GTA A.M. PEAK MODEL

Version 4.0

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, average 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 the details of individual route planning.

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 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 4) has been calibrated using data from the 2001 Transportation Tomorrow Survey (TTS) and the 2001 Canada Census. To obtain complete coverage of the external areas the 2001 TTS was supplemented by data from the 1996 TTS, for the Region of Waterloo and County of Northumberland, and by 1991 Census Place of work – Place of residence data for the Region of Haldimand-Norfolk and the County of Brant. Model results have been validated using 2001 Cordon and transit ridership counts. In addition a number of operational improvements have been made relative to the earlier versions.

There are currently three versions of the simplified model:

1. An A.M. Peak period model for the entire GTA (Including Hamilton)
2. A P.M. Peak period model for the entire GTA (Including Hamilton)
3. A P.M. Peak period model developed specifically for the Regional Municipality of Halton.

This introduction is common to all 3 models.

The two GTA models are both based on the 1996 GTA zone system supplemented by 26 external zones. Some minor revisions, primarily re-calibration of the trip distribution component, will be necessary in order to adapt the model to the 2001 GTA zone system. A refinement in the current release is the ability to use the same emme2bank to run both the A.M. and P.M. models with little or no risk of "interference" between the two models or accidental loss of results.

The Halton model covers the same geographic area as the GTA models but uses a more detailed zone system within the region of Halton. The same 26 external zones are used and the GTA zones are retained in Peel Region and Parts of Hamilton. More aggregate zones are used in the rest of Hamilton, the City of

Toronto and in the Regions of Durham and York. The modelling procedures and the macros are identical to those used in the GTA P.M. model.

1.1 Summary Description

Figure 1 shows the flow of information through the trip generation, mode split and trip distribution components of the model.

Figure 1 - Flow Diagram

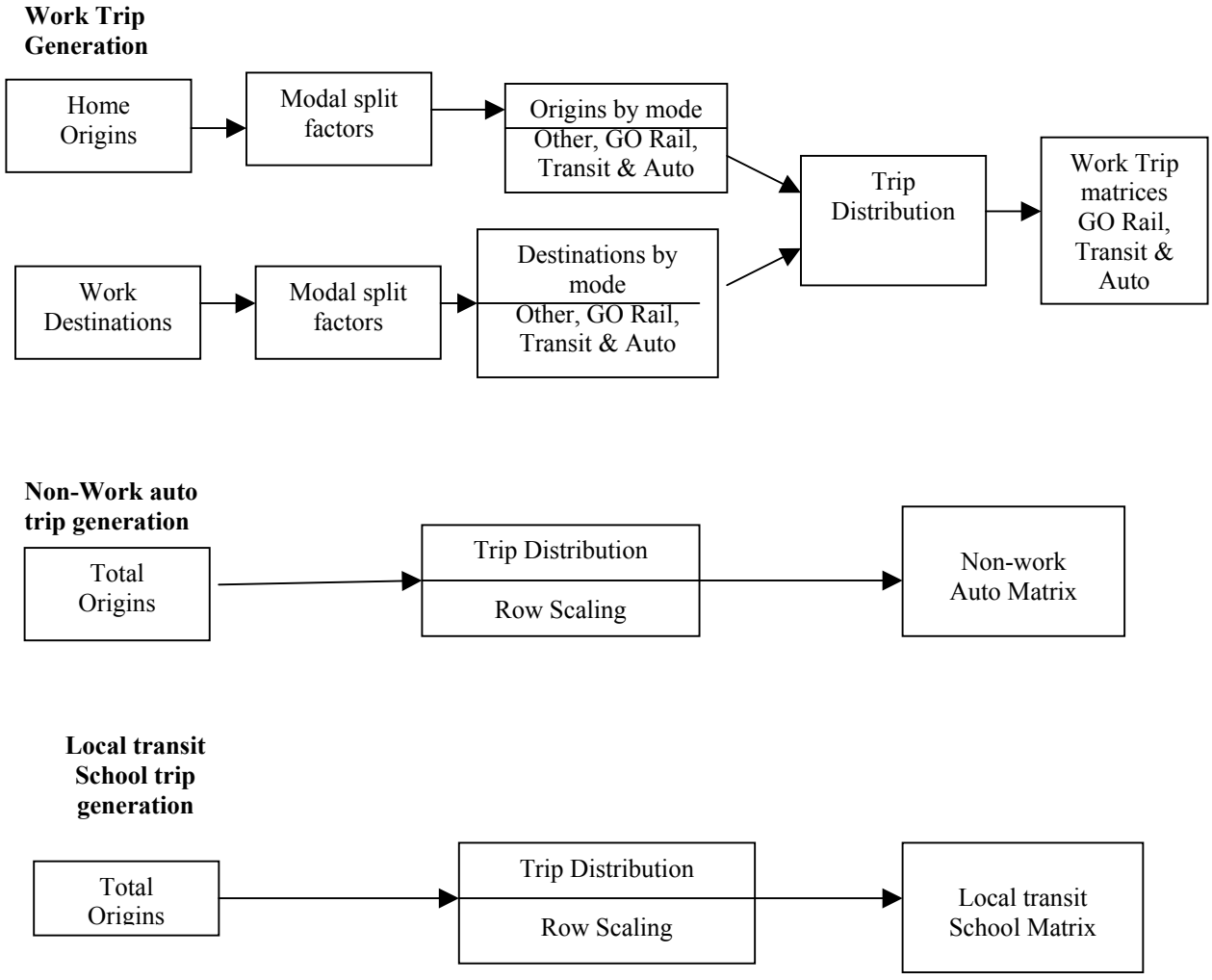


Table 1 provides a summary of the main features of the model. The model has been calibrated using the 1996 TTS data

Table 1 - Features of the A.M. Peak Period Model

Time period	a.m. peak 3 hrs (6:00 - 8:59)
Geographic Scope	GTA, including Hamilton-Wentworth, plus 10 adjacent Counties and Regional Municipalities
Zone system	GTA96 plus 26 external zones (1703 total)
Trip purpose categories	1. Work destinations (all modes) 2. Home to School (local transit only) 3. Non work destinations (Auto only)
Modes	1. Auto (Driver & Passenger) 2. Transit (Excluding GO Rail access) 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. Simulation of HOV lanes including the formation of new car-pools (Optional). 4. Inclusion of an additional auto matrix that may be used to represent GO Rail access, truck movements or external and through trips from outside the simulated area.

The definition of the GTA includes the Regional Municipality of Hamilton-Wentworth in the context of the model and this documentation. The revised GTA model is compatible with the existing Durham region sub-model that uses a more detailed zone system. It is anticipated that similar Regional sub-components may be developed for other areas.

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 in section 3.7.2 of the emme/2 User's Manual (Release 9). 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 reduced number of non zero values and the absence of decimal places.
c) The standard output tables produced by emme/2 are more readable and easier to analyse.

A number of supplementary features may be used in conjunction with the basic model including adjustment of the trip distribution to reflect changes in level of service and the analysis of HOV lanes. The full range of supplementary options is described in Chapter 2.

1.1 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. Trips within and between the external zones are excluded. The home location is assumed to be the trip origin for first trips to work regardless of the actual trip origin given in the TTS database. The model does not require the input of destination trip rates for school trips made by local transit because the pattern of trip destinations is assumed to remain the same for each origin zone. In the work and non-work auto categories the origins and destinations are balanced to the same global totals prior to trip distribution by applying user specified global weights to each. The origin weight has to be set to a value between 0 and 1. The destination weight is automatically calculated as 1 minus the origin weight. It is recommended that an origin weight of 1 be used on the basis that future population forecasts are likely to be more reliable than estimates of employment.

Table 2 - Trip Generation Categories

		TTS Trip Total
Employment Based Trip Rates		
	Work trip destinations - all modes	1,582,885
Population Based Trip Rates		
	Work trip origins - all modes	1,590,235
	Non work auto trip origins	730,005
	School trip origins using local transit	113,421
Composite Trip Rates		
	Non-work auto trip destinations	727,745

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

Non work GO Rail trips (6.7% of total a.m. peak GO Rail trips - TTS data)

Non work or school local transit trips (5.5% of total a.m. peak transit trips - TTS data)

The model uses global adjustment factors, prior to trip assignment, to correct for these exclusions.

The base case trip generation rates were obtained from the TTS data at an aggregated level. The zone ensemble "gg", in the emme2bank, contains the zone aggregations that are used. The zone aggregations are sub-divisions of Planning Districts with the first digit of a 2-digit number or 2 digits of a 3-digit number, being the planning district number. There are 84 aggregations as shown in Figure 2. In the external areas the rates are for trips to or from the GTA and are calculated individually for each of the 26 external zones. 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 3 and 4 show the base case trip generation rates calculated from the TTS data. The non-work auto destination rate is the reported number of trips divided by a composite value equal to employment plus half the population. The relative weighting gives population and employment approximately equal value since assuming that approximately half of the population is employed. The trip rates for areas outside the GTA are for trips to or from the GTA only, hence the slight difference in origin and destination trip totals. The bold italic numbers in Table 4 have been manually adjusted due to reflect incomplete coverage in the TTS. The values for Cambridge and Kitchener/Waterloo are from the 1996 TTS.

The reported non-work trip generation rates have been increased by 5% globally to reflect the known under-reporting of non-work related trips 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. Non-work trips made by auto in the a.m. peak period were estimated to be under-reported by 15%; however, the average reported trip rate, in that category, was 19% higher in 2001. Much of that increase may be attributed to more complete reporting in the 2001 survey compared to 1996.

Table 3 - Trip Generation Rates

	Origins per 1000 population			Destinations per 1000	
	Work	non-work	local transit	Employment	emp+pop/2
gg		auto	school	work	non-work
11	292	60	32	614	60
12	392	216	26	733	35
20	287	68	34	470	88
30	273	93	48	562	104
40	314	133	24	576	147
50	267	145	38	613	150
60	293	82	37	451	97
70	316	109	41	552	101
80	276	137	29	591	151
90	261	125	29	587	142
100	268	103	43	621	134
110	270	151	37	598	176
120	279	123	39	610	124
130	253	113	40	569	138
140	270	134	32	477	191
150	301	156	32	529	205
160	276	140	33	580	133
170	232	99	0	548	89
180	301	155	1	515	186
190	268	122	0	488	130
201	316	171	12	538	180
202	229	155	0	636	86
210	301	172	13	518	192
221	280	163	4	538	152
222	299	167	11	573	194
231	221	168	15	433	157
232	257	150	12	535	231
240	252	115	2	488	124
250	281	105	0	514	131
260	320	117	0	437	102
270	298	160	6	534	162
280	310	172	2	535	164
291	327	142	11	587	188
292	304	177	16	508	199
293	263	218	17	633	163
300	296	120	0	565	136
311	301	202	13	596	173
312	270	361	1	680	104
313	307	211	7	535	216
314	308	189	12	612	216
315	261	134	0	801	97
320	252	127	0	574	215
331	360	122	4	540	65
332	346	154	6	612	128
333	345	271	17	664	38
334	338	155	6	604	153
335	286	192	18	468	226
341	338	107	1	534	77
342	320	118	0	454	167

Table 3 (Cont.) - Trip Generation Rates

	Origins per 1000 population			Destinations per 1000	
	Work	non-work auto	local transit school	emp.	emp+pop/2
gg				Work	non-work
351	361	119	0	601	90
352	305	152	7	535	201
353	238	169	15	588	138
354	305	153	11	468	190
355	253	169	0	593	151
356	318	177	8	531	184
361	271	192	8	544	238
362	324	154	4	529	280
363	309	168	11	567	185
364	303	141	19	543	151
365	316	177	11	600	174
366	310	184	11	648	151
367	251	196	11	613	64
368	284	122	18	531	139
371	300	139	0	496	159
372	316	111	1	531	96
381	309	164	0	533	150
382	289	162	0	612	152
391	258	187	5	584	182
392	282	257	2	535	220
393	316	195	4	537	253
394	312	184	2	590	189
401	288	177	1	580	180
402	277	167	4	526	169
403	302	183	3	590	172
404	198	56	10	549	73
410	280	124	1	460	116
420	272	149	1	439	168
430	280	162	4	426	184
440	257	88	0	399	97
450	267	142	3	542	118
461	240	150	18	505	215
462	230	102	15	526	151
463	228	115	22	581	148
464	201	201	25	544	64
Mean values					
Toronto	281	113	36	602	117
Durham	276	154	9	512	174
York	305	175	9	596	158
Peel	305	164	11	580	155
Halton	294	178	3	553	181
Hamilton	245	133	13	531	153
Total	285	140	21	584	141

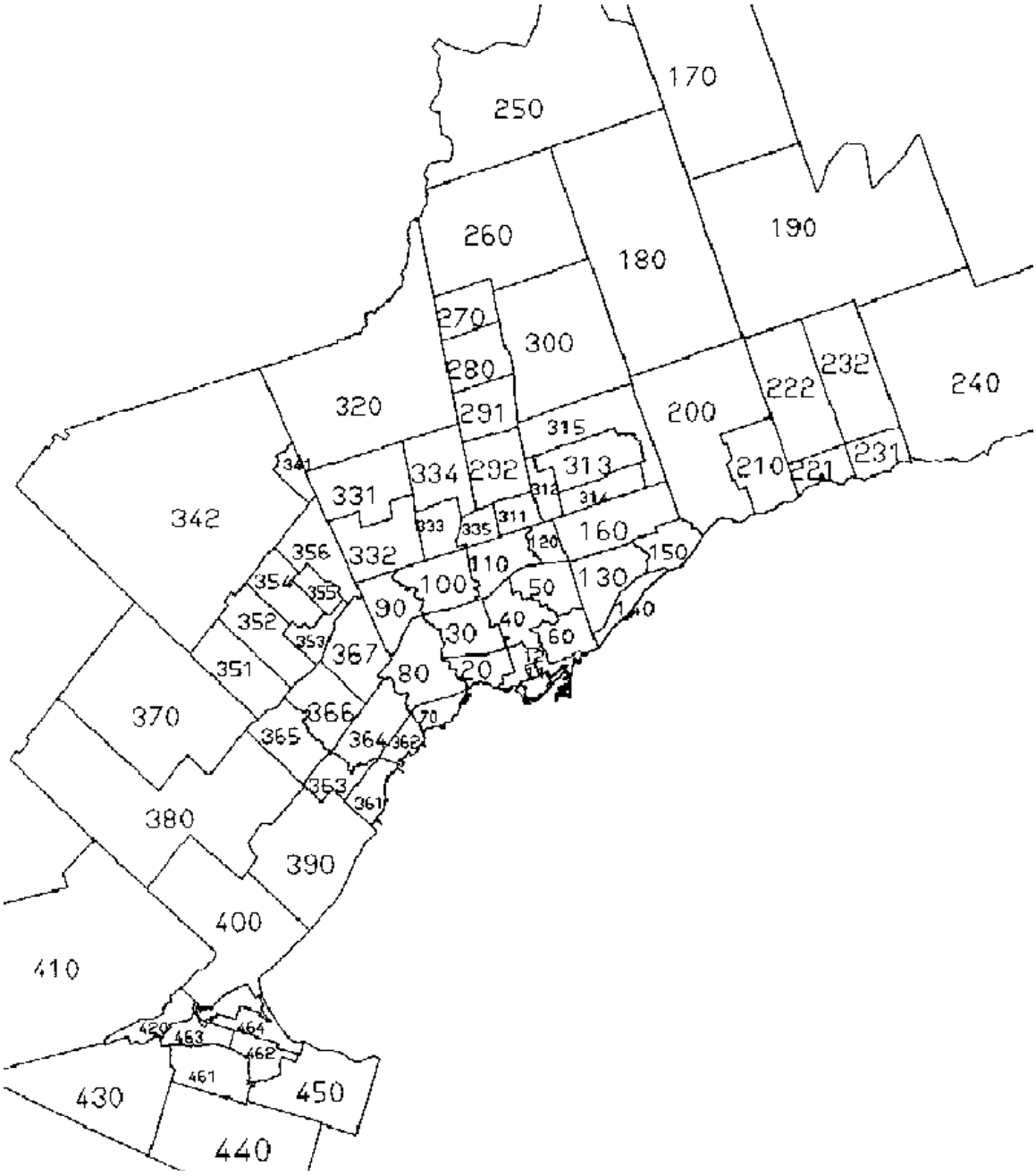
Table 4 – External Trip Generation Rates

