 as the first part of the matrix description, 58 is the auto vehicle matrix, 57 is the auto person matrix, 59 is the transit matrix, 40 is the number of auto assignment iterations, .3 and .3 are assignment closing criteria.
	level3.mac	%1% - %8%	see Assignment, assign.mac for parameter descriptions.	Macro to run a simple auto and transit assignment without altering or saving auto and transit time and distance matrices.
	assignsm.mac	%1% %2%	1 = three letters or numbers description used as a DOS file extension. 2 = scenario number you want the summary data from.	Macro creates two batchout files, one for auto and another for transit. These files are used as input into the Excel file snline11.xls. The batchout files must be modified in DOS to remove the lines above the EMME2 line containing :"from to length modes link…."
Network Macros	sc5to95.mac sc5to21.mac snline11.xls			Creates the 1995 base network from the ultimate network Creates the 2021 base network from the ultimate network Use Excel macro "run screenline macro" to summarize screenline volumes.
Miscellaneous Macros	93to95ex.mac 93to21ex.mac default.mac			Developes the 1995 external trip table from the 1993 external travel demand matrix. Developes the 2021 external trip table from the 1993 external travel demand matrix. Sets default values of emme2 modules to provide consistant results beteen databanks used by TRANS Agencies.
Model Applications LEVEL1	level195.mac level121.mac	%1% - %8%	see Assignment, assign.mac for parameter descriptions.	Macro for land use changes. Model run from trip generation to assignment, 5 cycles. level195.mac is for 1995 simulation, level121.mac is for 2021 simulation.
LEVEL2	level295.mac level221.mac	%1% - %8%	see Assignment, assign.mac for parameter descriptions.	Major network changes. Model run from trip distribution to assignment, 5 cycles. level295.mac is for 1995 simulation, level221.mac is for 2021 simulation.
LEVEL3	level3.mac	%1% - %8%	see Assignment, level3.mac for parameter descriptions.	Auto and Transit assignment macro for minor network changes.

Note: **For details on how to use the macro parameters, go into the DOS editor and read the macro contents.**

6.3 Overview of Using the TRANS Model Within EMME2

The TRANS model is a traditional 4 step travel demand model utilizing trip generation, trip distribution, mode split and trip assignment models. The documentation contained in the previous chapters outlines the characteristics of these four sub-models. A brief description of the sub-models follows:

- *Trip generation*, in which trip productions and attractions at each zone are calculated as a function of the zone's land use characteristics. The results are expressed as an array of trips originating in each zone, and an array of trips destined to each zone.

- *Trip distribution*, in which the generated trips are distributed among the zones, as a function of zonal land use as well as road and transit network characteristics. The results are expressed as person-trip origin-destination matrices.

- *Modal split*, in which the total number of trips are apportioned by mode. Mode split is calculated for three modes: auto vehicle, auto person, and transit person. The results are expressed in terms of matrices for each mode.

- *Trip assignment*, in which the auto driver, auto person and transit person matrices are loaded onto specific road links and transit routes, respectively. The results are expressed in terms of directional auto volumes for each road link, and for transit by transit passengers by route, road link or transitway link.

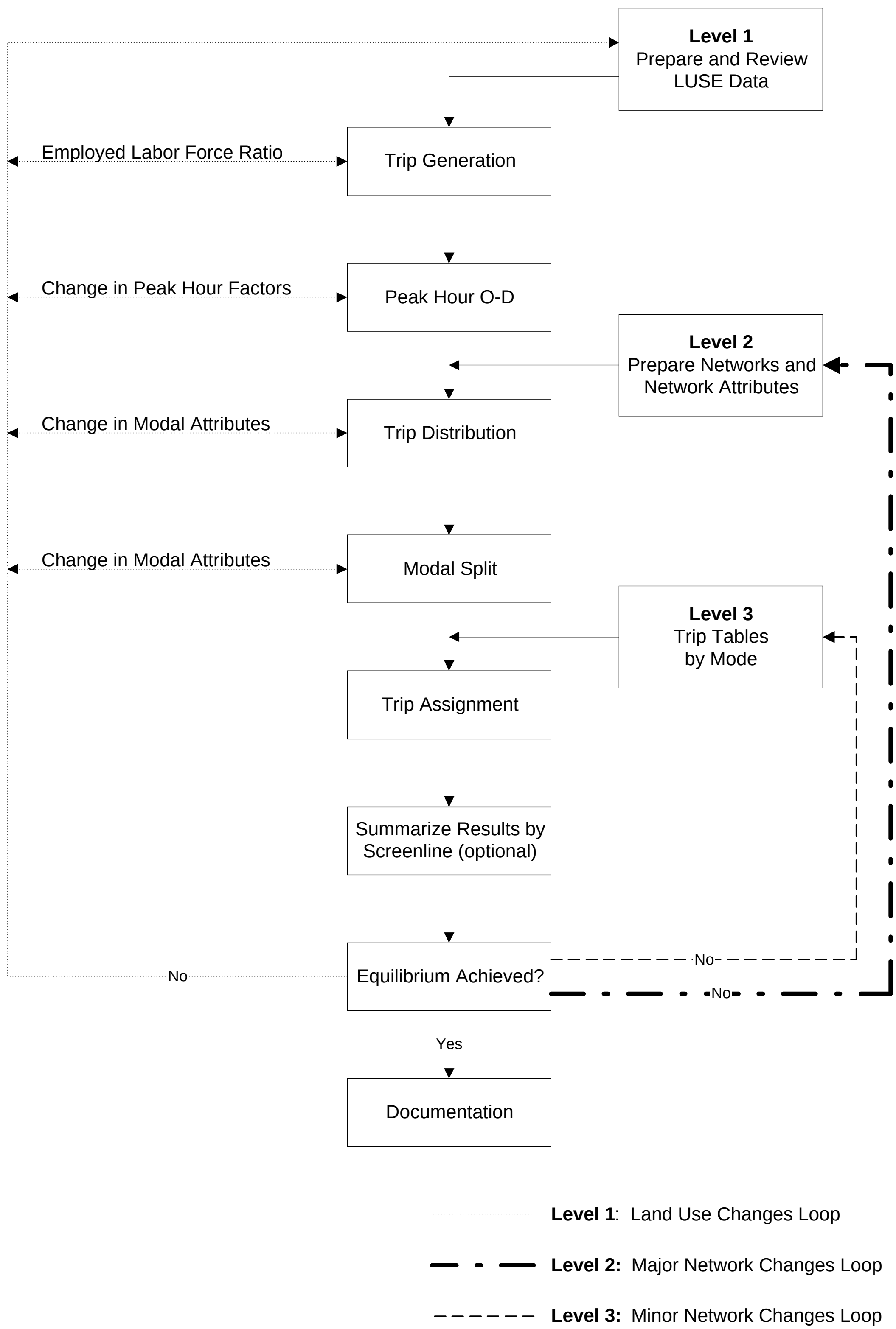
The modeling application being used determines which of the four models you require running. Exhibit 6.7 provides a graphic illustrating the three modeling applications commonly used and described below:

- Land Use Changes - This involves a complete model run to test the impact of land use options on the transportation system in a future year.

- Major Network Changes - Tests the impact of major network alterations such as new bridge crossings over the Ottawa River, assuming that the land use remains unaltered but that trip distribution would alter significantly.

- Minor Network Changes - Carries out a trip assignment to analyze the impact of minor network alterations such as road widening, road additions and transit route modifications. This involves assigning to the new network a base trip table obtained in either the Major Network Changes or Land Use Changes outlined above.

Exhibit 6.7 TRANS Model Applications



6.4 Application of the TRANS Model within EMME2

The TRANS model is for the most part used to analyze travel demand in the three methods as outlined earlier in this chapter. Each of the methods will be described below.

6.4.1 Full Model Runs -Land Use Changes (Use LEVEL195.MAC and LEVEL121.MAC)

To analyze a planning horizon as 1995 or 2021, a full model run is required since a new land use scenario is being investigated. This involves running the model beginning with the trip generation model and ending with the trip assignment model, see Exhibit 6.6 and 6.7. Different macros are required depending on the year being simulated since several components of the modal split macro differ between 1995 and 2021. To run a 1995 simulation, use LEVEL195.MAC, to run the 2021 simulation use LEVEL121.MAC. If a different horizon year is required, the user must modify the modal split sub-macro used in the appropriate LEVEL1 macro to account for the required UTA definition as well as alter land use and networks as necessary.

Special care is required to apply the model to forecast travel past 1995. As Exhibit 6.7 illustrates, the modeling process for a future year involves using several feedback loops depicted as dotted lines throughout the modeling process. They define points at which user input and judgement are required when operating the model. Chapter 7 outlines the assumptions used to simulate 2021 demand.

The user is required to input into the macro default values to control the auto assignment stopping criteria. For LEVEL1 simulations, past experience indicates that the following defaults be used.

Number of iterations: 40
Stopping criterion : relative gap 0.3
Stopping criterion: normal gap 0.3

6.4.2 Major Network Changes (Use macro LEVEL2.MAC)

Major network alterations are assumed to impact on trip distribution, modal split and assignment. In this case each of the three models will be run until an equilibrium is established, see Exhibit 6.7. The number of cycles required before equilibrium is reached is dependant on the severity of alterations to the network. Indicators you can use to determine that the model is stabilizing is the differences in the auto and transit demand matrices between the cycles as well as differences between the assigned volumes on the networks at screenlines. The macro is set up to cycle 5 times.

6.4.3 Minor Network Changes (Use macro LEVEL3.MAC)

If you are interested in finding the impact of widening or building a new arterial road, then you could modify the road and transit network and then carry out a trip assignment. It is assumed that there is no need to run the modal split model in this case since the network changes will not significantly alter modal choice. In this case you would run the macro LEVEL3.MAC. The macro carries out the auto assignment followed by the transit assignment. The transit assignment utilizes the auto delay on roadways within the transit volume delay functions, implying that the auto assignment must be done before the transit assignment. It is good practice to do both the auto and transit assignment even if only the auto assignment is required. EMME2 will inform you if any errors occur in the transit network which could have an impact on the modeling work at a later date. The criteria to control when the auto assignment stops should be considered depending on the model application. If you are primarily interested in traffic volumes, then the following macro parameters below can be used:

Number of iterations: 20
Stopping criterion: relative gap 0.3
Stopping criterion: normal gap 0.3

On the other hand, if you are interested in link travel times for an analysis where all the link travel times will be weighted later by the number of trips and then summed to give a single value of travel time for a particular network, then tighter limits could be placed on the auto assignment as follows:

Number of iterations: 100
Stopping criterion: relative gap 0.05
Stopping criterion: normal gap 0.05

7. Forecasting Application

This section outlines the process used to apply the 1995 model to the 2021 horizon year. Forecasting travel demand past the year the model was calibrated requires certain precautions. The purpose of this section is to outline the steps taken to modify the model to forecast future travel demand so that the user can apply a similar approach to model other time horizons.

7.1 Data Needs

7.1.1 Trip Generation Demographics

In order to use the model to forecast travel demand, you require demographic data prepared at the zonal level for use in the trip generation equations. The 2021 demographics estimates were obtained from the RMOC and CUO Planning Departments and are compared to 1995 values in Exhibit 7.1. Note that the 45 to 64 age group more than doubles, the age group of 65 and over increases threefold, while the remaining age groups for persons ages between 5 and 44 remain in the same order of magnitude as those observed in 1995. The number of households increases 1.5 times while population increases at a lower amount of 1.39 times, indicating that the number of persons per household decreases with time. Total employment increases by 54 percent. The employment growth (54%) is higher than the population growth (34%) of persons in the age co-horts (15-64) who would likely hold the majority of jobs. The higher growth in employment figures suggest that more jobs could result if people hold more than one job, the proportion of women entering the workforce continues to increase or people aged over 64 continue to work in the future. Since the work trip generation equations do not include the 65+ age co-hort, it is possible that work trips may be under-estimated in the 2021 forecast. This topic is dealt with further in section 7.6.2.

Exhibit 7.1 - Demographics, 1995 and 2021

Variable	Variable name	1995	2021	Increase over 1995
Total Population	POP	960,400	1,331,000	1.39
Popul. aged 5-14	POP5-14	134,400	111,400	0.83
Popul. aged 15-24	POP15-24	126,500	136,100	1.08
Popul. aged 25-44	POP25-44	344,700	347,800	1.01
Popul. aged 45-64	POP45-64	195,100	407,000	2.09
Popul. aged 65 and over		85,000	276,000	3.25
Dwelling units	DWEL	374,400	562,300	1.50
Total Employment	EMP	454,900	698,300	1.54
School Enrollment				
Primary & Secondary	SCHS	117,100	78,300	0.67
Post Secondary	SCHP	78,400	58,500	0.75
GLA (gross leasible floor area in 1000 sq ft.)	GLA	13,150	18,113	1.38

7.1.2 Modal Split Demographic

Number of vehicles per household is a demographic variable used in the modal split models. Separate estimates of this variable are required for both the work trip and school trip modal split models. This variable was not prepared by the Planning Departments and therefore another means was used to estimate this data. It was found that the most satisfactory estimate was obtained from logit models developed on a person level and aggregated to a zonal level, estimating the percentage of households in a traffic zone with 0, 1 or 2 or more vehicles per household. The model was developed using the 1995 OD Survey as the data source. Further details on the development of this model is provided in Appendix 2.

7.2 Networks and Attributes

The 2021 auto and transit networks were based on the work carried out in the Transportation Master Plans of the RMOC and CUO. Appendix 1 contains a listing of the road and transit improvements assumed in the networks for the year 2021.

