Appendix D
Brampton 2006
P.M. Peak Model Report

WORKING DOCUMENT

BRAMPTON 2006 P.M. PEAK MODEL

Documentation & Users' Guide

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Contents

1.0 Introduction

The name "Simplified GTA model" has been adopted to distinguish between this model and the "Full GTA model" developed at the University of Toronto. The model is "simplified" in terms of its ease of application. The level of detail, defined by the zone system and network information, is the same in both models. The simplified GTA model has been used in a number of sub-area studies that involve the splitting of GTA zones for more detailed site specific analysis.

The simplified approach is based on the extrapolation of existing (observed) travel behaviour patterns as opposed to using mathematical equations to synthesize those relationships. Assumptions as to future changes in trip rates, mode choice factors, mean trip length and auto occupancy have to be explicitly stated as inputs to the modelling process.

The model uses a pre-distribution (trip end) mode split component that favours the incorporation of assumptions that reflect long term socio-economic trends, household decisions (such as car ownership) and general, area wide, levels of service rather than details that pertain to specific trips..

The trip distribution component is unique to the simplified model incorporating features of both the more traditional "gravity" and "Fratar" techniques. The results reflect both the existing O-D specific travel patterns at an aggregate level as well as the existing trip length distribution at a more detailed level. The latter feature enables the trip distribution process to be applied to areas of new development for which there is no existing travel information.

The trip generation, mode split and trip distribution components are based on a 3 hour peak period. The total auto person trip matrix is converted to a peak hour auto driver matrix prior to assignment. The transit assignment, if required as an output, is for the 3 hour peak period. The model, in its most basic form, does not use any network, or level of service information, to generate the trip matrices. Some of the supplementary features, discussed in Chapter 2, can be used to modify the trip distribution component to reflect anticipated changes in level of service.

The current release (version 5) has been calibrated using data from the 2006 Transportation Tomorrow Survey (TTS) release 0.1. Subsequent releases may change the trip control totals but are not expected to affect other aspects of the model in any meaningful way. The trip rates and mode split factors may need to be updated for consistency with the TTS database. The parent (GTA version) of the model is based on the 2001 GTA zone system plus 26 external zones. The Brampton model incorporates additional zone and network detail within the City of Brampton, the Town of Caledon and in the Milton area of the Region of Halton.

Compared with previous releases the changes made to the operating procedures and macros are minor.

- The modal split factors used as input assumptions are now expressed as percentages of the total trips. In previous versions they were expressed as percentages of the residual number of trips after previous modes had been removed.
- Separate peak hour factors are applied to work and non-work auto trips. A global factor is used for non work trips. The factors for auto work trips are by origin as were the combined factors used in previous versions of the model.
- The matrix used to convert auto persons to auto drivers (vehicles) now contains the number of auto drivers as a proportion of total auto persons. By applying zero factors in the appropriate areas the matrix may also be used to remove trips from the matrix as an alternative to using "all or nothing" assignment procedures for remote areas where information on future network improvements is not readily available. Previously the matrix contained auto occupancy factors.
- Mode "z" (GO Rail egress mode) is redundant due to the trip end sub-mode split component of the model that adds the GO Rail egress trip component to the appropriate road and transit matrices. The use of mode "z" is no longer permitted during the assignment of either GO Rail or local transit trips.
- Minor changes have been made to the zone aggregations (ensemble gg) used in the calibration of the trip generation component of the model.

1.1 Summary Description

Table 1 provides a summary of the main features of the GTA P.M. peak period model. ***Figure 1*** shows the flow of information through the Trip Generation, Mode Split and Trip Distribution components of the model. The modelling procedures are similar to those used in the simplified GTA model for the a.m. peak period but the combinations of trip purposes and mode have been changed to reflect the greater diversity of trip making activity that occurs in the p.m. peak period

Table 1 - Features of the GTA P.M. Peak Period Model

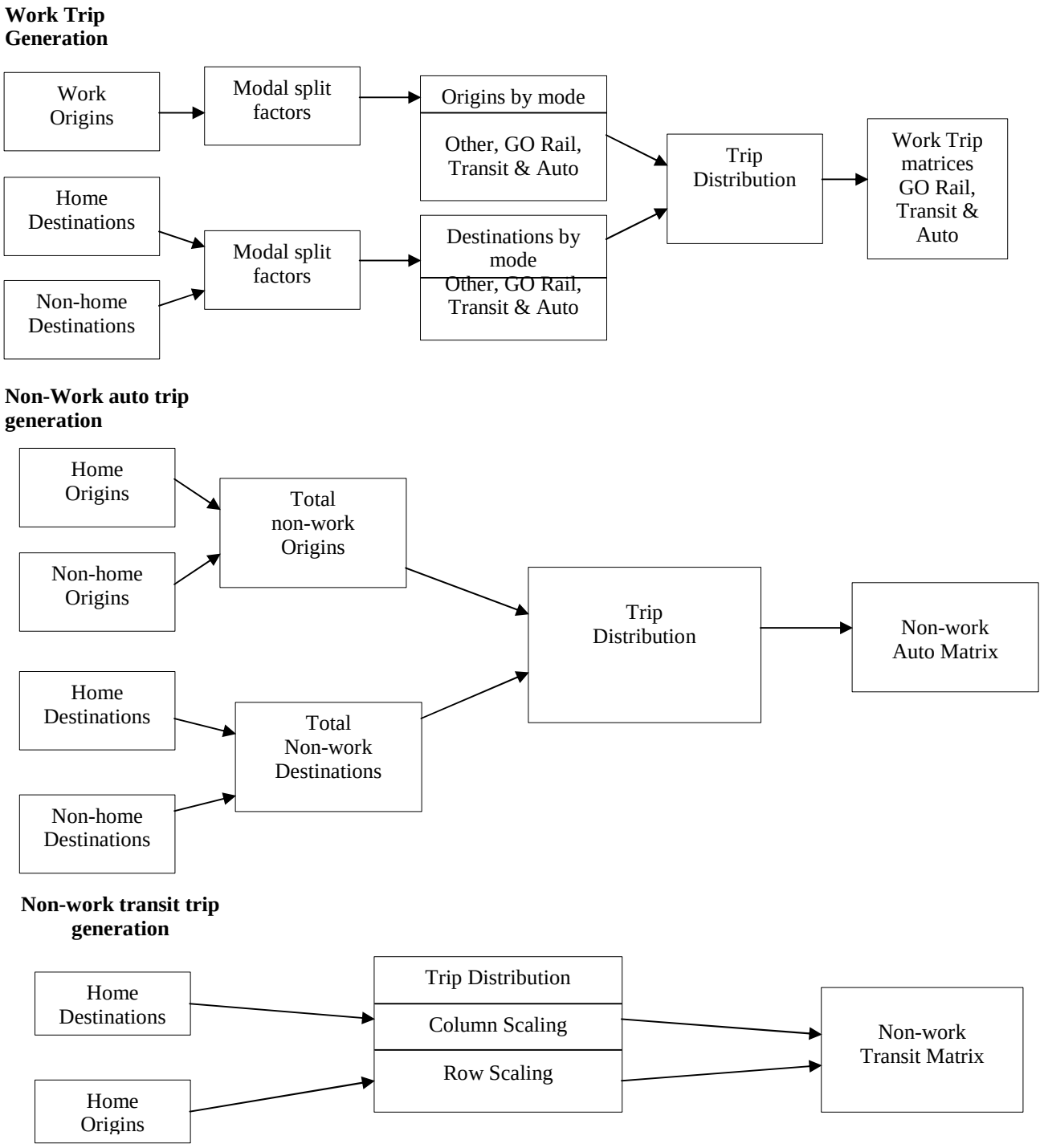
Time period	p.m. peak 3 hrs (3:01 - 6:00)
Geographic Scope	GTA, including the City of Hamilton, plus 10 adjacent Counties and Regional Municipalities
Zone system	GTA2001 plus 26 external zones (1743 total)
Trip purpose categories	1. From Work (all modes) 2. Non-work origin (Auto & transit)
Modes	1. Auto (Driver & Passenger) 2. Transit (Excluding GO Rail) 3. GO Rail 4. Other, primarily walk & cycle (Trips not distributed or assigned)
Special Features	1. Bucket rounding used at all stages for the calculation of trip end control totals and distributed cell values 2. Modified auto trip distribution reflecting projected changes in travel time (Optional). 3. Sub-mode split that adds the egress component of GO Rail trips to the auto driver and local transit matrices prior to trip assignment. 4. Simulation of HOV lanes including the formation of new car-pools (Optional). 5. Inclusion of an additional auto matrix that may be used to represent subway access, truck movements or external and through trips from outside the simulated area (Optional).
Network used in calibration & validation	2001 GTA integrated auto and transit (Including HOV lanes)

The Brampton model differs from the parent GTA model in the level of zone detail within the City of Brampton and in parts of Milton adjacent to the Brampton boundary. There are 129 additional zones in Brampton and 17 in Halton Hills bringing the total number of zones to 1889.

The definition of the GTA includes the City of Hamilton in the context of the model and this documentation.

School trips are not treated as a separate trip purpose because the trip generation and distribution procedures are the same as for other non-work related trips. Further stratification of trip purpose is unlikely to yield significantly different results unless the population forecasts can be stratified by age to reflect differences in ageing trends in different areas. The trip generation rates have been modified to take into account the known under reporting of non-work and school travel in the TTS.

Figure 1 - Flow Diagram



The model produces traffic assignments for auto drivers and local transit. In the trip generation and mode split components the auto mode includes both auto passengers and auto drivers. A subsequent auto occupancy calculation is used to generate the auto driver matrix that is assigned. The mode-split component includes an "other" mode category (Primarily walk and cycle) but the trips are not distributed or assigned.

Bucket rounding is used, wherever applicable, to produce control totals and individual matrix cell values that are integers. The bucket rounding function (bint) is described in full on page 3-67 of the emme/2 User's Manual (Release 8). The advantages of using rounded integer values are:

a) Rounding errors are eliminated as a source of differences when data are exported from emme/2 for external analysis.
b) The size of the data files used to store, or transfer, matrix data is reduced dramatically due to the smaller number of non zero values and obviating the need for decimal places.
c) The standard output tables produced by emme/2 are more readable and easier to analyse.

1.2 Trip Generation

Trip generation rates are applied to estimates of population and employment in order to obtain the trip end totals used as input to the subsequent stages of the model. ***Table 2*** shows the categories of trip used in the trip generation component of the model. A user specified global weighting factor is applied to balance the total number of work trip origins and destinations to a common total value. The recommended default value of the origin weight for work trips is 0.0 and 0.5 for non-work trips. The destination weight is automatically calculated as 1 minus the origin weight.

Table 2 - Trip Generation Categories

	2006 TTS	2001 TTS
Employment Based Trip Rates		
Work trip origins - all modes	1,496,055	1,650,477
Population Based Trip Rates		
Work to home destinations - all modes	1,211,057	1,349,188
Non work to home destinations -auto mode	680,177	756,800
Non work to home destinations - transit mode	142,616	123,982
Home origins – auto mode	476,210	585,324
Home origins - transit mode	39,482	40,337
Composite Trip Rates (applied to employment plus 50% population)		
Work to non-home destinations - all modes	284,998	335,117
Non-home non-work origins - auto mode	912,725	1,005,768
Non-home destinations with non-work origins - auto mode	708,758	649,085

Note: The 2001 data tabulation included trips internal to the external areas. The 2006 tabulation does not.

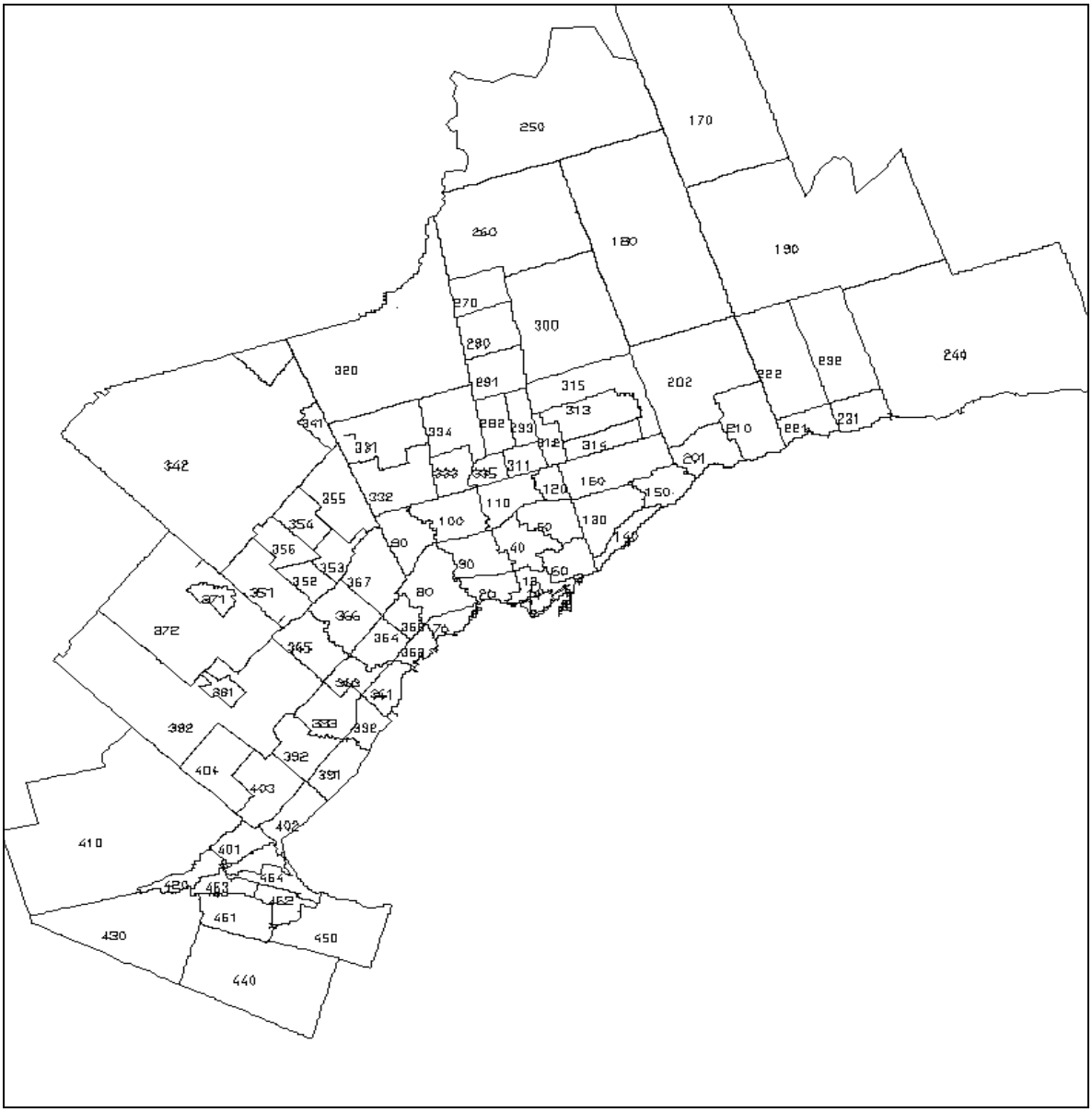
The following trip categories are not included in the trip generation component of the model:

1. GO Rail trips with a non work origin (9.9% of total p.m. peak period GO Rail trips in 2006 compared to 7.9% in 2001 – TTS data)
2. Transit trips with a non-home destination and a non-home or work origin (4.3% of total p.m. peak transit trips in 2006 – 4.4% in 2001)
3. Trips made by school bus , taxi, motorcycle or an unknown mode of transport. The last 3 categories account for less than 0.5% of reported trips in the TTS.

The model uses global adjustment factors, prior to trip assignment, to correct for the exclusion of the 1st two categories of trip.

The use of separate auto and transit trip generation rates in the non-work trip categories recognises the strong correlation between mode choice and trip purpose in those categories. 55% of p.m. peak period transit trips are school related compared with less than 5% of auto trips (2006 TTS data).

Figure 2 - Aggregations Used in Trip Generation



Base case trip generation rates were obtained from the TTS data at an aggregated level as shown in ***Figure 2***. The zone ensemble "gg", in the emme2bank, contains those zone aggregations. They are sub-divisions of Municipality with the first 2 digits being the number used to represent the municipality in the TTS database. The same aggregations and values are used in both the Brampton and GTA versions of the model.

The trip generation rates used in future forecasts can be based on the same aggregations, a different set of aggregations or individual values for each traffic zone.

Tables 5 and 6 show the trip generation rates used in the calibration of the model. These rates were calculated directly from the 2006 TTS data. Trip rates to or from home locations are per 1000 population.

Work trip rates from employment locations are per 1000 employment. A composite rate, based on employment plus half the population, is used for trips to and from other locations. The trip rates for areas outside the GTA, shown in ***Table 6,*** are for trips to or from the GTA only. The number of external non work related transit trips in the TTS database is too small to be meaningful.