(Trips to or from the GTA and Hamilton)

Zone	Locations	Origins per 1000 population: Work	non-work auto	local transit school	Destinations per 1000: emp. work	emp+pop/2 non-work
4001	Northumberland	***20***	***5***	***0***	***25***	***5***
4002	City of Peterborough	16	6	0	19	6
4003	Peterborough County	99	13	0	49	7
4004	Kawartha Lakes South	46	13	0	26	11
4005	Kawartha Lakes North	65	18	0	28	21
4100	Simcoe South	183	21	0	84	12
4101	Simcoe West	118	15	0	43	12
4102	Barrie	62	9	0	25	7
4103	Simcoe North	18	6	0	9	5
4104	Orillia	15	12	0	13	9
4201	Orangeville	131	21	0	67	13
4202	Dufferin County	***80***	***11***	***0***	***50***	***11***
4301	Guelph	40	7	0	39	8
4302	Wellington South	190	26	***0***	65	23
4303	Wellington North	57	6	0	30	6
4401	Cambridge	***39***	***2***	***0***	***62***	***6***
4402	Kitchener-Waterloo	***13***	***3***	***0***	***16***	***3***
4403	Brant County	***75***	***16***	***0***	***60***	***8***
4404	Haldimand-Norfolk	***15***	***3***	***0***	***15***	***3***
4405	Grimsby	101	21	0	83	13
4406	St Catharines	14	3	0	19	5
4407	Niagara-Fort Erie	7	4	0	14	4
4408	West Lincoln	57	9	0	27	3

Note – the above locations do not necessarily describe the location of the zone boundaries. Some zones include other municipalities adjacent to the one named (e.g. St Catharines includes Niagara-on-the-lake and Thorold).

Figure 2 - Aggregations Used in Trip Generation



1.2 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 areas not shown have the same aggregations as are used for trip generation (Figure 2). Tables 5 and 6 show 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 external mode split factors shown in Table 6 apply to work trips made to or from the GTA and Hamilton. Zones not shown in Table 6 are zero for both GO rail and local transit as are all the destination values and the origin values for the other mode. The values for Cambridge and Kitchener-Waterloo are from the 1996 TTS.

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.

Figure 3 - Zone Aggregations Used for Modal Split

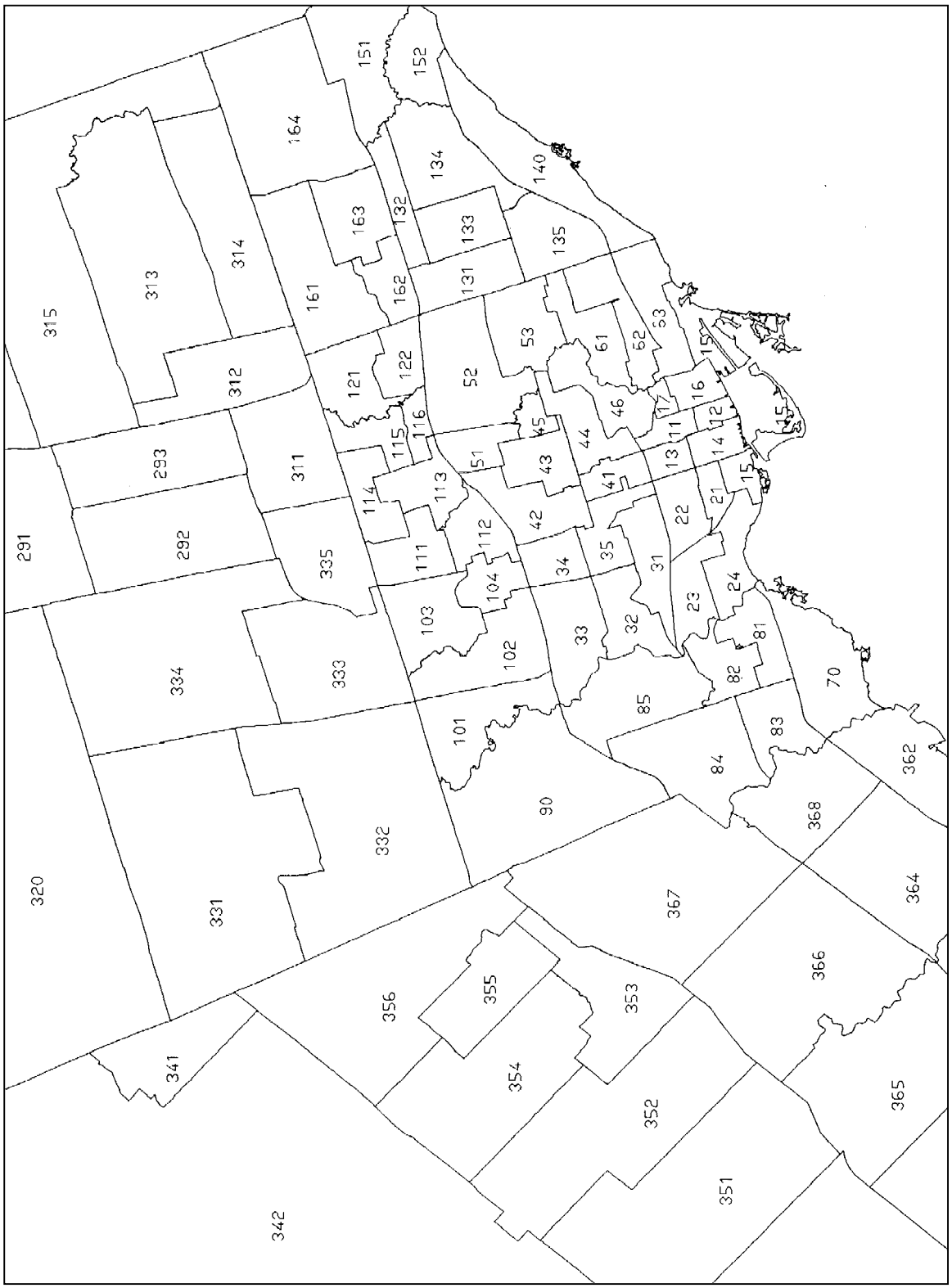


Table 5 – Mode Split Factors (%)

	Work Trip Origins			Work Trip Destinations		
Gm	Other	GO Rail	Transit	Other	GO Rail	Transit
11	38.4	0.5	58.1	8.6	10.3	56.8
12	44.1	1.1	34.6	5.7	27.6	59.6
13	24.1	0.6	60.1	12.2	6.2	48.3
14	36.2	0.6	45.0	8.7	16.2	49.4
15	17.2	0.0	48.5	5.1	2.8	22.5
16	33.1	0.0	52.5	9.4	8.8	35.2
17	23.6	0.5	59.9	11.1	3.3	39.4
21	15.3	0.0	43.8	9.0	0.9	28.7
22	12.2	0.0	44.0	13.7	0.8	31.3
23	4.3	0.2	41.6	9.8	1.1	24.8
24	7.2	0.1	44.3	6.8	0.7	24.4
31	6.7	0.4	36.1	9.3	0.3	18.7
32	1.7	0.0	26.1	3.3	0.2	15.7
33	3.5	2.3	30.7	6.5	0.8	12.6
34	7.4	0.0	33.1	2.3	0.3	22.7
35	4.8	0.0	39.1	5.8	0.6	25.8
41	5.7	0.0	34.6	8.6	1.6	29.4
42	3.3	0.1	31.8	3.6	0.6	25.0
43	9.1	0.4	38.9	8.3	1.9	37.3
44	8.6	0.0	44.7	7.8	4.2	43.1
45	0.0	0.0	12.7	4.9	1.4	17.5
46	6.3	0.0	34.5	5.8	0.7	28.7
51	1.2	0.0	20.9	0.3	1.0	27.0
52	1.9	0.5	20.8	1.8	0.3	14.6
53	4.2	0.0	33.8	2.6	0.2	14.5
61	5.1	0.0	35.7	6.6	0.0	20.1
62	6.4	0.2	46.4	10.8	0.5	33.7
63	7.4	0.0	36.6	12.1	0.9	25.8
70	4.2	4.9	17.7	3.7	1.0	11.5
81	3.1	1.4	25.6	3.0	0.3	13.6
82	2.4	0.3	31.7	1.5	0.9	25.4
83	1.9	1.9	22.7	1.6	0.3	13.0
84	2.6	0.6	20.4	3.8	0.0	10.2
85	2.3	0.8	20.9	2.4	0.3	11.5
90	2.3	1.4	17.2	1.6	0.2	8.8
101	3.0	0.5	15.5	1.9	0.0	11.3
102	2.0	0.0	26.8	3.4	0.0	14.5
103	2.8	0.6	32.1	1.5	0.0	16.2
104	3.3	0.0	23.0	0.9	0.4	9.2
111	3.0	0.1	30.7	2.8	0.3	14.8
112	2.6	0.0	30.4	3.1	0.0	18.7
113	6.6	0.2	44.9	3.4	0.9	30.1
114	4.1	0.4	29.4	4.6	0.0	12.4
115	3.4	0.6	21.5	8.3	0.0	14.4
116	3.6	1.4	23.7	3.1	0.0	9.7
121	0.6	2.1	25.8	0.7	0.0	9.8
122	1.7	1.6	31.7	1.6	0.0	12.2
131	1.9	0.6	24.5	2.4	0.0	13.6
132	3.1	3.3	25.7	2.0	0.3	15.1
133	2.0	0.7	29.9	2.0	0.0	17.8
134	1.7	3.1	24.3	2.9	0.3	12.2
135	2.8	0.5	36.3	4.3	0.1	16.3
140	2.3	4.4	24.2	2.6	0.3	11.2

Table 5 (Cont.) – Mode Split Factors (%)

	Work Trip Origins			Work Trip Destinations		
gm	Other	GO Rail	Transit	Other	GO Rail	Transit
151	0.6	8.4	12.1	1.4	0.0	7.9
152	2.5	7.0	17.2	5.3	0.0	10.7
161	1.5	2.0	23.6	1.9	0.0	11.1
162	2.8	1.8	21.1	2.4	0.0	10.1
163	2.9	2.1	21.1	2.1	0.1	11.3
164	2.2	2.1	23.6	1.3	0.3	11.4
170	4.7	0.0	0.0	9.7	0.0	0.0
180	1.4	1.9	0.6	2.2	0.0	1.5
190	2.5	1.0	0.6	4.3	0.0	0.0
201	0.9	10.9	2.3	1.2	1.0	0.9
202	0.0	7.0	0.0	0.0	0.0	0.0
210	1.2	13.7	3.2	2.2	0.7	1.5
221	1.7	7.9	1.7	0.6	0.5	1.1
222	1.1	10.7	1.7	4.0	0.2	0.4
231	2.7	3.9	3.4	2.4	0.3	3.0
232	2.7	4.7	2.3	4.5	0.1	2.0
240	1.8	3.8	0.6	3.5	0.0	0.5
250	1.5	0.6	0.2	3.8	0.0	0.0
260	0.3	1.9	0.9	2.2	0.0	0.0
270	2.3	4.1	2.9	2.5	0.0	1.6
280	1.7	2.5	3.0	3.0	0.0	0.8
291	1.0	4.6	6.2	2.0	0.0	2.1
292	1.3	5.8	8.2	3.1	0.2	3.6
293	0.4	8.4	11.4	0.5	0.0	6.1
300	3.3	5.1	0.0	4.2	0.0	0.4
311	2.1	2.8	16.4	1.3	0.0	6.2
312	2.2	2.9	8.8	0.5	0.1	4.7
313	1.0	6.6	4.6	1.7	0.0	2.9
314	0.7	3.5	13.7	0.6	0.0	5.4
315	0.0	0.0	0.0	1.6	0.0	0.0
320	1.7	1.8	1.8	2.5	0.0	0.3
331	0.0	2.3	3.2	0.0	0.0	2.9
332	1.0	1.0	4.9	0.5	0.0	4.0
333	0.7	1.4	13.0	0.2	0.0	5.5
334	0.3	3.1	4.8	0.3	0.0	1.9
335	1.9	0.2	17.3	4.9	0.0	12.1
341	1.1	2.0	0.9	1.7	0.0	0.0
342	1.1	1.8	0.5	2.3	0.0	0.0
351	0.0	3.9	3.8	0.0	0.0	0.7
352	1.3	4.6	4.3	2.6	0.2	4.4
353	0.0	0.0	0.0	0.4	0.0	4.1
354	1.1	3.7	5.5	1.7	0.0	4.1
355	0.0	1.9	0.0	0.9	0.0	2.6
356	1.0	3.8	3.7	2.8	0.2	2.7
361	2.1	16.7	5.3	2.3	0.5	3.4
362	1.9	9.2	5.4	7.0	1.4	5.4
363	1.2	7.8	4.7	1.5	0.2	4.3
364	1.7	5.6	12.1	2.1	0.1	6.3
365	0.7	8.1	2.0	0.9	0.0	3.4
366	0.3	7.1	6.8	0.4	0.0	5.3
367	1.5	2.0	13.2	0.7	0.0	5.3
368	1.7	2.9	13.9	2.6	0.3	6.5
371	3.0	7.5	0.8	6.2	0.0	0.9
372	2.2	3.5	0.7	4.2	0.0	0.0