7.3 UTA Definition

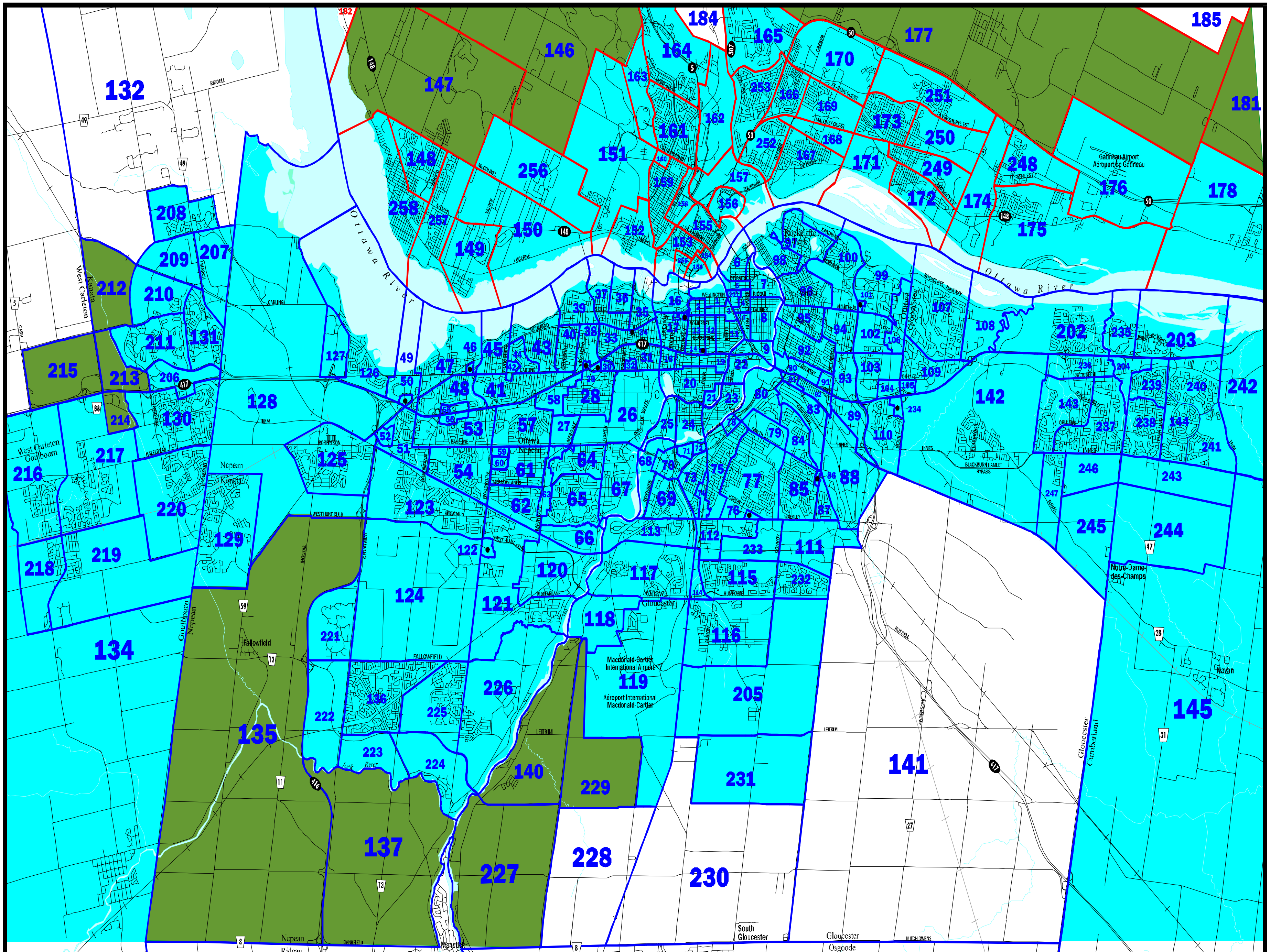
It was assumed that the area serviced by public transit would increase between 1995 and 2021. The additional zones obtaining transit service in 2021 compared to 1995 are zones 135, 137, 140, 146, 147, 177, 181, 212 to 215and 227, see Exhibit 7.2.

7.4 Quebec Transit Flag

During the model calibration process, it was found that the variable Province was required in the work and school modal split models to account for the differences in transit service attributes in the RMOC and CUO for the year 1995. In 1995, transit mode share was greater in the RMOC than the CUO. This is in part due to the size of the CUO and the associated transit infrastructure that can be provided for an area containing a population of about 250,000 residents compared to the 750,000 RMOC population. In keeping with the assumptions used in the RMOC Transportation Master Plan Study, it was assumed that the CUO transit system would be comparable to that of the RMOC by the year 2021. Therefore, for the 2021 model simulation, it is assumed that the Quebec and RMOC value of the Province flag are set to 0, thereby increasing transit use in the CUO over 1995 conditions.

7.5 Travel Cost

It was assumed the cost of travel in the peak hour remains the same for 2021 as existed in 1995 for both auto and transit. It is important to maintain the relative costs between the two modes in correct perspective. By using the 1995 costs, this is accomplished. If you wanted to assume that fuel and parking costs increased 10% for 2021 while transit fare remained unchanged, then the auto cost should be factored upwards by 10%. Travel cost is only used in the work trip logit model and therefore does not influence mode split for the remaining trip purposes.



1995 UTA	ZONES ADDED FOR 2021		

Exhibit 7.2 Urban Transit Area (UTA) Traffic Zones

RMOC ZONES:	1-145, 201-247
CUO/MRC ZONES:	146-185, 248-258
EXT ZONES:	186-200

7.6 Under-Reporting of Trip Purposes

7.6.1 "Other to Home" Trips

Analysis was carried out to determine if new factors are required to convert from the peak period to the peak hour for 2021 trip generation attractions and productions. To gain insight into this issue, trip rates for the 24 hour, pm peak period and peak hour were analyzed based on the 1986 and 1995 OD Survey databases,(see Exhibit 7.3).

The analysis focuses on trip rates involves quantifying the number of trips for a given time period and trip purpose and then dividing this amount by the population aged 10 and over in the year under study. A comparison of the 24 hour trip rates indicates that the NHB (non-home based) trip rate for 1995 was 73 percent of the 1986 rate, while all the other trip purposes had trip rates for 1995 within plus or minus 5% of the 1986 rates. This lower trip rate for NHB trips is also apparent in the other time periods contained in the exhibit. This tends to suggest that non-home based trips may have been under-reported in the 1995 phone survey compared to the 1986 mail survey or that in 1995 fewer trips of this type were made per capita compared to 1986. It is possible that the 1986 survey approach may have been more accurate at reporting these discretionary trips. To account for this discrepancy in the trip rate trend, the 2021 non-home based work trips were factored upwards by 20% in the macro FACTOR.MAC.

Another discrepancy between the 1986 and 1995 trip rates occurs in the trip rates for transit. A comparison of the transit trip rates for school for all time periods indicates that the rates for the two years for the geographic areas remained relatively constant. For the work trip purpose, the 1995 transit rates decline by about 40% over the 1986 rates in the NCR for all time periods.

For "Other" and NHB trip purposes in the 24 hour and off peak periods, transit trip rates in 1995 were about half of the 1986 rates. In the PM peak hour, the transit trip rates for 1995 decreased 70% for "Other" trips and 60% for NHB trip purposes over the 1986 rates. This significant decrease in transit use is possibly due to the 1995 transit fare policies in the RMOC where persons using single tickets or paying by cash (i.e. discretionary transit users) paid a premium to use transit in the peak period while in 1986 no premium was charged. If the RMOC transit fare did not discriminate against peak period travel, it could be assumed that the "Other" and NHB trips would have similar decreases in trip rates between 1986 and 1995 as observed in the off-peak period. In general, the off-peak period decrease in transit trips for "Other" and NHB trips was in the order of 50%. If 50% was used as the decrease in transit trips in the peak hour for "Other" and NHB trips, then an additional 2500 transit trips while 2500 fewer auto person trips would have occurred in the 1995 PM peak hour.

Therefore, it was assumed that if the 1995 model was to be applied to a future year, the diversion curves for mode split in the modal split model should be altered to increase transit model split accordingly. This was done by running the 1995 model and modifying the constant in the modal split diversion curve equations until an additional 2000 transit trips were obtained in the first equation (auto trips under 15 minutes) and the second curve until 500 additional transit trips occurred. The decision to assign 2000 transit trips to the first curve (auto trips under 15 minutes)

Exhibit 7.3 - 1986 and 1995 Trip Rates by Time Periods

Time	Trip		Auto			Transit			Sum, All Modes			Sum, Auto & Transit		
Period	Purpose	Area	1986	1995	95/86	1986	1995	95/86	1986	1995	95/86	1986	1995	95/86
PM Peak Hour	LH	RMOC	0.029	0.029	1.02	0.002	0.001	0.81	0.034	0.036		0.030	0.031	
		CUO	0.030	0.030	1.01	0.001	0.001	0.49	0.033	0.035		0.031	0.031	
		NCR	0.029	0.029	1.02	0.002	0.001	0.75	0.034	0.036	1.06	0.030	0.031	1.00
	NHB	RMOC	0.067	0.057	0.85	0.013	0.005	0.41	0.088	0.069		0.080	0.062	
		CUO	0.071	0.063	0.90	0.006	0.002	0.37	0.082	0.069		0.076	0.065	
		NCR	0.068	0.059	0.86	0.011	0.004	0.40	0.086	0.069	0.80	0.079	0.063	0.80
	OTHER	RMOC	0.063	0.053	0.84	0.013	0.004	0.31	0.082	0.065		0.075	0.057	
		CUO	0.050	0.067	1.35	0.004	0.002	0.44	0.058	0.075		0.054	0.069	
		NCR	0.060	0.056	0.94	0.011	0.003	0.31	0.076	0.068	0.89	0.070	0.060	0.85
	SCHOOL	RMOC	0.003	0.004	1.05	0.005	0.005	0.92	0.012	0.011		0.009	0.008	
		CUO	0.005	0.008	1.67	0.003	0.004	1.18	0.011	0.017		0.008	0.012	
		NCR	0.004	0.005	1.26	0.005	0.005	0.96	0.011	0.013	1.12	0.008	0.009	1.09
	WORK	RMOC	0.067	0.071	1.06	0.041	0.027	0.65	0.121	0.109		0.108	0.098	
		CUO	0.074	0.085	1.15	0.020	0.015	0.77	0.096	0.106		0.094	0.100	
		NCR	0.069	0.075	1.09	0.036	0.024	0.66	0.115	0.108	0.94	0.105	0.098	0.94
	Total	NCR	0.229	0.224	0.98	0.064	0.037	0.58	0.322	0.293	0.91	0.293	0.261	0.89
PM Peak Period	LH	RMOC	0.071	0.074	1.04	0.006	0.004	0.62	0.085	0.093		0.077	0.078	
		CUO	0.066	0.071	1.07	0.003	0.002	0.52	0.075	0.083		0.069	0.073	
		NCR	0.070	0.073	1.05	0.006	0.003	0.60	0.083	0.091	1.10	0.075	0.077	1.02
	NHB	RMOC	0.156	0.129	0.83	0.030	0.013	0.42	0.203	0.160		0.186	0.142	
		CUO	0.149	0.142	0.95	0.013	0.007	0.51	0.177	0.161		0.163	0.149	
		NCR	0.154	0.133	0.86	0.026	0.011	0.43	0.196	0.160	0.82	0.180	0.144	0.80
	OTHER	RMOC	0.145	0.124	0.86	0.028	0.010	0.37	0.186	0.156		0.111	0.101	
		CUO	0.043	0.144	3.38	0.013	0.004	0.35	0.132	0.163		0.099	0.102	
		NCR	0.137	0.129	0.95	0.024	0.009	0.37	0.173	0.158	0.96	0.108	0.101	0.93
	SCHOOL	RMOC	0.011	0.013	1.10	0.025	0.020	0.81	0.062	0.068		0.036	0.033	
		CUO	0.011	0.022	1.97	0.014	0.014	1.01	0.057	0.092		0.025	0.036	
		NCR	0.011	0.015	1.32	0.022	0.019	0.84	0.061	0.074	1.22	0.034	0.034	1.00
	WORK	RMOC	0.134	0.141	1.05	0.083	0.051	0.62	0.240	0.213		0.217	0.192	
		CUO	0.153	0.180	1.17	0.036	0.029	0.81	0.196	0.220		0.189	0.209	
		NCR	0.139	0.151	1.08	0.072	0.046	0.64	0.229	0.215	0.94	0.211	0.196	0.93
	Total	NCR	0.511	0.501	0.98	0.149	0.087	0.59	0.743	0.698	0.94	0.608	0.551	0.91
Off-Peak	LH	RMOC	0.353	0.352	1.00	0.045	0.025	0.57	0.428	0.436		0.398	0.377	
		CUO	0.292	0.347	1.19	0.021	0.011	0.50	0.331	0.403		0.313	0.358	
		NCR	0.338	0.351	1.04	0.039	0.022	0.55	0.404	0.427	1.06	0.377	0.372	0.99
	NHB	RMOC	0.457	0.318	0.70	0.056	0.022	0.39	0.578	0.404		0.514	0.340	
		CUO	0.375	0.277	0.74	0.019	0.008	0.40	0.434	0.329		0.394	0.285	
		NCR	0.437	0.308	0.70	0.047	0.018	0.38	0.543	0.385	0.71	0.485	0.326	0.67
	OTHER	RMOC	0.384	0.415	1.08	0.047	0.028	0.60	0.465	0.506		0.431	0.443	
		CUO	0.277	0.385	1.39	0.020	0.008	0.43	0.309	0.441		0.297	0.394	
		NCR	0.358	0.407	1.14	0.040	0.023	0.57	0.428	0.489	1.14	0.399	0.430	1.08
	SCHOOL	RMOC	0.047	0.039	0.82	0.037	0.041	1.13	0.129	0.147		0.083	0.080	
		CUO	0.041	0.044	1.06	0.022	0.015	0.68	0.119	0.134		0.063	0.059	
		NCR	0.046	0.040	0.88	0.033	0.035	1.05	0.126	0.144	1.14	0.078	0.074	0.95
	WORK	RMOC	0.167	0.218	1.31	0.064	0.045	0.71	0.256	0.298		0.231	0.263	
		CUO	0.213	0.291	1.36	0.034	0.024	0.73	0.264	0.337		0.247	0.315	
		NCR	0.178	0.237	1.33	0.057	0.040	0.70	0.258	0.308	1.19	0.235	0.277	1.18
	Total	NCR	1.358	1.342	0.99	0.216	0.137	0.63	1.760	1.753	1.00	1.574	1.479	0.94
Weekday 24 Hour	LH	RMOC	0.523	0.522	1.00	0.063	0.035	0.55	0.632	0.640		0.586	0.556	
		CUO	0.451	0.518	1.15	0.030	0.014	0.46	0.509	0.595		0.481	0.532	
		NCR	0.505	0.521	1.03	0.055	0.029	0.53	0.603	0.629	1.04	0.561	0.550	0.98
	NHB	RMOC	0.688	0.520	0.76	0.094	0.039	0.42	0.871	0.649		0.782	0.559	
		CUO	0.613	0.502	0.82	0.037	0.017	0.46	0.709	0.580		0.650	0.519	
		NCR	0.670	0.516	0.77	0.080	0.033	0.42	0.832	0.631	0.76	0.750	0.549	0.73
	OTHER	RMOC	0.540	0.556	1.03	0.075	0.039	0.52	0.663	0.684		0.614	0.594	
		CUO	0.396	0.546	1.38	0.033	0.013	0.40	0.450	0.623		0.429	0.559	
		NCR	0.505	0.553	1.10	0.065	0.032	0.50	0.612	0.668	1.09	0.570	0.585	1.03
	SCHOOL	RMOC	0.081	0.083	1.02	0.112	0.102	0.91	0.324	0.368		0.194	0.185	
		CUO	0.076	0.099	1.31	0.063	0.051	0.80	0.302	0.375		0.139	0.150	
		NCR	0.080	0.087	1.09	0.100	0.089	0.88	0.319	0.370	1.16	0.180	0.176	0.98
	WORK	RMOC	0.501	0.539	1.08	0.241	0.151	0.63	0.817	0.773		0.742	0.690	
		CUO	0.559	0.666	1.19	0.111	0.080	0.71	0.702	0.790		0.671	0.746	
		NCR	0.515	0.571	1.11	0.210	0.133	0.63	0.789	0.777	0.98	0.725	0.704	0.97
	Total	NCR	2.275	2.249	0.99	0.510	0.317	0.62	3.155	3.076	0.97	2.785	2.565	0.92

Note: Population used for trip rates are persons aged 10 and over.

and 500 to the second curve maintains the same proportion of total "other" trips between the two diversion curves. To account for the assumed increase in transit trips, the modifications mentioned above were incorporated into the 2021 modal split macro (ms_all21.mac).