The trip generation rates used in future forecasts can be based on the same aggregations, a different set of aggregations or individual values for each traffic zone.

Non work trips are known to be under reported in the TTS. Estimates of the amount of under-reporting were made after the 1996 TTS through a comparison of non-respondent trip rates with those of respondents having the same demographic characteristics. ***Table 7*** shows the estimated mean level of under-reporting. The estimates from the 1996 study have been further adjusted to improve the match between the simulation and cordon counts. The adjustment factors shown are applied to the trip rates shown in ***Tables 5 and 6***. The change in observed trip rates between 1996 and 2006 is included as trend information only.

1.3 Mode Split

Mode split factors have to be supplied for both the origins and destinations of trips starting from work. The origins and destinations for each mode are factored to a common total, using a specified weighting factor, prior to calculation of the split for the next mode. The mode split factors applied in the running of the model may be based on the same aggregations as used in the calibration, a different set of aggregations or on individual zone values.

Figure 3 shows the zone aggregations used in the calibration of the mode split component of the model. The same aggregations and values are used in both the Brampton and GTA versions of the model. The areas not shown have the same aggregations as are used for trip generation (***Figure 2***). ***Tables 8 and 9*** shows the base case modal split factors calculated from TTS data. The zone aggregation ensemble "gm" is used. The numbering convention is the same as for the aggregations used in trip generation (i.e. the first 1 or 2 digits are the planning district number). The total number of aggregations for the GTA and Hamilton is 127.

The factors are applied sequentially to determine the subsequent mode shares after the previous mode has been subtracted from the total. The sequence of application is

i) Other (Walk an Cycle)
ii) GO Rail
iii) Local Transit

The remaining trips are assumed to be made by automobile (Driver or passenger).

The origins and destinations for each mode are scaled to a common total, using a user specified weighting factor, prior to the calculation of the split for the next mode.

A post trip distribution sub-mode split is applied to GO Rail trips. The procedure is described in ***section 1.5*** - Transit assignment.

Table 5 - Trip Generation Rates (TTS)

	Origin rate per 1000 population or employment				Destination rate per 1000 population or employment				
From	work	home	home	other	work	work	not work	not work	Not work
To	all	all	all	all	home	not home	home	home	not home
Mode	all	auto	transit	auto	all	all	auto	transit	auto
11	554	29	24	65	217	52	39	55	52
12	641	25	16	37	250	45	31	46	41
20	433	47	19	112	196	52	64	47	88
30	497	50	14	130	190	48	77	49	91
40	503	74	11	164	195	53	113	38	117
50	543	74	10	161	171	46	121	48	105
60	384	55	15	119	198	50	76	50	95
70	470	90	11	117	194	34	105	22	96
80	520	83	7	210	184	62	127	32	158
90	528	63	7	156	179	41	94	33	101
100	575	56	11	142	185	44	87	38	85
110	526	68	11	169	184	47	113	48	116
120	546	63	7	152	216	51	101	46	111
130	512	66	13	179	175	55	92	45	137
140	434	80	12	161	174	46	114	46	112
150	471	84	5	179	199	39	115	39	120
160	528	66	7	135	186	39	100	41	107
170	429	86	0	117	177	29	132	0	113
180	422	83	0	226	186	45	124	1	174
190	368	94	6	267	169	41	149	50	183
201	468	100	1	199	210	51	142	9	155
202	406	99	10	141	241	35	143	62	100
210	463	92	2	198	213	44	131	5	164
221	456	108	16	206	213	61	143	26	206
222	489	107	2	186	205	44	136	7	149
231	372	106	1	174	162	45	123	2	162
232	408	107	0	259	180	47	135	1	199
240	424	106	0	169	170	33	125	1	148
250	389	82	4	176	201	35	126	8	141
260	383	85	2	140	219	48	135	16	86
270	476	114	1	243	215	62	140	6	188
280	493	97	6	177	230	45	146	30	133
291	407	98	1	108	223	26	119	23	91
292	419	88	0	215	205	56	135	0	176
293	570	80	4	153	201	44	162	19	120
300	528	104	0	140	203	50	141	13	131
311	495	90	5	165	207	47	145	26	125
312	615	93	18	126	224	53	150	78	95
313	417	89	0	222	209	49	144	0	150
314	512	75	0	169	199	50	111	1	112
315	591	57	7	152	298	52	101	38	170
320	420	93	1	196	187	44	131	58	132
331	441	75	2	116	215	31	120	11	73
332	540	62	2	156	227	59	126	11	103
333	591	61	40	77	242	42	104	168	81
334	493	66	0	133	216	44	118	0	100
335	383	78	0	202	207	65	134	1	149
341	529	91	3	167	243	53	123	12	142
342	442	105	13	126	216	40	133	32	122

Table 5(Cont.) - Trip Generation Rates (TTS)

	Origin rate per 1000 population or employment				Destination rate per 1000 population or employment				
From	work	home	home	other	work	work	not work	not work	Not work
To	all	all	all	All	home	not home	home	home	not home
Mode	all	auto	transit	Auto	all	all	auto	transit	auto
351	549	81	2	93	210	25	114	17	78
352	464	83	1	154	193	45	98	11	112
353	502	81	2	190	202	69	108	8	177
354	447	93	4	135	207	42	117	11	106
355	513	74	3	65	211	27	99	5	74
356	446	88	1	160	219	55	111	3	135
361	484	117	2	190	212	41	153	21	166
362	473	106	23	257	206	51	151	74	177
363	556	108	4	240	221	57	152	23	177
364	495	67	4	176	205	57	98	13	142
365	524	98	2	153	221	49	133	4	118
366	550	81	3	119	217	45	109	8	100
367	552	70	0	84	168	34	104	0	70
368	477	84	0	178	204	56	117	0	137
371	455	116	0	223	226	63	132	3	193
372	510	83	0	102	212	35	121	2	114
381	472	101	1	178	245	61	134	7	137
382	550	84	1	142	224	46	110	3	110
391	553	98	1	197	184	46	175	8	150
392	499	132	2	237	181	50	210	6	183
393	488	110	0	274	225	63	149	1	205
394	451	107	3	141	224	35	153	7	109
401	536	110	7	190	183	39	150	7	118
402	516	107	0	283	189	60	157	1	234
403	531	117	0	184	232	49	159	3	152
404	379	101	31	166	232	32	131	66	107
410	429	96	0	155	199	29	138	1	144
420	462	115	0	197	181	35	150	15	152
430	428	135	2	289	203	55	163	79	262
440	383	98	51	87	170	29	141	98	94
450	504	96	11	156	198	37	136	42	125
461	417	108	6	267	170	47	139	3	212
462	468	79	1	194	163	43	108	16	152
463	509	78	11	181	157	47	98	32	129
464	521	78	7	72	156	23	102	26	86
Brampton	487	86	2	141	207	47	108	9	119
2001 TTS	519	87	3	156	230	58	118	8	127
Change	-6%	-2%	-33%	-10%	-10%	-19%	-8%	9%	-6%
Toronto	536	62	12	132	190	49	92	43	97
Durham	431	101	2	200	192	45	134	7	166
York	516	85	2	169	212	50	133	12	127
Peel	519	87	3	146	210	47	117	12	119
Halton	508	107	1	210	213	51	152	4	167
Hamilton	475	96	7	195	174	42	127	23	158
GTAH total	517	80	7	156	198	48	114	25	120
2001 TTS	537	84	7	151	211	51	113	25	121
Change	-4%	-5%	-1%	3%	-6%	-6%	1%	0%	0%

Table 6 – External Trip Generation Rates for Trips to/from the GTA

		Origin Rate per 1000 population or employment			Destination Rate per 1000 population or employment			
From		work	home	not home or work	work	work	not work	Not work
To		all	all	all	home	not home	home	not home
Mode		all	auto	auto	all	all	auto	auto
Northumberland	4001	***35***	***6***	***20***	***25***	***5***	***10***	***10***
City of Peterborough	4002	21	2	4	11	3	2	2
Peterborough County	4003	18	4	3	15	1	4	7
Kawartha Lakes South	4004	23	14	11	52	2	11	16
Kawartha Lakes North	4005	29	10	16	49	5	14	23
Simcoe South	4100	44	***25***	6	***110***	14	***10***	***15***
Simcoe West	4101	6	6	4	***30***	***5***	***5***	***5***
Barrie	4102	29	***6***	7	***50***	10	***5***	***5***
Simcoe North	4103	11	***3***	5	12	2	5	9
Orillia	4104	10	***3***	6	5	1	5	5
Orangeville	4201	***55***	***30***	***40***	120	22	***25***	***30***
Dufferin County	4202	***15***	***10***	***10***	47	5	***10***	7
Guelph	4301	***45***	***6***	***10***	27	9	6	8
Wellington South	4302	***50***	***25***	***30***	137	***20***	***20***	***40***
Wellington North	4303	***25***	2	***6***	29	***8***	***5***	***5***
Cambridge	4401	***35***	***5***	2	30	***8***	***6***	***6***
Kitchener-Waterloo	4402	***20***	1	5	10	***3***	***3***	***5***
Brant County	4403	55	7	11	28	6	3	6
Haldimand	4404	***20***	***6***	***6***	***20***	***2***	***8***	***2***
Grimsby	4405	72	21	16	84	19	9	21
St Catharines	4406	17	3	5	15	4	2	3
Niagara-Fort Erie	4407	13	3	8	9	2	3	6
West Lincoln	4408	27	8	7	43	2	3	7

The trip rates for the counties of Northumberland and Haldimand are from the previous version of the model. The 2006 TTS did not include these two areas. The rates shown in bold italics have been manually adjusted to improve the fit with external cordon count data.

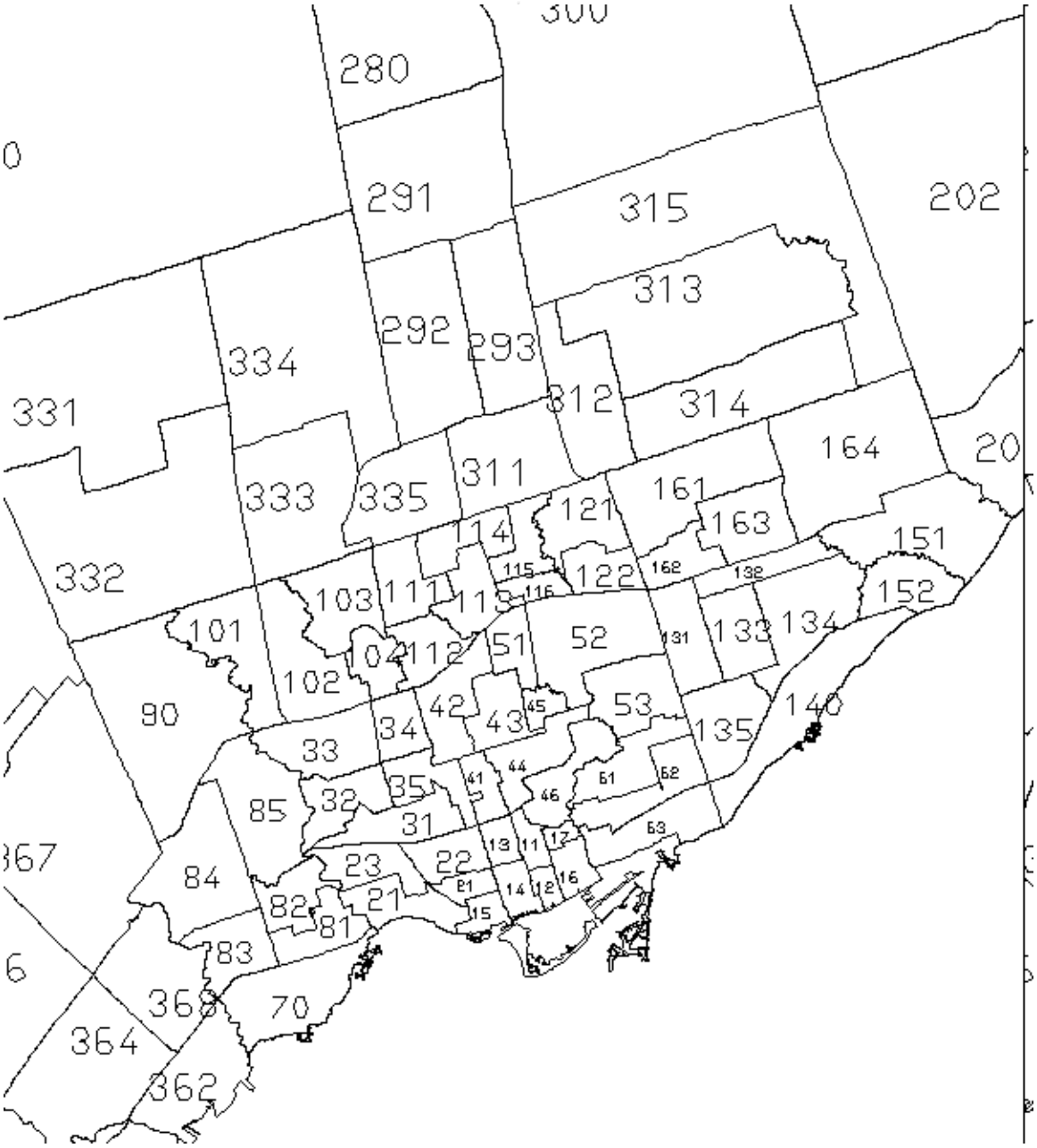
Table 7 – Adjustment of Non-work Trip Generation Rates

Trip Category	Estimated mean level of under-reporting in 1996 (P.M. Peak Period)	Adjustment factor	Reported change in mean trip rate since 1996 (For households in the GTA and Hamilton)
Home origins – auto	17%	1.25	+3%
Home origins – transit	17%	1.25	-10%
Non-home origins – auto.	20%	1.25	+10%
Home destinations – auto	17%	1.10	+9%
Home destinations – transit	9%	1.10	-16%
Non-home destinations – auto	20%	1.25	+11%

Table 9 – External non-zero Mode Split Factors (%)

Municipality	Zone	Origins	Destinations	
		Transit	GO Rail	Transit
City of Peterborough	4002	1.9	5.6	1.6
Peterborough County	4003	12.4	5.2	
Kawartha Lakes South	4004		2.4	1.2
Kawartha Lakes Noorth	4005		1.5	
Simcoe South	4100		1.2	2.6
Simcoe West	4101		5.8	
Barrie	4102		0.4	3.8
Simcoe North	4103		1.0	
Orillia	4104		9.8	
Orangeville	4201		1.4	
Guelph	4301	1.4	1.9	7.6
Wellington South	4302		2.4	
Wellington North	4303		3.4	3.6
Cambridge	4401			0.7
Kitchener-Waterloo	4402	0.9		1.2
Brant	4403		1.0	0.9
Grimsby	4405		1.8	0.4
St Catharines	4406	1.7	1.9	2.5
Niagara/Fort Erie	4407		3.3	2.2
West Lincoln	4408		2.1	

Figure 3 - Zone Aggrgations Used for Modal Split



Areas not shown use the same aggregations as for trip Generation (See Figure 2)

Table 8 - Work Trip Mode Split Factors (%)