Table 5 (Cont.) – Mode Split Factors (%)

gm	Work Trip Origins			Work Trip Destinations		
	Other	GO Rail	Transit	Other	GO Rail	Transit
381	2.9	3.8	0.7	2.8	0.0	0.0
382	0.0	7.0	0.0	1.3	0.3	0.0
391	2.8	13.3	2.5	2.4	1.1	2.1
392	1.4	17.1	1.4	0.7	1.0	0.8
393	2.3	15.0	2.2	2.6	0.0	2.5
394	0.4	17.1	1.1	1.9	0.0	0.8
401	1.6	2.5	1.0	1.8	0.5	1.6
402	1.9	7.9	2.3	1.8	0.5	2.0
403	1.2	8.1	0.9	1.3	0.2	1.5
404	0.0	2.5	0.0	3.8	0.0	0.0
410	1.8	2.7	0.2	2.6	0.0	0.6
420	5.2	1.2	2.1	7.8	0.0	3.1
430	1.2	1.3	0.5	3.1	0.0	0.9
440	1.7	0.0	0.0	3.5	0.0	1.4
450	0.5	0.8	2.2	1.5	0.0	2.0
461	2.9	1.8	4.6	4.7	0.0	5.0
462	3.4	1.2	6.4	4.9	0.2	6.6
463	11.8	2.8	13.2	7.7	0.1	9.8
464	8.0	2.1	7.0	2.8	0.0	3.8
Mean Values						
Toronto	6.2	1.2	31.3	5.1	7.1	28.9
Durham	1.7	7.8	2.0	2.7	0.4	1.4
York	1.3	3.5	7.3	1.3	0.0	4.3
Peel	1.2	5.7	6.2	1.3	0.1	4.6
Halton	1.8	10.1	1.4	2.1	0.4	1.4
Hamilton	4.1	1.7	4.9	5.0	0.0	5.7
Total	3.7	3.7	16.4	3.6	3.7	16.1

Table 6 – Non-Zero External Mode Split Factors (%)

(For trips made to or from the GTA and Hamilton)

Zone	Description	Work Trip Origins to the GTA or Hamilton	
		GO Rail	Transit
4002	City of Peterborough	1.4	5.0
4003	Peterborough County	1.1	0.0
4004	Kawartha Lakes South	1.1	1.1
4100	Simcoe South	2.0	2.5
4101	Simcoe West	0.8	2.5
4102	Barrie	1.5	4.9
4103	Simcoe North	0.0	2.3
4104	Orillia	0.0	3.5
4201	Orangeville	1.5	0.0
4301	Guelph	1.2	3.9
4302	Wellington South	2.7	0.0
4303	Wellington North	4.8	0.0
4401	Cambridge	***0.0***	***2.5***
4402	Kitchener-Waterloo	***0.4***	***2.1***
4405	Grimsby	2.7	0.0
4406	St Catharines	1.0	3.6

1.3 Trip Distribution

Trips to 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. School trips made by local transit are distributed by factoring each row of the applicable "base" matrix to the desired row totals. 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 matrices have been derived from the 2001 TTS data, supplemented by 1996 TTS data for Waterloo and Northumberland and 1991 Census Place of Work – Place of Residence data for the Regional municipality of Haldimand-Norfolk and the County of Brant. These "probability" matrices have the following properties

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 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 is no existing trip data. The resulting trip length distribution should be similar to that observed in other areas. The GO Rail and transit matrices do have some zero row and column totals. These are in areas where there is currently no ridership at all even at a very aggregate level (e.g. Planning District).

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 values. 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 have 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 high propensity for very short trips to occur, either intra-zone or between adjacent zones. 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 7. 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. A single interval would likely have been sufficient. At the time the calibration of the trip distribution component was carried out the model was structured to provide estimates of trip movements within and between external zones.

The structure (trip rates) for external zones was subsequently changed to only include trips to/from the GTA and Hamilton. The external values (interval 25) in all the base matrices were changed to zero at that time. Since the values in the matrices represent relative probabilities there was no need to change other values.

The base matrix for local transit school trips was obtained through the same process as was used for the auto trip distribution except that in addition to the third dimension balancing coefficients the column balancing coefficients were also applied in calculating the base matrix prior to normalizing the values in each row to sum to a value of 1. At the current time the same base local transit school matrix is being used as in the 1996 version of the model.

Figure 4 - Zone Aggregations Used for Trip Distribution

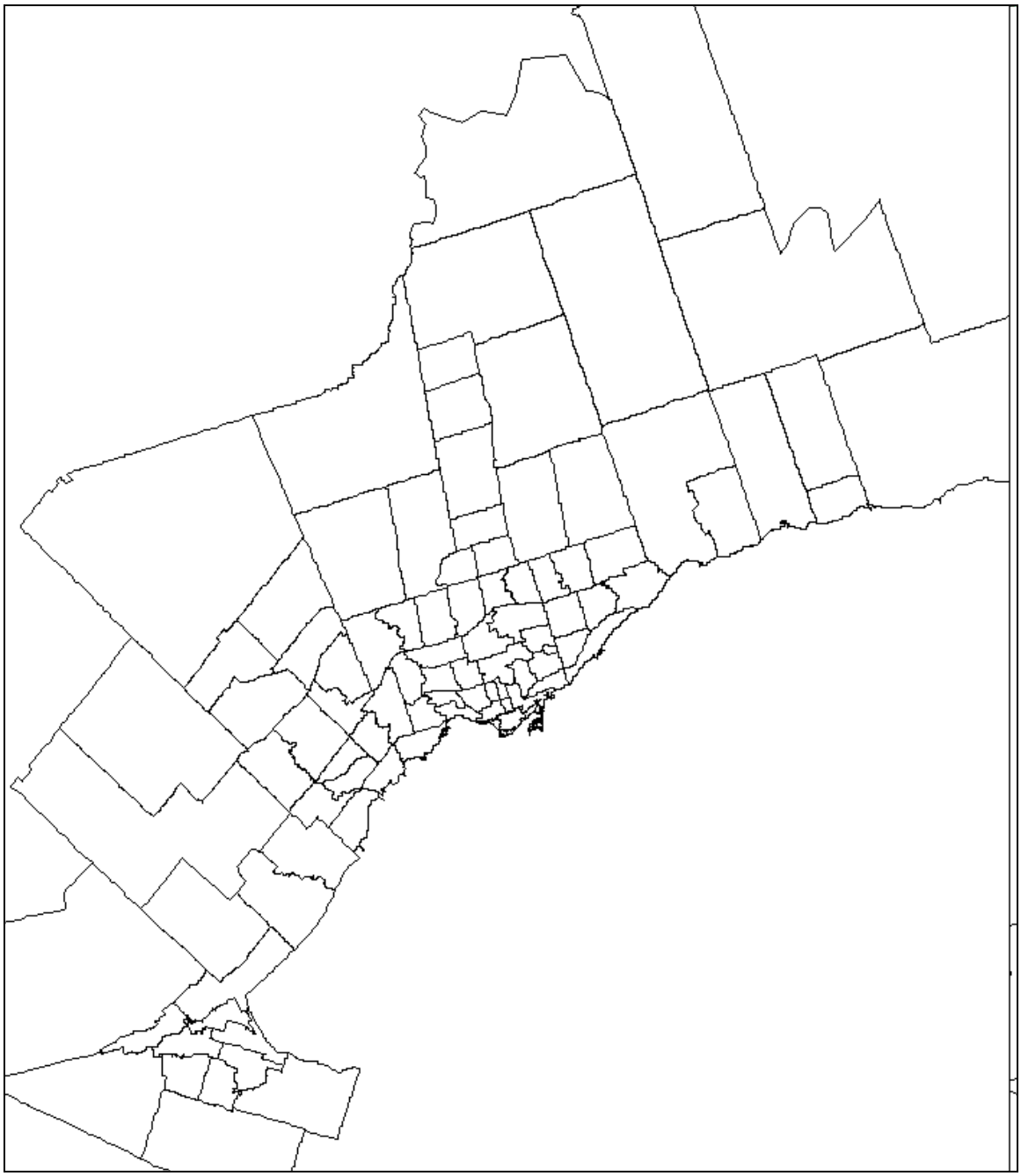


Table 7 – Calibration of Auto Trip Distribution

Third Dimension		Auto Work		Auto Non-Work	
Index	Lower bound (minutes)	Observed trips (TTS)	Balancing Coefficients	Observed trips (TTS)	Balancing Coefficients
Intra-zone group					
1	0	18735	1.86548	96205	2.63789
2	0.5	32496	1.22053	99831	1.3849
3	3.5	38741	1.00135	83430	.73701
4	5.5	29463	.79973	41741	.37635
5	7.5	31314	.68505	25674	.20176
6	12.5	9826	.53207	5077	.13622
Inter-zone group					
7	0	39305	1.45849	53260	2.14266
8	5.5	48122	1.16025	43475	1.16356
9	7.5	95758	1.00101	58481	.77137
10	10.5	112727	.9488	47483	.65028
11	13.5	109354	.89267	35405	.64209
12	16.5	101282	.89431	26033	.62974
13	19.5	111990	.87714	24437	.67183
14	23.5	144914	.87618	27843	.65824
15	30.5	109570	.85458	18196	.7021
16	40.5	138109	.87038	23285	.68677
External areas					
17	East in	5991	.8977	1735	.8131
18	East out	1983	.90761	1459	.70872
19	North in	22934	.92692	3743	.82437
20	North out	3747	.89233	2534	.72416
21	West in	18354	.88706	3165	.77426
22	West out	3321	.92949	1796	.75891
23	South in	17262	.80419	3830	.66594
24	South out	6355	1.10209	2227	1.03825
25	Ext. to Ext.	365304	.9172	217082	.83329

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 primary purpose of the trip distribution process is to "smooth" out the TTS data replacing many 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 8 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 total number of cells in each trip matrix is approximately 3 million (1703 x 1703). 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 today between these areas the number will not become significant within the time frame to which the model is applied. In the case of GO rail and local transit there are some entire municipalities for which there are no trips recorded in the TTS database. In these cases the entire

block of rows and/or columns has been left as zero. Any trip ends assigned to those zones at the mode split stage of the model are ignored in the trip distribution process.

Table 8 - Trip Distribution Matrices

Trip Category	No. of trips (2001 TTS)	Number of non zero cells	
		2001 TTS	Base matrix (Possible O-D pairs)
Auto work	1,438,030	57,085	1,903,127
GO Rail work	55,179	2,446	138,612
Local Transit work	237,014	11,099	515,268
Auto Non work	871,369	22,570	1,114,542
Local Transit School	117,806	4,711	148,048

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 the original 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. The histograms and link scattergrams produced by these comparisons are contained in Appendix C. Table 9 gives a summary of those results.

Table 9 – Validation of Trip Distribution

	Observed 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	19.5	14.9	19.6	14.9	24	.984	.999
Auto non-work	9.7	12.3	9.8	12.3	30	.924	.984
GO Rail	35.5	11.0	35.5	10.9			
Local Transit	14.9	9.4	15.1	9.4			

1.4 Auto Assignment

Prior to assignment the matrices for the different trip purposes are aggregated. An auto occupancy matrix is used to calculate the number of auto vehicles (auto drivers) and a peak hour factor is applied. The base case auto occupancy factors are shown in Tables 10 and 11. 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 10 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 at the region to region level. These values, shown in Table 11, are used for all trip movements not shown in Table 11.

Intra-municipal trip movements within the Cities of Brampton and Mississauga are further sub-divided by the zone groups used for trip generation and mode split (See Figure 2). These values, also shown in Table 10, are used where the zone group to zone group movement exceeds 1000 persons. Those movements are excluded from the municipal averages used for the remaining cells.

In general it can be seen that average auto occupancy is lower for medium length trips than it is for either short trips or very long trips. Intra-municipal trips (values shown in bold type) 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.

Table 10 - Auto Occupancy Factors – By Municipality (gp) or Zone Group (gg)

From	To		From	To		From	To		From	To		From	To		From	To	
1	1	**1.19**	5	1	1.18	9	9	**1.44**	13	12	1.14	20	21	1.19	29	4	1.15
	2	1.21		3	1.19		10	1.26		13	**1.33**		31	1.08		5	1.14
	3	1.30		4	1.32		33	1.24		14	1.46	21	13	1.15		10	1.17
	4	1.14		5	**1.38**		35	1.16		15	1.20		16	1.13		11	1.18
	5	1.12		6	1.30		36	1.11		16	1.25		20	1.11		12	1.09
	6	1.22		10	1.07	10	1	1.21		31	1.16		21	**1.39**		16	1.07
	13	1.07		11	1.21		3	1.27		33	1.18		22	1.14		29	**1.42**
	36	1.07		12	1.18		4	1.15		36	1.08		23	1.22		31	1.19
2	1	1.30		13	1.16		8	1.15	14	1	1.23		31	1.11		33	1.15
	2	**1.33**		16	1.14		9	1.25		6	1.37	22	1	1.12		36	1.01
	3	1.19		31	1.11		10	**1.34**		13	1.27		13	1.02	30	30	**1.20**
	4	1.10		33	1.18		11	1.23		14	**1.45**		16	1.08		31	1.10
	8	1.17		36	1.06		33	1.27		16	1.14		20	1.05	31	1	1.22
	9	1.20	6	1	1.28		35	1.18	15	1	1.48		21	1.11		4	1.13
	10	1.15		2	1.19		36	1.14		5	1.17		22	**1.32**		5	1.14
	33	1.11		4	1.23	11	1	1.20		13	1.19		23	1.17		10	1.11
	36	1.10		5	1.20		3	1.14		14	1.49		31	1.08		11	1.15
3	1	1.28		6	**1.28**		4	1.22		15	**1.49**	23	13	1.08		12	1.16
	2	1.47		12	1.06		5	1.22		16	1.29		16	1.12		13	1.16
	3	**1.35**		13	1.14		10	1.15		31	1.08		20	1.10		16	1.16
	4	1.24		14	1.27		11	**1.40**	16	1	1.27		21	1.20		29	1.10
	5	1.17		16	1.11		12	1.23		4	1.24		22	1.12		31	**1.37**
	8	1.25		31	1.10		13	1.21		5	1.17		23	**1.28**		33	1.10
	9	1.20		36	1.10		16	1.09		10	1.21		24	1.08		36	1.09
	10	1.21	7	1	1.18		29	1.17		11	1.26	24	20	1.12	32	32	**1.12**
	11	1.22		7	**1.33**		31	1.11		12	1.24		22	1.07	33	1	1.16
	31	1.14		8	1.27		33	1.15		13	1.18		23	1.13		3	1.14
	33	1.24		36	1.11		36	1.05		15	1.43		24	**1.25**		4	1.16
	35	1.17	8	1	1.19	12	1	1.29		16	**1.43**	25	25	**1.18**		5	1.17
	36	1.21		2	1.22		5	1.34		29	1.06		27	1.13		8	1.07
4	1	1.16		3	1.21		10	1.25		31	1.17		31	1.09		9	1.12
	3	1.22		4	1.25		11	1.30		33	1.11	26	26	**1.25**		10	1.16
	4	**1.33**		7	1.10		12	**1.50**		36	1.14		27	1.19		11	1.32
	5	1.21		8	**1.36**		13	1.19	17	17	**1.05**	27	27	**1.27**		29	1.13
	6	1.23		9	1.16		16	1.27	18	18	**1.31**		28	1.12		31	1.21
	10	1.08		10	1.06		31	1.07	19	19	**1.27**		29	1.08		33	**1.30**
	11	1.28		33	1.05	13	1	1.27		23	1.07		31	1.06		35	1.08
	13	1.12		35	1.09		4	1.25	20	1	1.14	28	27	1.09		36	1.05
	16	1.01		36	1.08		5	1.23		5	1.26		28	**1.35**	34	9	1.14
	31	1.05	9	1	1.12		6	1.26		13	1.13		29	1.27		33	1.10
	33	1.08		3	1.19		10	1.16		16	1.15		31	1.11		34	**1.16**
	36	1.08		8	1.35		11	1.28		20	**1.28**	29	1	1.16		35	1.14