7.6.2 Work to Home Trips

The economy in 1995 was not as robust as in 1986 with the NCR experiencing high unemployment rates and slow economic growth compared to 1986. For this reason, a comparison was made of employed labor force and population aged 24 to 65 in 1986, 1995 and that estimated for 2021 (see Exhibit 7.4).

Exhibit 7.4 - Work Trip Analysis

	Year		
Variable	1986	1995	2021
Population 25-44	284,800	344,700	347,800
Population 45-65	151,500	195,100	407,000
Population (24-65)	436,300	539,800	754,800
Population (24 and over)	561,500	699,500	1,083,500
Total Employment	409,300	454,900	698,300
Ratio of Population (24- 65) to total Employment	0.938	0.843	0.925
Ratio of Population (24 and over) to total Employment	1.372	1.538	1.552

The results indicate that the ratio of population to employment for 1995 may be low compared to 1986 and 2021. The daily work trip rates in Exhibit 7.3 for all modes indicate that work trips decreased from 1986 to 1995 by 3 percent in the 24 hour period and 6 percent in the peak hour. This trend could be in part due to the changing characteristics of the workforce where part-time workers are comprising a larger component of the work force and are traveling outside the pm peak hour and period time intervals. The characteristics of the work force is dynamic and will change over time. Many assumptions could be made to alter the trip rate for work trips in the future on a per capita basis. For example, will a large proportion of the people between the ages 65 to 75 be a part of the 2021 workforce compared to today? For this study, it was decided to marginally increase the peak hour work trips by 5 percent for 2021 in the macro FACTOR.MAC.

7.7 Simulation Results

Exhibit 7.5 illustrates the travel demand by mode and purpose for the 1995 model. Note that the numbers in this table differ from those in Exhibit 5.9. This is because as the model development work progressed, modifications were made to the 1995 network and to the school trip generation model. In addition logit model estimates of vehicles per household were used in the modal split model rather than those obtained directly from the 95 OD survey. This last item was included to ensure that the vehicle per household models provided satisfactory results for the base year and also allows for consistent comparisons to future model simulation runs.

Exh 7.5 - 1995 Model Versus 2021 Model Travel by Purpose and Mode
Revised nework and new school trip gen. equation

Trip	Source	Total Trips				Inside UTA (Interzonal)			Outside UTA (Interzonal)			Intrazonal Trips		
Purpose		Total Persons	Auto Person	Auto Veh.	Transit	Auto Person	Auto Veh.	Transit	Auto Person	Auto Veh.	Transit	Auto Person	Auto Veh.	Transit
Work	OD Survey	78,780	59,551	49,238	19,229	49754	40685	18717	7800	6780	449	1,997	1,773	63
	Model	81,293	61,720	49,166	19,573	51073	40370	19527	9371	7861	0	1,276	935	46
School	OD Survey	7,392	3,727	1,712	3,665	3125	1509	3623	415	197	21	187	6	21
	Model	7,432	3,583	1,637	3,849	2818	1419	3834	645	215	0	120	3	15
Other	OD Survey	124,905	116,949	93,353	7,956	94032	74953	7754	8766	7066	56	14,151	11,334	146
	Model	125,923	118,062	89,251	7,861	99998	76365	7754	9019	6912	0	9,045	5,974	107
Total	OD Survey	223,898	193,048	155,167	30,850	146911	117147	30094	16981	14043	526	16,335	13,113	230
(see note)	Model	227,469	196,186	150,918	31,283	153889	118154	31115	19035	14988	0	10,441	6,912	168

Note: Total trips includes external travel demand of 12,821 auto persons and 10,864 auto vehicle trips. These trips are from a 1995 external trip matrix.

Exhibit 7.6 - 1995 Model Versus OD Survey Travel by Purpose and Mode
Revised nework and new school trip gen. equation

Trip	Source	Total Trips				Inside UTA (Interzonal)			Outside UTA (Interzonal)			Intrazonal Trips		
Purpose		Total Persons	Auto Person	Auto Veh.	Transit	Auto Person	Auto Veh.	Transit	Auto Person	Auto Veh.	Transit	Auto Person	Auto Veh.	Transit
Work	95 model	81,293	61,720	49,166	19,573	51073	40370	19527	9371	7861	0	1,276	935	46
	2021 model	110,569	79,960	63,556	30,609	69640	55117	30564	8592	7154	0	1,728	1,285	45
	2021 / 95	1.36	1.30	1.29	1.56	1.36	1.37	1.57	0.92	0.91	0	1.35	1.38	0.97
School	95 model	7,432	3,583	1,637	3,849	2818	1419	3834	645	215	0	120	3	15
	2021 model	7,674	3,838	1,839	3,836	3128	1652	3821	548	183	0	162	4	15
	2021 / 95	1.03	1.07	1.12	1.00	1.11	1.16	1.00	0.85	0.85	0	1.35	1.38	0.97
Other	95 model	125,923	118,062	89,251	7,861	99998	76365	7754	9019	6912	0	9,045	5,974	107
	2021 model	196,443	178,955	135,528	17,487	158320	120861	17384	8391	6452	0	12,244	8,215	103
	2021 / 95	1.56	1.52	1.52	2.22	1.58	1.58	2.24	0.93	0.93	0	1.35	1.38	0.97
Total	95 model	227,469	196,186	150,918	31,283	153889	118154	31115	19035	14988	0	10,441	6,912	168
(see note)	2021 model	337,255	285,323	219,731	51,932	231088	177630	51769	17531	13789	0	14,134	9,504	163
	2021 / 95	1.48	1.45	1.46	1.66	1.50	1.50	1.66	0.92	0.92	0	1.35	1.38	0.97

Note: 1995 Total trips includes external travel demand of 12,821 auto persons and 10,864 auto vehicle trips. These trips are from a 1995 external trip matrix.
2021 Total trips includes external travel demand of 22,570 auto persons and 18,808 auto vehicle trips. These trips are from a 2021 external trip matrix.
1995 model results differ from those in Exhibit 5.9 since the new numbers reflect the new school trip generation equations and most recent 1995 network.

Exhibit 7.6 compares the 1995 simulation with 2021 traffic demand forecasts by trip purpose and mode. Total person trips increased 48% between 1995 to 2021, total auto person trips increased by 45% and transit by 66%. Total work trips increased by 36%, school trips increased marginally by 3% while "Other" trips increased 56%.

Exhibits 7.7 and 7.8 illustrate the 1995 and 2021 assignment results as well as traffic counts. Comparison of Exhibit 7.7 with Exhibit 5.11 illustrates the differences in the two 1995 travel demand estimates.

7.8 Comparison to Master Transportation Plan Results

In 1996, RMOC staff carried out extensive work using the old version of the TRANS model to develop the current Transportation Master Plan (TMP). Using the new TRANS model, a model run was carried out using the same land use and final road and transit networks as identified in the TMP. A comparison of the simulation results is contained in Exhibit 7.9. The exhibit reports a simulated demand and a revised demand based on TDM and other assumptions to reduce auto travel demand that were used in the MTP study.

In all cases, the V/C ratio of the new model is under .9, and in all instances with the exception of Manotick screenline, where the V/C ratio is greater than the TMP value. Transit screenline modal split is higher in the new model at Leitrum, CNR_East, Rideau North, Rideau Center- Queensway and at the CPR Line. Transit mode split drops across the Interprovincial screenline from 31% to 23%. at Rideau South and Eagleson screenlines. No transit trips are reported in the new model at Russelll-417 since no transit routes cross this line. In the new model, the rapid transit line from Kanata to VIA Rail Station replaces several transit routes in the old model that traveled along Walkley Road and then went northbound along Highway 417 crossing the Russell-417 screenline.

Analysis of travel demand on the CUO side, the new model tends to reduce travel crossing the Ottawa River compared to the old model. 2021 outbound total person trips in the old model was 23,950 compared to 19,400 in the new model. Note that both the old model and new model include a new bridge crossing in the Masson area. The 1995 outbound total person trips across the Ottawa River was 16,300, implying the new model estimates traffic growth of 19% while the old model growth was 47%. Transit also decreases from 7700 in the old model to 4600 trips with the new model. In general, the new model tends to keep CUO travel demand within the CUO more than the old model. This is evident in the significant increase of inbound total person travel across most CUO screenlines. This is in part a result of the new trip distribution model.

Exhibit 7.7 - 1995 Auto and Transit PM Peak Hour- Outbound

Screenline	TOTAL PERSONS Observed Counts	Survey Assigned	Model	Model / Counts	AUTO PERSONS Observed Counts	Survey Assigned	Model	Model / Counts	AUTO VEHICLES Observed Counts	Survey Assigned	Model	Model / Counts	TRANSIT Observed Counts	Survey Assigned	Model	Model / Counts
Ottawa River (LN2,3,4)	15,574	16,642	16,323	1.05	13,168	13,931	13,318	1.01	10,180	10,886	10,425	1.02	2,406	2,711	3,005	1.25
Rideau River (LN19,20,32,33)	28,284	30,970	30,974	1.10	21,792	22,008	22,469	1.03	16,509	17,521	17,467	1.06	6,492	8,962	8,505	1.31
CPR (LN27, 28, 29)	19,880	21,224	20,078	1.01	14,931	14,443	14,461	0.97	11,236	11,720	11,244	1.00	4,949	6,781	5,617	1.13
Ottawa Central Area (LN35-38)	35,356	36,488	35,748	1.01	19,495	19,907	20,369	1.04	13,523	14,822	15,828	1.17	15,861	16,581	15,379	0.97
Rideau Canal (LN34, 39)	29,370	26,903	26,436	0.90	20,707	19,252	19,756	0.95	15,301	15,009	15,408	1.01	8,663	7,651	6,680	0.77
Fallowfield (LN9, 43)	7,777	7,823	7,714	0.99	7,039	6,667	6,944	0.99	5,551	5,514	5,481	0.99	738	1,156	770	1.04
Eagleson (LN10)	8,897	10,263	8,448	0.95	7,897	8,961	7,137	0.90	6,049	7,116	5,652	0.93	1,000	1,302	1,311	1.31
Green Creek (LN16)	11,319	13,215	12,424	1.10	8,189	9,515	9,648	1.18	6,607	7,703	7,582	1.15	3,130	3,700	2,776	0.89
CNR West / Acres (LN11,12)	18,982	19,701	18,167	0.96	16,245	16,255	15,474	0.95	12,678	13,362	12,159	0.96	2,737	3,446	2,693	0.98
CNR East (LN13,14,15)	13,555	13,998	12,568	0.93	12,274	12,680	11,067	0.90	10,595	10,383	8,773	0.83	1,281	1,318	1,501	1.17
Western Parkway (LN24,25)	18,528	20,159	17,321	0.93	15,683	16,483	14,327	0.91	12,339	13,355	11,216	0.91	2,845	3,676	2,994	1.05
Leitrim / Ramsayville (LN7,8)	6,114	5,956	5,051	0.83	6,099	5,934	5,042	0.83	4,669	5,035	4,103	0.88	15	22	9	0.60
Ile de Hull (LN60)	21,061	22,020	22,595	1.07	17,551	18,644	18,677	1.06	12,896	14,273	14,648	1.14	3,510	3,376	3,918	1.12
Boul. Gamelin (LN 61)	14,297	10,418	10,611	0.74	13,003	9,661	9,674	0.74	9,853	7,496	7,586	0.77	1,294	757	937	0.72
Ch. de la Montagne (LN62)	5,058	3,601	4,142	0.82	3,638	2,633	3,476	0.96	2,805	2,095	2,709	0.97	1,420	968	666	0.47
Deschenes (LN63)	5,211	4,099	4,121	0.79	4,041	3,185	3,562	0.88	2,959	2,457	2,773	0.94	1,170	914	559	0.48
Q64	3,546	3,203	2,934	0.83	3,146	3,012	2,835	0.90	2,425	2,357	2,250	0.93	400	191	99	0.25
Q65	13,577	13,963	14,682	1.08	11,885	12,308	12,529	1.05	8,370	9,518	9,843	1.18	1,692	1,655	2,153	1.27
Q66	2,698	2,167	2,151	0.80	2,668	2,167	2,146	0.80	1,953	1,782	1,727	0.88	30	-	5	0.17
Montee Paiement (LN67)	9,171	8,587	8,523	0.93	8,081	7,770	7,326	0.91	5,953	5,994	5,771	0.97	1,090	817	1,197	1.10
Q68	4,834	4,465	5,067	1.05	4,514	4,209	4,493	1.00	3,371	3,152	3,564	1.06	320	256	574	1.79