	Origins				Destinations			
gm	walk/cycle	GO Rail	Transit	Auto	walk/cycle	GO Rail	Transit	Auto
11	12.3	10.4	50.2	27.1	34.6	0.2	34.5	30.7
12	6.9	29.8	40.6	22.8	29.7	0.5	27.9	42.0
13	18.0	5.1	42.6	34.3	24.9	0.8	40.1	34.2
14	11.5	19.1	37.9	31.5	37.4	0.4	27.3	35.0
15	7.2	4.4	24.1	64.4	25.6	0.3	29.5	44.6
16	14.3	7.9	31.1	46.7	34.0	0.2	31.2	34.6
17	12.3	9.2	36.3	42.3	28.5	0.0	47.8	23.7
21	16.7	0.5	17.7	65.1	18.4	0.0	37.5	44.2
22	15.7	0.6	29.0	54.7	13.8	0.3	42.5	43.3
23	13.8	0.4	24.5	61.3	7.8	0.4	40.2	51.5
24	10.9	3.0	23.0	63.1	9.6	0.0	45.2	45.3
31	9.2	0.0	22.6	68.2	6.1	0.0	34.4	59.5
32	3.7	0.0	13.4	83.0	2.1	0.0	28.0	70.0
33	4.8	0.6	18.1	76.5	2.5	1.1	22.8	73.6
34	2.2	0.1	24.3	73.4	3.5	0.0	29.3	67.2
35	6.7	0.5	25.5	67.3	5.4	0.3	40.2	54.1
41	10.1	1.5	31.0	57.3	9.2	0.3	29.6	60.8
42	4.8	0.4	21.4	73.4	3.7	0.0	31.8	64.6
43	7.5	2.9	35.0	54.6	8.3	0.0	41.8	50.0
44	8.5	3.9	42.7	44.9	10.7	0.2	38.1	51.0
45	4.7	1.1	28.0	66.2	2.9	0.0	17.7	79.4
46	4.2	0.4	23.5	71.9	7.6	0.2	32.2	60.0
51	1.7	0.0	30.3	68.0	2.6	0.0	20.4	77.0
52	2.4	0.3	13.1	84.2	2.3	0.8	22.9	73.9
53	2.3	0.2	17.9	79.6	3.7	0.2	34.6	61.5
61	7.2	0.5	26.2	66.1	6.1	0.0	32.8	61.1
62	12.0	0.9	27.5	59.6	7.0	0.5	49.8	42.6
63	14.7	2.2	21.3	61.7	8.1	1.0	36.9	54.0
70	4.4	0.7	13.4	81.4	4.3	5.3	19.1	71.3
81	2.5	0.0	16.1	81.3	2.7	2.8	17.2	77.3
82	1.4	0.5	24.3	73.8	3.5	0.0	30.2	66.3
83	1.3	0.5	12.5	85.7	0.4	1.1	14.2	84.3
84	2.3	0.0	12.6	85.1	2.1	0.8	20.2	76.9
85	1.6	0.0	11.5	86.9	1.1	1.3	20.1	77.6
90	1.4	0.1	9.3	89.3	2.2	1.4	19.7	76.6
101	1.1	0.0	11.1	87.8	2.1	0.0	17.9	80.0
102	2.1	0.2	10.3	87.4	1.9	0.4	27.2	70.4
103	1.5	0.4	17.1	81.0	1.5	0.0	27.3	71.3
104	2.2	0.0	13.9	83.9	3.3	0.0	18.9	77.7
111	3.3	0.0	16.6	80.1	4.7	0.3	29.5	65.5
112	3.7	0.0	24.3	72.0	1.9	0.0	26.7	71.4
113	4.5	1.7	32.3	61.5	6.4	0.1	43.4	50.1
114	2.3	0.7	12.1	84.9	2.0	0.2	31.8	66.0
115	1.5	0.0	7.6	90.9	1.1	1.1	26.2	71.5
116	2.0	1.0	16.6	80.4	1.7	0.0	23.4	74.8
121	2.7	0.0	13.0	84.3	2.1	2.6	27.6	67.7
122	3.4	0.0	12.6	84.0	4.2	0.8	32.6	62.4

Table 8 (Cont.) - Work Trip Mode Split Factors (%)

	Origins				Destinations			
gm	walk/cycle	GO Rail	Transit	Auto	walk/cycle	GO Rail	Transit	Auto
131	2.0	1.1	13.9	83.1	2.3	0.0	20.0	77.8
132	2.6	0.4	19.4	77.6	3.7	1.7	21.3	73.3
133	3.3	0.3	11.9	84.4	2.7	0.9	30.1	66.3
134	4.4	0.0	13.0	82.6	1.7	2.8	28.0	67.5
135	1.6	1.0	17.7	79.7	1.0	0.2	37.4	61.4
140	3.2	0.8	10.9	85.0	1.7	5.1	21.5	71.7
151	1.6	0.0	9.3	89.1	0.5	11.0	17.6	70.9
152	4.0	0.0	7.0	89.1	1.7	5.5	23.1	69.6
161	2.2	0.0	11.0	86.9	1.4	1.3	23.2	74.1
162	2.1	0.0	14.0	83.9	2.8	2.4	26.8	68.1
163	2.2	0.0	14.1	83.7	2.8	3.2	19.9	74.2
164	1.2	0.0	10.3	88.6	1.2	1.3	25.2	72.4
170	4.6	0.0	0.0	95.4	3.1	0.0	0.6	96.2
180	1.4	0.0	0.7	97.9	0.8	2.0	0.8	96.4
190	5.2	0.0	1.0	93.8	3.2	0.8	0.0	96.0
201	1.4	1.3	1.7	95.6	0.9	11.0	2.4	85.7
202	8.9	4.4	0.0	86.7	2.0	2.0	0.0	95.9
210	3.3	0.7	1.7	94.3	1.8	13.2	3.6	81.3
221	1.8	0.9	2.3	95.0	2.3	10.7	2.3	84.7
222	2.7	0.0	1.1	96.2	1.1	9.4	1.5	87.9
231	3.2	0.2	2.6	94.0	3.0	3.3	3.5	90.3
232	5.2	0.2	1.3	93.3	3.1	6.6	2.2	88.1
240	2.2	0.0	1.4	96.4	1.2	4.5	0.4	93.9
250	6.2	0.0	1.1	92.7	2.0	1.0	1.2	95.8
260	1.7	0.0	0.0	98.3	0.6	2.0	2.3	95.0
270	2.4	0.0	2.1	95.6	2.2	3.5	3.1	91.2
280	1.6	0.0	0.8	97.6	1.0	5.4	2.5	91.0
291	1.1	0.0	2.2	96.7	0.3	8.6	4.8	86.4
292	2.7	0.0	4.9	92.4	1.3	6.6	10.1	82.1
293	0.7	0.0	4.6	94.6	0.6	7.0	8.1	84.2
300	1.5	0.0	1.0	97.5	1.5	4.3	1.0	93.2
311	1.2	0.2	5.6	92.9	1.9	3.7	14.4	80.0
312	0.5	0.1	5.4	94.1	0.0	3.4	7.2	89.4
313	1.5	0.0	2.8	95.7	0.7	8.8	5.2	85.4
314	1.1	0.0	3.5	95.4	1.2	5.0	13.1	80.6
315	2.3	2.2	2.0	93.5	1.8	3.7	7.2	87.3
320	0.6	0.0	1.9	97.5	0.4	5.3	0.9	93.4
331	6.9	0.0	0.0	93.1	1.6	3.4	3.5	91.6
332	0.7	0.1	5.9	93.3	0.6	2.1	5.7	91.6
333	0.2	0.0	5.5	94.3	0.8	3.6	7.7	87.8
334	1.4	0.0	2.9	95.7	0.9	5.0	5.2	89.0
335	3.8	0.0	8.8	87.3	1.4	0.7	17.0	80.9
341	3.2	0.0	0.0	96.8	3.1	1.4	0.7	94.8
342	3.2	0.0	0.0	96.8	1.8	1.8	0.8	95.5

Table 8 (Cont.) - Work Trip Mode Split Factors (%)

	Origins				Destinations			
gm	walk/cycle	GO Rail	Transit	Auto	walk/cycle	GO Rail	Transit	Auto
351	0.7	0.0	6.5	92.8	0.6	6.0	4.9	88.6
352	3.4	0.0	3.1	93.4	1.8	3.7	6.5	88.0
353	1.3	0.0	4.6	94.1	1.4	3.5	6.8	88.3
354	2.4	0.0	2.0	95.6	0.9	4.6	6.3	88.3
355	0.7	0.1	5.3	94.0	0.2	4.3	5.9	89.6
356	2.6	0.2	2.6	94.6	1.2	4.4	3.6	90.8
361	2.6	1.8	2.8	92.8	2.1	13.9	3.4	80.6
362	2.6	0.8	6.6	90.0	1.8	12.4	5.3	80.4
363	2.2	0.1	3.5	94.2	2.4	8.0	4.9	84.7
364	1.9	0.0	7.3	90.8	1.5	8.2	11.5	78.7
365	0.8	0.0	4.5	94.8	0.6	7.8	4.9	86.7
366	0.8	0.1	7.3	91.8	0.7	6.1	8.8	84.3
367	0.3	0.1	6.3	93.3	1.7	1.0	9.8	87.5
368	2.5	0.2	6.8	90.6	1.6	4.3	13.2	80.9
371	5.0	0.0	0.0	95.0	2.5	3.9	0.2	93.4
372	0.0	0.0	0.0	100.0	0.0	4.1	0.0	95.9
381	2.7	0.0	0.0	97.3	3.1	3.1	0.5	93.4
382	1.1	0.0	1.3	97.6	0.4	6.5	1.7	91.4
391	1.7	1.2	1.4	95.7	2.7	11.1	1.9	84.3
392	3.0	0.8	1.0	95.2	3.7	13.5	0.8	82.0
393	2.6	1.1	2.1	94.1	1.7	11.6	1.5	85.3
394	0.7	0.4	0.4	98.5	0.3	17.0	0.3	82.3
401	2.9	0.0	4.2	92.9	2.9	5.8	2.1	89.2
402	1.7	0.6	2.4	95.2	1.6	8.7	1.9	87.8
403	1.2	0.4	1.6	96.7	1.1	7.0	1.3	90.6
404	0.0	0.0	0.0	100.0	0.0	3.9	0.0	96.1
410	2.9	0.0	0.4	96.7	1.6	1.8	0.0	96.6
420	7.7	0.0	3.0	89.3	4.9	1.8	2.5	90.9
430	1.1	0.0	3.7	95.1	0.9	2.3	0.7	96.2
440	1.2	0.0	2.6	96.1	0.6	1.2	1.2	97.1
450	1.5	0.0	3.1	95.4	1.4	0.5	2.0	96.0
461	4.6	0.0	7.9	87.5	2.5	1.2	5.1	91.2
462	6.8	0.0	7.1	86.1	4.3	0.8	11.2	83.7
463	7.7	0.0	9.6	82.7	12.0	2.0	10.8	75.3
464	2.3	0.0	2.6	95.1	4.4	0.7	7.1	87.8
Brampton	1.7	0.1	4.4	93.8	1.1	4.3	5.6	88.9
2001 TTS	1.6	0.0	4.3	94.1	1.1	3.9	5.0	90.0
Toronto	6.2	7.7	27.2	58.9	7.5	1.2	30.5	60.9
Durham	3.0	0.6	1.8	94.6	1.9	8.2	2.2	87.8
York	1.3	0.0	4.5	94.2	1.1	4.8	7.2	87.0
Peel	1.3	0.1	5.7	92.9	1.3	6.0	6.9	85.8
Halton	2.1	0.6	1.6	95.6	1.6	9.2	1.2	88.0
Hamilton	5.3	0.0	6.9	87.7	4.3	1.4	6.1	88.1
GTAH	4.1	3.9	15.8	76.2	4.1	3.9	15.8	76.2
2001 TTS	3.8	3.5	15.5	77.2	3.8	3.5	15.5	77.2

1.4 Trip Distribution

Trips that start from work are distributed by two-dimensional balancing of a "base" matrix to the desired origin and destination zone totals for each of the three modes (auto, GO Rail and local transit). Non-work auto trips are distributed in the same manner. The two non-work transit trip purposes are distributed by factoring each row or column of the applicable "base" matrix to the desired row or column totals - origin total for “from home” trips and destination total for “to home” trips. The input "base" matrices are not trip matrices. They define an initial probability distribution that is comparable in its role to the impedance component of a gravity model function. The base matrices are derived from the 2006 TTS data and have the following characteristics:

a) When balanced to the TTS trip end totals they produce a trip pattern that is almost identical to the TTS at an aggregated level (e.g.: PD to PD) but which is more uniformly distributed at the individual traffic zone level.
b) The observed TTS trip length distribution is closely maintained.
c) The matrices for the auto mode have non-zero values in every row and column. The matrices can therefore be used to obtain trip distributions in newly developed areas for which there are no existing trip data. The resulting trip length distribution in those areas will be similar to that observed in neighbouring areas.

Figure 4 shows the zone aggregations used in the calibration of the base trip distribution matrices. The first step in that process was to aggregate the observed trip tables from the TTS database to these aggregations. The mean value of the zone to zone trip movements that make each aggregated group to group movement was calculated by dividing the total trip movement by the total number of zone to zone pairs that make up that aggregated block. For example if there were 5 zones in the zone group containing the origin zone and 7 zones in the group containing the destination zone then the total number of trips between the origin group and the destination group would be divided by 35 (5 x 7) to obtain the mean value. The mean value is substituted in the observed matrix for all the zone pairs that make up the aggregation. In the case of GO Rail and local transit work trips the revised matrix is used as the base matrix for the distribution of those two modes. The implied assumption is that the zones within each block are equally attractive with the resulting number of trips determined only by the relative magnitudes of the required origin and destination totals, i.e. the basics of a gravity model formulation.

Using the mean value within each block does not work well for the auto trip distribution due primarily to the much higher propensity for very short trips to occur, either intra-zone or between adjacent zones within a zone group or between zones immediately adjacent to the two sides of a zone group boundary. The values in the base auto trip distribution matrices, both work and non-work, have been adjustment to more accurately reflect the actual trip length distribution. The method of adjustment uses the three-dimensional trip balancing feature available in emm/2. An index matrix, used as the third dimension, was created based on the auto travel times between zones obtained from an equilibrium assignment of the 2001 TTS trip data to the 2001 road network. Separate index values were assigned to origin and destination cells within the same zone group from those representing trip movements between different zone groups. Separate index values were also used for trips to and from external areas. The number of observed (TTS) trips represented by each index value was recorded and used as the third dimension control totals in balancing the matrix of mean values to the original TTS row and column trip totals by zone. The third dimension balancing coefficients were saved and applied to the appropriate cells in the matrix of mean values to produce the final base matrix for each of the two trip purposes. The time intervals, trip totals and balancing coefficients are shown in ***Table 10***. The travel time intervals were selected to provide a reasonably uniform distribution of trip totals for each index value within the two categories – intra and inter zone group. There is little variation in the balancing coefficients for inter-group trips over 13.5 minutes in length.

Figure 4 - Zone Aggregations Used for Trip Distribution

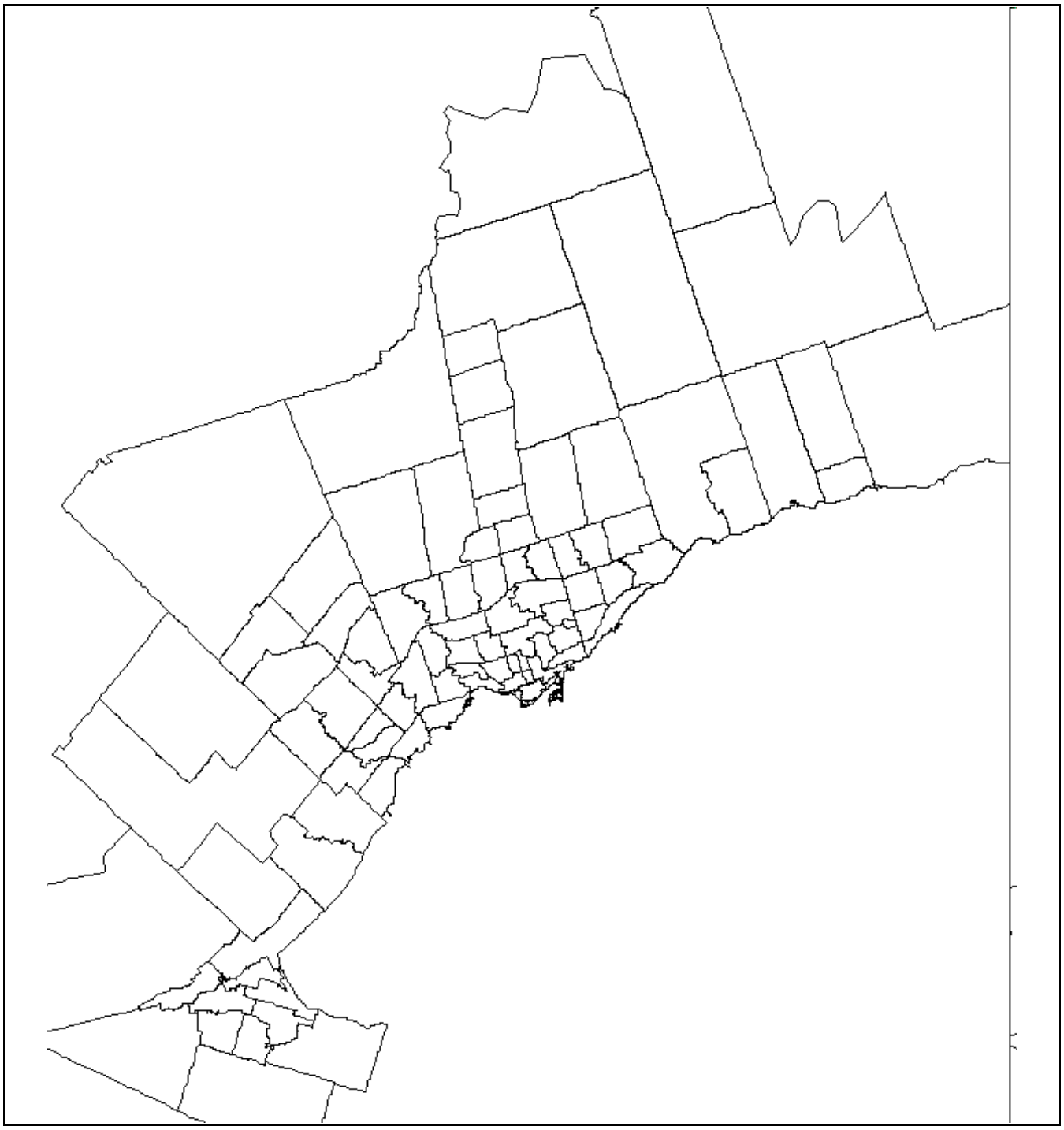


Table 10 – Calibration of Auto Trip Distribution

Third Dimension		Auto Work		Auto Non-Work	
Index	Lower bound (minutes)	Observed trips (TTS)	Balancing Coefficient	Observed trips (TTS)	Balancing Coefficient
Intra zone group					
1	0	16893	1.83543	138486	2.39785
2	0.5	32047	1.38747	154432	1.41901
3	3.5	38898	1.07235	149443	0.83424
4	5.5	29359	0.81167	82129	0.50499
5	7.5	31863	0.65646	57256	0.29992
6	12.5	9032	0.45062	14469	0.2057
Between groups					
7	0	37226	1.53292	112111	2.23784
8	5.5	45643	1.26167	94899	1.28966
9	7.5	88074	1.04153	137884	0.91093
10	10.5	102606	0.96653	103708	0.68578
11	13.5	98029	0.89969	72918	0.6236
12	16.5	86373	0.8694	52889	0.64829
13	19.5	99277	0.86916	47581	0.64464
14	23.5	132807	0.8853	53659	0.69171
15	30.5	111427	0.87896	36191	0.69107
16	40.5	114982	0.85163	32802	0.74772
External areas					
17	East in	1933	0.80698	2808	0.74162
18	East out	5337	0.93187	3922	0.85514
19	North in	3932	0.91187	5403	0.79126
20	North out	21761	0.93187	8118	0.85514
21	West in	7618	0.92675	5748	0.78603
22	West out	17311	0.93187	6743	0.85514
23	South in	7155	0.94095	7815	0.85055
24	South out	14748	0.93187	7729	0.85514

External Areas

East – Northumberland, Peterborough (City & County) and Kawartha Lakes
North – Simcoe County, Barrie, Orillia, Orangeville, Dufferin County, Wellington North
West – Region of Waterloo, Guelph, Brant County and Wellington South
South – Regions of Niagara and Haldimand-Norfolk
In – inbound to the GTA
Out – outbound from the GTA

The base matrices for non work transit trips were obtained through the same process as was used for the auto trip distribution except that in addition to the third dimension balancing coefficients either the column balancing coefficients, for trips from home, or the row balancing coefficients, for trips to home, were also applied in calculating the base matrix prior to normalizing the values in each row or column to sum to a total value of 1.