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 10 (Cont.) - Auto Occupancy Factors by Municipality or Zone Group (gg)

From	To		From	To		From	To		From	To		From	To		From	To	
34	36	1.07	36	8	1.11	38	39	1.11	43	43	**1.35**	Peel sub-areas (gg)					
35	1	1.18		9	1.14	39	1	1.15		46	1.13	352	363	1.24	364	360	1.38
	3	1.08		10	1.08		8	1.15	44	46	**1.15**	354	353	1.26		362	1.25
	4	1.29		11	1.06		35	1.07	45	40	1.08		354	**1.43**		363	1.16
	8	1.09		13	1.15		36	1.09		45	**1.27**		355	1.46		364	**1.39**
	9	1.18		16	1.12		39	**1.29**		46	1.16		356	1.28	365	359	1.20
	10	1.17		31	1.05		40	1.12	46	36	1.09		363	1.16		360	1.17
	11	1.30		33	1.08		46	1.05		39	1.11	356	352	1.46		361	1.37
	33	1.11		35	1.12	40	1	1.12		40	1.11		353	1.19		362	1.15
	34	1.50		36	**1.21**		36	1.06		41	1.25		354	1.29		363	1.09
	35	**1.15**		38	1.11		38	1.08		42	1.13		356	**1.39**	366	360	1.21
	36	1.10		39	1.15		39	1.10		43	1.18		363	1.19		361	1.25
	39	1.15		40	1.05		40	**1.30**		45	1.16	361	357	1.47		362	1.42
36	1	1.16	37	35	1.13		46	1.08		46	**1.27**	362	358	1.41		363	1.16
	2	1.13		36	1.07	41	40	1.15	Peel sub-areas (gg)			363	359	1.44	367	363	1.29
	3	1.12		37	**1.23**		41	**1.19**	352	352	**1.44**		360	1.15	368	363	1.31
	4	1.17		38	1.18		46	1.16		353	1.57		361	1.09		364	1.38
	5	1.12	38	36	1.11	42	42	**1.33**		356	1.13		363	**1.07**			
	7	1.11		38	**1.23**		46	1.12		362	1.06						

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 11 - Auto Occupancy Factors – By Region

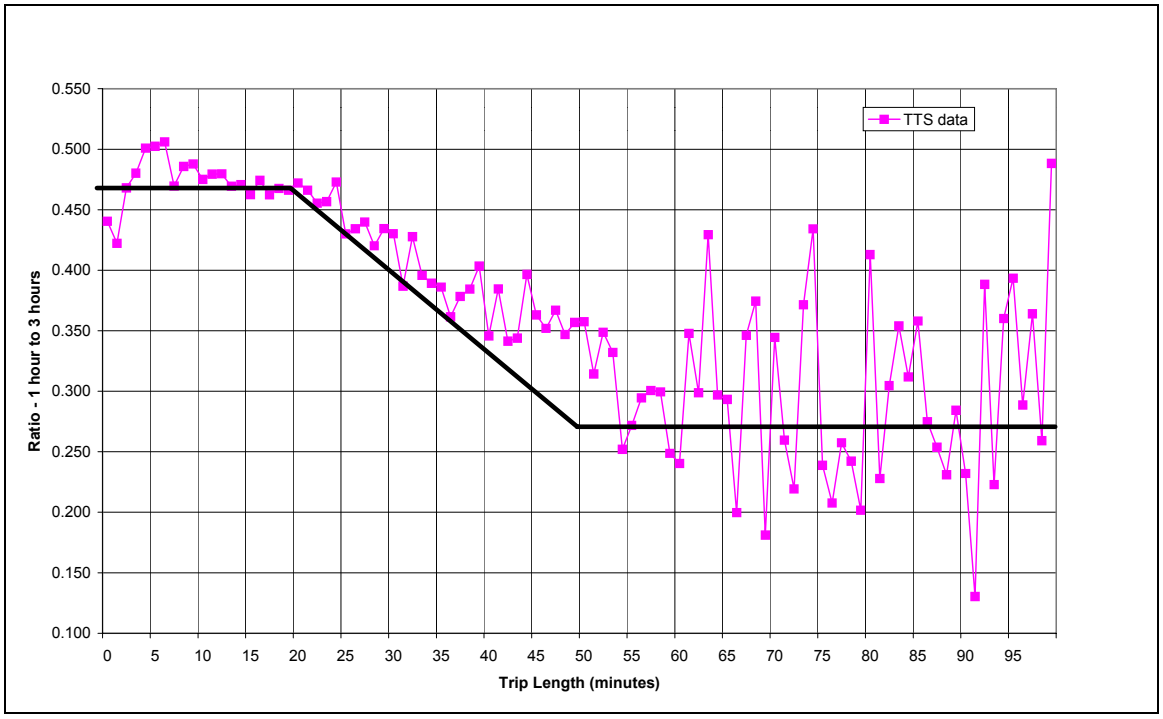
From \ to	Toronto	Durham	York	Peel	Halton	Hamilton	External
Toronto	**1.12**	1.10	1.11	1.09	1.11	1.08	1.12
Durham	1.12	**1.11**	1.10	1.09	1.18	1.18	1.14
York	1.09	1.12	**1.12**	1.07	1.11	1.11	1.07
Peel	1.11	1.15	1.05	**1.15**	1.10	1.07	1.15
Halton	1.05	1.07	1.05	1.06	**1.06**	1.08	1.09
Hamilton	1.09	1.03	1.03	1.04	1.06	**1.16**	1.06
External	1.11	1.08	1.08	1.11	1.11	1.11	**n/a**

Values exclude those trip movements shown in Table 10

Table 12 – Peak Hour Factors

	1 hour	3 hours	Ratio
Trips (2001 TTS)	857,890	1,923,043	0.446
trips < 20 mins	615,870	1,312,958	0.469
% of total & assumed ratio	72%	68%	0.47
trips > 50 mins	41,821	127,381	0.328
% of total & assumed ratio	5%	7%	0.27

Figure 5 – Peak Hour Factor



The factor applied to convert peak period to peak hour is based on the estimated travel time by road in 2001 between each zone pair. A conversion factor of 0.47 is applied to trips with a travel time of less than 20 minutes and 0.27 for trips greater than 50 minutes. Linear interpolation is used to determine the appropriate factor for trips with a travel time greater than 20 minutes but less than 50 minutes. These factors were obtained from the 2001 TTS data shown in Table 12. The factor for long trips has been reduced by almost 20% for 2 reasons. Firstly the TTS data is based on trip start time whereas the volume assigned to a link in the network includes trips from many different origins requiring different amounts of time to reach that point. Across the network as a whole these delays are likely to produce a more uniform dispersal of trip times particularly for long trips. The peak hour factor for long trips is reduced further to take into account the accumulated effect of delays due to congestion on critical links in the network. If the resulting queues are not dissipated until after the peak period is over then the number of trips observed, based on trip start time, actually represents a longer period time than the 3 hours for which the data was extracted. Figure 5 shows a comparison of the assumed relationship with the observed data from TTS. The conversion factors, and the time ranges to which they apply, may be modified when applying the model to future scenarios.

The modelling procedures include the option to add in a "background traffic" matrix prior to assignment. This matrix is used to represent the auto egress component of GO Rail and subway trips as reported in the 2001 TTS. The TTS gives the access station and the GTA zone of trip origin. The matrix, extracted from the 2001 TTS data, is peak period auto drivers. In the modelling procedure the peak hour factor is applied but no auto occupancy factor. The model has provision for factoring the supplementary matrix both globally and selectively by destination zone (station) to reflect projected growth in GO Rail and subway ridership.

1.5 Transit Assignment

The transit assignment is performed in two stages. GO Rail trips are assigned allowing the use of all transit modes. The integrated GTA network has been modified to include the auxiliary transit mode "z" on most

road links outside the City of Toronto with a fixed operating speed of 40 kph. Mode “z” is used to represent the auto access component of GO Rail trips. The assignment procedure does not "force" trips on to GO Rail if the network provides a more attractive alternative using local transit. The assigned GO Rail volumes may therefore be slightly less than the volumes obtained from the mode split calculations. GO Rail volumes can also be obtained by aggregating the trip matrix to station catchment area (ensemble gs). These volumes will be consistent with the mode-split calculations.

Local transit trips are assigned without permitting the use of modes “r” or “z” (GO Rail and GO Rail access). The resulting transit assignment does not include the use of local transit to provide access or egress to GO Rail stations, other than in the City of Toronto, unless local transit provides for a faster alternative than mode “z” (highly unlikely).

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 separate networks can be used. The latter is strongly recommended for most applications.

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.

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. Some have already been built into current Halton Region model applications.

2.1 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.

2.2 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 2001 trip distribution.

2.3 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:

$P_2 = 1.01(1- x)$

$P_3 = 0.16(1 - x)$

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 Table 6 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 p.m. peak period (0.85 and 0.1).

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.

2.4 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 13. 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 13 - 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.

1. The original zone numbers are retained, either as one of the sub-zone numbers or as dummy zones with zero population and employment.
2. 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 Validation

Validation of the model consists primarily of comparisons between a 2001 "Base Case" simulation, the 2001 TTS data and available cordon count information. The network used in the calibration of the model was Release 1 of the 2001 integrated network developed at the DMG. The same network, with minor modifications made by City of Mississauga staff, was used in the validation.

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 1996 TTS database. The base case simulation (2001aa) uses a combination of population from the census and employment data from the TTS. The total GTA population reported in the TTS is 3.3% lower than that given by the census. 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. No adjustment has been made to the trip rates but a global adjustment factor of .97 is recommended when applying the trip rates to population estimates based on census data.

Table 14 - Population Data by Region

	2001 TTS	2001 Census	Base Case (2001aa)
Toronto	2,368,717	2,476,177	2,476,178
Durham	492,197	506,901	506,897
York	720,954	729,254	729,245
Peel	954,231	988,948	988,947
Halton	364,107	375,229	375,229
Hamilton	485,957	490,268	490,275
Total GTA	5,386,163	5,566,777	5,566,771

Employed Labour Force is not calculated or used directly in the model but is clearly a factor in determining trip generation rates. Table 15 compares the TTS and Census data. 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 15 - 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 GTA	2,753,450	2,835,200	-81,750	-2.9%

Table 16 provides a comparison of employment data. The same comments, with respect to timing and definitions, apply as for the employed labour force. In addition the TTS employment figures do not include workers who live outside the TTS area. Scaling factors have been applied to increase the total employment

by approximately 2000 in the Region of Halton and approximately 9,500 in the City of Hamilton based on previous estimates of the proportion of total employment in those areas that consists of residents from outside the 2001 survey area. The census and adjusted TTS employment totals for the GTA are almost identical. If future employment estimates are derived from either the TTS or census data no adjustment of employment based trip rates should be necessary.

Table 16 - Employment by Region

	2001 TTS	2001 Census	Base Case (2001aa)	Difference (Relative to the census)	
Toronto	1,339,544	1,327,610	1,339,544	11,934	0.9%
Durham	164,319	163,550	164,319	769	0.5%
York	353,380	350,165	353,380	3,215	0.9%
Peel	480,866	487,495	480,866	-6,629	-1.4%
Halton	163,067	173,940	165,071	-8,869	-5.1%
Hamilton	182,599	188,370	192,106	3,736	2.0%
Total GTA	2,683,775	2,691,130	2,695,286	4,156	0.2%

3.2 Trip Generation, Mode Split and Distribution

Table 17 compares the simulated trip total in each trip category. The mean and standard deviation of trip time shown have been generated using the travel matrix produced by an equilibrium assignment of the TTS data to the road network. The simulation includes trip movements to and from some areas not included in the TTS (Brant, Haldimand-Norfolk and the excluded sections of Northumberland, Peterborough, Simcoe, Dufferin and Wellington Counties). Trips external to the GTA and Hamilton have been excluded from the values shown in Table 17 in order to provide a consistent comparison. The simulated auto non-work trip total is higher than the TTS data due to the adjustment of trip rates that takes into account the known under-reporting of trips in that category in the TTS data.

Table 17 - Trip Totals and Travel Time Distributions within the GTA and Hamilton

Trip Category	2001 TTS data			Base Case Simulation (2001aa)		
	Total trips	Minutes by road		Total trips	Minutes by road	
		Mean	S.D		Mean	S.D
GO Rail Work	54,543	53.8	14.2	54,557	53.6	14.4
Local Transit Work	234,270	20.1	12.5	234,880	20.5	12.5
Auto Work	1,171,543	20.7	14.9	1,167,721	21.0	15.2
Auto Non-Work	709,716	9.6	11.2	738,353	10.1	11.5
Local Transit School	113,184	12.3	11.2	113,879	11.9	11.0
Total auto person	1,881,423	16.5	14.7	1,906,074	16.8	14.9
Total GO Rail	58,469	53.7	14.3	58,376	53.6	14.4
Total local transit	366,967	17.3	12.6	369,685	17.7	12.7
Peak hour auto driver	700,232	16.1	13.5	720,936	15.7	13.3

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

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 18 compares the base case simulated work trip self containment with the corresponding values obtained from the TTS data. The table is for the a.m. peak period and includes trips by all modes that have "work" as the destination trip purpose. Trips from 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 with the TTS data. The observed values from the 1986, 1996 and 2001 surveys are included to give an indication of the historical trend.

Table 19 is similar to Table 18 but for peak period auto person and peak hour auto driver trips by origin (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, less than half the length of work trips. 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.