Inbound

Screenline	TOTAL PERSONS Observed Counts	Survey Assigned	Model	Model / Counts	AUTO PERSONS Observed Counts	Survey Assigned	Model	Model / Counts	AUTO VEHICLES Observed Counts	Survey Assigned	Model	Model / Counts	TRANSIT Observed Counts	Survey Assigned	Model	Model / Counts
Ottawa River (LN2,3,4)	9,212	7,097	6,338	0.69	7,344	5,141	5,421	0.74	5,596	4,376	4,229	0.76	1,868	1,956	917	0.49
Rideau River (LN19,20,32,33)	22,151	19,825	20,456	0.92	19,662	17,639	18,267	0.93	14,774	14,655	14,228	0.96	2,489	2,186	2,189	0.88
CPR (LN27, 28, 29)	12,467	12,543	12,437	1.00	10,422	10,905	11,157	1.07	8,294	9,019	8,722	1.05	2,045	1,638	1,280	0.63
Ottawa Central Area (LN35-38)	19,517	16,024	17,238	0.88	13,921	10,162	12,024	0.86	10,338	8,217	9,278	0.90	5,596	5,862	5,214	0.93
Rideau Canal (LN34, 39)	20,575	18,267	20,055	0.97	15,562	14,075	16,218	1.04	11,893	11,841	12,513	1.05	5,013	4,192	3,837	0.77
Fallowfield (LN9, 43)	3,312	2,036	3,061	0.92	3,242	1,971	2,982	0.92	2,448	1,640	2,330	0.95	70	65	79	1.13
Eagleson (LN10)	4,803	5,074	4,700	0.98	4,643	4,902	4,411	0.95	3,834	4,166	3,505	0.91	160	172	289	1.81
Green Creek (LN16)	3,805	3,501	4,261	1.12	3,551	3,296	3,953	1.11	2,609	2,567	3,086	1.18	254	205	308	1.21
CNR West / Acres (LN11,12)	13,180	10,498	11,195	0.85	12,510	9,914	10,631	0.85	9,830	8,478	8,344	0.85	670	584	564	0.84
CNR East (LN13,14,15)	8,442	6,235	5,794	0.69	8,016	6,082	5,514	0.69	6,570	5,076	4,320	0.66	426	153	280	0.66
Western Parkway (LN24,25)	11,548	10,703	9,856	0.85	10,596	9,831	9,062	0.86	8,246	8,199	7,099	0.86	952	872	794	0.83
Leitrim / Ramsayville (LN7,8)	3,028	1,924	1,782	0.59	3,017	1,907	1,762	0.58	2,180	1,609	1,413	0.65	11	17	20	1.82
Ile de Hull (LN60)	7,236	6,796	8,432	1.17	6,486	6,298	7,943	1.22	5,166	5,211	6,167	1.19	750	498	489	0.65
Boul. Gamelin (LN 61)	7,580	4,095	4,515	0.60	6,800	3,695	4,231	0.62	5,310	3,068	3,283	0.62	780	400	284	0.36
Ch. de la Montagne (LN62)	2,280	1,175	1,712	0.75	1,960	1,113	1,645	0.84	1,537	842	1,286	0.84	320	62	67	0.21
Deschenes (LN63)	1,758	1,115	1,576	0.90	1,732	1,096	1,508	0.87	1,343	879	1,176	0.88	26	19	68	2.62
Q64	986	576	1,089	1.10	941	551	1,050	1.12	742	492	822	1.11	45	25	39	0.87
Q65	4,727	3,265	4,901	1.04	4,547	3,072	4,705	1.03	3,456	2,554	3,658	1.06	180	193	196	1.09
Q66	1,239	908	1,009	0.81	1,239	908	1,008	0.81	870	740	799	0.92	0	-	1	
Montee Paiement (LN67)	5,311	2,404	2,271	0.43	5,236	2,343	2,147	0.41	3,777	1,913	1,649	0.44	75	61	124	1.65
Q68	2,374	1,864	2,314	0.97	2,294	1,847	2,268	0.99	1,657	1,414	1,780	1.07	80	17	46	0.58

Exhibit 7.8 - 2021 Auto and Transit PM Peak Hour- Outbound

Screenline	TOTAL PERSONS Observed Counts	TOTAL PERSONS Survey Assigned	TOTAL PERSONS Model	TOTAL PERSONS Model / Counts	AUTO PERSONS Observed Counts	AUTO PERSONS Survey Assigned	AUTO PERSONS Model	AUTO PERSONS Model / Counts	AUTO VEHICLES Observed Counts	AUTO VEHICLES Survey Assigned	AUTO VEHICLES Model	AUTO VEHICLES Model / Counts	TRANSIT Observed Counts	TRANSIT Survey Assigned	TRANSIT Model	TRANSIT Model / Counts
Ottawa River (LN2,3,4)	15,574	16,642	19,389	1.24	13,168	13,931	14,844	1.13	10,180	10,886	11,572	1.14	2,406	2,711	4,545	1.89
Rideau River (LN19,20,32,33)	28,284	30,970	41,293	1.46	21,792	22,008	30,104	1.38	16,509	17,521	23,381	1.42	6,492	8,962	11,189	1.72
CPR (LN27, 28, 29)	19,880	21,224	26,225	1.32	14,931	14,443	17,641	1.18	11,236	11,720	13,714	1.22	4,949	6,781	8,584	1.73
Ottawa Central Area (LN35-38)	35,356	36,488	46,721	1.32	19,495	19,907	24,237	1.24	13,523	14,822	18,803	1.39	15,861	16,581	22,484	1.42
Rideau Canal (LN34, 39)	29,370	26,903	33,346	1.14	20,707	19,252	24,542	1.19	15,301	15,009	19,160	1.25	8,663	7,651	8,804	1.02
Fallowfield (LN9, 43)	7,777	7,823	14,549	1.87	7,039	6,667	12,423	1.76	5,551	5,514	9,780	1.76	738	1,156	2,126	2.88
Eagleson (LN10)	8,897	10,263	13,393	1.50	7,897	8,961	11,038	1.40	6,049	7,116	8,758	1.45	1,000	1,302	2,355	2.36
Green Creek (LN16)	11,319	13,215	16,201	1.43	8,189	9,515	12,360	1.51	6,607	7,703	9,734	1.47	3,130	3,700	3,841	1.23
CNR West / Acres (LN11,12)	18,982	19,701	27,997	1.47	16,245	16,255	22,835	1.41	12,678	13,362	17,997	1.42	2,737	3,446	5,162	1.89
CNR East (LN13,14,15)	13,555	13,998	20,850	1.54	12,274	12,680	18,085	1.47	10,595	10,383	14,300	1.35	1,281	1,318	2,765	2.16
Western Parkway (LN24,25)	18,528	20,159	22,588	1.22	15,683	16,483	18,412	1.17	12,339	13,355	14,494	1.17	2,845	3,676	4,176	1.47
Leitrim / Ramsayville (LN7,8)	6,114	5,956	12,208	2.00	6,099	5,934	11,588	1.90	4,669	5,035	9,292	1.99	15	22	620	41.33
Ile de Hull (LN60)	21,061	22,020	21,534	1.02	17,551	18,644	16,475	0.94	12,896	14,273	12,802	0.99	3,510	3,376	5,059	1.44
Boul. Gamelin (LN 61)	14,297	10,418	8,878	0.62	13,003	9,661	7,688	0.59	9,853	7,496	5,984	0.61	1,294	757	1,190	0.92
Ch. de la Montagne (LN62)	5,058	3,601	6,381	1.26	3,638	2,633	4,582	1.26	2,805	2,095	3,530	1.26	1,420	968	1,799	1.27
Deschenes (LN63)	5,211	4,099	6,617	1.27	4,041	3,185	5,272	1.30	2,959	2,457	4,109	1.39	1,170	914	1,345	1.15
Q64	3,546	3,203	3,214	0.91	3,146	3,012	2,941	0.93	2,425	2,357	2,322	0.96	400	191	273	0.68
Q65	13,577	13,963	16,148	1.19	11,885	12,308	12,505	1.05	8,370	9,518	9,727	1.16	1,692	1,655	3,643	2.15
Q66	2,698	2,167	2,132	0.79	2,668	2,167	1,986	0.74	1,953	1,782	1,564	0.80	30	-	146	4.87
Montee Paiement (LN67)	9,171	8,587	9,541	1.04	8,081	7,770	7,631	0.94	5,953	5,994	5,984	1.01	1,090	817	1,910	1.75
Q68	4,834	4,465	6,325	1.31	4,514	4,209	5,294	1.17	3,371	3,152	4,196	1.24	320	256	1,031	3.22

Inbound

Screenline	TOTAL PERSONS Observed Counts	TOTAL PERSONS Survey Assigned	TOTAL PERSONS Model	TOTAL PERSONS Model / Counts	AUTO PERSONS Observed Counts	AUTO PERSONS Survey Assigned	AUTO PERSONS Model	AUTO PERSONS Model / Counts	AUTO VEHICLES Observed Counts	AUTO VEHICLES Survey Assigned	AUTO VEHICLES Model	AUTO VEHICLES Model / Counts	TRANSIT Observed Counts	TRANSIT Survey Assigned	TRANSIT Model	TRANSIT Model / Counts
Ottawa River (LN2,3,4)	9,212	7,097	12,223	1.33	7,344	5,141	9,954	1.36	5,596	4,376	7,761	1.39	1,868	1,956	2,269	1.21
Rideau River (LN19,20,32,33)	22,151	19,825	26,876	1.21	19,662	17,639	23,722	1.21	14,774	14,655	18,464	1.25	2,489	2,186	3,154	1.27
CPR (LN27, 28, 29)	12,467	12,543	14,083	1.13	10,422	10,905	12,347	1.18	8,294	9,019	9,656	1.16	2,045	1,638	1,736	0.85
Ottawa Central Area (LN35-38)	19,517	16,024	23,552	1.21	13,921	10,162	15,229	1.09	10,338	8,217	11,730	1.13	5,596	5,862	8,323	1.49
Rideau Canal (LN34, 39)	20,575	18,267	24,298	1.18	15,562	14,075	19,443	1.25	11,893	11,841	14,980	1.26	5,013	4,192	4,855	0.97
Fallowfield (LN9, 43)	3,312	2,036	6,188	1.87	3,242	1,971	5,727	1.77	2,448	1,640	4,454	1.82	70	65	461	6.59
Eagleson (LN10)	4,803	5,074	7,658	1.55	4,643	4,902	6,993	1.51	3,834	4,166	5,545	1.45	160	172	665	4.16
Green Creek (LN16)	3,805	3,501	5,973	1.57	3,551	3,296	5,259	1.48	2,609	2,567	4,122	1.58	254	205	714	2.81
CNR West / Acres (LN11,12)	13,180	10,498	16,782	1.27	12,510	9,914	15,532	1.24	9,830	8,478	12,191	1.24	670	584	1,250	1.87
CNR East (LN13,14,15)	8,442	6,235	11,140	1.32	8,016	6,082	10,225	1.28	6,570	5,076	8,011	1.22	426	153	915	2.15
Western Parkway (LN24,25)	11,548	10,703	11,311	0.98	10,596	9,831	10,279	0.97	8,246	8,199	8,076	0.98	952	872	1,032	1.08
Leitrim / Ramsayville (LN7,8)	3,028	1,924	4,639	1.53	3,017	1,907	4,447	1.47	2,180	1,609	3,524	1.62	11	17	192	17.45
Ile de Hull (LN60)	7,236	6,796	9,034	1.25	6,486	6,298	8,293	1.28	5,166	5,211	6,390	1.24	750	498	741	0.99
Boul. Gamelin (LN 61)	7,580	4,095	5,748	0.76	6,800	3,695	5,316	0.78	5,310	3,068	4,091	0.77	780	400	432	0.55
Ch. de la Montagne (LN62)	2,280	1,175	2,356	1.03	1,960	1,113	2,052	1.05	1,537	842	1,585	1.03	320	62	304	0.95
Deschenes (LN63)	1,758	1,115	3,915	2.23	1,732	1,096	3,638	2.10	1,343	879	2,838	2.11	26	19	277	10.65
Q64	986	576	1,243	1.26	941	551	1,168	1.24	742	492	914	1.23	45	25	75	1.67
Q65	4,727	3,265	9,135	1.93	4,547	3,072	8,306	1.83	3,456	2,554	6,459	1.87	180	193	829	4.61
Q66	1,239	908	1,880	1.52	1,239	908	1,835	1.48	870	740	1,452	1.67	0	-	45	
Montee Paiement (LN67)	5,311	2,404	3,794	0.71	5,236	2,343	3,236	0.62	3,777	1,913	2,495	0.66	75	61	558	7.44
Q68	2,374	1,864	4,007	1.69	2,294	1,847	3,709	1.62	1,657	1,414	2,911	1.76	80	17	298	3.73

Exhibit 7.9 - 2021 Demand Analysis : Old vs New TRANS Model

Exhibit 7.9 - 2021 Demand, MTP Model Forecast (Old Model)

	Simulated Demand			Revised Demand and Screenline Capacity						
Screenline	Transit	Auto Persons	Auto Vehicle	Transit	Auto Persons	Auto Vehicle	Transit Mode Split	PCU	Capacity- (PCU)	V/C
Interprovincial	7,699	16,249	13,079	7,172	15,818	11,631	31%	13,376	15,036	0.89
Rideau South	1,455	9,168	7,465	2,168	8,031	6,084	21%	6,996	7,135	0.98
Manotick	230	2,030	1,600	325	1,845	1,368	15%	1,573	2,982	0.53
Rideau-Manotick	1,685	11,198	9,065	1,899	10,468	7,931	15%	9,120	10,117	0.90
Leitrim	526	9,216	7,398	1,438	7,914	6,135	15%	7,055	8,167	0.86
Eagleson	4,455	14,754	12,251	4,812	14,012	11,171	26%	12,847	14,464	0.89
CNR_West	4,520	15,642	12,692	4,986	14,369	10,886	26%	12,519	13,905	0.90
CNR_East	3,131	11,354	9,190	3,544	10,362	7,791	25%	8,960	10,999	0.81
Russell-417	1,011	5,628	4,897	970	5,228	4,549	16%	5,231	6,998	0.75
Greens_Creek	4,841	15,653	12,884	6,101	13,570	10,016	31%	11,518	12,553	0.92
Rideau North	1,921	8,006	6,381	2,578	6,952	5,227	27%	6,011	6,500	0.92
Rideau Cen-Qway	8,164	19,032	15,404	10,736	15,372	11,735	41%	13,495	16,769	0.80
CPR Line	8,000	19,609	15,714	7,615	15,822	11,896	32%	13,680	16,079	0.85
Bilberry Creek	2,764	12,108	9,960	3,332	10,945	8,383	23%	9,640	10,637	0.91
Fallowfield	3,452	14,049	11,437	4,232	12,569	9,975	25%	11,471	13,036	0.88

2021 Demand, New TRANS Model

	Simulated Demand			Revised Demand and Screenline Capacity						
Screenline	Transit	Auto Persons	Auto Vehicle	Transit	Auto Persons	Auto Vehicle	Transit Mode Split	PCU	Capacity- (PCU)	V/C
Interprovincial	4,545	14,844	11,572	4,234	14,450	10,291	23%	11,834	15,036	0.79
Rideau South	748	7,676	5,081	1,115	6,724	4,141	14%	4,762	7,135	0.67
Manotick	217	2,437	1,909	307	2,215	1,632	12%	1,877	2,982	0.63
Rideau-Manotick	965	10,113	6,990	1,088	9,454	6,116	10%	7,033	10,117	0.70
Leitrim	620	7,317	5,789	1,695	6,283	4,801	21%	5,521	8,167	0.68
Eagleson	2,355	11,038	8,758	2,544	10,483	7,986	20%	9,184	14,464	0.63
CNR_West	2,772	12,654	9,918	3,058	11,624	8,507	21%	9,783	13,905	0.70
CNR_East	2,765	9,858	7,659	3,130	8,997	6,493	26%	7,467	10,999	0.68
Russell-417	0	5,450	4,360	0	5,063	4,050	0%	4,658	6,998	0.67
Greens_Creek	3,841	13,349	10,511	4,841	11,573	8,171	29%	9,397	12,553	0.75
Rideau North	2,264	4,888	3,757	3,038	4,244	3,078	42%	3,539	6,500	0.54
Rideau Cen-Qway	8,239	18,644	14,543	10,835	15,059	11,079	42%	12,741	16,769	0.76
CPR Line	8,584	17,641	13,714	8,171	14,234	10,382	36%	11,939	16,079	0.74
Bilberry Creek	2,098	9,433	7,465	2,529	8,527	6,283	23%	7,225	10,637	0.68
Fallowfield	2,126	10,544	8,315	2,606	9,433	7,252	22%	8,340	13,036	0.64

8. FURTHER RESEARCH INTO MODEL DEVELOPMENT

From the model re-calibration project, the following areas were identified where further study could be directed to enhance the TRANS model.