The primary purpose of the trip distribution process is to "smooth" out the TTS data replacing most of the zeros in the observed trip table with values that can be used as the base for future trip distribution. Most of the non-zero cell values in the TTS trip matrices are single observations representing an expanded total of approximately 20 trips (5% sample). ***Table 11*** provides a comparison of the number of non-zero cells in each base matrix with the number of non-zero cells in the corresponding TTS trip matrix. The totals shown exclude trips within or between external zones. Version 5 of the model differs from previous versions, and their documentation, in this regard. The total number of cells in each GTA trip matrix is over 3 million (1743 x 1743). Zero values remain where there are no trips recorded in the TTS trip database even at the aggregated group to group level. The implied assumption is that if there are no trips at all today between these areas the number will not become significant within the time frame to which the model is applied.

Table 11 - Trip Distribution Matrices

Trip Category	No. of trips (2006 TTS)	Number of non zero cells	
		2006 TTS	Base matrix
Auto work	1,154,331	49,277	1,974,433
GO Rail work	57,052	2,412	156,246
Local Transit work	225,299	10,030	561,435
Auto Non work	1,389,143	37,728	1,459,464
Local transit to home	141,743	5,649	254,162
Local transit from home	39,414	1,810	115,820

The other objectives of the trip distribution process were to maintain the observed O-D pattern at the aggregate level and the overall trip length distribution. To test how well these objectives are achieved each of the base matrices was balanced to the original trip totals from the TTS. Comparisons were made comparing the resulting trip length distributions and trip assignments with those obtained from the original TTS trip matrices. The trip length comparisons were done on the basis of travel time by road for all modes. Similarly free flow minimum time path (all or nothing) assignments on the road network were used to assess the similarity of the trip patterns. The use of all or nothing assignments ensures that the link volumes that are being compared consist of the same aggregation of O-D pairs. ***Table 12*** gives a summary of those results. It may be concluded that the differences in both trip length distribution and assigned link volumes that result from the application of aggregated trip rates, aggregated mode splits and the much more detailed distribution of trips, is negligible.

Table 12 – Validation of Trip Distribution

	Observed (TTS) Time Distribution		Simulated Time Distribution		Linear Regression Equation Simulated vs. TTS link volumes		
	Mean	S.D.	Mean	S.D.	Intercept	Gradient	R squared
Auto Work	23.5	20.2	23.6	20.2	16	.987	.997
Auto non-work	11.8	16.2	11.9	16.1	45	.938	.976
GO Rail work	52.6	16.2	52.5	16.2	0	.998	.9999
Local Transit work	19.4	13.6	19.6	13.5	2	1.004	.998
Local transit to home	13.4	11.8	13.4	11.7	2	.974	.985
Local transit from home	10.9	8.5	10.9	8.4	2	.923	.970

An additional step required in the development of the City of Brampton model was to convert the base distribution matrices from the GTA to the local zone system. The cell values in the trip distribution base matrices were obtained by dividing the value for the corresponding cell in the GTA base matrix by the total number of O-D pairs that make up the same cell in the local matrix. The underlying assumption is that the local sub-zones that make up a GTA zone are all equally attractive as an origin or destination with the relative magnitudes of the trip movements determined solely by the total number of origins or destinations within each sub-zone. The base trip matrices used as input to the distribution of non-work transit trips are normalized again so that the values in each row or column, as appropriate, sum to a total value of 1.

Tests conducted during the validation of the Halton Region model in 2001 demonstrated that the above procedure produces no discernible change in the trip distribution at the GTA zone level. Trip distributions produced at the more detailed zone level and then aggregated to the GTA zone level produce almost identical trip assignments to those where the trip distribution is performed at the GTA zone level.

1.5 Transit Assignment

After the trip distribution, prior to trip assignment, an egress sub-mode split is performed on GO rail trips to determine both the mode of egress and the stations at which riders alight from GO rail. These splits are determined by the zone of the final destination. The two matrices, “mfpm09” .and “mfpm10” contain the observed distributions from the 2006 TTS. The combined totals from the two matrices add up to 100% for each destination zone. Obvious anomalies in the TTS data have been removed by manual review and adjustment. The distribution for adjacent zones is used for zones which have no reported GO rail riders. In the application of the model the auto component of trips with auto egress is added to the

auto person trip table. The transit component of trips with transit egress is added to the local transit trip table. The GO rail component of all GO Rail trips is used to construct a new GO Rail trip matrix with the traffic zone containing the egress GO rail station as the destination zone. ***Table 13*** shows the station reference numbers used in the extraction and manipulation of the GO Rail data. Node numbers refer to the 2001 DMG integrated road and transit network that does not include GO Rail stations added since 2001.

The transit assignment is performed in two stages, first GO rail matrix is assigned and then the local transit matrix. The use of all transit modes is permitted for the GO Rail assignment but the heavy rail mode "r" is not permitted in the local transit assignment.

A transit network is not needed for Trip Generation, Mode Split and Trip Distribution. The model can be used to analyse future transit demand on an existing network without the need for detailed specification of future service levels on every route. The scenario used for the transit assignment is specified separately from the scenario used for the road assignment. A single integrated network can be used for both assignments or two independent networks can be used.

The transit assignment macro contains the following values for the parameters that have to be specified in order to perform a transit assignment. The same values are used for both the GO rail and local transit components.

Source for effective headways = actual line headways with maximum (option 2)
Maximum effective headway = 15
Source for boarding times = same value for entire network (option 1)
Boarding time = 2
Source for wait time factors = same value for entire network (option 1)
Wait time factor = 0.5
Wait time weight = 2
Auxiliary transit time weight = 1
Boarding time weight = 1

Changing the above values is unlikely to have any significant effect on the assigned volumes but will change the computed travel costs. The transit travel cost (equivalent time) matrix is not saved as a standard output.

1.6 Auto Assignment

Prior to assignment, the matrices for the different trip purposes are aggregated. Factors are applied to convert from the peak period (3 hours) to a peak one hour period. A global factor of 0.35 is applied to non work trips and 0.4 to the auto egress component of GO Rail trips, both factors based on 2006 TTS data. The peak hour in Brampton is assumed to be represented by trips with start times from 4:30 to 5:29 p.m.. A factor of 0.44 is applied to auto work trips from within the City of Brampton based on the 2006 TTS. Trips from other areas are likely to have a more dispersed time distribution by the time they reach the City of Brampton. The peak hour factor for trips originating elsewhere is assumed to be 0.4 with the exception of trips originating In Halton which appear to have a more pronounced peak. The same factor (0.44) applied to trips from Brampton is therefore applied to trips from the Region of Halton. ***Table 14*** gives a summary of the peak hour factors.

Table 13 - GO Rail Station Reference Numbers

Station	TTS	GO Rail transfer node	Zone Number	Local Transit
Hamilton	GS02	91044	2520	Yes
Aldershot	GS50	91039	2052	No
Burlington	GS03	91038	2059	Yes
Appleby	GS04	91037	2077	Yes
Oakville West	GS05	91036	2003	No
Oakville	GS06	91035	2014	Yes
Clarkson	GS07	91034	1539	Yes
Port Credit	GS08	91033	1547	Yes
Long Branch	GS09	91200	1	Yes
Mimico	GS10	91032	10	No
Exhibition	GS11	91027	153	Yes
Union	SS38	91001	225	Yes
Danforth (Main)	GS13	91004	369	Yes
Scarborough	GS14	91006	402	No
Eglinton	GS15	91007	405	Yes
Guildwood	GS16	91008	458	No
Rouge Hill	GS17	91010	449	Yes
Pickering	GS18	91011	541	Yes
Ajax	GS19	91013	569	Yes
Whitby	GS20	91015	616	Yes
Oshawa	GS01	91017	664	Yes
Milton	GS21	91084	2124	Yes
Lisgar	new	91086	1517	Yes
Meadowvale	GS22	91087	1512	Yes
Streetsville	GS23	91088	1503	Yes
Erindale	GS24	91090	1578	Yes
Cooksville	GS25	91093	1566	Yes
Dixie	GS26	91094	1560	No
Kipling	SS01	91095	4	Yes
Georgetown	GS48	91141	2164	Yes
Mount Pleasant	GS53	91166	1675	No
Brampton	GS47	91140	1804	Yes
Bramalea	GS46	91139	1903	Yes
Malton	GS45	91138	1611	No
Etobicoke North	GS44	91134	61	Yes
Weston	GS43	91124	124	No
Bloor	SS09	91122	169	Yes
Bradford	GS32	91080	1310	Yes
Newmarket	GS31	91078	1254	Yes
East Gwillimbury	GS55	91079	1253	No
Aurora	GS30	91075	1239	Yes
King City	GS29	91071	1286	No
Maple	GS28	91069	1076	Yes
Rutherford	GS52	91068	1078	Yes
York Univ.	GS54	91146	96	No
Richmond hill	GS33	91115	1122	Yes
Langstaff	GS34	91113	1150	Yes
Old Cummer	GS35	91109	328	Yes
Oriole	GS36	91106	324	Yes
Stouffville	GS41	91061	1301	Yes
Mount Joy	GS56	None	1214	
Markham	GS40	91060	1206	Yes
Centennial	GS58	None	1197	
Unionville	GS39	91059	1185	Yes
Milliken	GS38	91057	1181	Yes
Agincourt	GS37	91056	380	No
Kennedy	SS29	91055	410	Yes

Table 14 – Peak Hour Factors

Auto work trips from		
	Brampton	0.44
	Halton	0.44
	All other origins	0.4
Non work trips		0.35
GO Rail egress		0.4

An auto occupancy matrix is used to convert the number of peak hour auto persons to auto vehicles (auto drivers). The base case auto occupancy factors are shown in ***Tables 15 and 16***. The factors are the number of auto drivers plus passengers divided by the number of auto drivers in the 2001 TTS data. Three different levels of aggregation have been used to calculate the factors with municipality (Planning district in Toronto) being the primary one. ***Table 15*** shows the average auto occupancy factors for all trip movements between municipalities where the expanded TTS auto person trip total exceeds 1000 persons (approximately 50 observations). Municipal to municipal trip movements of less than one thousand auto persons have been aggregated together at the region to region level. These values, shown in ***Table 16***, are used for all trip movements not shown in ***Table 15***.

Intra-municipal trip movements within the Cities of Brampton and Mississauga were further sub-divided by the zone groups used for trip generation and mode split.

In general, the average auto occupancy is lower for medium length trips than it is for either short trips or very long trips. Intra-municipal trips generally have the highest level of auto occupancy. The TTS data does not include trip information for people under the age of 11 nor are these included in the model. The average auto occupancy figures used in the model are therefore likely to be lower than the values one would expect to observe on the street.

The total auto vehicle matrix also includes the auto vehicle trips specified in a supplementary auto driver matrix. At the present time this matrix consists of observed (TTS) auto driver access/egress trips to and from local transit, predominantly subway stations. The matrix extracted from the TTS data is for the peak 3 hours (15:01 to 18:00). The same peak hour factor is applied as for non work trips. The model has provision for factoring the supplementary matrix selectively by origin zone to represent projected growth in local transit and, in particular, TTC subway use.

The supplementary matrix could also be used to represent other trips not included in the basic model. Two potential uses are:

a) The addition of vehicle trips to, from and between the three external cordon stations (401 East of Port Hope, 401 West of Cambridge and the Peace Bridge in Fort Erie)
b) The addition of an auto equivalency matrix representing projected truck movements.

The model includes options to stratify the total auto driver matrix into separate matrices representing 1, 2 and 3 plus auto occupancy and to estimate the number of new high occupancy vehicles that might be formed as a result of exclusive high occupancy vehicle lanes. These procedures are described in ***section 2.3***.

Table 15 - Auto Driver Factors – By Municipality or Zone Group (gg)

To	From		To	From		To	From		To	From		To	From		To	From	
1	**1**	**0.80**	5	1	0.84	10	1	0.84	14	1	0.82	22	21	0.85	31	1	0.85
	2	0.73		4	0.78		3	0.77		6	0.81		**22**	**0.79**		3	0.81
	3	0.80		**5**	**0.75**		4	0.73		13	0.78		23	0.85		4	0.82
	4	0.79		6	0.78		8	0.82		**14**	**0.74**		24	0.80		5	0.86
	5	0.89		10	0.88		9	0.78	15	1	0.93		31	0.92		10	0.85
	6	0.82		11	0.82		**10**	**0.72**		13	0.74	23	16	0.93		11	0.79
	8	0.80		12	0.81		11	0.79		14	0.81		20	0.93		12	0.86
	13	0.95		13	0.80		33	0.72		**15**	**0.77**		21	0.87		13	0.91
	16	0.81		16	0.76		35	0.86		16	0.82		22	0.85		16	0.81
	31	0.77		31	0.90		36	0.92	16	1	0.77		**23**	**0.77**		29	0.86
	36	0.85		33	0.88	11	1	0.80		4	0.81		24	0.75		30	0.83
2	1	0.80		36	0.92		3	0.83		5	0.81		31	0.89		**31**	**0.77**
	2	**0.77**	6	1	0.81		4	0.83		10	0.84	24	22	0.90		33	0.88
	3	0.82		4	0.84		5	0.80		11	0.80		23	0.86		36	0.90
	4	0.78		5	0.84		10	0.79		12	0.75		**24**	**0.78**	32	**32**	**0.75**
	8	0.78		**6**	**0.79**		**11**	**0.75**		13	0.77	25	**25**	**0.78**	33	1	0.86
	9	0.90		8	0.93		12	0.76		15	0.71		27	0.85		3	0.84
	10	0.87		13	0.80		13	0.73		**16**	**0.75**	26	**26**	**0.84**		4	0.83
	36	0.83		14	0.89		16	0.78		29	0.82		27	0.79		5	0.82
3	1	0.79		16	0.84		29	0.75		31	0.76	27	26	0.82		8	0.84
	2	0.79		31	0.97		31	0.82		33	0.84		**27**	**0.78**		9	0.83
	3	**0.76**		36	0.82		33	0.85		36	0.79		28	0.84		10	0.83
	4	0.82	7	1	0.86		36	0.91	17	**17**	**0.85**		29	0.86		11	0.83
	8	0.79		**7**	**0.83**	12	1	0.83	18	**18**	**0.78**		31	0.95		13	0.91
	9	0.85		8	0.82		5	0.77	19	**19**	**0.76**		33	0.89		29	0.82
	10	0.81		36	0.92		11	0.73	20	13	0.91	28	27	0.89		31	0.86
	11	0.81	8	1	0.80		**12**	**0.77**		15	0.86		**28**	**0.78**		**33**	**0.80**
	33	0.79		2	0.78		13	0.84		16	0.88		29	0.78		35	0.89
	35	0.80		3	0.82		16	0.82		**20**	**0.75**		31	0.93		36	0.95
	36	0.89		4	0.77		31	0.86		21	0.80	29	1	0.84	34	33	0.93
4	1	0.84		7	0.82	13	1	0.84		22	0.90		4	0.78		**34**	**0.79**
	2	0.89		**8**	**0.78**		4	0.81		23	0.91		5	0.91		35	0.77
	3	0.84		9	0.80		5	0.76		31	0.85		10	0.81		36	0.97
	4	**0.80**		10	0.89		6	0.76	21	1	0.90		11	0.81	35	1	0.86
	5	0.79		33	0.92		10	0.85		13	0.85		12	0.80		3	0.86
	6	0.84		35	0.87		11	0.87		16	0.86		16	0.94		8	0.90
	10	0.83		36	0.85		12	0.86		20	0.81		27	0.90		9	0.85
	11	0.80	9	3	0.81		**13**	**0.74**		**21**	**0.78**		28	0.80		10	0.83
	13	0.81		8	0.80		14	0.71		22	0.76		**29**	**0.75**		31	0.96
	31	0.92		**9**	**0.71**		15	0.75		23	0.88		31	0.83		33	0.85
	33	0.85		10	0.78		16	0.77		31	0.91		33	0.86		34	0.77
	36	0.90		33	0.77		31	0.83	22	13	0.84		36	0.91		**35**	**0.85**
				35	0.81		33	0.90		16	0.87	30	**30**	**0.82**		36	0.81
				36	0.85		36	0.88		20	0.88		31	0.85		37	0.86

Bold text denotes intra-municipal values.
Trip movements of less than 1000 auto persons (~50 observations) not included.
Municipal codes are shown in Figure 3.