Table 18 – Municipal Self Containment of a.m. Peak Period Work Trips

	% of Total Work Trip Origins				% of Total Work Trip Destinations			
	1986 TTS	1996 TTS	2001 TTS	**2001aa**	1986 TTS	1996 TTS	2001 TTS	**2001aa**
PD1-Toronto	60	58	60	**66**	10	12	12	**11**
PD2-Toronto	11	11	12	**19**	25	25	26	**42**
PD3-Toronto	20	17	16	**19**	27	24	25	**30**
PD4-Toronto	17	15	16	**19**	19	18	18	**20**
PD5-Toronto	15	12	13	**16**	12	10	10	**12**
PD6-Toronto	13	11	12	**16**	34	31	31	**45**
PD7-Toronto	20	12	11	**14**	20	15	17	**23**
PD8-Toronto	16	18	16	**18**	21	19	18	**20**
PD9-Toronto	24	18	18	**19**	14	12	13	**13**
PD10-Toronto	29	27	23	**25**	23	17	17	**18**
PD11-Toronto	14	13	15	**17**	17	14	14	**15**
PD12-Toronto	7	7	7	**8**	9	7	7	**7**
PD13-Toronto	25	18	21	**23**	24	20	22	**24**
PD14-Toronto	5	5	5	**6**	19	19	16	**21**
PD15-Toronto	7	6	7	**8**	24	19	22	**27**
PD16-Toronto	12	16	19	**20**	21	19	20	**24**
Brock	47	35	31	**25**	77	68	71	**72**
Uxbridge	23	24	25	**24**	51	52	50	**53**
Scugog	32	27	34	**33**	68	68	67	**65**
Pickering	14	13	15	**14**	21	21	23	**23**
Ajax	21	15	14	**14**	31	29	27	**27**
Whitby	25	21	20	**20**	34	31	33	**33**
Oshawa	56	43	39	**39**	63	54	51	**53**
Clarington	40	24	26	**24**	48	57	61	**60**
Georgina	28	26	27	**24**	75	75	74	**73**
East Gwillimbury	6	8	6	**5**	31	29	24	**21**
Newmarket	31	24	33	**33**	44	37	41	**41**
Aurora	19	19	17	**18**	29	32	30	**31**
Richmond Hill	20	18	14	**15**	27	23	24	**25**
Whit.-Stouff.	19	15	16	**16**	30	25	25	**25**
Markham	20	24	27	**27**	17	19	22	**22**
King	9	11	13	**12**	27	27	25	**21**
Vaughan	18	24	27	**29**	12	18	24	**24**
Caledon	15	20	20	**19**	46	45	47	**45**
Brampton	40	34	35	**36**	55	51	52	**55**
Mississauga	43	45	50	**51**	44	44	44	**46**
Halton Hills	36	27	25	**23**	75	63	55	**58**
Milton	37	39	36	**34**	58	48	36	**32**
Oakville	36	32	28	**29**	43	38	32	**33**
Burlington	40	38	36	**37**	52	50	42	**44**
Flamborough	20	20	14	**12**	42	42	32	**35**
Dundas	18	17	16	**21**	40	29	39	**51**
Ancaster	15	13	14	**13**	30	28	27	**30**
Glanbrook	6	9	10	**10**	18	30	28	**26**
Stoney Creek	21	20	17	**18**	31	34	28	**29**
Hamilton	76	69	65	**68**	70	66	66	**67**

Table 19 – Municipal Self Containment of Auto Trips by Destination

	Peak Period Auto Person				Peak Hour Auto Driver			
	1986 TTS	1996 TTS	2001 TTS	**2001aa**	1986 TTS	1996 TTS	2001 TTS	**2001aa**
PD1-Toronto	37	36	35	**45**	37	35	37	**45**
PD2-Toronto	15	17	22	**26**	15	15	19	**25**
PD3-Toronto	24	24	26	**30**	24	23	25	**29**
PD4-Toronto	27	27	31	**34**	22	21	26	**31**
PD5-Toronto	21	24	26	**31**	17	20	23	**28**
PD6-Toronto	21	23	24	**27**	17	19	20	**27**
PD7-Toronto	26	23	21	**24**	22	21	16	**23**
PD8-Toronto	26	34	35	**39**	24	31	30	**36**
PD9-Toronto	28	28	31	**32**	24	25	30	**29**
PD10-Toronto	32	34	32	**36**	29	34	31	**34**
PD11-Toronto	27	29	31	**37**	24	24	26	**34**
PD12-Toronto	13	18	19	**20**	13	13	15	**18**
PD13-Toronto	35	32	33	**37**	36	32	30	**37**
PD14-Toronto	15	16	22	**21**	11	10	18	**21**
PD15-Toronto	19	22	25	**26**	16	21	22	**26**
PD16-Toronto	22	34	34	**36**	19	28	29	**34**
Brock	44	43	30	**24**	52	48	45	**33**
Uxbridge	32	39	40	**38**	37	39	45	**41**
Scugog	38	40	44	**42**	40	44	42	**45**
Pickering	23	31	36	**34**	21	28	33	**38**
Ajax	29	34	36	**36**	31	30	35	**38**
Whitby	33	39	40	**39**	31	44	39	**42**
Oshawa	64	57	56	**56**	67	57	60	**57**
Clarington	43	36	38	**35**	45	37	40	**35**
Georgina	35	34	39	**36**	49	42	48	**42**
East Gwillimbury	10	14	13	**12**	9	17	12	**12**
Newmarket	41	40	48	**48**	40	40	52	**51**
Aurora	27	34	33	**34**	25	33	33	**34**
Richmond Hill	24	34	34	**35**	21	31	31	**32**
Whit.-Stouff.	24	21	26	**25**	22	24	26	**28**
Markham	28	43	46	**45**	26	39	45	**43**
King	10	16	20	**16**	7	16	21	**19**
Vaughan	21	35	40	**41**	19	29	37	**39**
Caledon	21	31	28	**25**	18	29	36	**29**
Brampton	48	48	51	**53**	51	48	53	**52**
Mississauga	51	58	64	**66**	54	60	66	**67**
Halton Hills	42	40	39	**37**	45	37	39	**40**
Milton	46	53	50	**51**	44	49	52	**53**
Oakville	50	52	54	**54**	45	52	54	**56**
Burlington	49	52	55	**56**	48	52	56	**56**
Flamborough	24	28	24	**21**	21	30	25	**23**
Dundas	28	25	32	**36**	27	25	27	**34**
Ancaster	29	26	31	**31**	21	23	29	**29**
Glanbrook	7	12	11	**9**	5	14	11	**10**
Stoney Creek	28	30	27	**27**	30	28	29	**26**
Hamilton	76	74	73	**75**	78	74	73	**75**

3.3 Road assignment

Table 20 shows comparisons between the simulated peak hour traffic volumes from the base case (2001aa) assignment and cordon count data across the inter-regional screen lines within the GTA. The corresponding volumes obtained from a peak hour assignment of the TTS data are included for comparison. The simulated volumes are generally higher than the TTS volumes due to inclusion of simulated trips to and from areas not included in the TTS and the adjustment of non-work trip rates to reflect the under-reporting of those trips in the TTS.

The cordon count data were collected in the spring and summer of 2001 whereas the TTS data used to calibrate the model were collected in the fall. On average the model under simulates the observed screen line volumes in the peak direction by 2% and the reverse direction by 5%. The most serious discrepancy is an 11% difference between the observed and simulated traffic across the East Toronto boundary. While some of the percentage differences are larger across other screen lines the absolute magnitude of the differences are smaller. A number of problems exist in using the cordon count data as a comparison base for validation. The difference in timing relative to the TTS is one problem. Substantial variations in traffic volumes can occur on a day to day basis but most of the counts are for a single day, not an average taken over an extended period times. Anomalies in the cordon count data for individual count stations exist both with respect to the counts taken in previous and the counts on adjacent links taken by different regions.

Table 20 – Inter-Regional Screen Line Comparisons

Screen line	Dir	Cap. Vph	Count	2001 TTS	Sim. 2001aa	TTS/ Count	**sim/ count**	Sim v/c
Peak Direction								
York > Toronto	S	73600	49823	48984	49748	0.98	1.00	0.68
Durham > Toronto	W	34700	30562	27185	26180	0.89	0.86	0.75
Peel > Toronto	E	50000	33499	33374	35029	1.00	1.05	0.70
Halton > Peel	E	30300	20135	16149	18746	0.80	0.93	0.62
Peel > York	E	13200	7619	8055	7597	1.06	1.00	0.58
Durham > York	W	14500	1049	891	1495	0.85	1.42	0.10
Hamilton > Halton	N	14900	10628	9968	10416	0.94	0.98	0.70
External > Halton	E	21300	12891	7450	12904	0.58	1.00	0.61
External > York	S	6600	5550	5084	5517	0.92	0.99	0.84
External > Durham	W	10400	993	55	634	0.06	0.64	0.06
Total		**269500**	**172749**	**157195**	**168266**	**0.91**	**0.97**	**0.62**
Reverse Direction								
York < Toronto	N	73600	32629	30963	33498	0.95	1.03	0.46
Durham < Toronto	E	34700	9762	10671	9430	1.09	0.97	0.27
Peel < Toronto	W	47400	24214	25870	24002	1.07	0.99	0.51
Halton < Peel	W	30200	8768	9471	10026	1.08	1.14	0.33
Peel < York	W	13200	8850	5334	5281	0.60	0.60	0.40
Durham < York	E	20000	529	567	508	1.07	0.96	0.03
Hamilton < Halton	S	14900	7194	7979	6381	1.11	0.89	0.43
External < Halton	W	21300	8107	4573	4283	0.56	0.53	0.20
External < York	N	6600	1893	1731	1165	0.91	0.62	0.18
External < Durham	E	10400	704	386	341	0.55	0.48	0.03
Total		**272300**	**102651**	**97545**	**94916**	**0.95**	**0.92**	**0.35**

The network representation, particularly the location of centroid connectors, and the correct identification of the appropriate links that correspond to the count locations is also critical to the comparison. Each discrepancy between simulated and observed volumes needs to be investigated individually to determine the source of the problem (counts, network representation or the model). Such detailed validation needs to be done on an area specific basis, usually as one of the first steps in a planning study. The initial focus of the validation of the 2001 GTA model has been on the modelling needs of the City of Mississauga. Table 21 shows the results for the screen lines within the City of Mississauga. The network representation used in these comparisons contains some minor modifications made by the City including some differences in the selection of links that identify the inter-regional components of the screen lines. As a result the volumes and capacities may not be entirely consistent with those shown in Table 20.

Table 21 – City of Mississauga Screen Line Comparisons

A.M. Peak Hour - Peak Direction

Screen line	Dir	Cap(1 hr)	count	01 TTS	2001aa	TTS/ count	sim/ count	sim v/c
Mississauga/Toronto	E	57900	39924	38483	39640	0.96	0.99	0.68
Mississauga/Halton	E	32200	19524	16339	19073	0.84	0.98	0.59
Credit River	E	34500	32559	32811	33417	1.01	1.03	0.97
E of Hwy 10 in Mississauga	E	44100	39047	27983	41265	0.72	1.06	0.94
N of the QEW in Mississauga	N	11500	7602	5839	6837	0.77	0.90	0.59
S of Hwy 401 in Mississauga	S	26000	14836	15781	14955	1.06	1.01	0.58
Brampton/Mississauga	S	28700	21475	18091	20325	0.84	0.95	0.71
Total		**234900**	**174967**	**155327**	**175511**	**0.89**	**1.00**	**0.75**

A.M. Peak Hour - Reverse Direction

Screen line	Dir	Capacity	count	01 TTS	2001aa	TTS/ count	sim/ count	sim v/c
Mississauga/Toronto	W	57900	30235	31875	29092	1.05	0.96	0.50
Mississauga/Halton	W	32200	10597	8833	10027	0.83	0.95	0.31
Credit River	W	34500	18965	18775	15481	0.99	0.82	0.45
E of Hwy 10 in Mississauga	W	42000	24571	28308	19413	1.15	0.79	0.46
N of the QEW in Mississauga	S	11500	7459	6740	7833	0.90	1.05	0.68
S of Hwy 401 in Mississauga	N	26000	19690	20117	22229	1.02	1.13	0.85
Brampton/Mississauga	N	28700	9585	8183	8503	0.85	0.89	0.30
Total		**232800**	**121102**	**122831**	**112577**	**1.01**	**0.93**	**0.48**
2 Directions Combined		**467700**	**326844**	**302678**	**319241**	**0.93**	**0.98**	**0.68**

3.4 Transit assignment

Table 22 shows a comparison of the results obtained from a simulation run using the GTA A.M. model with an assignment of the 2001 TTS data. In the validation of the TTS data showed that the number of a.m. peak period transit trips reported was within 2% of actual TTC ridership counts. Reported GO Rail ridership was within 3% of the counts. Peak period counts were not available for other transit operators. Daily ridership differed by between -20% (Mississauga) and +65% (Richmond Hill) with the TTS numbers being generally higher than the estimated counts provided by the transit operators.

Table 22 – A.M. Peak Period Transit (GTA model – GO Rail included)

Screen line	Peak direction					Reverse direction				
	Dir	# of routes	TTS	2001aa	Ratio	Dir	# of routes	TTS	2001aa	Ratio
Toronto										
North Toronto Boundary	S	45	23237	24443	1.05	N	33	5032	5968	1.19
East Toronto Boundary	W	8	11513	12822	1.11	E	4	436	389	0.89
West Toronto Boundary	E	64	38910	43002	1.11	W	42	3458	3159	0.91
Humber River	E	53	55503	58270	1.05	W	37	12608	12506	0.99
South of Hwy 401	S	76	67733	68161	1.01	N	48	23014	22809	0.99
Bala Sub-division		32	20391	22648	1.11	E	31	6488	7024	1.08
Sub-total		246	196895	206698	1.05		164	44548	44831	1.01
Peel										
Mississauga/Halton	E	21	16718	19933	1.19	W	13	904	500	0.55
Credit River	E	38	20786	22850	1.10	W	25	2924	2454	0.84
E of Hwy 10	E	80	38812	39914	1.03	W	68	9855	6572	0.67
N of the QEW in Mississauga	N	12	1225	1242	1.01	S	16	9328	3865	0.41
S of Hwy 401 in Mississauga	S	16	1300	1098	0.84	N	20	3137	2937	0.94
Brampton/Mississauga	S	14	3092	2699	0.87	N	19	1444	1094	0.76
Peel/York	E	4	447	304	0.68	W	2	38	45	1.20
Sub-total		185	82380	88040	1.07		163	27631	17467	0.63
York										
South York	S	15	3228	3149	0.98	N	7	134	500	3.73
East of Hwy 400	E	5	1277	884	0.69	W	7	2010	1622	0.81
West of Hwy 404	E	8	740	1398	1.89	W	10	3066	2805	0.91
Sub-total		28	5245	5431	1.04		24	5210	4926	0.95
Durham										
South of Hwy 401	N	76	67733	68161	1.01	S	48	23014	22809	0.99
Total		535	352254	368330	1.05		399	100404	90033	0.90
Bi-direction total		934	452658	458363	1.01					

4.0 Model Operation

4.1 Emme2bank

The emme2bank used to run the model may be a copy of an existing emme2bank already set up to run the model or a new emme2bank can be created using the command "emme2 newbank". If a new emme2bank is created it will need to be initialised with the required base matrices, zone ensemble and extra attribute data. The minimum recommended dimensions for a new emme2bank are shown in Table 23. The emme2bank will use about 800 Mbytes of disk space.