There is a problem with the quality of the GLA land use estimates for 1995. The data is dated and primarily accounts for retail space at larger shopping centers. The data excludes a significant amount of strip development along major roads as Merivale Road and Innes Road. The data excludes stand alone facilities as super stores which are becoming important retail centers more so now than in the past. It is believed that the problem with this variable was a key factor in the limited success of the trip generation and trip distribution of retail related trips.

Further work is required in quantifying total, retail and non-retail employment. The model was developed by estimating non-retail employment for the work trip generation equations based on the ratio of 1986 total employment to retail employment.

The trip distribution model uses four functions that places different travel disutility between travel across the Ottawa River as well as travel within Quebec and Ontario. This approach provided the most appropriate fit to the 1995 data. No attempt was made to develop separate trip generation and distribution functions for rural versus urban. Some of the rural zones in Quebec have a significant population and employment opportunities which may tend to distort the new model since these zones are large and tend to be located far from the center of Hull. Hull is a smaller urban area than Ottawa and does not have the draw that Ottawa has on it's rural areas. Hull rural areas may be more independent implying that separate models may be appropriate to overcome this problem.

From the onset of the modal split model development, it was considered desirable to have two auto modes, single occupant vehicle and shared ride as well as transit. It was found that the model could not be developed in this manner since it was not possible to distinguish between cost and travel time of the auto modes the way the database was developed. The database was developed without taking into account linked trips. An example of a linked trip is an auto driver leaving work to pick up a passenger and then continuing home. In the current database, the auto driver makes two trips, a work-to-other trip (serve passenger) and then an other-to-home trip. If the trips were linked, it would be recorded as a work-to-home trip. It would also be able to compare the trip time and cost this person incurs as compared with the passenger. If the database is rebuilt in this manner, it may be possible to develop the two auto modes for the work trip. This would increase the amount of work trips and decrease trips in the other trip categories. New trip generation, distribution as well as modal split models would have to be developed.

It may be useful to include walk and bike modes in the model. Recent work was done in conjunction with Carleton University into the development of logit models for these modes based on the PM peak period. If this were done it would be necessary to develop new trip generation, trip distribution and model split models. The model would likely be based on the PM peak period and then factored to the peak hour.

The new 1995 network developed as outlined in the report could be further refined in the CUO network, particularly in the Hull area. A detailed review is recommended to verify if additional turn penalties should be coded into the network.

It is recommended that traffic counts be carried out at major roadways feeding traffic into the National Capital Region. This data will be required to verify external travel demand used in the model and to obtain appropriate trends in external traffic long term growth.

A study should be carried out to determine the need to have special trip generators for the Mac Donald Cartier Airport, the CN train station and any other unique land use facilities where travel demand to and from the sites was not captured to the full extent using the 95 OD Survey.

For the 2021 network, it will be necessary to review the network in the area around the bridgeheads across the Ottawa River and the Rideau Canal. The new network does not take into account the new HOV lane on Portage Bridge, changes to the operation of MacKenzie King Bridge and traffic operational changes around the Rideau Centre and Ottawa University area.

APPENDIX 1

List of EMME2 Road Improvement Tags and Major Transit Route Changes

EMME2 Road Improvement Tags

SOUTHEAST: Gloucester-Letrium, River Ridge		Emme2 Tag	Stage	Length	Number of Lanes		
Facility	Limits			(km)	1995	2021	Beyond 2021
RDS-Roads							
Airport Parkway	Brookfield-Airport	59211	5-10	6.4	2	4	
Armstrong/Strandherd	Bridge over Rideau River	tagged in Nep. S		na	0	4 auto, 2 bus	
Armstrong	Rideau River-River Rd	72110		0.4	0	4	
Armstrong	River Rd-Bowesville	61211		5.9	2	4	
Armstrong	Bowesville-Hwy 31	61311		4.3	0/2	2	
Bowesville	Armstrong-Leitrim	56110		2.4	0/2	2	
Bowesville	Leitrim-Airport Parkway	56110	5-10	2.1	0/2	2	
Conroy	Bank-Hunt Club	57211		3.4	2	4	
Conroy	Hunt Club-Walkley	57211	5-10	2.4	2	4	
Highway 31	Mitch Owens-Leitrim	54211		6	2	4/5	
Hunt Club	Hawthorne-Hwy 417	22120		1.3	0	4	
Limebank	Armstrong-Leitrim	69211		2	2	4	
Limebank	Leitrim-River Rd	69211		2.7	2	4	
River Road	Limebank-Hunt Club	91212	5-10	1.6	2	4	
				40.9			
RDS-Transit							
Airport Parkway	Brookfield-Airport (BOL)			6.4	4	6	
Park&Ride	@Leitrum		5-10	na	na	na	
				6.4			
Other Future Roads							
Fallowfield Bridge	Fallowfield-Leitrim	tagged in Nep. S		2.1	0	0	4
Hunt Club Extension	Hwy 417-Baseline Rd	22220		0.4	0.0	0	4
Outer Trans. Corridor - North Option	Hazeldean-Russell/Rockdale	tagged in Nep. S		55.1	0	0	2
Outer Trans. Corridor - South Option	Hazeldean-Russell/Rockdale	tagged in Nep. S		62.3	0	0	2
				119.9			
Other Future Transit							
Transitway	Southeast Transitway-Rideau River						

SOUTHWEST - Nepean		Emme2 Tag	Stage	Length	Number of Lanes		
Facility	Limits			(km)	1995	2021	Beyond 2021
RDS-Roads							
Fallowfield	Hwy 416-Prince of Wales	1211		8.1	2	4	
Greenbank	Strandherd-Alvern	3211		2.1	2	4	
Greenbank	Fallowfield-Hunt Club	2211		4.2	2	4	
Highway 416	Hwy 16-Queensway	80110		19.0	4	4	
Jockvale	Hwy 16-Cambrian	103300		1.7	2	4	
Jockvale	Cambrian-Strandherd	103200		1.7	0	2	
Prince of Wales	Woodroffe-Merivale	46211		3.6	2	4	
Prince of Wales	Merivale-Fisher	46211		6.5	2	4	
Strandherd	Fallowfield-Greenbank	71110		3.4	0	4	
Strandherd	Greenbank-Woodroffe	70211		2.3	2	4	
Strandherd	Woodroofe-Rideau River	72110		1.4	0	4	
Strandherd/Armstrong	Bridge over Rideau River	72110		0.4	0	4 auto, 2 bus	
Woodroffe	Strandherd-Fallowfield	6211		3.6	2/4	4	
Woodroffe	Fallowfield-Slack	6211		2.5	2	4	
Woodroffe	Sportsplex-Baseline	104200		2.5	4/5	6	
Woodroffe	Hwy 16-Bren Maur	109200		0.4	2	0	
				63.5			
RDS-Transit							
Park&Ride	@Fallowfield		0-5	na	na	na	
Park&Ride	@South of Strandherd			na	na	na	
Transitway	Baseline-CNR Line		5-10	1.1	0	2	
Transitway	CNR Line-Sportsplex			1.0	0	2	
Transitway	Sportsplex-Fallowfield			3.0	0	2	
Transitway	Fallowfield-Strandherd		5-10	3.8	0	2	
Woodroffe BOL	CNR Line-Sportsplex		5-10	1.0	4	6	
Woodroffe BOL	Slack-Fallowfield		5-10	2.5	2	4	
				12.4			
Other Future Roads							
Fallowfield Bridge	Fallowfield-Leitrim	4120		2.1	0	0	4
Merivale	Hwy 16-Amberwood	8211		2.4	2	2	4
Outer Trans. Corridor - North Option	Hazeldean-Russell/Rockdale	78120		55.1	0	0	2
Outer Trans. Corridor - South Option	Hazeldean-Russell/Rockdale	79110		62.3	0	0	2
				62.3			
Other Future Transit							

EAST - Gloucester, Cumberland		Emme2 Tag	Stage	Length	Number of Lanes		
Facility	Limits			(km)	1995	2021	Beyond 2021
RDS-Roads							
BBHBP	Innes/Walkley Connection to Navan	16211		2.2	4	6	
BBHBP Extension	Navan-Trim	18110		6.9	0	2	
Highway 417/17	Cyrville Rd-Montreal	81211		5.8	4	5	
Innes	Hwy 417-Blair (for EA Innes Rd West P-53)	16211		1.3	4	6	
Innes	Orleans-Jeanne D'Arc	15211	5-10	2.5	2	4	
Innes	Jeanne D'Arc-Tenth Line	15211	5-10	1.4	2	4	
Innes	Tenth Line-Trim	15211		3.0	2	4	
Mer Bleue	Innes-BBHBP Ext.	36211		1.0	2	4	
Navan	BBHBP-BBHBP Ext.	13211		1.5	2	4	
St Joseph	Tenth Line-Trim	23211		1.7	2	4	
Trim	Innes-Hwy 17	38211		3.7	2	4	
Walkley	Hwy 417-Base Line	50110		0.5	2	4	
Walkley	Base Line-BBHBP	48110		2.0	0	2	
				33.5			
RDS-Transit							
Blair BOL	Transitway-Innes			1.7	2	4	
Highway 17 BOL (EB)	Blair Station-Place d'Orleans		0-5	9.0	5	6	
Park&Ride	@Innes			na	na	na	
Park&Ride	@Navan			na	na	na	
Park&Ride	Hwy 17@Trim			na	na	na	
Transitway	Hurdman-Hwy 417			5.0	0	2	
Transitway	Hwy 417-Page			6.8	0	2	
Transitway	Page-Trim			6.2	0	2	
				28.7			
Other Future Roads							
Champlain Road Extension	Rockcliffe Parkway Extension-Champlain	27110		0.6	0	0	2
Highway 17	Montreal-Trim	81311		9.3	4	4	6
Innes	Trim-Frank Kenny	15311		1.0	2	2	4
Orleans Blvd Extension	Navan-Innes	37110		1.2	0	0	4
Ottawa River Bridge	@Trim Road	88110		2.9	0	0	4
Rockcliffe Parkway Extension	Champlain-Tenth Line Rd	32110		1.5	0	0	2
Rockcliffe Parkway Extension	Rockcliffe Pkwy near Green Creek-Champlain	75110		4.5	0	0	2
				6.0			
Other Future Transit	None						

QUEBEC		Emme2 Tag	Stage	Length	Number of Lanes		
Facility	Limits			(km)	1995	2021	Beyond 2021
RDS-Roads							
Autoroute Deschenes (NB)	McConnell Laramee-Autoroute de l'Outaouais	95100		17.0	0	2	
Autoroute Deschenes (SB)	McConnell Laramee-Autoroute de l'Outaouais	95100		17.2	0	2	
Autoroute Deschenes Ramps	@Pink	95100		0.4	0	2	
Autoroute Deschenes Ramps	@de la Gatineau	95100		0.1	0	2	
Autoroute Deschenes Ramps	@Autoroute 105	95100		0.2	0	2	
Autoroute Deschenes Ramps	@des Erables	95100		0.3	0	2	
Autoroute Deschenes Ramps	@Autoroute de l'Outaouais	95100		0.2	0	1	
Aylmer	de la Colline-Montcalm	95400		9.2	2	4	
McConnell-Laramee	Earley-Klock/Broad	95700		1.4	2	4	
McConnell-Laramee (EB)	de la Montagne-St. Joseph	95200		2.6	0	2	
McConnell-Laramee (WB)	de la Montagne-St. Joseph	95200		2.4	0	2	
McConnell-Laramee Ramps	@St. Joseph	95200		0.5	0	1	
Pink	Terry Fox-de la Montagne	95500		9.8	2	4	
Verendrye Est	Labrosse-Lorrain	95000		2.7	0	4	
Verendrye Ouest	Greber-Montee Paiement	95600		2.2	2	4	
Verendrye Ouest	Principale-Cannes	95300		1.9	0	2	
				68.0			