Table 15 (Cont.) - Auto Driver Factors by Municipality or Zone Group (gg)

To	From		To	From		To	From		To	From		To	From	
35	39	0.94	38	**38**	**0.80**	46	43	0.83	354	366	0.89	364	**363**	0.79
36	1	0.83		39	0.88		45	0.82		367	0.83		364	**0.77**
	2	0.84	39	1	0.88		**46**	**0.80**	355	354	0.75		365	0.78
	3	0.86		8	0.90	Within Peel (gg)				**355**	**0.8**		366	0.79
	4	0.86		35	0.91	341	**341**	**0.85**		367	0.87		367	0.84
	5	0.87		36	0.89	342	341	0.76	356	351	0.73		368	0.79
	7	0.88		38	0.84		**342**	**0.76**		352	0.74	365	363	0.78
	8	0.84		**39**	**0.78**	351	**351**	**0.77**		353	0.86		364	0.84
	9	0.83		40	0.85		352	0.83		354	0.77		**365**	**0.77**
	10	0.87	40	36	0.91		356	0.76		355	0.8		366	0.85
	11	0.90		38	0.80		366	0.79		**356**	**0.78**		367	0.9
	13	0.87		39	0.88		367	0.86		366	0.88	366	363	0.85
	31	0.92		**40**	**0.81**	352	**352**	**0.77**		367	0.86		364	0.83
	33	0.93		41	0.80		353	0.79	361	**361**	**0.85**		365	0.81
	35	0.93	41	40	0.84		354	0.81		362	0.76		**366**	**0.78**
	36	**0.85**		**41**	**0.80**		356	0.75		363	0.79		367	0.86
	38	0.82	42	**42**	**0.85**		365	0.85	362	361	0.85		368	0.75
	39	0.81	43	**43**	**0.78**		366	0.84		**362**	**0.74**	367	366	0.85
	40	0.88	45	40	0.94		367	0.85		364	0.77		**367**	**0.78**
37	35	0.89		**45**	**0.80**	353	354	0.75	363	361	0.79	368	364	0.8
	36	0.95	46	36	0.85	354	352	0.8		**363**	**0.74**		366	0.9
	37	**0.82**		39	0.89		353	0.82		364	0.82		367	0.77
	38	0.87		40	0.86		**354**	**0.72**		365	0.8		**368**	**0.73**
38	35	0.90		41	0.72		355	0.71		366	0.83			
	36	0.90		42	0.80		356	0.73		367	0.9			

Bold text denotes intra municipal or zone group values.
Intra municipal values for Brampton (35) and Mississauga (36) exclude the records used to calculate the zone group to zone group values within those two municipalities.
Trip movements of less than 1000 auto persons (~50 observations) not included
Group and Municipal codes are shown in Figures 2 and 3 respectively.

Table 16 - Auto Driver Factors – By Region

From \ to	Toronto	Durham	York	Peel	Halton	Hamilton	External
Toronto	**0.85**	0.86	0.88	0.88	0.92	0.82	0.83
Durham	0.83	**0.83**	0.84	0.89	0.83	0.86	0.80
York	0.83	0.89	**0.85**	0.84	0.94	0.85	0.84
Peel	0.85	0.94	0.91	**0.97**	0.90	0.87	0.86
Halton	0.81	0.89	0.91	0.90	**0.86**	0.90	0.84
Hamilton	0.79	1.00	0.73	0.85	0.89	**0.80**	0.84
External	0.70	0.84	0.78	0.83	0.86	0.86	**0.81**

The data used to calculate these values exclude the trip movements shown in ***Table 15***

The model calibration and validation have been performed using tangential volume delay functions. The tangential volume delay functions have the same functional form as the widely used BPR functions up to the nominal link capacity specified in the link attribute data. Above capacity a straight line that is a tangent to the BPR curve at that point is used. The emme2 equilibrium assignment procedure converges much faster using the tangential volume delay functions than it does with the traditional BPR functions particularly in situations where a large part of the network is assigned over capacity. The performance of the tangential volume delay functions is very similar to that of conical volume delay functions in this regard. The emme2bank includes volume delay functions to represent the time equivalent of tolls on Highway 407. The implied value of travel time ($24 per hour relative to the tolls that were in place in 2001) is based on experience in applying the a.m. peak model.

2.0 Supplementary Features

The following features are not part of the basic model but are either available, as supplementary macros, or can be easily incorporated.

2.1 Screen Line Summaries

An Excel spreadsheet has been set up to provide a summary of the number of vehicles and transit passengers crossing selected screen lines. The required data is exported from emme/2 as a text file which is then copied to the input page of the spreadsheet. The spreadsheet has been formatted to permit the results from multiple assignments to be saved and compared. The spreadsheet also calculates capacity and volume to capacity ratios.

2.2 Trucking

The basic modelling and assignment procedures do not include trucks. If total link volumes, including trucks, is required as an output the recommended procedure is to apply appropriate adjustment factors to the assigned auto volumes. A network calculation can be performed to apply different factors by link type, vdf number or any other link attribute. Alternatively appropriate factors, calibrated on the basis of cordon and other count data, can be stored as an extra attribute and applied more selectively. The latter approach has been used with the Halton Region P.M. peak model. For the City of Brampton model it is recommended the appropriate factors be incorporated into the screen line spreadsheet. Cordon count data, including the existing (2006) number of trucks is included in the spreadsheet.. Additional calculations, external to the model, can be done using that spreadsheet.

2.3 Trip Length Adjustment

Trip distribution in the basic model is an extrapolation of existing travel patterns without consideration of improvements in the network or other changes in level of service that might occur in the future. The trip length adjustment procedure allows such changes to be taken into account. The home to work auto trip distribution is modified to reflect projected changes in travel between zones based on the equilibrium assignment of the initial trip table produced by the model. The simulated travel times for single occupant vehicles from the initial trip distribution are compared with the base year (2001) travel times. An elasticity factor is applied to increase, or decrease, the "impedance" value for each cell in the base matrix used as input to the trip end balancing procedure. The result of the adjustment is to increase the number of trips between origins and destinations where there is a projected improvement in travel time and to decrease the number trips between zones where there is a projected increase in travel time. The sensitivity of the adjustment is controlled by a coefficient the default value of which (0.03) has been set based on experience with the a.m. Peak model. The default value will produce a trip length distribution that lies approximately midway between one having the same mean trip length (km) and one having the same mean travel time as the observed 2006 trip distribution.

2.4 HOV Assignment

The model includes routines to perform an HOV assignment and to estimate the number of new HOVs that might be formed as a result of potential time savings. Both routines require a road network that has each HOV lane coded as a separate series of nodes and links from the general use lanes. General use links require the mode codes "i" and "j" in addition to the mode code "c". Links restricted to vehicles with two or more occupants require the mode code "i" in addition to the mode code "c". Mode code "c" should be the only auto mode on links restricted to vehicles with 3 more occupants.

The first step in the HOV assignment procedure is to stratify the total auto vehicle matrix into 3 matrices representing 1 occupant, 2 occupant and 3 plus occupant vehicles. The stratification formulae are:

$$P_2 = 0.85(1- x)$$

$$P_3 = 0.1(1 - x)$$

Where

x = mean auto occupancy used to convert auto person trips to auto vehicles (Table 6).

P_2 is the proportion of automobiles with two occupants

P_3 is the proportion of automobiles with three or more occupants.

The coefficients have been calibrated to provide a distribution that matches the auto occupancy distribution observed across selected screen lines in the GTA. The observed distribution was obtained from available Cordon Count data. The

implied auto occupancy, calculated from the distribution, will be higher than that shown in ***Tables 11 and 12*** since the calibration takes into account persons under the age of 11 who are not included in other components of the model. The coefficients may be modified if desired and are different from the recommended values for use in the a.m. peak period (1.01 and 0.16).

A multiclass assignment is used to calculate link volumes and travel time matrices for each of the three categories of vehicle (1 person, 2 persons and 3 plus persons). A second procedure estimates the number of new HOVs that might be formed as a result of differences in travel time between the three categories. Two factors are used to calculate the diversion. The first is the proportion of the occupants of single person vehicles that will get together to form two person "car pools" for each minute of time saving that there is between one and two person vehicles. The second factor is the proportion of one and two person vehicle occupants that will combine to form three person "car pools" for each additional minute of time saving between two and three person vehicles. The procedure has been tested using values of 0.02 and 0.01 respectively for these two factors reflecting the observed experience when carpool lanes were first introduced on the Shirley highway in Washington D.C. The factors may be modified to reflect local experience. A second multiclass assignment completes is performed to complete the procedure.

2.5 Zone Splitting

Zone splitting can be used to increase the level of network detail and assignment results for a specific sub-area. The procedure to do that is to run the model using the existing zone system for which the model has been calibrated. The trips contained in the resulting auto driver trip table are then re-distributed between the sub-zones that make up each of the original zones on the basis of population and employment. A macro is available to perform the re-distribution using the weights shown in ***Table 17***. These weights have been calculated on the basis of average trip generation rates and combination of trip purposes. The population and employment numbers assigned to the sub-zones are used to determine the proportion of trips to be assigned to each sub-zone. The total number of trips remains the same even if the total population or employment differs from the zone total used to run the model.

Table 17 - Population and Employment Weights for Zone Splitting

	Employment Weight		Population weight	
	Origins	Destinations	Origins	Destinations
a.m. model	0.05	0.9	0.95	0.1
p.m. model	0.8	0.35	0.2	0.65

The zone splitting procedure can be applied within the same emme2bank as was used to run the model providing that the following rules are followed in assigning numbers to the sub-zones.

4. The original zone numbers are retained, either as one of the sub-zone numbers or as dummy zones with zero population and employment.
5. Any new zone numbers that are assigned must have a zone number higher than that of any existing zone.

Failure to adhere to the above rules will cause corruption of the matrix data already contained in the emme2bank.

3.0 Model Validation

Validation of the model consists primarily of comparisons between a 2006 "Base Case" simulation, the 2006 TTS data and available cordon count information. The simulations include both the GTA and City of Brampton model results. It should be noted that most of the data used as input to the two models is identical at the aggregate level used in this analysis. The TTS data is not currently available at the level of detail used in the City of Brampton model. Trip assignments using the TTS data therefore have to be done using the GTA network. The network used in the calibration of the GTA model was Release 1 of the 2001 integrated network developed at the DMG.

3.1 Land Use Data

The trip generation rates and mode split factors have been calculated using the population and employment data contained in the 2006 TTS database. As part of the calibration process adjustment factors have been calculated to correct for differences between the TTS population and employment numbers and the land use data from which the future forecasts are generated. It is recommended that these same adjustment factors be applied to future the forecasts. The base case simulation uses (2006b2) uses land use data from several sources. Data for the City of Brampton were obtained from staff at the City of Brampton. Elsewhere the TTS population and employment have been used factored by Regional municipality to the mid point of the 2001 and 2011 reference scenario produced by Hemson Consulting in the report "growth Outlook for the Greater Golden Horseshoe" dated January 2005. Data for the Region of Hamilton were supplied by the Region of Peel. ***Table 18*** provides a comparison of the three sets of data. The total GTA population reported in the TTS is 3.1% lower than that given by the census. The current census numbers do not include any estimate of the "census undercount" which will presumably result in a larger discrepancy. The TTS is known to under represent infants, under the age of 1, and seniors, over the age of 75, many of whom live in collective homes not included in the survey. Since neither of these two categories of people is likely to make any significant number of trips the TTS trip rates will be artificially high when applied to the total population. The recommended adjustment factors are used to correct for any difference between the TTS and the data used as the base for future forecasts. If those forecasts are based on the census then a global adjustment factor of .97 is recommended. The adjustments shown in Table 18 are recommended if the future forecasts are consistent with the Hemson numbers and the City of Brampton estimates for 2006..

Table 18 - Population Data by Region

	2006 TTS	2006 Census	Base Case (2006b2)	Recommended Adjustment
Toronto	2,445,990	2,503,017	2,675,000	0.92
Durham	539,457	561,186	595,000	0.91
York	857,563	892,712	910,000	0.95
Peel	1,119,208	1,159,405	1,189,556	0.97
Halton	422,672	439,204	455,000	0.93
Hamilton	487,012	504,559	525,000	0.93
Total GTA	5,871,902	6,060,083	6,323,674	
City of Brampton	416,375	433,806	451,710	0.96

Employed Labour Force is not calculated or used directly in the model but is clearly a factor in determining trip generation rates. ***Table 19*** compares the 2001 TTS and Census data. Comparisons for 2006 are not yet available. The Census and TTS occurred at different times of the year, which may account for some of the differences. There may also be some difference due to definition, for example the census includes people who worked the previous week but who were not actually employed on the day of the census. No adjustments to trip rates have been made or are recommended at this time.

Table 20 provides a comparison of employment data. The same comments, with respect to timing and definitions, apply as for the employed labour force. Data from the 2006 Census were not available at the time this comparison was prepared. The data that the City of Brampton, and most other agencies, use as the basis for their employment forecasts are based on employment surveys. These surveys count the number of available jobs at each place of employment whereas both the census and TTS count the number of persons who are currently employed. The difference can be as much as 20%.

Table 19 - Employed Labour Force by Region

	2001 TTS	2001 Census	Difference	
Toronto	1,192,866	1,228,015	-35,149	-2.9%
Durham	253,498	247,395	6,103	2.5%

York	379,915	387,620	-7,705	-2.0%
Peel	507,829	535,330	-27,501	-5.1%
Halton	188,799	204,600	-15,801	-7.7%
Hamilton	230,543	232,240	-1,697	-0.7%
Total GTAH	2,753,450	2,835,200	-81,750	-2.9%

Table 20 - Employment by Region

	2006 TTS	2006 Census	Base Case (2006b1)	Difference (Relative to TTS)		Recommended Adjustment
Toronto	1,338,756		1,490,000	151,244	11%	0.9
Durham	184,971		225,000	40,029	22%	0.8
York	407,627		490,000	82,373	20%	0.82
Peel	555,764		621,038	65,377	12%	0.9
Halton	190,503		235,000	44,497	23%	0.8
Hamilton	183,274		220,000	36,726	20%	0.85
Total GTAH	2,860,895		3,300,859	439,964		
Brampton	144,421		154,830	10,365	7%	0.95

3.2 Trip Generation, Mode Split and Trip Distribution

Table21 compares the simulated trip total, mean travel time and standard deviation of travel time in each trip category with the observed 2006 TTS data. The trip times used to calculate the mean and standard deviation were obtained from an equilibrium assignment of the TTS data to the road network. The same travel time matrix is used for all trip categories, both simulated and observed. The 2006b1 land use scenario is the base case used for validation including the recommended adjustment factors shown in ***Tables 18 & 20.*** Trips external to the GTAH are excluded from the comparison The simulated non-work trip totals are higher than in the TTS data due to the adjustment of trip rates that takes into account the estimated under-reporting of trips in those categories in the TTS data. In addition the simulated peak hour driver trip matrix includes the home end egress component of GO rail trips not included in the TTS trip matrix. In addition the TTS peak hour trip matrix has been extracted for a 1 hour time window of trip start times common to all areas. In the simulation the application of different peak hours based on trip length reduces the proportion of long trips occurring in the peak hour relative to the number of short trips. Both these factors contribute to the lower average trip time in the simulation (16 minutes) in the simulation relative to the TTS (17.2 minutes).