Table 23 – Emme2bank Dimensions

Attribute	Dimension
Scenarios	20
Centroids	1750
Nodes	16,000
Links	40,000
Turns	8,000
Transit vehicle types	10
Transit lines	800
Transit line segments	35,000
Full matrices	50
Origin matrices	200
Destination matrices	200
Scalars	999
Functions per class	99
Operators per function	2,000
Log book	500
Demarcation entries	100
Extra attributes	1 million

If the same emme2bank is to be used to run the GTA p.m. model it is recommended that the minimum number of full matrices is increased to 150 and the minimum number of scenarios to 30. This larger emme2bank will require 1.3 Gbytes of disk space.

Matrices

The matrices used in the running of the model are identified by name, not number. The matrix numbers may vary as each matrix is assigned to the first available number when first initiated. Matrix names generally consist of 4 characters, the first 2 of which are always the letters "am". The other two characters are generally those used as the matrix number in the previous version of the model. An exception to the previous naming convention is the scalars used to store the results of the transit assignment. These values result from network calculations the output of which has to be stored in a scalar matrix identified by I.D., not name. Appendix A contains a listing of the current matrix directory. Table 24 provides a summary of the current allocation by primary function.

The matrices used as input to the trip distribution component of the model have been pre-loaded along with the base matrices containing the 2001 travel times and GO Rail egress trips. For most applications of the model these matrices do not require modification and should be protected from accidental modification. The matrices are listed in Table 25. It is important to remember than cell values in the base matrices used as input to the trip distribution represent relative probabilities, not trips. They include values for cells where the existing row and/or column trip totals are zero. The matrices must be balanced to the required row and column trip totals before a meaningful trip assignment can be performed.

Table 24 - Matrix Allocation Table

Matrix name	Status	Description
msam		
01-26	User Defined	Input parameters
27-58	Calculated	Performance Indicators
59-67	Calculated	Validation check totals
99	Reserved	Internal use
ms (Matrix I.D.)		
201-212	Calculated	Transit assignment performance indicators
moam or mdam		
01-13	User Defined	Trip rates and mode split factors
18	User Defined	Population/Employment
20-41	Calculated	Trip end totals
42-51	Calculated	Performance Indicators (by zone or link aggregation)
97-99	Reserved	Internal use
mfam		
01-09	Protected	Base case trip distribution & other input matrices
17-31	Calculated	Simulated trip and travel time matrices

Table 25 – Base Matrices

mfam01	Home to work Auto
mfam02	Home to work GO Rail
mfam03	Home to work local transit
mfam04	Non-work auto
mfam05	Local transit school
mfam06	From home transit
mfam07	2001 travel times
mfam08	Auto occupancy factors
mfam09	Background traffic (GO Rail & subway auto access)

Zone Ensembles

A number of zone ensembles have been pre-defined or allocated for specific purposes as shown in Table 26.

Table 26 – Zone Ensembles

Letter	Description and/or use
A	Calibration of trip distribution
G	Calibration & Input of trip generation Rates
M	Calibration & Input of mode split factors
P	Planning district
R	Regions
S	GO Station catchment areas
Q	Output of performance indicators

Volume Delay Functions

The 2001-travel time matrix currently contained in the emme2bank was generated using tangential volume delay functions, also contained in the emme2bank. These times are used as the base reference in applying peak hour factors and in calculating a number of performance indicators.

The application of tolls can be taken into account in the auto assignment by adding the time equivalent of the toll to the appropriate volume delay function. This is done by appending " + X * length" to the end of the function. The appropriate value of X is determined from an assumed value of travel time and the toll rate using the expression:

X = Toll rate ($ per km) * 60 / value of travel time ($ per hr)

A travel time value of $24 per hour (X = 0.25) has been found to produce the best results under existing conditions. It should be noted, however, that each person has a different value of travel time. When free flow conditions exist on parallel routes only those people who put a high value on their time are likely to use a toll facility. As congestion levels on parallel routes increase it becomes worthwhile for those with a lower value of travel time to pay the toll. In theory it is therefore not appropriate to assume a constant value of travel time for all drivers. Unfortunately it is not possible to incorporate a sliding scale, depending on link conditions elsewhere in the network, into the volume delay functions.

Network Scenarios

It is recommended that a new scenario be created for each model run. The current base road network was developed prior to the 2001 re-calibration of the model. Many of the node numbers are not consistent with the 2001 Integrated GTA network developed by the DMG.

Extra Attribute Data

Table 27 lists the extra attributes that have to be defined prior to any application that requires their use.

Table 27 - Extra Attributes

Attribute	Type	Required for	Description
@board	Line	Transit assignment	Passenger boardings
@truck	Link	User calculations (optional)	User defined - % truck traffic
@lkagg	Link	Performance Indicators	User defined

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.

4.2 Macros

The macros that run the model have been developed as independent modules. A master macro "pmod.mac" calls the modules in the proper sequence. Table 28 shows the current list of macros including those used in the supplementary features (Trip length adjustment and HOV assignment).

Table 28 - Macros

Macro name	Function
amod.mac	Calls the other macros in the required order
amod0	Sets run ID and calling arguments used by subsequent macros
amod1	Updates matrix input data using an external file
amod2	Work trip generation, mode split and distribution
amod4	Non work trip generation and distribution. Matrix aggregation
amod5	Transit assignment
amod6	Road assignment
amod7	Performance Indicator and trip end summary report
amod8	Modal split and auto performance report
amod9	Link aggregation performance report
amod10	Trip length adjustment
amod11	Road assignment with HOV lanes
amod12	Generation of new HOVs

The master macro "amod.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 sequence 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 "amac0" must be repeated as the first macro in each stage. If any performance reports have already been generated the output file should be copied, or renamed, prior to running the next stage otherwise the information in it will be lost.

The macro "amod0" requires three calling arguments defined in the master macro (amod.mac). Those arguments are:

Arg1 The name used to identify the run (Max 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 (may be the same as Arg2)

The macros “amod7”, “amod8” and “amod9” generate the reports that summarize the results of the model run. These reports are written to the file “Arg1_am.rep”. Any previous file of that name is deleted. **The link summaries generated by “amod9” are computer intensive and time consuming to produce. It is recommended that “amod9” be skipped if a fast turn around is required. The report can be generated later.**

The macro “amod10” performs the trip length adjustment described in section 2.2. The macro also re-calculates the total auto person and peak hour auto driver trip matrices. Macros “amod6” through “amod9” must be repeated in order to obtain the revised assignment results and performance indicators.

The macros “amod11” and “amod12” are used to perform the HOV assignment procedures described in section 2.4. “amod11” stratifies the auto driver matrix into 1, 2 and 3+ occupants and performs the initial multiclass assignment. “amod12” estimates the number of new HOV that might be forms as a result of the difference in travel time, and then performs a new multiclass assignment using the revised trip matrices.

The recommended way to disable one or more of the sub-macros is to insert a "/" as the 2nd character of the call line thus making it into a comment line. The following is an example of the master macro file “amod.mac” modified to run (or re-run) just the auto assignment and performance indicator summaries.

```
username
~<amod0 2001aa 2001 2001
~/<amod1
~/<amod2
~/<amod3
```

```
~/<amod4
~/<amod5
~<amod6
~<amod7
~<amod8
~<amod9
q
```

The following command line will execute the above macro in batch mode.

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

Where "filename" is a temporary file used for output of the emme2 dialog.

4.3 Input Data

The macro "amod1" reads matrix input data contained in the file "x_am", where "x" is the first argument used to call "amod0". This file may be used to selectively modify the simulation parameters (msam01 through msam26), enter population and employment data and to redefine the trip generation rates and/or mode split factors as desired. It is recommended that matrices requiring change be deleted and re-created rather than modifying the values in the existing matrix. The macro will then run even if the there is no existing matrix of that name whereas attempting to modify a non-existing matrix will cause a fatal area. If modifying an existing matrix it is important to remember that only the cells that are specified are changed. It is therefore essential to include zero values in the list.

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 moam18 and the employment data as destination matrix mdam18. The population and employment data is usually imported in the "x_am" file at the start of the model run.

Table 29 provides a list of the other input parameters that can be modified, together with recommended values for the years 2001, 2006, 2011, 2016 and 2021. The 2021 values are also recommended for subsequent years. The recommended method of modification is to include specification of the desired scalar matrices and values in the "x_am" file for each model run. Any scalars not included will retain the values from the previous run.

It is recommended that a new "x_am" file be created for each model run using an appropriate name to identify the year and development scenario. The file should be saved, along with the output summary report, in order to provide a complete record of the input data for that model run. Every "x_am" file should include specification of values for all of the scalars listed in Table 29 as well as any origin or destination vectors that may be selectively modified for different years or simulation scenarios. The inclusion of all the scalar values in the appropriate "x_am" file will help prevent the accidental use of the wrong values from a previous run.

Table 29 - Recommended "Base Case" Input Parameter Values

msam	Description	2001	2006	2011	2016	2021
01	Work trip origin factor	0.97	0.95	0.92	0.89	0.85
02	Work trip destination factor	1	1	1	1	1
03	Auto non-work origin factor	0.97	1	1.04	1.07	1.10
04	Local transit School factor	0.97	0.97	0.97	0.97	0.97
05	Work trip origin weight	1	1	1	1	1
06	Work trip other m/s factor	1	1	1	1	1
07	Work trip GO Rail m/s factor	1	1	1	1	1
08	Work trip transit m/s factor	1	1	1	1	1
09	M/s origin weight - other mode	0.5	0.5	0.5	0.5	0.5
10	M/s origin weight – GO Rail	0.3	0.3	0.3	0.3	0.3
11	M/s origin weight - Local Transit	0.5	0.5	0.5	0.5	0.5
12	GO Rail non work factor	1.07	1.07	1.07	1.08	1.08
13	Local transit excluded factor	1.06	1.06	1.06	1.07	1.07
15	Peak hour factor for short trips	0.48	0.48	0.48	0.48	0.48
16	Peak hour factor for long trips	0.27	0.27	0.27	0.27	0.27
17	Upper bound for short trips (mins.)	20	20	20	20	20
18	Lower bound for long trips (mins.)	50	50	50	50	50
19	Background traffic factor	1	1.1	1.25	1.4	1.5
20	2 Person HOV conversion factor	0.03	0.03	0.03	0.03	0.03
21	3 Person HOV conversion factor	0.02	0.02	0.02	0.02	0.02
22	Auto occupancy adjustment factor	1	1	1	1	1
23	Trip length adjustment coefficient	0.03	0.03	0.03	0.03	0.03
24	2 person hov coefficient	1.01	1.01	1.01	1.01	1.01
25	3 person hov coefficient	0.016	0.016	0.016	0.016	0.016

4.4 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 29)
2. Performing matrix calculations to adjust the base case data. 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 "x_am" file at the start of each model run.

4.5 Trip Distribution

The trip distribution can be modified by the creation of a new base matrix for the desired mode and trip purpose combination(s) (mfam01 through mfam06). It is recommended that a protected copy of the original matrix be made prior to removing the protection from the matrix to be modified. Applying a factor greater than 1 to the desired cells in the original base matrix will increase the number of simulated trips between those O-D pairs. A factor of less than 1 will reduce the number of the trips. The magnitude of the

change, however, is likely to be less than the factor applied due to the moderating effect of the trip end balancing procedure.

4.6 Auto Occupancy

The auto occupancy matrix (mfam08) may be modified by:

1. Applying the appropriate global adjustment factor (msam22).
2. Performing matrix calculations on the base case matrix (mfam08) as input
3. Importing a new matrix (mfam08).

4.7 Background Traffic (GO Rail Egress)

(This section still needs to be updated from 1996).

In the current applications of the model the background traffic matrix (mfpm12) is used to represent the auto egress component of trips made by GO Rail. The matrix may be modified by:

1. Applying the appropriate global adjustment factor (ms36).
2. Applying origin specific adjustment factors (mo9). Table 30 identifies the GTA traffic zones that contain GO Rail stations together with recommended growth factors for the years 2001 and 2011. These factors are based on the observed growth in GO Rail ridership between 1996 and May of 2000 and projected GO Rail ridership based on GO Transit's 10-year capital development plan. The projections assume no change in egress mode split and do not take into account future parking constraints. Table 31 identifies the zones associated with subway park n' ride and reported use in 1996 (TTS data).
3. Performing matrix calculations using the protected copy of the base case matrix (mf12) as input.
4. Importing a new matrix (mf15)

Table 30 - GO Rail Stations and Growth Factors

GTA Zone	Station	96 TTS Pm peak driver egr.	96 > 00 Obs. Growth Total riders	Recommended Growth Factors 2001	2011
16	Mimico	66	0.95	1	1
1	Long Branch	102	1.07	1	1
1547	Port Credit	849	0.96	1	1
1539	Clarkson	1809	1.13	1.1	1.1
2014	Oakville	1416	1.06	1.1	1.5
2003	Oakville West	509	1.44	1.5	1.6
2077	Appleby	443	1.48	1.5	1.6
2059	Burlington	698	1.44	1.5	1.5
2052	Aldershot	110	1.63	2	2
2520	Hamilton	95	2.88	3	3
368	Danforth	60	0.81	1	1
402	Scarborough	502	1.66	1.7	1.7
405	Eglinton	438	1.38	1.4	1.5
458	Guildwood	262	1.12	1.1	1.2
449	Rouge Hill	694	1.17	1.2	1.3
541	Pickering	1338	1.02	1	1.5
569	Ajax	851	1.08	1.1	1.3
616	Whitby	1085	1.48	1.5	1.8
664	Oshawa	526	1.54	1.5	1.7
22	Kipling	102	1.07	1	1
1561	Dixie	338	1.25	1.3	1.3
1566	Cooksville	684	1.28	1.3	1.3

1578	Erindale	646	1.07	1.1	1.4
1503	Streetsville	265	1.88	2	4
1512	Meadowvale	418	1.23	1.3	3
2124	Milton	299	1.15	1.2	2.5
169	Bloor	0	1.02	1	1
124	Weston	132	1.27	1.3	1.3
61	Etobicoke North	315	1.35	1.4	1.4
1611	Malton	194	1.50	1.5	2
1629	Bramalea	526	1.37	1.4	2
1649	Brampton	830	1.13	1.1	2
2164	Georgetown	243	1.24	1.3	3
1076	Maple	76	2.53	3	4.5
1286	King City	71	2.19	2	3
1239	Aurora	174	1.99	2	3
1254	Newmarket	229	1.76	2	3
4100	Bradford	173	2.56	3	4
324	Oriole	142	0.91	1	1
328	Old Cummer	151	1.34	1.4	1.4
1150	Langstaff	316	1.47	1.5	1.7
1122	Richmond Hill	468	1.12	1.1	1.5
380	Agincourt	132	1.74	2	2
1181	Milliken	20	1.86	2	3
1185	Unionville	213	1.80	2	4
1206	Markham	207	1.69	1.8	4
1331	Stouffville	0	1.57	1.6	3

Table 31 - Subway Park and Ride

Zone	Station	96 TTS pm peak Driver egr.
33	Kipling	1072
34	Islington	757
45	Old Mill	130
98	Downsview	91
104	Lawrence West	59
106	Wilson	914
142	Keele	81
143	High Park	80
144	Runnymede	39
157	Dundas W	64
169	Keele	98
196	Castlefrank	72
199	St Clair	89
225	Union	218
232	Bloor/Yonge	83
258	Broadview	90
262	Greenwood	57
295	Yorkdale	1084
300	York Mills	207
307	Shepperd	259
317	Finch	2435
396	Victoria Park	177
399	Warden	369
410	Kennedy	859
426	Scarborough TC	55

4.8 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 Table 29 or Appendix A in order to identify the appropriate matrix scalars.