INSIDE GREENBELT		Emme2 Tag	Stage	Length	Number of Lanes		
Facility	Limits			(km)	1995	2021	Beyond 2021
RDS-Roads							
Airport Parkway Ramps	@Hunt Club	no penalty	0-5	1.0	0	1	
Airport Parkway Ramps	@Walkley	no penalty	0-5	1.0	0	1	
Albert	Booth-Empress	106200		1.0	4	4 auto, 2 bus	
Alta Vista Parkway	Walkley-Nicholas	60110		5.5	0	4	
Baseline	Richmond-Greenbank	7211		2.3	2	4	
Blair	Innes-Meadowbrook	108200		1.2	2	4	
Bronson	G. Dunbar Br.-Canal	52211		1.5	4	6	
Bronson	Laurier-Wellington	53110		0.5	0	6	
Coventry	Belfast-Approximately 100m E of St. Laurent	35211		0.4	2	4	
Cyrville & Cummings	Innes-Ogilvie	58211		2.9	2	4	
Hawthorne	Hunt Club-Russell	67211, 68110	0-5	1.8	2	4	
Hunt Club	Hwy 416-CNR Line	21211		8.1	4	6	
Hunt Club	CNR Line-Prince of Wales	21211		0.6	4	6	
Hunt Club	Prince of Wales-Bowesville	21211		1.1	4	6	
Hunt Club	Bowesville-Airport Parkway	20212		2.7	4	6	
Hunt Club	Airport Parkway-Bank	19211		0.9	4	6	
Innes	Hwy 417-Blair	17211		1.5	4	6	
Merivale	Slack-Amberwood	8311		1.0	2	4	
Queensway	Vanier-Pickering	82211		0.5	6	8	
Queensway (EB)	St. Laurent-Hwy 417	82211		1.1	3	4	
River Road	McArthur-Montreal	not in model		0.2	2	4	
Riverside	Hogs Back-Heron	105200		0.5	4	6	
Various Cycling Facilities	various		0-5	var	var	var	
Various Cycling Facilities	various		5-10	var	var	var	
Various Cycling Facilities	various			var	var	var	
Walkley	Russell-Sheffield	49211		0.7	2	4	
				34.9			
RDS Transit							
Baseline BOL	Woodroffe-Prince of Wales	107200		5.0	4	6	
Carling BOL	Western Pkwy-Woodroffe E			1.1	4	6	
CBD Bypass BOL&TP	various			?	var	var	
CN Rail Corridor	SE Transitway-Train Station			?	na	na	
CN Rail Corridor	Kanata North-SE Transitway			?	na	na	
CP Ellwood Rail Sub	Lebretton Flats-Billings Bridge (pilot)		5-10	7.5	na	na	
CP Ellwood Rail Sub	Lebretton Flats-Billings Bridge			7.5	na	na	
E-W CNR Rail Corridor	Carling-Russell	89110		18.2	na	na	
Fisher BOL	Dynes-NCC Driveway			2.6	2	4	
Heron BOL	Bronson-Bank			1.2	4	6	
Transitway Station	@McKenzie King Bridge		0-5	na	na	na	
Transitway Station	@Lebreton		5-10	na	na	na	
Various Transit Priority	various		0-5	var	var	var	
Various Transit Priority	various		5-10	var	var	var	
Walkley BOL	Russell-Heron			2.6	4	6	
				40.7			
Other Future Roads							
Blair	Innes-Walkley Rd Ext.	11110		1.4	0	0	2
Blair Road Extension	Rockcliffe Parkway-Blair	12110		0.2	0	0	2
Catherine Street Extension (WB)	Booth-Champlain Arterial Ext.	87110		0.5	0	0	3
Catherine Street Extension (WB)	Elgin-Nicholas	84120		1.1	0	0	3
Chamberlain Street Extension (EB)	Booth-Champlain Arterial Ext.	86110		0.5	0	0	3
Champlain Arterial Extension	Ottawa River Parkway-Carling	65110		2.0	0	0	4
Industrial Avenue Extension	Riverside-Alta Vista Parkway	14120		0.9	0	0	4
Kirkwood Extension	Scott-Richmond	44110		0.3	0	0	2
Lees Avenue Extension (EB)	Elgin-Main	85120		0.4	0	0	3
Preston Street Extension	Ottawa River Parkway-Scott	47220		0.4	0	0	2
Russell Road Extension	Walkley-Russell	64221		0.6	0	0	2
Scott Street Extension	Scott-Richmond	30110		0.3	0	0	4
Vanier Parkway Extension	King Edward-Vanier Parkway	9110		1.2	0	0	4
				9.6			
Other Future Transit	None						

WEST - Kanata & Stittsville		Emme2 Tag	Stage	Length	Number of Lanes		
Facility	Limits			(km)	1995	2021	Beyond 2021
RDS-Roads							
Campeau	Terry Fox-March	100200		2.7	2	4	
Carling	March-Herzberg	26211	5-10	1.4	2	4	
Carling	Herzberg-Moodie	26211	5-10	4.3	2	4	
Castlefrank	Bridge over Hwy 417	62110, 63211		1.0	0	6 (auto)	
Eagleson	Stonehaven-Hope Side	33211		2.1	2	4	
Hazeldean	Regional Rd 5-Terry Fox	24211	5-10	4.4	2	4	
Highway 417	Terry Fox-Hwy 416	83211		7.5	4	4 auto, 2 bus	
Hope Side Road	Eagleson-Richmond	93211		2.0	2	4	
Hope Side Road	Moodie-Hwy 416 Corridor	55110		2.0	0	2	
Hope Side Road	Richmond-Moodie	55110		2.0	0	2	
Hope Side Road	Hwy 416 Corridor	92211		2.2	2	4	
Katimavik	Castlefrank-Eagleson	101200		1.4	2	4	
March	Solandt-Klondike	34311	now	1.9	2	4	
March	Klondike-RR9	34311		3.0	2	4	
March	Hertberg-Terry Fox	34211		3.3	4	6	
Moodie	Richmond-Moodie	102200		0.5	0	2	
Terry Fox	Campeau-Richardson Side Road	40110		3.8	2	4	
Terry Fox	Eagleson-Winchester	43110		3.6	0	2	
Terry Fox	Eagleson-Hwy 417	41211, 42211		2.3	2	4	
Terry Fox	Campeau-Existing Terry Fox	40310		2.2	0	2	
				53.6			
RDS-Transit							
Highway 417 BOL	Acres-Eagleson (WB)			6.5	4	6	
Park&Ride	@Kanata Town Centre			na	na	na	
Park&Ride	@Carp			na	na	na	
Transitway	Woodroffe-Pinecrest			2	0	2	
Transitway	Pinecrest-Acres		0-5	2	0	2	
Transitway	Kanata Town Centre			2.5	0	2	
Transitway Station	@Kanata Town Centre			na	na	na	
				13.0			
Other Future Roads							
Timm Drive	Moodie-Richmond	73120		1.7	0	0	2
				1.7			
Other Future Transit	None						

Major Transit Route Changes Between 1995 and 2021

Route Additions	
Route Number	**Description**
2s	Downtown (Bank and Somerset) - Blair Station via Montreal Road
8n	Heron Gate Mall - Hull via Alta Vista Drive / Transitway
8s	Hull - Heron Gate Mall via Alta Vista Drive / Transitway
418	South Keys Station - Kanata via Barhaven
425	Hurdman Station - Orleans South via Transitway / Innes Road / Blackburn Hamlet Bypass
463	Kanata - Lebreton Station via Queensway / Ottawa River Pkwy / Transitway
47	Lebreton - Gloucester (Conroy and Leitrim) via Transitway
495	Kanata - Orleans Station via Queensway / Transitway / Innes Road / Blackburn Hamlet Bypass / Trim Roa
496	Stittsville (Main Street) - Barhaven (Jockvale Road) via Fallowfield Road
83	Hull - Heron Gate Mall via Transitway / Walkley Road
86e	Lebreton - Southvale Crescent via Transitway / Industrial Avenue / Russell Road
86w	Hurdman Station - Baseline Station via Transitway / Fisher Avenue / Meadowlands Road
94	Hull - Airport via Transitway / Airport Parkway
142	Gloucester South, local route (Greenboro Station / Hwy 31 / Conroy Road)
142d	Gloucester South, local route (Greenboro Station / Hwy 31 / Conroy Road)
146w	Gloucester South, local route (Billings Bridge Station - Greenboro Station)
156x	Lincoln Fields - Britannia, local route
174x	Carlingwood Mall - Greenbank and Canfield Road via Woodroffe Avenue
178	Nepean Centre, local loop along Woodroffe Avenue
180	Hawthorne Road (near Hunt Club Road) - Hurdman Station via Russell Road / Elmvale Mall / St. Laurent E
182x	Kanata - Shirleys Bay via March Road / Carling Avenue
194	Cite College - Hurdman Station via St. Laurent Blvd / Elmvale Mall / Transitway
199x	Blair Station - Hurdman Station via Industrial Avenue / Star Top Road / Cyrville Road / Blair Road
441	Alta Vista Transitway along Leitrim Road between Conroy Road and Alert Road
900	Rapid Transit Line from Ottawa South (Leitrim Road) - Ottawa River (CP Alignment)
902	Rapid Transit Line from Ottawa - East Quebec
910	Rapid Transit Line from North Kanata - VIA Train Station (CN Alignment)

Cancelled Routes	
Route Number	**Description**
8	Heron Gate Mall - Hull via Alta Vista Drive / Transitway
42	Lebreton Station - Ottawa South (Hunt Club Road) via Transitway
95x	Baseline Station - Blair Station via Transitway
96	Carlingwood Mall - Airport via Transitway
112	Billings Bridge Station - Hurdman Station via Walkley Road / St. Laurent Blvd / Transitway
112x	Don Reid Drive - Hurdman Station via St. Laurent Blvd / Transitway
117	St. Laurent Station - Billings Bridge Station via Transitway / Walkley Road / St. Laurent Blvd
142n	Gloucester South, local route (starting and ending at Greenboro Station)
142s	Gloucester South, local route (starting and ending at Greenboro Station)
146	Greenboro Station - Billings Bridge Station, local route
177	Baseline Station - Nepean South, along Woodroffe Avenue
189	Lebreton Station - Riverside Drive via Bronson Avenue
192	Elmvale Mall - Hurdman Station via Sheffield Road / Transitway
192x	Hawthorne Road - Hurdman Station via Sheffield Road / Elmvale Mall / Transitway
193	Orleans, local route (along Queensway and St. Joseph Blvd)
196	Airport - Greenboro Station via Airport Parkway / Transitway
197	Local Route between Bank Street and Riverside Drive (starting and ending at Billings Bridge Station)

Note: These routes do not include routes with minor changes between 1995 and 2021
(virtually all routes are affected by new bus lanes, transitway extensions
along existing roads, etc.)

APPENDIX 2

Logit Model for Estimating Zonal Auto Ownership

Development of Vehicle per Household Models

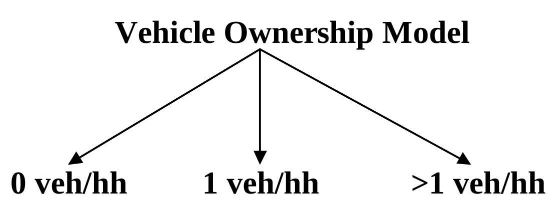
1. Overview

The purpose of this study was to develop models for estimating future vehicle ownership by traffic zone as input into the TRANS modal split models. Logit models were selected for this modeling task since they can include explanatory variables indicating the characteristics of the land use such as household size, number of workers in the household and employment density that can influence zonal vehicle ownership. By including these type of variables in the model, future vehicle ownership will be sensitive to changing demographic patterns.

Two models were developed, one for estimating vehicle ownership for persons making work to home trips and another model for persons making school to home trips. Separate models were required since each model takes into account a unique group of trip makers in the traffic zone. Only those persons making the particular trip purpose by auto and transit were included in the database from which the models were developed. This was necessary to ensure the model was built using the sample of persons in households making the trips under study.

Once the models were developed, they were aggregated to the zonal level and used to estimate the percentage of households in a traffic zone containing no vehicles, one vehicle or more than one vehicle. This information was then fed into the modal split models to determine modal split for work and school trips.

Exhibit 1.1 Logit Model for Vehicle Ownership



2. Database Preparation

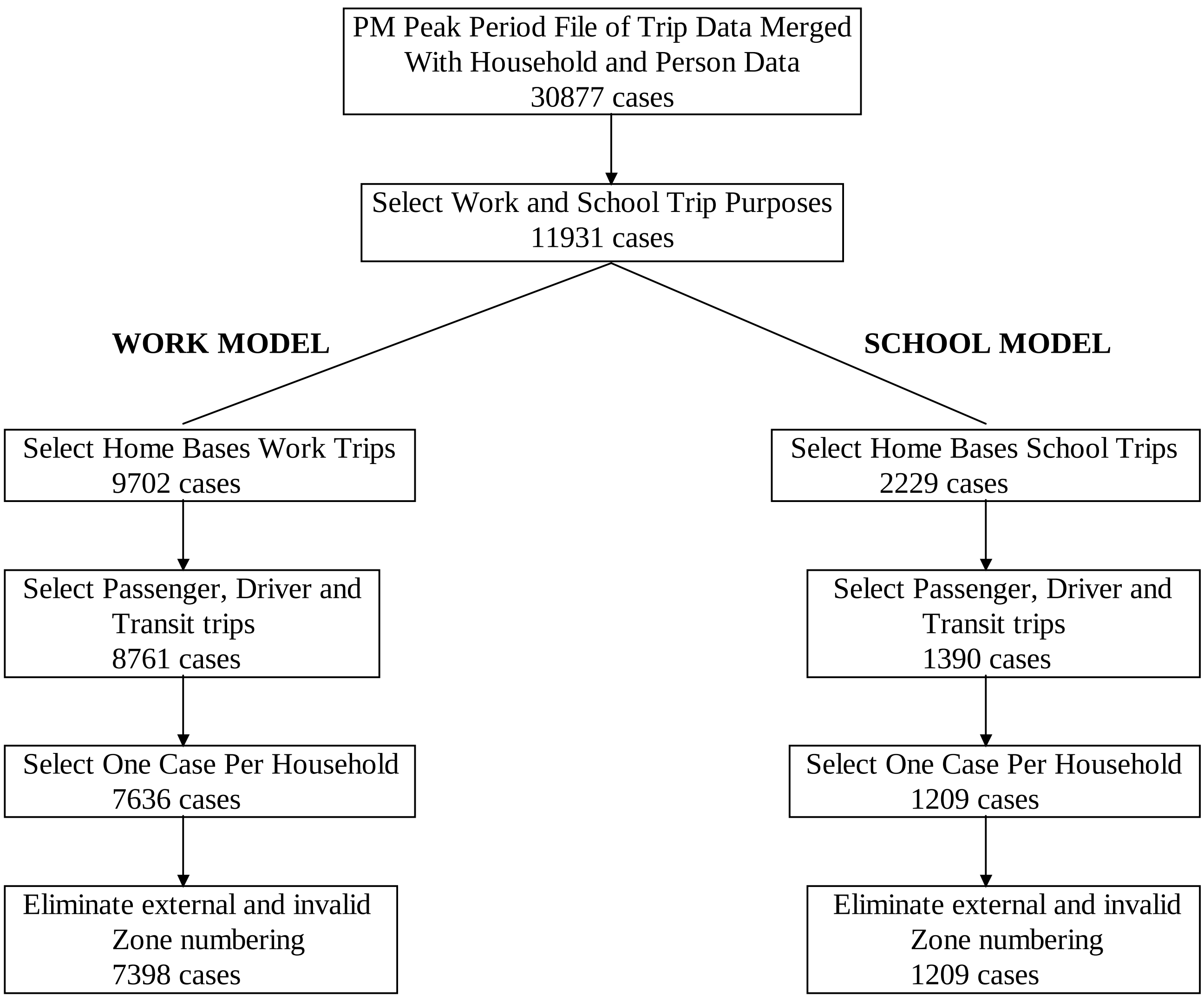
The 1995 Origin Destination Survey was the principal data source for developing the models. In the survey, data was collected at the household, person and trip level, see Exhibit 2.1.