The comparison shows that the GTA and Brampton versions of the model reproduce both the number of observed (TTS) trips and the observed trip length distributions with a high degree of accuracy in all trip categories.

Table 21 - Trip Totals and Travel Times within the GTA and Hamilton

	2006 TTS data			Base Case Simulation (2006b1)		
Trip Category	Total trips within the GTAH	Minutes by road		Total trips within the GTAH	Minutes by road	
		Mean	S.D		Mean	S.D
From work Transit	223,960	18.8	12.5	225,822	19.2	12.4
From work Auto	1,074,536	21.7	16.7	1,066,512	22.1	17.0
Non-work Auto	1,340,857	10.5	11.7	1,678,879	10.9	11.6
Non-work Transit	157,540	13.3	11.8	198,769	13.4	12.4
Total auto person	2,415,771	15.5	15.2	2,745,391	15.3	15.0
Total GO Rail	61,452	53.3	17.4	60525	53.5	17.5
Total local transit	422,213	16.0	12.3	452,874	16.5	12.7
Peak hour auto driver	708349	17.2	15.6	853.201	16.0	15.4

Municipal self containment (the number of trips that have both the origin and destination within the same municipal expressed as a percentage of the total origins or destinations for that municipality) is one measure that reflects the characteristics of the trip distribution and the amount of travel (person or vehicle km) that are being generated in total. A high self containment factor is desirable from the point of view of minimising total travel demand.

Table 22 compares the base case simulated work trip self containment with the corresponding values obtained from the TTS data. The table is for the p.m. peak period and includes trips by all modes that have "work" as the origin trip purpose. Trips to work are excluded. Trips to and from areas outside the GTA and Hamilton are also excluded from the origin and destination totals throughout for consistency. The observed values from the 1986, 1996 and 2001 surveys are included in order to give an indication of the historical trend. The municipalities in the Regions of Durham and York and the Planning Districts in Toronto are each represented by a single zone in the Region of Halton. The values shown therefore represent the intra-zonal movement of a single zone in those areas.

Table23 is similar to ***Table 22*** but for peak period auto person and peak hour auto driver trips by destination (generally the home end) only. The higher proportion of non-work trips should produce a slightly higher level of self containment in the simulation relative to the TTS data since non-work trips are, on average, about half the length of work trips made by automobile. The simulated peak hour driver trip matrix also includes the GO rail auto egress, producing a further increase in peak hour self containment relative to the TTS.

The TTS data shows the amount of trip self containment in the City of Brampton remaining constant since 2001.and no clear pattern in the surrounding municipalities. The simulation model produces approximately the same level of work trip self containment for City of Brampton as does the TTS – 1% less at the origin end and 2% more at the destination end. The simulation model produces slightly higher levels of total auto trip self containment than is shown by the TTS. That difference can be attributed to the increased number of work trips that are included to compensate for under reporting in TTS. Non work trips are generally shorter, and therefore more likely to be selfd contained than are work trips.

Table 22 – Municipal Self Containment of p.m. Peak Period Work Trips

	Proportion of total origins with destinations in the same municipality					Proportion of total destinations with origins in the same municipality				
	TTS				Sim.	TTS				Sim.
	1986	1996	2001	2006	2006	1986	1996	2001	2006	2006
PD 1 of Toronto	14%	15%	15%	16%	18%	56%	58%	58%	61%	71%
PD 2 of Toronto	25%	27%	25%	27%	32%	12%	13%	11%	13%	16%
PD 3 of Toronto	28%	27%	26%	24%	27%	21%	18%	17%	17%	19%
PD 4 of Toronto	19%	19%	19%	19%	21%	18%	18%	17%	19%	21%
PD 5 of Toronto	13%	10%	11%	10%	12%	16%	14%	14%	13%	16%
PD 6 of Toronto	34%	33%	31%	32%	37%	14%	13%	12%	13%	15%
PD 7 of Toronto	21%	16%	16%	12%	14%	21%	14%	11%	10%	13%
PD 8 of Toronto	22%	21%	19%	18%	20%	17%	20%	17%	16%	19%
PD 9 of Toronto	15%	14%	13%	13%	12%	24%	20%	18%	20%	20%
PD 10 of Toronto	24%	18%	17%	15%	16%	30%	28%	24%	23%	25%
PD 11 of Toronto	18%	16%	15%	14%	16%	14%	15%	15%	14%	15%
PD 12 of Toronto	10%	9%	8%	9%	11%	8%	10%	8%	9%	11%
PD 13 of Toronto	26%	22%	23%	22%	24%	27%	20%	21%	20%	22%
PD 14 of Toronto	17%	20%	18%	17%	18%	5%	5%	6%	7%	7%
PD 15 of Toronto	25%	19%	23%	21%	23%	8%	7%	8%	8%	8%
PD 16 of Toronto	22%	19%	21%	24%	26%	14%	16%	19%	21%	23%
Brock	81%	68%	74%	68%	39%	49%	31%	30%	31%	27%
Uxbridge	54%	50%	52%	50%	46%	29%	28%	27%	26%	26%
Scugog	72%	67%	66%	64%	50%	35%	30%	35%	34%	31%
Pickering	23%	24%	22%	21%	20%	15%	15%	15%	15%	14%
Ajax	31%	30%	32%	29%	26%	23%	16%	16%	14%	14%
Whitby	35%	35%	35%	36%	32%	27%	24%	21%	22%	21%
Oshawa	63%	56%	55%	52%	50%	58%	43%	41%	39%	38%
Clarington	49%	58%	61%	60%	52%	36%	26%	27%	29%	26%
Georgina	78%	74%	74%	67%	61%	31%	30%	26%	21%	19%
East Gwillimbury	27%	26%	35%	28%	20%	5%	6%	9%	9%	8%
Newmarket	46%	42%	44%	39%	32%	33%	29%	34%	31%	30%
Aurora	33%	30%	30%	24%	23%	22%	19%	20%	17%	18%
Richmond Hill	27%	25%	24%	26%	26%	20%	19%	15%	17%	18%
Whitchurch-Stouffville	32%	28%	23%	23%	22%	23%	19%	16%	21%	21%
Markham	19%	22%	23%	27%	26%	21%	27%	29%	28%	28%
King	34%	21%	27%	12%	8%	11%	10%	14%	7%	5%
Vaughan	11%	20%	25%	26%	25%	17%	27%	29%	29%	29%
Caledon	44%	47%	46%	44%	29%	16%	24%	22%	24%	19%
Brampton	**56%**	**52%**	**52%**	**52%**	**51%**	**41%**	**35%**	**36%**	**34%**	**36%**
Mississauga	45%	45%	45%	44%	43%	44%	47%	52%	51%	52%
Halton Hills	76%	63%	54%	58%	48%	37%	30%	26%	30%	29%
Milton	57%	45%	33%	37%	32%	38%	36%	34%	25%	24%
Oakville	44%	39%	34%	35%	34%	38%	34%	32%	32%	32%
Burlington	53%	51%	44%	44%	42%	41%	41%	38%	40%	40%
Flamborough	39%	44%	29%	39%	31%	20%	23%	13%	20%	17%
Dundas	45%	31%	38%	34%	40%	22%	19%	17%	18%	22%
Ancaster	33%	25%	26%	18%	17%	17%	12%	14%	11%	10%
Glanbrook	18%	38%	22%	18%	14%	7%	13%	10%	8%	6%
Stoney Creek	32%	34%	29%	30%	25%	22%	21%	19%	19%	19%
Hamilton	71%	67%	67%	65%	60%	76%	68%	63%	60%	58%

Note: The TTS trip totals are based on trips internal to the GTAH for all years. Trip totals for the 2006 simulation include origins and destinations external to the GTAH – hence the lower simulated values for municipalities immediately adjacent to the GTAH boundary.

Table 23 – Municipal Self Containment of Auto Trips by Destination

	P.M. Peak period auto person					P.M. Peak hour auto driver				
	TTS				Sim.	TTS				Sim.
	1986	1996	2001	2006	2006	1986	1996	2001	2006	2006
PD 1 of Toronto	32%	29%	28%	30%	40%	33%	28%	25%	30%	40%
PD 2 of Toronto	22%	27%	28%	30%	37%	18%	25%	23%	25%	35%
PD 3 of Toronto	28%	28%	29%	32%	38%	28%	22%	23%	25%	34%
PD 4 of Toronto	34%	35%	36%	39%	44%	27%	30%	31%	34%	42%
PD 5 of Toronto	24%	24%	27%	29%	35%	22%	22%	22%	23%	32%
PD 6 of Toronto	30%	30%	30%	33%	40%	26%	23%	22%	28%	38%
PD 7 of Toronto	29%	26%	23%	26%	30%	25%	19%	19%	19%	30%
PD 8 of Toronto	35%	43%	41%	41%	48%	30%	37%	33%	33%	45%
PD 9 of Toronto	35%	33%	34%	36%	39%	32%	27%	28%	26%	34%
PD 10 of Toronto	36%	38%	31%	35%	41%	36%	34%	27%	31%	36%
PD 11 of Toronto	29%	31%	32%	34%	41%	27%	27%	26%	28%	39%
PD 12 of Toronto	18%	23%	20%	22%	26%	15%	17%	14%	17%	25%
PD 13 of Toronto	39%	37%	37%	38%	43%	38%	33%	32%	33%	40%
PD 14 of Toronto	22%	22%	23%	26%	27%	17%	21%	19%	17%	24%
PD 15 of Toronto	25%	25%	27%	26%	30%	22%	19%	17%	19%	30%
PD 16 of Toronto	29%	33%	36%	37%	43%	22%	26%	28%	29%	39%
Brock	60%	46%	42%	44%	34%	56%	44%	33%	42%	33%
Uxbridge	43%	51%	46%	45%	48%	41%	42%	37%	41%	43%
Scugog	48%	49%	50%	56%	52%	43%	41%	41%	51%	48%
Pickering	30%	39%	40%	44%	46%	23%	32%	35%	33%	42%
Ajax	37%	41%	42%	43%	44%	34%	29%	35%	39%	42%
Whitby	42%	46%	44%	47%	46%	36%	42%	41%	44%	44%
Oshawa	69%	61%	60%	60%	61%	64%	58%	56%	54%	57%
Clarington	51%	45%	48%	50%	44%	51%	35%	40%	43%	41%
Georgina	46%	42%	47%	46%	46%	40%	35%	40%	39%	42%
East Gwillimbury	16%	16%	16%	22%	19%	16%	12%	12%	18%	18%
Newmarket	51%	51%	54%	54%	53%	45%	41%	48%	48%	49%
Aurora	35%	40%	41%	40%	42%	25%	29%	34%	30%	39%
Richmond Hill	33%	38%	39%	42%	45%	26%	33%	32%	32%	41%
Whitchurch-Stouffville	26%	36%	32%	34%	35%	22%	25%	29%	32%	33%
Markham	36%	44%	46%	50%	52%	29%	38%	41%	43%	49%
King	23%	21%	21%	23%	19%	17%	24%	18%	13%	18%
Vaughan	25%	38%	43%	44%	46%	22%	35%	39%	41%	43%
Caledon	36%	37%	36%	43%	37%	29%	33%	34%	37%	33%
Brampton	**58%**	**55%**	**56%**	**56%**	**58%**	**51%**	**48%**	**48%**	**48%**	**55%**
Mississauga	58%	62%	67%	68%	70%	56%	59%	63%	65%	68%
Halton Hills	56%	53%	50%	54%	55%	50%	40%	42%	46%	53%
Milton	58%	57%	54%	47%	48%	53%	51%	52%	41%	46%
Oakville	61%	58%	60%	59%	61%	53%	50%	51%	52%	58%
Burlington	61%	61%	61%	64%	66%	54%	54%	58%	59%	64%
Flamborough	31%	32%	30%	35%	31%	29%	29%	26%	31%	29%
Dundas	33%	36%	35%	31%	39%	30%	29%	26%	29%	39%
Ancaster	31%	28%	36%	38%	40%	27%	24%	29%	30%	36%
Glanbrook	10%	15%	15%	11%	10%	13%	13%	12%	8%	9%
Stoney Creek	35%	33%	33%	35%	33%	34%	28%	31%	29%	31%
Hamilton	79%	76%	73%	71%	70%	76%	71%	71%	68%	68%

Note: The TTS trip totals are based on trips internal to the GTAH for all years. Trip totals for the 2006 simulation include origins and destinations external to the GTAH – hence the lower simulated values for municipalities immediately adjacent to the GTAH boundary.

3.3 Network assignments

Table 24 compares the results of the base case simulations with assignments of the TTS data. The assigned vehicle km produced by the models is higher than the TTS assignment. That difference can be attributed to 3 reasons:

1. The TTS data excludes trips made by people who live outside the survey area. The models include estimates of all external trips.
2. It is known that there is a significant amount of under-reporting of non-work trips in the TTS data. Adjustment factors have been applied in the models.
3. In the model simulations any auto egress component of GO rail trips is assigned to the auto network. The TTS assignment only includes trips with auto driver as the primary mode.

Table 24 - Comparison of Assigned Volumes

	TTS data		Brampton
	Database	Assignment	model
Auto Vehicle km (000's)*			
Toronto		3,252	3474
Durham		1098	1330
York		2210	2425
Mississauga		1445	1590
Brampton		720	865
Peel (Total)		2368	2707
Halton		1236	1413
Hamilton		819	891
Boardings (000's)			
Subway	291	304	317
GO Rail	63	30	.51
Streetcar	58	50	50
Highway coach	11	84	91
TTC Bus	303	261	333
Mississauga Bus	38	41	57
Brampton Bus	16	9	12
Other Bus	54	43	44
Passenger km (000's)			
Subway		2049	2,033
GO Rail		1012	1,693
Streetcar		137	152
Highway coach		1383	745
TTC Bus		1101	1,385
Mississauga Bus		278	324
Brampton Bus		46	27
Other Bus		747	745

* Excluding centroid connectors

Table 24 includes the number of boardings actually reported in the TTS database as well as the number that results from the assignment of the trip matrix to the emme/2 transit network. The slight over simulation of local transit volumes reflects the previously discussed differences between the TTS and the simulation models but the differences are less significant than for auto travel. The number of simulated boardings for Brampton Transit buses is less than reported in the TTS database (12,000 Vs 16,000). A likely explanation is that the transit network currently being used was coded in 2001 and has not been updated to include any new routes that have been added since 2001. The problem is therefore more likely to be related to network representation than the structure of the model and its calibration.

In the case of GO rail the number of assigned boardings is significantly less than the number of reported boardings because the assignment procedure does not force people to use GO Rail if there is a faster alternative using other modes of transit. ***Table 24A*** compares the number of GO Train riders alighting at each station throughout the GO Rail system. There are two sources of count data available to compare the simulation results with. One is actual station counts taken in October 2006 and the other is the reported station use in the 2006 TTS. In most cases there is close agreement between these two numbers. The table also shows the results from assigning the TTS trip table to the transit network permitting

the use of mode "z" for egress. The simulated number of destinations in the GO Rail origin zone to destination station is shown as well as the results from assigning that matrix to the transit network without permitting the use of mode "z". 76% of GO Rail riders use automobiles to access or egress the system at the home end (Compared with 7% of local transit riders). The emme2 assignment procedure does guarantee the selection of the same station that is used in real life as can be seen from the comparison of the TTS station assignment with the reported station use in the TTS database. The trip end mode split component in the model does a better job in this regard but, while the total number of trips in the matrix closely matches the observed total, there are problems in the assignment. These problems relate mostly to the coding of the transit network. With the exception of adding Mount Pleasant station no changes have been made to the 2001 transit network. In addition to Mount Pleasant 7 other stations (Kennedy, Centennial, Mount Joy, York University Rutherford Road, East Gwillimbury and Lisgar) have been added to the GO Rail system but are not currently in the network. Some of the other stations do not have transfer links that connect the station node directly to the centroid used to represent the station in the trip matrix. As a result the emme2 assignment may select a different egress point from GO rail or may find a different route that does not use GO Rail at all. These problems, however, do nor affect the stations in the City of Brampton (Bramalea, Brampton and Mount Pleasant).

3.4 Screen Line Comparisons

Table 25 provides a comparison of the number of auto vehicles crossing screen lines within the City of Brampton and across selected inter-regional boundaries. Individual station counts for the Brampton screen lines are shown in ***Table 26***. The numbers shown are for the p.m. peak hour and include the number of private auto vehicles observed in the 2006 cordon count program, the volume obtained by assigning the TTS auto vehicle matrix to the network together with the results of the base case simulation (2006b1). Initial model runs gave results that were very close to the TTS assignments but showed some significant differences relative to the cordon count. The eastbound flow of traffic from Halton region into Brampton was under represented by 40%. Southbound traffic to the City of Mississauga was also under simulated while westbound traffic from York Region to Brampton and from Brampton to Halton was over simulated. To reduce the magnitude of these discrepancies the calibration factors shown in ***Table 25A*** were applied to the auto work base distribution matrix prior to running the model to produce the results shown for model run 2006b1.