4.9 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.

The macro "amod7" produces a report listing the values of all the matrix scalars contained in the emme2bank. This report can be used as a permanent record of the input parameters, control totals, calculated trip totals and global performance indicators.

The macros "amod7" and "amod8" produce reports that summarise trip data by the zone groups contained in zone ensemble "gq". Figure 4 shows the groupings as they are currently defined in the emme2bank.

Figure 6 - Aggregations Used for Output Summaries

(To be added)

The macro "amod7" produces two reports containing the following information

Report 1
- Population.
- Employment
- Total trip origins
- Work tip destinations
- Non-work destinations

Report 2
- GO Rail origins
- Local transit origins
- Auto person origins
- Peak hour auto driver origins
- GO Rail destinations
- Local transit destinations
- Auto person destinations
- Peak hour auto driver destinations

Calculated performance indicators contained in the report produced by "amod8"
- 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 macro “amod9” calculates totals and averages for link aggregations defined by non-zero values of the extra link attribute "@lkagg". The report that is produced contains the following for each category of link.

- 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.

The link categories may be used to define screen lines, geographic areas, categories of road, or any combinations of these attributes. The extra link attribute “@lkagg” must be created prior to running “amod9”.

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 un-weighted average that does not take into account the different sizes of the aggregations.
- 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 numbers must be defined as centroids in the network in order for them to be used as valid reference numbers.

Other matrix and link attribute data may be exported for external analysis using modules 3.14 and 2.41...

Appendix A - Emme/2 Matrix Directory

Note – the matrix I.D. numbers are from the GTA model development emme2bank. These numbers may differ from those used in other emme2banks.

Matrix Directory

Matrix:	Flags:	Modified:	Description:	Value:
ms01: am01		03-04-06 10:26	Work trip origin factor	.97
ms02: am02		03-04-06 10:26	Work trip destination factor	.97
ms03: am03		03-04-06 10:26	auto non-work factor	.97
ms04: am04		03-04-06 10:26	transit non-work factor	.97
ms05: am05		03-04-06 10:26	Work Trip origin weight (1)	1
ms06: am06		03-04-06 10:26	Work trip other m/s adjustment (1)	1
ms07: am07		03-04-06 10:26	Work trip GO Rail m/s adjustment (1)	1
ms08: am08		03-04-06 10:26	Work trip transit m/s adjustment (1)	1
ms09: am09		03-04-06 10:26	m/s origin weight - other mode (0.5)	.5
ms10: am10		03-04-06 10:26	m/s origin weight - GO Rail (0.3)	.3
ms11: am11		03-04-06 10:26	m/s origin weight - local transit (0.5)	.5
ms12: am12		03-04-06 10:26	GO Rail non work factor (1.07)	1.07
ms13: am13		03-04-06 10:26	Local transit excluded factor (1.06)	1.06
ms14: am15		03-04-06 10:26	Peak hour factor for short trips (.48)	.48
ms15: am16		03-04-06 10:26	Peak hour factor for long trips (.27)	.27
ms16: am17		03-04-06 10:26	Upper limit for short trips (20 minutes)	20
ms17: am18		03-04-06 10:26	Lower limit for long trips (50 minutes)	50
ms18: am19		03-04-06 10:26	Background traffic factor (1)	1
ms19: am22		03-04-06 10:26	Auto occupancy adjustment	1
ms20: am23		03-04-06 10:26	Trip length adjustment coefficient (.03)	.03
ms21: am24		03-04-06 10:26	2 person HOV coefficient (1.01)	1.01
ms22: am25		03-04-06 10:26	3+ person HOV coefficient (.16)	.16
ms23: am26		03-04-06 10:26	new HOV coefficient (.01)	.01
ms24: am27		03-04-06 10:28	2001aa Total population	7574639
ms25: am28		03-04-06 10:28	2001aa Total employment	3480452
ms26: am29		03-04-06 10:28	2001aa Employment per 1000 population	459
ms27: am30		03-04-06 10:35	2001aa Peak hour auto driver trips	1027949
ms28: am31		03-04-06 10:27	home to work total trips	2023195
ms29: am32		03-04-06 10:27	2001aa Home to work other trips	74232
ms30: am33		03-04-06 10:27	2001aa Home to work GO trips	55686
ms31: am34		03-04-06 10:27	2001aa Home to work transit trip total	241633
ms32: am35		03-04-06 10:28	2001aa home to work auto trips	1651644
ms33: am41		03-04-06 10:32	2001aa non-work auto trips	1032850
ms34: am42		03-04-06 10:33	2001aa local transit school trips	115189
ms35: am46		03-04-06 10:34	2001aa total auto person trips	2684495
ms36: am47		03-04-06 10:35	2001aa total GO Rail trips	59517
ms37: am48		03-04-06 10:36	2001aa total transit trips	374912
ms38: am49		02-11-26 14:31	initialized	0
ms39: am50		02-11-26 14:31	initialized	0
ms40: am51		02-11-26 14:31	initialized	0
ms41: am52		02-11-26 14:31	initialized	0
ms42: am53		02-11-26 14:31	initialized	0
ms43: am54		02-11-26 14:31	initialized	0
ms44: am55		02-11-26 14:31	initialized	0
ms45: am56		02-11-26 14:31	initialized	0
ms46: am57		02-11-26 14:31	initialized	0
ms47: am58		02-11-26 14:31	initialized	0
ms48: am59		03-04-06 10:31	2001aa Unadj. Non work auto origins	1120141824
ms49: am60		03-04-06 10:31	2001aa unadj non-work auto destinations	1009447488
ms50: am61		03-04-06 10:27	Unadj. Home to work origin total	2023195904
ms51: am62		03-04-06 10:27	Unadj. Home to work Dest total	1927924096
ms52: am63		03-04-06 10:27	unadjusted home to work other origins	7366205
ms53: am64		03-04-06 10:27	unadj. home to work other dest.	7480266.5
ms56: am70		02-11-26 14:31	initialized	0
ms57: am71		02-11-26 14:31	initialized	0
ms68: am65		03-04-06 10:27	unadj. home to work GO origins	5543103
ms69: am66		03-04-06 10:27	unadj. home to work GO dest.	5579578
ms94: am67		03-04-06 10:27	unadj. home to work transit origins	23966322
ms95: am68		03-04-06 10:27	unadj. home to work transit dest.	24360424
ms201:am201		03-04-07 12:41	2001aa am subway boardings	272204
ms202:am202		03-04-07 12:41	2001aa am subway passenger km	1841501
ms203:am203		03-04-07 12:41	2001aa am streetcar boardings	43889
ms204:am204		03-04-07 12:41	2001aa am streetcar passenger km	139859
ms205:am205		03-04-07 12:41	2001aa am TTC bus boardings	279679
ms206:am206		03-04-07 12:41	2001aa am TTC bus passenger km	1136578
ms207:am207		03-04-07 12:41	2001aa am GO Rail boardings	52286
ms208:am208		03-04-07 12:41	2001aa am GO Rail passenger km	1684071
ms209:am209		03-04-07 12:41	2001aa am GO Bus boardings	54751

```
ms210:am210             03-04-07 12:41  2001aa am GO Bus passenger km                858153
ms211:am211             03-04-07 12:41  2001aa am other bus boardings                85408
ms212:am212             03-04-07 12:41  2001aa am other bus passenger km             509817

mo02: am01              03-04-06 10:19  tts01 home to work generation rate
mo03: am03              03-04-06 10:19  tts01 non-work auto origin rate
mo06: am05              03-04-06 10:19  tts01 local transit school rate
mo07: am11              03-04-06 10:19  2001TTS Home to work other m/s
mo08: am12              03-04-06 10:19  2001TTS Home to work GO Rail m/s
mo10: am13              03-04-06 10:19  2001TTS Home to work transitl m/s
mo114:am18              03-04-06 10:26  2001aa Validation - Population
mo14: am20              03-04-06 10:31  2001aa non-work pre-bal auto origins
mo15: am22              03-04-06 10:32  2001aa non-work auto origins
mo16: am23              03-04-06 10:33  2001aa local transit school origins
mo17: am27              03-04-06 10:33  2001aa total auto person origins
mo18: am28              03-04-06 10:35  2001aa total GO Rail origins
mo19: am29              03-04-06 10:36  2001aa total transit origins
mo20: am30              03-04-06 10:19  initialized
mo21: am31              03-04-06 10:27  2001aa Home to work total origins
mo22: am32              03-04-06 10:27  2001aa Home to work other origins
mo23: am33              03-04-06 10:27  Home to work GO origins
mo24: am34              03-04-06 10:28  2001aa Home to work transit origins
mo25: am35              03-04-06 10:28  2001aa Home to work auto origins
mo26: am41              03-04-07 12:41  2001aa Total origins
mo27: am42              03-04-07 12:42  2001aa employment per 1000 population
mo28: am43              03-04-06 10:34  2001aa Peak hour auto driver origins
mo29: am44              03-04-07 12:43  2001aa self containment (% of orig.)
mo30: am45              03-04-07 12:43  2001aa origin transit m/s (%)
mo31: am46              03-04-07 12:43  2001aa mean auto person time (01LOS)
mo86: am47              03-04-07 12:43  2001aa mean auto person time (equi.)
mo105:am48              03-04-06 10:19  initialized
mo109:am50              03-04-06 10:19  initialized
mo110:am51              03-04-06 10:19  initialized
mo111:am97              03-04-07 12:43  temp - aggregated auto time (equil.)
mo112:am98              03-04-07 12:44  temp - auto drivers excl. extras
mo113:am99              03-04-07 12:43  temp - aggregated auto persons

md01: am02              03-04-06 10:19  tts01 home to work generation rate
md06: am04              03-04-06 10:19  tts01 non-work auto destination rate
md07: am11              03-04-06 10:19  2001TTS Home to work other m/s
md08: am12              03-04-06 10:19  2001TTS Home to work GO Rail m/s
md09: am13              03-04-06 10:19  2001TTS Home to work transit m/s
md10: am14              03-04-06 10:19  Background traffic factors (GO access)
md95: am18              03-04-06 10:26  2001aa vaidation - Employment
md14: am20              03-04-06 10:31  2001aa non-work pre-bal auto dest
md15: am22              03-04-06 10:32  2001aa non-work auto destinations
md16: am23              03-04-06 10:33  2001aa local transit school dest.
md17: am27              03-04-06 10:33  2001aa total auto person dest.
md18: am28              03-04-06 10:35  2001aa total GO Rail dest.
md19: am29              03-04-06 10:36  2001aa total transit dest.
md20: am31              03-04-06 10:27  2001aa Total work destinations
md21: am32              03-04-06 10:27  2001aa Home to work other destinations
md22: am33              03-04-06 10:27  Home to work GO destinations
md23: am34              03-04-06 10:28  2001aa Home to work transit destinations
md24: am35              03-04-06 10:28  2001aa Home to work auto destinations
md25: am41              03-04-06 10:19  initialized
md71: am42              03-04-07 12:41  2001aa Non-work destinations
md80: am43              03-04-06 10:34  2001aa Peak hour auto driver dest.
md89: am45              03-04-07 12:43  2001aa destination transit m/s (%)
md90: am48              03-04-06 10:19  initialized
md91: am49              03-04-06 10:19  initialized
md92: am51              03-04-06 10:19  initialized
md93: am98              03-04-07 12:42  temp - transit (agg)
md94: am99              03-04-07 12:42  temp - auto + Go + Transit (agg)

mf01: am01      /r      03-02-15 20:58  Auto work trip distribution
mf02: am02      /r      03-01-17 19:38  GO Rail trip distribution
mf03: am03      /r      03-01-17 20:44  Local transit trip distribution
mf04: am04      /r      03-02-15 21:00  Auto non_work trip distribution
mf05: am05      /r      02-11-24 12:09  Local transit school trip distribution
mf06: am06      /r      02-11-24 12:11  Auto driver background traffic
mf07: am07      /r      03-01-20 06:58  2001 am peak travel times
mf08: am08      /r      03-04-06 10:19  auto occupancy factors
mf09: am09      /r      02-11-24 12:14  Background traffic
mf17: am11              03-04-06 10:29  2001aa home to work GO rail
mf18: am12              03-04-06 10:29  2001aa home to work transit
mf19: am13              03-04-06 10:30  2001aa home to work auto
mf32: am14              03-04-06 10:32  2001aa non-work auto person trips
mf33: am15              03-04-06 10:32  2001aa local transit school
mf34: am16              03-04-06 10:33  2001aa total auto person
mf37: am17              03-04-06 10:35  2001aa total GO Rail
```

```
mf99: am18              03-04-06 10:35  2001aa total transit
mf100:am21              03-04-06 10:56  2001aa auto travel times
mf103:am27              03-04-06 10:34  2001aa Peak hour auto driver trips
mf104:am31              03-04-06 10:31  temp non-work auto origins
```