Exhibit 2.1 1995 OD Survey Data

Household Data	Person Data	Trip Data
Location	Gender	Desination location
Dwelling type	Age	Trip purpose
Number of people	Driver's license	Start time
Number of autos	Work	Mode of travel
	Place of employment	Number of auto occupants
	Pay to park at work	Transit routes used
	Student status	
	School location	
	Start location of 1st trip	

The model was built by selecting from the OD survey persons making a trip in the pm peak period (3:30- 5:59pm). The peak period was used for building the model rather than the peak hour in order to obtain an adequate sample of individuals for building the model. The file was then filtered by removing non - work and non - school trips and trips made by modes other than auto and transit. Each of the samples was further filtered such that a household was only represented once in the work model file and in the school model file. Invalid and external zones were then removed from the database.

Exhibit 2.2 Database Preparation Process



3. Model Calibration

A literature search was carried out to gain insight into the variables to include in the model equations. Alternative methods of representing variables (e.g. log of a variable) were also investigated. From this investigation, area types as UTA, province and CBD were included in the model as well as trip origin employment density, number of persons employed per household, and destination population density. In addition, several age co-horts are included in the models.

Variables such as number of persons in a household, number of persons employed in a household, and area type influence the number of vehicles owned in a household. If there are more people employed in the household then there is a more likely chance of having more vehicles in the household because the income in the household may be higher. On the contrary, if the family income is lower due to few or no people employed in the household then there is a more likely chance of having one or no vehicle owned in the household. If that is the case then some members of the household will result to using the transit system.

The following list gives the variables used in both models and their definitions:

- Num_pers (number of persons per household): Defined by the 1995 OD Survey.

- Or_e_den (the origin zone employment density): The total employment from the OD Survey over the zone area.

- Uta_flag (urban transit area flag): A dummy variable: 1 if a zone is within the urban transit area, else it is 0. See map.

- Cbd_flag (central business district flag): A dummy variable: 1 if a zone is within the central business district (consisting of traffic zones 1-25, 153, 155, 201, 254, 255), else it is 0.

- No_15_24: The number of persons aged 15-24 divided by the number of persons per household.

- Num_emp: The number of persons employed in a household.

- De_p_den (the destination zone population density): The total population from the OD Survey over the zone area.

- Province (province flag): Quebec is labeled as 1 and Ontario is 0.

- Age5_14: The number of persons in a household between the ages 5 and 14.
- Age15_24: The number of persons in a household between the ages of 15 and 24.

- Age25_44: The number of persons in a household between the ages of 25 and 44.

3.1 Work Trip Model

The most suitable model for simulating vehicle ownership for persons making work to home trips is illustrated in Exhibit 3.1. Note that since the model contains only multinomial variables, the 0 vehicle per household model is normalized to zero. When this 0 is placed into the logit exponential probability function, the appropriate probability of 0 vehicles per household is obtained.

Exhibit 3.1 Work Model Results

Choice	num_pers	or_e_den	uta_flag	cbd_flag	no_15_24	num_emp	de_p_den	C
0 veh/hh	0*	0	0	0	0	0	0	0
1 veh/hh	0.577** 7.611***	-0.00874 -2.755	-2.109 -2.932	-0.639 -3.079	-1.212 -5.078	0.904 5.856	-0.133 -4.505	2.634 3.565
>1 veh/hh	0.900 11.661	-0.0204 -6.176	-3.110 -4.322	-0.932 -4.034	-1.449 -5.752	2.003 12.607	-0.275 -8.328	1.420 1.915

0 veh/hh	Zero vehicles in a household
1 veh/hh	One vehicle in a household
>1 veh/h	More than one vehicle in a household
Num_pers.	Number of persons per household
Or_e_den	Origin employment density
uta_flag	Coded as 1 if zone is within the UTA, else 0
cbd_flag	Coded as 1 if zone is within the CBD, else 0
no_15_24	Ratio of the number of persons aged 15-24 over the number of persons per household
Num_emp	Number of employed per household
De_p_den	Destination population density
*	Coefficients are normalized to zero.
**	Coefficient of variable.
***	t-statistic.

Summary of Statistics :

Number of choices	= 3
Number of 0 veh/hh	= 279 (3.77%)
Number of 1 veh/hh	= 2920 (39.47%)
Number of >1 veh/hh	= 4199 (56.76%)
Total number of choices	= 7398 (100 %)
Rhosq	= 0.3834
Rhobarsq	= 0.3825

3.2 School Trip Model

Exhibit 3.2 contains the calibrated model for estimating vehicle ownership for school to home trip makers.

Exhibit 3.2 School Model Results

Choice	num_pers	province	de_p_den	age5_14	age15_24	age25_44	num_emp	C
0 veh/hh	0*	0	0	0	0	0	0	0
1 veh/hh	.536** 3.487***	0.867 2.972	-0.00012 -2.333	-0.342 -1.689	-0.746 -4.192	0.263 1.781	0.807 5.482	0.235 0.593
>1 veh/hh	1.103 6.671	0.793 2.596	-0.00040 -6.574	-0.783 -3.676	-1.090 -5.808	0.276 1.758	1.406 9.029	-1.048 -2.360

0 veh/hh		Zero vehicles in a household
1 veh/hh	…	One vehicle in a household
>1 veh/hh	…	More than one vehicle in a household
Num_pers.	…	Number of persons per household
Province	…	Coded as 1 for Quebec and 0 for Ontario.
De_p_den	…	Destination population density.
Age5_14	…	Number of persons aged 5-14 in a household.
Age15_24	…	Number of persons aged 15-24 in a household.
Age25_44		Number of persons aged 25-44 in a household.
Num_emp		Number of employed per household
*		Coefficients are normalized to zero.
**	…	Coefficient of variable.
***	…	t-statistic.

Summary of Statistics :

Number of choices	= 3
Number of 0 veh/hh	= 129 (10.67%)
Number of 1 veh/hh	= 458 (37.88%)
Number of >1 veh/hh	= 622 (51.45%)
Total number of choices	= 1209 (100 %)
Rhosq	= 0.32
Rhobarsq	= 0.315

4. Model Evaluation

Evaluating the quality of logit models involves individual judgement and statistical analysis. The output of the logit estimation software includes estimated values of the coefficients of various variables, t-statistics of those coefficients and the correlation among variables. This set of statistical indicators can be used to judge the quality of the model.

4.1 T-Statistic

The t-statistic of a coefficient is useful for determining whether the variable contributes significantly in explaining vehicle ownership per household. A t-statistic of more than 1.65 or less than -1.65 indicates significance of more than 95 percent confidence interval. A t-statistic of greater than 2.3 or less than -2.3 shows significance of more than 99 percent confidence interval. All the variables used in the model are significant at the 99% confidence interval as shown in Exhibits 3.1 and 3.2. This illustrates that all the variables contribute significantly to the model to describe vehicle ownership per household.

4.2 Correlation Matrix

The variables included in the model are checked to ensure no significant correlation exists between variables in the utility functions. The criteria used in this study was to assume variables were not correlated if the correlation coefficient was under 0.8. The correlation matrix for the developed models are shown in Exhibit 4.1 for the work model and Exhibit 4.2 for the school model. The correlation statistics indicates that none of the variables are significantly correlated.

Exhibit 4.1 Work Correlation Matrix

	num_pers	or_e_den	uta_flag	cbd_flag	no_15_24	num_emp
or_e_den	-0.003					
uta_flag	-0.095	0.065				
cbd_flag	-0.115	0.0004	0.131			
no_15_24	0.323	-0.001	-0.009	-0.014		
num_emp	0.289	0.020	-0.074	-0.051	0.145	
de_p_den	-0.146	0.049	0.536	0.476	-0.015	-0.122

Exhibit 4.2 School Correlation Matrix

	num_pers	province	de_p_den	age5_14	age15_24	age25_44
province	-0.041					
de_p_den	-0.153	-0.207				
age5_14	0.543	-0.0081	-0.044			
age15_24	0.367	0.00025	0.033	-0.258		
age25_44	0.260	0.064	0.0094	0.300	0.212	
num_emp	0.388	0.021	-0.182	-0.135	0.306	0.028

4.3 Goodness of fit:

This measure resembles the squared multiple correlation coefficient (R^2) in the linear statistical model. If the model perfectly predicts the choices of all individuals in the sample, the likelihood function will have the value 1. Equally, if all the parameters in a logit model are 0, the model predicts that all the choices for any individual are equally likely. Here the model does not explain the choice variations and the likelihood function is much smaller.

The value of ρ^2 varies between 0 (no fit) and 1 (perfect fit). Given these parameters, there are no explanations for the goodness-of-fit for intermediate values for different circumstances. In fact for this type of automobile ownership model, a value around 0.4 is considered as perfect fit.

In the work model, the values of rho-square and rho-bar-square are 0.3834 and 0.3825 respectively. The school model has rho-square and rho-bar-square of .32 and .315. By including a greater number of socio-economic variables, the rho-squared will tend to increase.

4.4 Review of Individual Variables:

The value of the individual variables can be determined through an analysis of the coefficients of these variables. The sign of the coefficients should reflect the expected human behavior based on judgement and experience. The estimated coefficient is the best approximation available for its real value. These coefficients should only be included if they are significant with respect to their t-statistic.

4.4.1 Work Model

- ***Number of persons per household*** has the greatest value of t-statistic in the work model. This indicates its significance in the work model. Households with a larger number of persons tend to have more vehicles for convenience. This is proven by the signs of the coefficients. The positive sign indicates as the number of persons in the household increases, the chances of choosing 1 veh/hh and >1 veh/hh increases compared to 0 veh/hh respectively.

- ***Number of persons employed*** in the household is significant and the positive sign indicates as the number of people in the household employed increases the more likely 1 veh/hh and >1 veh/hh are chosen respectively. This is supported with the notion that when there are more people employed in a household, there is a greater chance of having more income and the possibility of purchasing more than one vehicle increases.

- ***Origin employment density*** variable is significant within the 99% confidence interval. These trips originate in the employment zone since these trips are from work to home. If the origin employment density is high, more people will likely have only one vehicle in the household. The opposite is true for a low origin employment density. These zones are usually found outside the central business district and tend to have a higher population density. A low origin employment density indicates that >1 veh/hh is favoured over 0 veh/hh.

- ***Destination population density*** variable has a negative value. If the destination population density is high, more people will likely have zero or one vehicle in the household. The opposite is true for a low population density. These zones are usually found outside the urban transit area or a fare distance from the central business district and a vehicle is the quickest way to travel. A low destination population density indicates that >1 veh/hh is favoured over 0 veh/hh.

- ***Uta_flag*** has a negative coefficient indicating that 0 veh/hh is favoured more for zones inside the urban transit area. The likelihood of choosing 1 veh/hh and >1 veh/hh increases for zones outside the uta. There is no bus service to these zones, so if any travel needs to be done to inside the uta a vehicle is required. This increases the likelihood of having a vehicle outside the uta.

- ***Cbd_flag*** suggests that if a person lives within the central business district there is less likely of a chance of owning a vehicle because most employment zones fall within the central business district. When there are longer distances to be traveled, a vehicle is preferred, therefore there is a more likely chance of choosing 1 veh/hh and >1 veh/hh.

- ***Number of persons aged 15-24 over the number of persons*** in the household variable is used to indicate indirectly how age affects vehicle ownership. The negative sign indicates as this number increases, the more likely chance of 0 veh/hh being chosen. >1 veh/hh would increase if the value for this variable was lower and there were higher values for the younger and older ratios. A lower age group may increase vehicle ownership for the convenience of the family. A higher age group would have more licensed drivers in the household making the independence of owning a vehicle a greater priority.

4.4.2 School Model

- ***Number of persons in household*** is an important variable because of its high t-statistic. The positive sign indicates as the number of persons in the household increases, the chances of choosing 1 veh/hh and >1 veh/hh increases compared to 0 veh/hh respectively. As the number of persons in a household increases, it is more convenient to own at least one vehicle.

- ***Number of persons employed in the household*** is one of the higher significant variables in the school model. The positive sign indicates that as the number of people in the household employed increases the more likely 1 veh/hh and >1 veh/hh are chosen respectively. This is proven when there are more people employed in a household, there is a greater chance of having more income and the possibility of purchasing more than one vehicle increases.

- ***Destination population density*** variable has a negative value. If the destination population density is high, more people will likely have zero or one vehicle in the household. The opposite is true for a low population density. These zones are usually found outside the urban transit area or a fare distance from the central business district and a vehicle is the quickest way to travel. A low destination population density indicates that >1 veh/hh is favoured over 0 veh/hh.

- ***Province*** is an important variable. The positive sign of the province variable shows that people in Quebec prefer to own a vehicle. This is consistent with the travel characteristics of the region. People living in Quebec and working in down town in Ottawa and elsewhere in Ontario prefer to share the vehicle then drive alone.

- ***Number of persons aged 5-14*** variable is the least significant variable in the model. Although, it is still significant at the 99% confidence interval. The negative sign indicates that as this number increases, the more likely chance of 0 veh/hh being chosen. >1 veh/hh increases when there are more older persons in the household in comparison to this age group.

- ***Number of persons aged 15-24*** variable is the most significant variable between the age categories. The negative sign shows that as this number increases, the more likely chance of 0 veh/hh being chosen. >1 veh/hh would increase when this age group drops in number with respect to the other age groups in the household.

- ***Number of persons aged 25-44*** variable has a negative sign which shows that as this number increases, the more likely chance of 1 and >1 veh/hh being chosen. 0 veh/hh would increase if there are more children in comparison to this age group in the household.

5. Validation :

The quality of the model to predict vehicle ownership is analyzed using the macro and micro approaches. In macro validation, the choice distribution, given by the developed model, are compared with the actual distribution of choices from the database. This will show the difference in predicted vehicle ownership and actual vehicle ownership share. In micro validation, the choice prediction of every trip record is compared with the actual choice of the individual. This will give the percent right prediction of the model. This is an unambiguous indicator of model's reliability.