Table 25A – Calibration Factors Applied to Auto Work Trip Distribution

From	To	Factor
Brampton	Mississauga	**2.00**
Georgetown	Brampton	**2.00**
Milton	Brampton	**2.00**
Oakville	Brampton	**2.00**
Burlington	Brampton	**2.00**

Using the adjusted work trip distribution the most significant discrepancy is a 22% over representation of westbound trips East of Hwy 10 and West of Hwy 410. All the extra volume, however, is on Hwy 407 where the cordon count volume is less than half the capacity and significantly less than the observed counts on other sections of highway 407. Eastbound trips West of Hwy 410 are under represented by 18%. There are a number of stations where the cordon count volume exceeds the capacity of the road by more than 10% suggesting that there could be a problem with either the count data or the coding of the network. The applicable counts are highlighted in bold italics in ***Table 26.***

Both the TTS and the simulation under represent trips east of Pearson airport particularly on Highway 409. A probable cause of this problem is that a significant portion of passenger related airport traffic is not reported in the TTS. Both the TTS and the model over simulate traffic on the QEW relative to the cordon count data. This has been an ongoing problem with previous versions of the model possibly related to more than average peak spreading caused by severe congestion. Neither of these two problems is likely to have significant influence within the City of Brampton.

Table 24A – GO Rail Station Use

Corridor & Station		Oct-06 Count	2006 TTS database	2006 TTS assign	2006b1 matrix	2006b1 assign
	Union		1454		763	230
Lakeshore West	Danforth	194	333	407	0	6
	Scarborough	457	365	1624	450	1509
	Eglinton	809	943	76	1139	3
	Guildwood	926	952	948	931	910
	Rouge Hill	1603	1903	1351	1357	1334
	Pickering	2923	2301	2611	2320	2316
	Ajax	2667	2656	2700	2638	2611
	Whitby	2919	3008	3352	2663	3158
	Oshawa	1882	2661	2709	2589	2589
Lakeshore east	Exhibition	28	0	0	0	0
	Mimico	393	643	666	553	520
	Long Branch	541	792	912	820	852
	Port Credit	1440	1906	2051	1642	1873
	Clarkson	3423	3521	3654	3376	3366
	Oakville	3625	3704	4756	3729	4380
	Bronte	1642	1605	1575	1514	1513
	Appleby	2191	2252	1879	1835	1823
	Burlington	1992	1893	2916	2042	2736
	Aldershot	443	394	79	624	0
	Hamilton	465	532	47	567	47
Stouffvile	Kennedy	54	261	0	11	0
	Agincourt	433	412	548	550	548
	Milliken	542	626	852	860	852
	Unionville	1070	1014	2043	1135	2006
	Centennial	565	593	0	531	0
	Markham	701	561	1154	754	1106
	Mount Joy	713	655	0	687	0
	Stouffville	282	356	294	307	294
Bradford	York Univ.	26	15	0	39	0
	Rutherford	907	1158	0	694	0
	Maple	370	319	1338	696	1304
	King City	449	527	442	445	442
	Aurora	1103	1009	840	921	840
	Newmarket	464	429	839	588	839
	East Gwillimbury	403	224	0	260	0
	Bradford	310	218	0	231	0
Milton	Milton	1005	898	748	846	748
	Lisgar			0	28	0
	Meadowvale	1878	1506	165	1700	165
	Streetsville	1984	1732	1678	1559	1627
	Erindale	1579	1534	955	1653	900
	Cooksville	2367	2965	2785	3365	278
	Dixie	666	754	4	989	4
	Kipling	166	260	124	134	124
Richmond Hill	Oriole	295	163	17	312	0
	Old Cummer	441	530	0	522	0
	Langstaff	1105	1116	7	1226	7
	Richmond Hill	2078	2156	1925	2424	1925
Georgetown	Bloor	15	57	0	0	0
	Weston	317	295	282	272	265
	Etobicoke	620	608	756	761	756
	Malton	551	525	2368	1085	1441
	Bramalea	**1817**	**1956**	**1523**	**2263**	**1498**
	Brampton	**1815**	**2034**	**1539**	**1103**	**1174**
	Mount Pleasant	**769**	**743**	**667**	**653**	**649**
	Georgetown	591	630	461	491	461
	Total (Excl. Union)	**59014**	**61203**	**58665**	**60884**	**51795**

Table 25 – Screen Line Comparisons

		Capacity	Cordon	TTS	Model	Ratios	
		vph	count	Assign ment	2006b2	TTS / count	Sim / count
Brampton							
	Mississauga > Brampton	31200	22377	23181	24902	1.04	1.11
	Brampton > Mississauga	31200	15043	8689	12839	0.58	0.85
	Brampton > Caledon	14050	7442	7969	8216	1.07	1.03
	Caledon > Brampton	14050	3720	2536	3970	0.68	1.07
	Brampton > Halton	8800	6734	5475	6374	0.81	0.91
	Halton > Brampton	8800	3899	2019	3984	0.52	0.90
	York > Brampton	11700	7949	7747	8430	0.97	1.15
	Brampton > York	11700	6889	5520	6538	0.80	0.96
	East of Hwy 10 (Westbound)	16900	12149	13438	13739	1.11	1.22
	East of Hwy 10 (Eastbound)	16200	9831	6160	8382	0.63	0.83
	West of 410 (Westbound)	9400	9447	8584	8649	0.91	0.99
	West of 410 (Eastbound)	9400	6807	4807	5793	0.71	0.82
Total		**183400**	**112287**	**96125**	**112554**	**0.86**	**1.00**
Inter-regional							
	Toronto > Peel (T)	49100	38023	33076	34552	0.87	0.91
	Peel > Toronto (T)	49100	33210	26114	26428	0.79	0.80
	Toronto > Peel (P)	44300	31647	26210	27652	0.83	0.88
	Peel > Toronto (P)	44300	29547	23841	24795	0.81	0.84
	Peel > Halton (P)	39700	26087	25099	27628	0.96	1.04
	Halton > Peel (P)	39700	17927	14050	18279	0.78	0.98
	Peel > Dufferin (P)	4500	3157	2585	2710	0.82	0.88
	Dufferin > Peel (P)	4500	1345	682	1331	0.51	1.00
	Halton > Wellington (H)	7100	5072	4155	5062	0.82	0.99
	Wellington > Halton (H)	7100	2868	2330	2056	0.81	0.83

The letter in brackets denotes which Region's database was used as the source of the cordon count information.

Table 26 – Individual Station Comparisons

Station		Capacity	Cordon count	TTS ass.	Sim. 2006b2	Cordon count	TTS ass.	Sim. 2006b2
Mississauga – Brampton			**Northbound**			**Southbound**		
330	Winston Churchill Blvd.	1800	1173	1210	1436	1158	643	866
208	Meadowale Blvd	1400	479	341	239	68	7	24
189	Mississauga Rd	2700	2064	1978	2080	1282	1278	1595
209	Financial Drive	500	120	339	374	370	69	91
89	Mavis Rd	1800	1464	1219	1280	864	325	832
190	McLaughlin Rd	700	972	583	704	865	161	404
82	Hurontario	2700	1768	2797	2956	1152	655	1156
191	Kennedy Rd	800	1027	734	869	275	526	403
160	Hwy 410	5400	5281	5875	5398	4220	2078	3155
161	Tomken Rd	1400	1275	779	1126	384	16	56
83	Dixie Rd	2700	2235	2618	2845	989	299	847
192	Bramalea Rd	1600	844	1222	1430	349	183	90
84	Torbram Rd	1600	858	1054	1360	321	41	165
85	Airport Rd	2700	1549	608	695	980	1313	1637
193	Goreway Drive	1600	415	738	1128	731	199	599
162	Finch Ave	1800	853	1088	981	1035	896	918
Total		**24800**	**22377**	**23181**	**24902**	**15043**	**8689**	**12839**

Table 26 (Cont.) – Individual Station Comparisons

	Station	Capacity	Cordon count	TTS ass.	Sim. 2006b2	Cordon count	TTS ass.	Sim. 2006b2
Brampton / Caledon				**Northbound**			**Southbound**	
151	Dixie Rd	900	559	704	490	206	255	235
169	McVean DR	700	168	298	242	27	7	5
170	Winston C. Blvd	900	104	288	141	110	31	16
171	Heritage Rd	550	165	289	210	31	7	15
172	Mississauga Rd	900	143	320	378	338	141	193
173	Creditview Rd	800	59	118	123	52	1	69
174	Chinguacousy Rd	800	173	120	131	100	74	143
175	McLaughllin Rd	800	281	297	329	166	257	312
176	Hurontario	1800	850	232	351	504	74	235
177	Kennedy Rd	1600	282	353	373	239	9	140
178	Heart Lake	700	950	527	578	456	261	309
179	Bramalea Rd	800	234	424	430	136	32	137
180	Torbram Rd	800	327	420	411	104	22	154
181	Airport Rd	900	540	634	581	190	298	416
182	Goreway Dr	700	277	135	317	78	66	105
184	The Gore Road	900	329	456	428	88	31	231
185	Clarkway Dr	800	154	520	330	42	65	71
186	Coleraine Dr	700	139	468	309	91	122	108
187	Hwy 50	1800	1708	1368	1483	762	781	1085
Total		**17850**	**7442**	**7969**	**7634**	**3720**	**2536**	**3978**
Brampton / Halton				**Westbound**			**Eastbound**	
65	Mayfield Road	900	228	586	506	353	353	491
63	Highway 7	900	839	626	647	348	497	625
62	Embleton Road	700	535	258	427	221	143	440
61	Steeles Avenue	900	1037	697	789	626	386	724
411	Highway 407	5400	4095	3308	3777	2351	641	1233
Total		**8800**	**6734**	**5475**	**6146**	**3899**	**2019**	**3812**
East of Hwy 10				**Westbound**			**Eastbound**	
66	Steeles Avenue	2700	2134	2010	2300	1937	1030	1446
67	Queen Street	700	***785***	614	693	547	216	257
69	Mayfield Road	900	875	697	806	469	480	604
188	Highway 7	1800	929	1475	1619	698	1264	1518
290	Clarence Street	500	***839***	361	378	403	133	65
291	Vodden Avenue	1000	837	717	835	570	215	370
292	Williams Parkway	1600	***2135***	1543	1528	1560	591	942
293	Sandalwood Parkway	1600	1058	1098	1130	988	148	680
409	Hwy 407	7200	2557	4924	5498	2659	2082	2245
	Total	**18000**	**12149**	**13438**	**14787**	**9831**	**6160**	**8128**
York / Brampton				**Westbound**			**Eastbound**	
80	Mayfield	900	321	281	386	303	436	417
334	Castlemore	900	642	524	605	429	316	368
78	Hwy 7	2700	1640	2030	2154	1250	748	793
407	Hwy 407	5400	4202	3902	4787	3829	2925	3710
134	Steeles Ave	1800	1144	1009	1186	1078	1095	1306
	Total	**11700**	**7949**	**7747**	**9118**	**6889**	**5520**	**6595**
West of 410				**Westbound**			**Eastbound**	
340	Highway 7 (Bovaird)	1800	***2194***	1945	2497	1425	1364	1552
341	Williams Pkwy	1600	***1937***	1738	2045	1103	485	703
343	Queen Street	2700	1908	2140	1845	1659	1620	1434
344	Clark Boulevard	1200	1005	399	400	425	258	625
347	Steeles Avenue	2700	2403	2362	2519	2195	1081	1297
	Total	**10000**	**9447**	**8584**	**9306**	**6807**	**4807**	**5618**

4.0 Model Operation

4.1 Initial Set-up

The simplest procedure for setting up the model is to copy the macros and an existing emme2bank that already contains the network, base matrices and zone ensembles that are required to run the model. A minimum of 1 Gigabyte of disk space will be required or 2 Gigabytes if the same emme2bank is to be used to run the a.m. version of the model as well as the p.m. model. The following steps are needed to construct an emme2bank from scratch.

1. Create the emme2bank (emme2 newbank). The following dimensions are the recommended minimums to run the City of Brampton model for the p.m. only.

20	Scenarios
1,920	Zone centroids
15,000	Nodes (including zone centroids)
42,000	Directional links
8,000	Turn table entries
15	Transit vehicle types
800	Transit lines
37,000	Transit line segments
50	Full matrices
100	Origin matrices
100	Destination matrices
999	Scalar matrices
99	Functions per class
2000	Function operators per class
500,000	Words for extra attributes
Yes	User data on transit segments (Only required if the transit assignment includes link specific functions)
Yes	Class specific auto volumes (Only required if HOV modules are to be used)

2. Set the following parameters in module 1.23
   Length of coordinate unit .001 km
   6 digit node numbers

3. Import or create a network. A network containing the correct number of zones must be created before any matrix or zone group can be created or imported.

4. Module 1.31 should be used to import the full matrices (mfpm01 through mfpm11) required as input to the model from an existing emme2bank that has been used to run the model. All functions and zone groups should also be imported.

5. Initialize the remaining matrices by using module 3.11 to read the file “pmpk_rates.prn”.

4.2 Emme2bank

Matrices

Matrices are identified by name, not ID number, throughout the model. All matrices used as input to or generated by the model have the letters "pm" as the first two characters of the name. The matrix IDs may change depending on the order in which they are created and the current availability of unused ID numbers. ***Appendix C*** contains a listing of the current matrix directory. It is recommended that a similar practise be adopted in assigning and naming other matrices that are to be stored in the emme2bank. Use a name to identify the matrix and let emme/2 assign a number to it.

Zone Ensembles

A number of zone ensembles have been pre-defined or allocated for specific purposes as shown in ***Table 27***.

Table 27 - Zone Ensembles

A	Calibration of trip distribution
G	Input of trip generation rates
J, K and L	Reserved for use in matrix convolutions
M	Input of mode split factors
P	Planning districts (Municipalities)
Q	Output summaries
R	Regions

Volume Delay Functions

The 2006-travel time matrix currently contained in the emme2bank was generated using tangential volume delay functions. Tangential volume delay functions converge faster and provide a less extreme response to over capacity situations than the widely used exponential volume delay functions. The link times generated are used as the base reference points when modifying the auto trip distribution to reflect projected changes in level of service. If the volume delay functions are modified the 2006 travel times may need to be recalculated for consistency.

Network Scenarios

It is recommended that a new scenario be created for each model run.

The HOV component of the model requires an HOV network in which all links with unrestricted auto use have been coded with the mode codes 'c', 'i' and 'j' in addition to any transit or auxilliary transit codes. Mode code 'j' must be omitted for links restricted to vehicles with 2 or more occupants. Mode codes 'i' and 'j' must be omitted for links restricted to vehicles with 3 or more occupants.

Extra Attribute Data

Table 28 lists the extra attributes that have to be pre-defined in order to use certain components of the model.

Table 28 - Extra Attributes

Attribute	Type	Required for	Description
@lkagg	Link	Performance Indicators (pmod9)	User defined
@per1	Link	HOV assignment (pmod11)	Assigned volume of 1 person vehicles
@per2	Link	HOV assignment (pmod11)	Assigned volume of 2 person vehicles
@per3	Link	HOV assignment (pmod11)	Assigned volume of 3+ person vehicles
@lov	Link	HOV conversion (pmod12)	Assigned volume of remaining LOVs
@hov	Link	HOV conversion (pmod12)	Assigned volume of original HOVs
@nhov	Link	HOV conversion (pmod12)	Assigned volume of new HOVs
@board	Line	Transit assignment (pmod5)	Transit boardings by line
@trvol	Link	Transit assignment (pmod5)	Transit volumes by link

It is recommended that user field ul1 be used to identify cordon count stations for the output of screen line data. The recommended procedure is described in section 4.10.

4.3 Macros

The macros that run the model have been developed as independent modules. ***Appendix A*** contains full documentation. The master macro "pmod_v5.mac" calls the other macros in the required order and can be modified to suit specific applications (e.g. modified trip distribution, hov assignments etc.). ***Table 29*** lists the macros that are currently operational.

Table 29 - Macros

Macro name		Function
pmod_v5.mac	*	Calls the other macros in the required order
pmod0_v5	*	Selects scenario and sets ID
pmod1_v5		Updates matrix input data using an external file
pmod2_v5	*	Work trip generation, mode split and distribution
pmod4_v5	*	Non work trip generation and distribution. Matrix aggregation
pmod5_v5		Transit assignment
pmod6_v5	*	Road assignment - (no consideration of HOV lanes)
pmod7_v5	*	Performance Indicator and trip end summary report
pmod8_v5	*	Modal split and auto performance report
pmod9_v5	*	Link aggregation report
pmod10_v5		Trip length adjustment
pmod11_v5		Road assignment with HOV lanes
pmod12_v5		Generation of new HOVs

The master macro "pmod_v5.mac" can be edited to include only those macros that are required for a given run. The macros need to be run in the correct order but do not necessarily have to be run as a single batch process provided that no modifications are made to the emme2bank between runs. The macro "pmod0" must be repeated as the first sub macro in each stage. Output files that need to be saved should be renamed before running the next stage otherwise they may be deleted or over written when the next stage is initiated. Macro "pmod5_v5" needs to be repeated after the trip length adjustment (pmod10) unless an HOV assignment (pmod11_v5 or pmod11_v5 and pmod12_v5) is to be performed in conjunction with the trip length adjustment. The two report macros, "pmod8_v5" and "pmod9_v5", may be repeated after the trip length adjustment and/or HOV assignment to obtain before and after summaries.

The macro "pmod0_v5" requires three calling arguments defined in the master macro (pmod_v5.mac). Those arguments are:

Arg1 The name used to identify the run (Maximum 6 alphanumeric characters with no spaces)
Arg2 The emme/2 scenario number for the road assignment
Arg3 The emme/2 scenario number for the transit assignment (Can be the same as Arg2)

If the results of an adjusted trip length or HOV assignment are to be saved as a new scenario, instead of over-writing the initial road assignbment, the macros must be run in 2 or 3 stages with the required changes to the value of Arg2 made between each run.

The macro "pmod1_v5" reads matrix input data contained in the file "xxxxxx_pm", where "xxxxxx" is the argument used to call "pmod0_v5". This file may be used to selectively modify the simulation parameters (ms01 through ms26 and ms36), enter new population and employment data and to redefine the trip generation rates and/or mode split factors. Trip

generation rates and mode-split factors, if included in the file, may be defined for individual zones or by zone groups contained in any existing zone ensemble.

The master macro "pmod_v5.mac" can be edited to include only those macros that are required for a given run. The recommended way to disable one of the sub-macros is to insert a "/" as the 2nd character of the call line thus making it into a comment line. The macros marked with asterisks are needed to run the model in its simplest form (i.e. No transit assignment, no adjustment of trip lengths and no HOV assignment).

The following is a sample listing of the macro (pmod_v5.mac) required to run the full model including trip length adjustment and an HOV assignment with the generation of new HOVs based on projected time savings.

```
~<pmod0_v5 06base 2006 2006
~<pmod1_v5
~<pmod2_v5
~<pmod3_v5
~<pmod4_v5
~<pmod5_v5
~<pmod6_v5
~<pmod7_v5
~<pmod8_v5
~<pmod9_v5
~<pmod10_v5
~<pmod11_v5
~<pmod12_v5
~<pmod8_v5
~<pmod9_v5
```

The macro may be run from the main menu within either emme2 or emme3 or in batch mode outside emme2. To run in batch mode an initial line containing the user's initials must be added at the beginning of the macro and a trailing line containing just the letter "q" at the end. The following command line can then be used to execute the macro in batch mode.

```
emme2 -m pmod_v5.mac batch >&filename&
```

Where "filename" is a temporary file used for output of the emme2 dialog. Omitting the string ">&filename&" will result in the dialog being displayed on screen during execution.

4.4 Input Data

The basic inputs required for a model run are a network and land use data (population and employment) by zone. The population data must be stored as origin matrix "mopm18" and the employment data as destination matrix "mdpm18". The population and employment data is usually imported in the "xxxxxx_pm" file at the start of each model run where "xxxxxx" is the identification code used as Arg1 in calling macro "pmod_v5.mac)". If an "_pm" file is used to modify the existing population and employment vectors (mopm18 and mdpm18) it is important that all zones be specified including those with zero values. A safe way to ensure that all no values are left unchanged from a previous run is to delete the old matrix and create a new one instead of modifying the existing values.

Table 30 provides a list of the other input parameters that can be modified, together with recommended values for the years 2006, 2011, 2016 and 2021. The 2021 values are also recommended for horizon years beyond 2021. The recommended method of modification is to include specification of the desired scalar matrices and values in the "_pm" file for each model run. Any scalars not included will retain the values from the previous run.

Table 30 - Recommended "Base Case" Input Parameter Values

mspm	Description	2006	2011	2016	2021
01	Work to home origin factor	1	1	1	1
02	Work to home destination factor	1	0.99	0.97	0.95
03	Work to non-home destination factor	1	0.99	0.99	0.99
04	Auto non-work factor	1	1.01	1.03	1.06
06	Transit home origin factor	1	1.01	1.02	1.03
07	Non work peak hour factor	0.3	0.3	0.3	0.3
08	Transit non-work to home factor	1	1	1	1
09	Trip generation origin weight	1	1	1	1
11	Other m/s adjustment factor	1	1	1	1
12	GO Rail m/s adjustment factor	1	1	1	1
13	Transit m/s adjustment factor	1	1	1	1
14	Pk hr driver fac. for GO egress	0.4	0.4	0.4	0.4
17	m/s origin weight - other	0.5	0.5	0.5	0.5
18	m/s origin weight – GO Rail	0.5	0.5	0.5	0.5
19	m/s origin weight - Local Transit	0.5	0.5	0.5	0.5
20	GO Rail excluded factor	1.07	1.07	1.08	1.08
21	Local transit excluded factor	1.06	1.06	1.07	1.07
22	Auto occupancy adjustment	1	1	1	1
23	Trip length adjustment coefficient	0.03	0.03	0.03	0.03
24	2 person hov coefficient	0.85	0.85	0.85	0.85
25	3 person hov coefficient	0.1	0.1	0.1	0.1
26	New HOV coefficient	0.01	0.01	0.01	0.01
36	Background traffic adjustment	1	1	1	1

Factors that need to be considered when defining or modifying the above assumptions

- Bias in the TTS
- Ageing of the population
- Strength of the economy
- Socio-economic trends
- Technology
- Level of service & cost (Transit)
- Cost of driving
- Auto availability
- Driver licensing
- School bus policies
- Environmental policies
- Peak spreading

It is recommended that a new "_pm" file be created for each model run using an appropriate name to identify the year and development/network scenario. The file should be saved, along with the output summary report, in order to provide a complete record of the input data for each model run. Every "._pm" file should include specification of values for all of the scalars listed in ***Table 30*** as well as any origin or destination vectors that may be selectively modified for different years or simulation scenarios. The inclusion of the values for all years and scenarios in the appropriate "_pm" files should help to prevent the accidental use of the wrong values from a previous run.

An excel spreadsheets “pmpk_rates” and “Brampton_popemp” have been created to assist in the creation of the “_pm” input files. The spreadsheet “pmpk_rates” contains 1 page for each of the following input vectors:

- Scalars (see ***Table 30)***
- Work trip origin rates
- Work trip to home destination rates
- Work trip to non-home destination rates
- Non-work auto home destination rates
- Auto home origin rates
- Auto non-work non-home origin rates
- Auto non-work non-home destination rates
- Transit home origin rates
- Non-work home transit destination rates
- "Other" mode origin mode splits
- "Other" mode destination mode splits
- GO rail origin mode splits
- GO rail destination mode splits
- Local transit origin mode splits
- Local transit destination mode splits

New vectors can be created by adding columns to the appropriate page(s) with a unique identification code assigned in row 2. The summary page "emme2" allows the appropriate columns to be selected from the other pages and formats them for input to emme2. The required columns can be copied to the "_pm" using any windows based text editor (Word, wordpad etc.) pasting them as unformatted text.

The spreadsheet "Brampton_popemp" can be used in the same manner to select the appropriate population and employment vectors.

4.5 Modification of Trip Generation Rates and Mode Split Factors

The base trip generation rates and mode split factors may be modified in one of the following ways prior to running the model.

1. Changing the appropriate global adjustment factor(s). (See ***table 30***)
2. Performing matrix calculations to adjust the base case data. The development emme2bank contains protected copies of the base case input matrices. These protected copies may be used as input to calculations with the results replacing the input matrices to the model (See ***appendix D***). Zone groupings may be used to perform selective calculations.
3. Importing new rates or factors to the required matrices. The required matrices may be included in the "-pm" file at the start of each model run.

4.6 Trip Distribution

The trip distribution can be modified using the matrices "mfpm20" for auto travel and "mfpm22" for transit travel. The trip distribution components of the model use the product of these matrices and the appropriate base matrix as input to the trip distribution. The default value for both these matrices is 1 throughout. After use the values should be reset to the default unless the same adjustments are to be made in all model runs. The adjustments are applied prior to trip balancing. Since the balancing process is likely to reduce the magnitude of any adjustment it may be necessary to over compensate by applying a factor that is larger than the desired adjustment. Adjustment factors can best be applied using zone groups – gp for municipality or gr for region.

Example: adding the following lines to the "_pm" input file would increase the level of self containment within the City of Brampton for both auto and local transit trips.

```
d matrix=mfpm20
a matrix=mfpm20,,1 Inc. the auto trip self  cont. for Brampton
  gp35  gp35  1.2
d matrix=mfpm22
a matrix=mfpm22,,1 Inc. the transit trip self  cont. for Brampton
  gp35  gp35  1.2
```

4.7 Auto Occupancy

The auto occupancy matrix (mfpm14) may be modified by:

1. Applying the appropriate global adjustment factor (ms22).
2. Performing matrix calculations to change the values in mfpm14
3. Importing a new matrix (mfpm14).

4.8 Background Traffic (Subway Egress)

In the current applications of the model the background traffic matrix (mfpm12) is used to represent the auto egress from subway park and ride lots. The matrix may be modified by:

1. Applying the appropriate global adjustment factor (mspm36).
2. Applying origin specific adjustment factors (mopm9). ***Table 31*** identifies the zones associated with subway park n' ride and reported use in 1996 (TTS data). (To be updated).
3. Performing matrix calculations using the protected copy of the base case matrix (mfpm12) as input.
4. Importing a new matrix (mf15)

4.9 Other Adjustment Factors

Other factors that can be adjusted prior to a model run are:

1. The weight assigned to the work trip origin total relative to the work trip destination total.
2. The weight assigned to the origin trip totals by mode relative to the destination total for the same mode.
3. GO Rail non-work factor.
4. Local transit excluded factor.

Refer to Appendix C in order to identify the appropriate matrix scalars.

Table 31 - Subway Park and Ride

Zone	Station	2001 TTS pm peak Driver egr. (3 hours)
oki		
34	Islington	1000
20	Old Mill	75
22	Kipling	2548
44	Royal York	63
98	Downsview	1085
104	Lawrence West	397
106	Wilson	1583
130	Jane	119
142	Keele	95
149	High Park	169
185	St Clair W	130
196	Castlefrank	71
259	Pape	176
278	Eglinton West	162
285	Eglinton	196
291	Lawrence	196
295	Yorkdale	2067
302	York Mills	588
307	Shepperd	352
309	North Yonge	279
311	Finch	4764
324	Bayview	133
338	Don Mills	960
366	Coxwell	57
367	Woodbine	105
368	Main	54
394	Warden	854
396	Victoria Park	271
410	Kennedy	1781
414	Lawrence E.	215
425	Scarborough TC	687
426	McCowan	308

4.10 Model Outputs

The primary outputs from a simulation run are the trip matrices and network assignments. Analysis of the results is possible within emme/2 or selected data may be exported for external analysis. Assignment results will remain in the emme2bank until the applicable scenario is deleted, modified or used for another model run. Subsequent model runs will over write matrix information. Output information that can be obtained from each model run includes the following reports:

1. A report listing the values of all the matrix scalars. This report can be used as a permanent record of the input parameters, control totals, calculated trip totals and global performance indicators. The report is generated by the macro "pmod7"

2. The following totals for each zone group defined in zone ensemble "gq"
   - Population.
   - Employment
   - From work trip origins
   - From home trip origins
   - To home trip destinations
   - Non home base non work trip origins

   The report is generated by the macro "pmod7".

3. The following trip end totals for each zone group defined in zone ensemble "gq"
   - GO Rail origins

- Local transit origins
- Auto person origins
- Auto driver origins
- GO Rail destinations
- Local transit destinations
- Auto person destinations
- Auto driver destinations

The report is generated by the macro "pmod7"

4. The following factors calculated for each zone group in zone ensemble "gq"
   - Activity rate (jobs per 1000 population)
   - Origin transit modal split (all trips)
   - Destination transit mode split (all trips)
   - Self-containment (% of all trip destinations that have their origin within the same zone group).
   - Mean auto person trip time by destination based on 1996 Levels of Service.
   - Mean auto person trip time by destination based on the projected level of service given by an equilibrium assignment to a future network.
   - Mean auto occupancy by destination

   The report is generated by the macro "pmod8"

5. The following trip matrices aggregated by zone group in zone ensemble "gq"
   - Peak hour auto driver trips
   - Peak period auto person trips
   - Peak period GO Rail trips
   - Peak period local transit trips

   The report is generated by the macro "pmod8". This part of the output report may be imported to a spreadsheet for the purpose of calculting O-D specific mode splits.

6. The following totals and averages are calculated for the link aggregations defined by non-zero values of the extra link attribute "@lkagg". The aggregations may be defined to represent screen lines, geographic areas, categories of road, or combinations of these attributes.
   - Number of links in the aggregation
   - Total assigned vehicle km
   - Total assigned vehicle hours
   - Mean speed (kph)
   - Capacity utilisation (assigned vehicle km / vehicle km of capacity)
   - Total link volume
   - Volume to capacity ratio

   The calculation of capacity utilisation differs from volume to capacity ratio in that the length of each link in the aggregation is used to weight the result. Capacity utilisation is the appropriate measure to use as the average for a geographic area. Volume to capacity ratio is more appropriate for screen line crossings. The report is generated by the macro "pmod9".

The zone ensemble “gq” has been initialize to provide the following aggregations of matrix data as output:

Group

1. City of Brampton
2. City of Mississauga
3. Town of Caledon
4. City of Vaughan
5. Remainder of York Region plus external areas to the North
6. City of Toronto
7. Region of Durham plus external areas to the East
8. Region Of Halton
9. City of Hamilton plus external areas to the South and West

The output reports are generated using the standard emme/2 output modules 3.12 and 3.14. There are some limitations inherent in that format.

- The emme/2 report format shows the sum, mean, minimum and maximum values at the end of each table. The mean value shown is an unweighted average that does not take into account the different sizes of the aggregations.

- The number of zone groups defined in zone ensemble "gq"and the printer device option will determine the size of the output report and the number of pages required to print the aggregated trip matrices. The maximum number of aggregations that can be printed on a single page at 15 cpi (Device option set for HP Laserjet) is 9. The maximum for 2 pages per trip matrix is 19.
- Origin and destination vectors are used to store the results of the calculations for each link aggregation. The zone numbers shown are the reference numbers for each link aggregations used in these vectors. There is no relationship to actual zones or zone system other than that a zone number must be defined as a centroid in the network in order for it to be a valid reference number.

Matrix and link attribute data may be exported for external analysis. Table 17 provides a list of the extra attribute data that is available in addition to the standard link attributes and assignment results. Appendix A contains a complete list of the available matrices. ***Appendix D*** contains an example of the output reports produced by the macros "pmod8" and "pmod9".

Appendix A - Macro Documentation

Emme2 Matrix Nomenclature

Matrices in emme2 are identified by a 1 to 6 character name preceded by a 2 character prefix that identifies the type of matrix.

mf for a full matrix (one element for each origin and destination pair)
mo for an origin matrix (one element for each origin zone)
md for a destination matrix (one element for each destination zone)
ms for a scalar (single value)

All the matrices used in the P.M. model have "pm" as the first two characters of the matrix name. Numeric values have been assigned as the 3rd and 4th characters.

The matrix mfxx99 is used in a number of places for the temporary storage of intermediate results.

When writing equations in emme2 the name segment of the matrix identifier must be enclosed in quotation marks (eg: mf"pm01"). The quotation marks have been omitted from this documentation for clarity.

An apostrophe mark (') following the matrix name indicates that the matrix used in the calculation is transposed (eg: mopm01' denotes a destination matrix containing the same values as the origin matrix mopm01)

Matrix calculations are performed element by element. In calculating a full matrix (type mf) the values for any origin matrix (type mo) included in the equation are applied to all destinations. The values for any destination matrix (type md) are applied to all origins and any scalar values (type ms) are applied to all elements. If the result matrix is of a lower type (eg: mdpmxx = mfpmxx) the necessary row and/or column values are aggregated.

Bucket rounding (function name "bint") is used to convert the final trip matrices to integer values. As each element in the matrix is calculated the value is truncated and the remainder added to the calculation of the next element.

pmod_v5.mac

This is the master control macro that performs the following functions:

1. Sets the user's initials (xxx) for emme2 logon.
2. Sets the calling arguments for macrp pmod0
   - Arg1 – The name (max. 6 characters) used to identify the input file, the matrices that are created during the run and the output report file.
   - Arg2 – The scenario number to be used for the road assignment
   - Arg3 – The scenario number to be used for the transit assignment (if applicable – may be the same as or different from Arg2)
3. Calls the macros for each module of the model in the desired order.

This macro needs to be edited before each new run. To skip the operation of a module the required line can be converted to a comment line by adding / as the 2nd character.
Eg: Changing the 6th line to read ~/<pmod5 _v5 would cause the transit assignment module to be skipped.