5.1 Macro validation

The choice distribution given by the developed model and actual vehicle ownership of the database is recorded in the exhibit below:

Exhibit 5.1 Macro Validation

	WORK			SCHOOL		
Choice	Number of observed cases	Number of Predicted cases	Error	Number of observed cases	Number of Predicted cases	Error
0 veh/hh	279	38	-241	129	65	-64
1 veh/hh	2920	2348	-572	458	433	-25
>1 veh/hh	4199	5012	813	622	711	89

As shown in the above exhibit for the work model, the number of predicted cases for 0 veh/hh is 38 while the actual observed cases is 279. Thus the model under-estimates 241. Similarly the number of predicted cases for 1 veh/hh was 2348 and for over 1 vehicle per household 5012 cases.

The same interpretation can be made for the school model where the model predicts 65, 433 and 711 compared to 129, 458 and 622 observed cases per vehicle ownership choice.

5.2 Micro Validation

The number of cases predicted correctly for zero, one and more than one vehicle in a household is represented in Exhibit 5.2.

Exhibit 5.2 Micro validation

	WORK			SCHOOL		
Choice	Number of Observed cases	Number of cases Predicted correctly	Percent Correct	Number of Observed cases	Number of cases Predicted correctly	Percent Correct
0 veh/hh	279	23	8%	129	35	27%
1 veh/hh	2920	1414	48%	458	251	55%
>1 veh/hh	4199	3481	83%	622	509	82%
Total	7398	4918	66%	1209	1209	66%

0

For the work model, 0 veh/hh has 23 cases predicted correctly and the observed number of cases is 279. Thus the percent correct value is 8%. Similarly, the percent of cases correctly predicted for 1 and over 1 veh/hh are 48% and 83% respectively. The overall percent predicted correct is 66%.

For school model, the number of cases correctly predicted for 0, 1 and more than 1 veh/hh are 27%, 55%, and 82% respectively. The overall percent predicted correct is 66.

6. Sensitivity Analysis

The sensitivity analysis is appropriate for evaluating the impact of socio-economic factors on different circumstances. The analysis is carried out to determine how vehicle ownership may change with variations to the socio-economic conditions. This can usually provide an indication to how the model interprets each individual attribute in the database. The logit model provides an opportunity for analyzing how the socio-economic factors affect an individual's choice.

When estimating the sensitivity analysis, the average value of each variable is obtained. These values are put into the utility equations to obtain initial probability percentages for each choice. Separately, each variable in both equations was increased and decreased by 10%. These new percentages were compared to the initial ones by taking a difference between them. For the dummy variables, they were initially either assumed 0 or 1. To find their sensitivity, they were changed to 1 or 0. Exhibit 6.1 summarizes the results obtained for both models.

Exhibit 6.1 Sensitivity Analysis

WORK				SCHOOL			
VARIABLES	0 VEHICLE	1 VEHICLE	>1 VEHICLE	VARIABLES	0 VEHICLE	1 VEHICLE	>1 VEHICLE
num_pers ↑ 10%	-0.36%	-2.25%	2.61%	num_pers ↑ 10%	-1.46%	-4.25%	5.70%
num_pers ↓ 10%	0.44%	2.22%	-2.66%	num_pers ↓ 10%	1.86%	4.01%	-5.87%
or_e_den ↑ 10%	0.03%	0.36%	-0.39%	province 0→1	-3.04%	3.14%	-0.10%
or_e_den ↓ 10%	-0.04%	-0.35%	0.39%	de_p_den ↑ 10%	0.38%	1.53%	-1.92%
de_p_den ↑ 10%	0.07%	0.69%	-0.76%	de_p_den ↓ 10%	-0.37%	-1.54%	1.90%
de_p_den ↓ 10%	-0.08%	-0.68%	0.75%	age5_14 ↑ 10%	0.22%	0.63%	-0.85%
uta_flag 1→0	-1.65%	-21.30%	22.94%	age5_14 ↓ 10%	-0.21%	-0.6%	0.85%
cbd_flag 0→1	2.02%	6.11%	-8.13%	age15_24 ↑ 10%	0.88%	0.94%	-1.82%
num_emp ↑ 10%	-0.40%	-4.36%	4.77%	age15_24 ↓ 10%	-0.8%	-1.01%	1.77%
num_emp ↓ 10%	0.49%	4.36%	-4.85%	age25_44 ↑ 10%	-0.1%	0.03%	0.10%
no_15_24 ↑ 10%	0.04%	0.08%	-0.12%	age25_44 ↓ 10%	0.14%	-0.03%	-0.11%
no_15_24 ↓10%	-0.04%	-0.08%	0.12%	num_emp ↑ 10%	-0.93%	-1.94%	2.87%
				num_emp ↓ 10%	1.08%	1.85%	-2.93%

7. Aggregation

The logit model was developed on an individual person basis where each record in the sample was used to build the model representing vehicle ownership. In order to use the model within a traffic zone system, an aggregation process was required to combine the vehicle ownership by household in a particular traffic zone.

Using the 1995 OD Survey, the percent of households in a traffic zone having no vehicle, one vehicle and more than one vehicle was obtained for the PM peak period work trip makers and school trip makers. The vehicle ownership models were then run to obtain zonal estimates of vehicle ownership.

After determining the percentage of households in each zone owning no vehicle, one vehicle, and more than one vehicle, statistical parameters were computed for each vehicle ownership category. These parameters are presented in Exhibits 7.1 and 7.2 for work trips and school trips, respectively. It should be noted that traffic analysis zones with limited survey data were eliminated from the statistical comparison described below. Instead, it was decided that the accuracy of the models be evaluated using only those zones with reliable vehicle ownership data. The number of traffic zones included in the analysis is indicated in Exhibits 7.1 and 7.2 below.

Exhibit 7.1 Statistical Parameters for Zonal Vehicle Ownership - Work Trips

Sample	Vehicle Ownership (veh/hh)	Mean (% of HH's)	Median	Standard Deviation	Skewness Statistic	Kurtosis Statistic	Number of Valid Observations	Assumed Sample Distribution
1995 O-D Survey	0	5.59	2.00	8.00	1.90	3.62	159	Non-Normal
	1	45.41	46.00	15.28	-0.14	-0.17	159	Normal
	2+	49.10	49.00	18.88	-0.001	-0.45	159	Normal
Model Results	0	4.34	2.11	9.75	7.29	63.86	159	Non-Normal
	1	45.52	47.16	12.95	-0.91	0.80	159	Normal
	2+	50.14	50.28	16.48	-0.13	0.66	159	Normal

Exhibit 7.2 Statistical Parameters for Zonal Vehicle Ownership - School Trips

Sample	Vehicle Ownership (veh/hh)	Mean (% of HH's)	Median	Standard Deviation	Skewness Statistic	Kurtosis Statistic	Number of Valid Observations	Assumed Sample Distribution
1995 O-D Survey	0	11.10	6.70	14.15	1.39	1.53	122	Non-Normal
	1	42.74	42.90	18.44	-0.06	-0.32	122	Normal
	2+	46.17	50.00	23.37	-0.12	-0.44	122	Normal
Model Results	0	7.49	5.01	7.60	2.60	9.63	122	Non-Normal
	1	46.76	47.19	11.98	-0.25	-0.55	122	Normal
	2+	45.75	47.69	17.49	-0.25	-0.48	122	Normal

The accuracy of the two models can be assessed by comparing the means of the observed and modeled vehicle ownership samples for each vehicle ownership category. Exhibit 7.3 presents the results of such a comparison.

Exhibit 7.3 Difference in Sample Means

Type of Trip	Vehicle Ownership (veh/hh)	Difference in Sample Means (Model - Observed)
Work	0	-1.25
	1	0.11
	2+	1.04
School	0	-3.61
	1	4.02
	2+	-0.42

The school trip model is less reliable than the work trip model, particularly for households owning less than two vehicles. However, even if the difference in means is quite small, it is necessary to determine whether the difference is statistically significant or whether the difference can be attributed to random error.

Before choosing an appropriate statistical test, the sample distributions must be known. From the results in Exhibits 7.1 and 7.2, it can be concluded that the one vehicle and more than one vehicle per household samples are normally distributed, regardless of whether the sample was estimated using the newly developed models or observed from the 1995 O-D Survey. Consequently, the relationship between the model results and the observed vehicle ownership data can be determined using a paired samples t test. The results of this test are shown in Exhibit 7.4.

Exhibit 7.4 Results of the Paired Samples T Test

Type of Trip	Vehicle Ownership (veh/hh)	Paired Differences (Model-Observed)				T Statistic	Degrees of Freedom	Significance (2-tailed)
		Mean	Standard Deviation	95% Confidence Interval				
				Lower	Upper			
Work	1	0.11	13.03	-1.93	2.16	0.11	158	0.91
	2+	1.04	12.53	-0.93	3.00	1.04	158	0.30
School	1	4.03	18.30	0.75	7.31	2.43	121	0.02
	2+	-0.42	18.84	-3.80	2.96	-0.25	121	0.81

In this table, the significance value represents the probability that the difference between the means of the modeled and observed vehicle ownership samples can be attributed to chance. If the two-tailed significance value is less than 0.05, the modeled vehicle ownership sample can be considered statistically different from the observed data at a 95% confidence interval. Conversely, as the significance value increases above 0.05, the two samples can be assumed to be increasingly similar, since any difference in the means of the two samples is likely due to coincidence.

Statistically speaking, the hypothesis that the two samples have similar means can only be rejected or not rejected. Thus, if the hypothesis is rejected (i.e. the two-tailed significance value is less than 0.05), the analyst can conclude that the model is poor. On the other hand, if the hypothesis is not rejected (i.e. the two-tailed significance value is greater than 0.05), the analyst can conclude only that there is no reason to assume the model is poor. While the model may be accurate, there is no way to prove this conclusively.

For the work trip model, the significance values for the one vehicle per household and more than one vehicle per household samples are relatively high, leading to the conclusion that the work trip model is reliable when results are aggregated to the zonal level. Since work trips comprise a large proportion of the total number of trips within an urban area, it is important that the work trip model be sufficiently accurate.

For the school trip model, the paired samples t test indicates that the model predicts households owning more than one vehicle with reasonable accuracy. Since over 45% of the households which make school trips have more than one vehicle, it is important that the model be able to predict such households correctly. From the high significance value associated with this level of vehicle ownership, it can be concluded that the model is reliable when predicting more than one vehicle per household. However, the modeled vehicle ownership sample for one vehicle per household cannot be considered statistically similar to the observed vehicle ownership sample since the significance value is less than 0.05, indicating that the model is weaker in this area.

Because the no vehicle per household samples are not distributed normally, a paired samples t test could not be used to compare the model results with the observed distribution. Instead, a Wilcoxon signed ranks test was used, which analyzes the difference between paired values. If the significance is found to be low, the analyst can reject the idea that the difference between the medians of the two samples is a coincidence. In this case, a high significance value is desired in order to prove that the two samples (modeled and observed vehicle ownership) are similar, and thus have similar medians.

Unfortunately, the Wilcoxon signed ranks test indicates a low significance value for both the school and work trip models. The two-tailed significance value for the school trip model is 0.011, while the corresponding value for the work trip model is 0.008. Because these values are less than 0.05, the hypothesis that the two samples have similar medians can be rejected at a more than 95% confidence interval, indicating that the model predictions are statistically different from the observed data. However, although the models are less reliable in their ability to predict households with no vehicles, such households comprise a relatively small proportion of the total population. Since the models are able to predict households with one or more vehicles accurately when aggregating data on a zonal basis, it can be concluded that the models are generally reliable for forecasting purposes, particularly when modeling work trips which dominate peak period travel.

APPENDIX 3

Revised School Trip Generation Model

During the model calibration process, additional work was carried out on the trip generation equations for the secondary school trip purpose. The main difference in the regressions This age go-hort was not available in the previous land use databanks for EMME2. For this study it was obtained directly form the 95 OD survey. The percentage that the 10-14 age group was of the 5 to 14 age group in 1995 was used to estimate 2021 population in the 10-14 age group. Another difference is that the old equations contained a sample of trips from 2:30pm to 5:59 pm with the intention of increasing the sample size to increase the quality of the regression equation. The trips were later factored by .6 to adjust to the peak period. In the new equations, the sample includes trips from 3:30pm to 5:59pm.

Trip Generation Regression Formulations

Version	Trip Purpose	Regression Details	Regression Equation	R^2
Updated Version	Sec_ Sch to home	Production, 1986 Existing Model	(.3059 * SCHS + .0691 * POP25-44 + 29)*.365	0.61
of the School trip		Production, 1995 Calib. (1)	(.231 * SCHS - .014 * POP25-44) * .6	0.68
Generation Model		*Production, 1995 Calib. (2)	(.142 * OD_SCHS)	0.594
as reported in				
model results in		Attraction, 1986 Existing Model	(.2684 * POP5-14 + .0422 * POP15-24 + .0337 * POP25-44 + 2) * .365	0.81
Section 7 of		Attraction, 1995 Calib. (1)	(0.102 * POP10-14 + .08123 * POP15-24 .0046 * POP25-44) * .6	0.78
Development of		Attraction, 1995 Calib. (2)	(0.08555 * POP15-24 + .02249 * POP25-45) * .6	0.77
the 1995 TRANS		*Attraction, 1995 Calib. (3)	(0.07072 * POP15-24 + .121 * OD_P1014)	0.773
Model, Aug/99				
Former Model as	Sec_ Sch to home	Production, 1986 Existing Model	(.3059 * SCHS + .0691 * POP25-44 + 29)*.365	0.61
reported in		Production, 1995 Calib. (1)	(.231 * SCHS - .014 * POP25-44) * .6	0.68
Exhibit 3.5 in		*Production, 1995 Calib. (2)	** (.171 * SCHS) * .6	0.7
Development of				
the 1995 TRANS		Attraction, 1986 Existing Model	(.2684 * POP5-14 + .0422 * POP15-24 + .0337 * POP25-44 + 2) * .365	0.81
Model, Aug/99		Attraction, 1995 Calib. (1)	(0.102 * POP10-14 + .08123 * POP15-24 .0046 * POP25-44) * .6	0.78
		Attraction, 1995 Calib. (2)	(0.08555 * POP15-24 + .02249 * POP25-45) * .6	0.77
		*Attraction, 1995 Calib. (3)	** (0.142 * POP15-24) * .6	0.75

Notes: * **Equations underlined and bold printed were sellected for new model calibration.**
The SPSS files contains the records used to carry out the regressions. The files are in c:\temp\tripgen directory
contain the appropriate zonal demographac data as well as trip attractions/ productions per zone.
** Secondary school trips multiplied by .6 to convert trips from a 2:29-5:59 period to 3:29-5:59 period.
The existing TRANS model scondary school trip equation was multiplied by .365 to correct for an error in the origional model equation.