Appendix B - Sample Printout of Performance Indicators

```
EMME/2 Module:  3.14       Date: 03-06-18 12:02       User: E145/DMG.UTYU..pmd           Page: 1358
 Project:        City of Mississauga Model 2001
 ---------------------------------------------------------------------------------------------------


 MATRICES BY ZONE GROUPS
 ***********************


 Data matrices:         mo33: am18      2001aa Validation - Population           (03-06-18 11:37)
                        md28: am18      2001aa vaidation - Employment            (03-06-18 11:37)
                        mo19: am41      2001aa Total origins                     (03-06-18 12:02)
                        md13: am31      2001aa Total work destinations           (03-06-18 11:37)
                        md19: am42      2001aa Non-work destinations             (03-06-18 12:02)

 Constraint matrix:     none

 Ensemble:              gq: Performance indicators                               (03-03-11 21:13)
 Aggregation:           sum

 Submatrix:             all zones


   zone      mo33      md28      mo19      md13      md19
  group      am18      am18      am41      am31      am42

   gq01    168040    435717     65079    293124     43538
   gq02    988826    340842    405542    187713    125750
   gq07    341937    162064    145135     95687     55888
   gq10    384112    200570    162478    123690     72602
   gq13    593263    200351    250120    114605     87962
   gq17    119544     29588     44320     14877     11474
   gq20    160888     52627     76381     28318     25242
   gq22     87413     28441     39853     15908     13188
   gq23    139052     53663     55704     25906     25304
   gq25    100629     24336     39266     13038     10535
   gq27    105951     46990     48548     25367     16395
   gq29    132031     42158     63214     23868     20886
   gq31    208612    121976    105880     77133     39717
   gq33    182022    117920     88967     73243     26240
   gq34     50596     14689     21733      7450      4992
   gq35    325426    119381    151954     66484     51807
   gq36    612925    346796    284082    207994     99721
   gq37     48184     13859     20551      7137      4931
   gq38     31471     16592     14456      9436      4754
   gq39    144738     66104     69984     37294     29411
   gq40    150836     68516     68070     38440     24182
   gq41     77426     20337     30715      8974      7996
   gq42    412849    171769    155088     94082     63052
   gq47   2007868    785166     89548     27203     14132

    sum   7574639   3480452   2496668   1616971    879699
    avg    315610    145019    104028     67374     36654
    min     31471     13859     14456      7137      4754
    max   2007868    785166    405542    293124    125750
```

MATRICES BY ZONE GROUPS
****

Data matrices:
mo11: am28 2001aa total GO Rail origins (03-06-18 11:43)
mo12: am29 2001aa total transit origins (03-06-18 11:43)
mo10: am27 2001aa total auto person origins (03-06-18 11:41)
mo21: am43 2001aa Peak hour auto driver origins (03-06-18 11:42)
md11: am28 2001aa total GO Rail dest. (03-06-18 11:43)
md12: am29 2001aa total transit dest. (03-06-18 11:43)
md10: am27 2001aa total auto person dest. (03-06-18 11:41)
md20: am43 2001aa Peak hour auto driver dest. (03-06-18 11:42)

Constraint matrix: none

Ensemble: gq: Performance indicators (03-03-11 21:13)
Aggregation: sum

Submatrix: all zones

zone group	mo11 am28	mo12 am29	mo10 am27	mo21 am43	md11 am28	md12 am29	md10 am27	md20 am43
gq01	171	24196	26582	10530	55314	143412	128084	41471
gq02	633	138228	256365	97057	2069	78685	225386	81628
gq07	1653	29929	112534	43410	389	22665	127711	48148
gq10	654	45296	116065	44010	264	37642	157564	59542
gq13	5102	58440	186809	68545	123	32190	169399	63545
gq17	835	311	42613	15360	0	154	25611	9650
gq20	6064	3134	67196	24539	243	2068	50939	20382
gq22	2628	1225	35921	13330	59	867	27870	11205
gq23	1484	2787	50836	19098	57	2711	47725	18468
gq25	614	166	37991	13612	0	122	23013	8866
gq27	1130	1406	45435	16665	0	847	40289	15321
gq29	2490	5365	55313	20498	13	2328	42074	15415
gq31	2939	7919	94715	35168	36	5310	111143	40969
gq33	848	7028	80800	31311	0	4822	94373	35040
gq34	319	127	21086	7430	0	73	12217	4326
gq35	4053	7319	139882	52279	28	4830	112710	41573
gq36	13538	21569	248245	94996	185	17007	288989	111113
gq37	853	126	19202	7231	0	31	11642	4478
gq38	437	51	13775	5351	11	0	13964	5380
gq39	6713	1188	61668	23778	261	1319	64505	25162
gq40	3256	1147	63011	23970	145	1214	60740	23568
gq41	393	152	29636	11282	0	104	16595	6402
gq42	1569	12628	136369	52211	58	12425	140504	53949
gq47	879	1141	86973	24665	0	52	35975	10725
sum	59255	370878	2029022	756326	59255	370878	2029022	756326
avg	2469	15453	84543	31514	2469	15453	84543	31514
min	171	51	13775	5351	0	0	11642	4326
max	13538	138228	256365	97057	55314	143412	288989	111113

MATRICES BY ZONE GROUPS
****

Data matrices:
mo20: am42 2001aa employment per 1000 population (03-06-18 12:03)
mo23: am45 2001aa origin transit m/s (%) (03-06-18 12:03)
md21: am45 2001aa destination transit m/s (%) (03-06-18 12:03)
mo22: am44 2001aa self containment (% of orig.) (03-06-18 12:03)
mo24: am46 2001aa mean auto person time (96LOS) (03-06-18 12:04)
mo25: am47 2001aa mean auto person time (equi.) (03-06-18 12:04)
mo27: am49 2001aa mean dest. auto occupancy (03-06-18 12:04)

Constraint matrix: none

Ensemble: gq: Performance indicators (03-03-11 21:13)
Aggregation: maximum

Submatrix: all zones

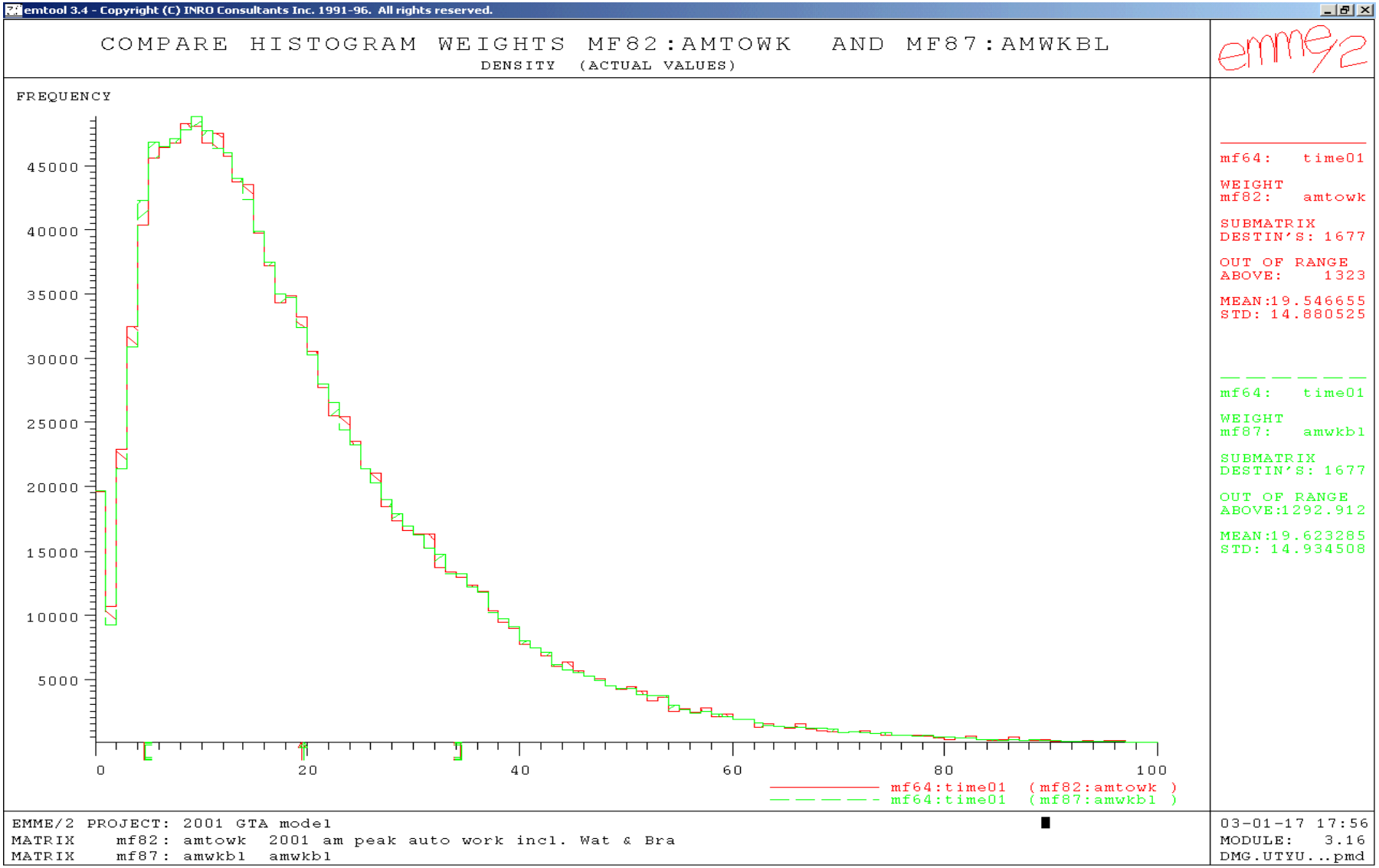
zone group	mo20 am42	mo23 am45	md21 am45	mo22 am44	mo24 am46	mo25 am47	mo27 am49
gq01	2592.00	47.49	43.88	63.82	12.55	11.97	1.16
gq02	344.00	34.97	25.70	54.72	15.05	14.42	1.22
gq07	473.00	20.77	15.03	41.93	14.14	14.03	1.22
gq10	522.00	27.96	19.26	46.26	13.53	13.29	1.24
gq13	337.00	23.34	15.96	46.90	16.02	16.20	1.26
gq17	247.00	.71	.60	27.43	28.03	29.07	1.16
gq20	327.00	4.10	3.88	20.68	23.95	24.70	1.19
gq22	325.00	3.08	3.01	28.17	21.40	22.55	1.18
gq23	385.00	5.06	5.37	35.48	17.19	18.30	1.20
gq25	241.00	.43	.53	26.70	30.00	30.80	1.13
gq27	443.00	2.93	2.06	29.05	20.96	21.22	1.17
gq29	319.00	8.49	5.24	24.83	19.32	19.36	1.22
gq31	584.00	7.50	4.56	20.15	17.97	18.13	1.23
gq33	647.00	7.93	4.86	18.98	16.65	16.86	1.21
gq34	290.00	.59	.59	22.67	30.72	32.85	1.12
gq35	366.00	4.84	4.11	30.70	16.55	17.93	1.23
gq36	565.00	7.61	5.55	28.62	17.26	16.60	1.22
gq37	287.00	.62	.27	17.52	23.20	24.92	1.13
gq38	527.00	.36	.00	20.52	20.51	22.10	1.14
gq39	456.00	1.71	2.00	22.71	20.23	19.91	1.19
gq40	454.00	1.70	1.95	26.70	17.96	18.34	1.19
gq41	262.00	.50	.62	24.53	23.07	23.99	1.14
gq42	416.00	8.39	8.12	36.31	13.36	13.88	1.21
gq47	391.00	1.28	.14	.00	60.19	60.00	1.10
sum	11800.00	222.37	173.30	715.39	509.81	521.41	28.48
avg	491.67	9.27	7.22	29.81	21.24	21.73	1.19
min	241.00	.36	.00	.00	12.55	11.97	1.10
max	2592.00	47.49	43.88	63.82	60.19	60.00	1.26

Appendix C – Trip Distribution Validation Plots

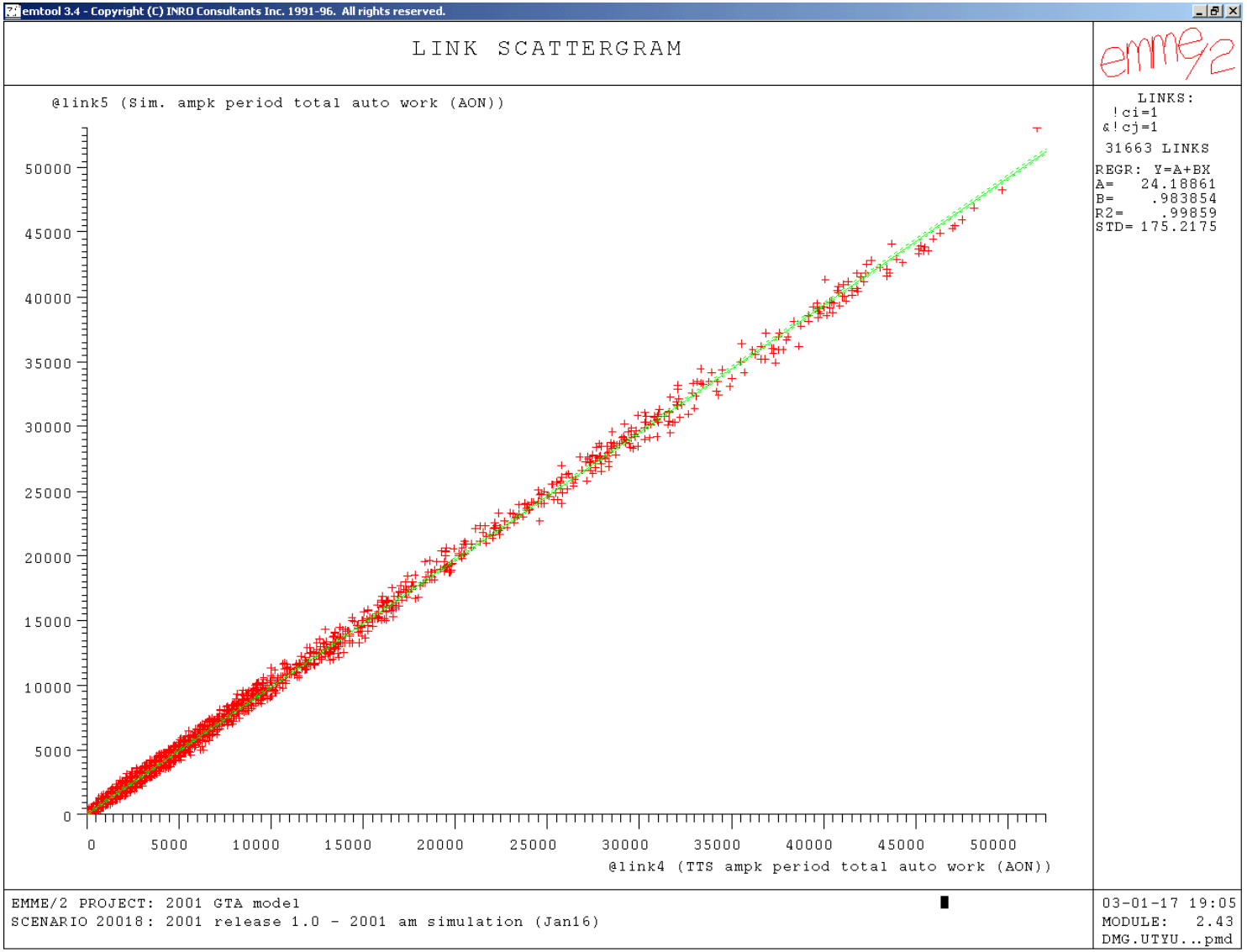
Comparisons between simulated and 2001 TTS data

- Auto work trip travel time distributions
- Auto work trip link scattergram -
- Auto non-work trip travel time distribution
- Auto non-work trip link scattergram
- GO Train work trip travel time distribution
- Local transit work trip travel time distribution

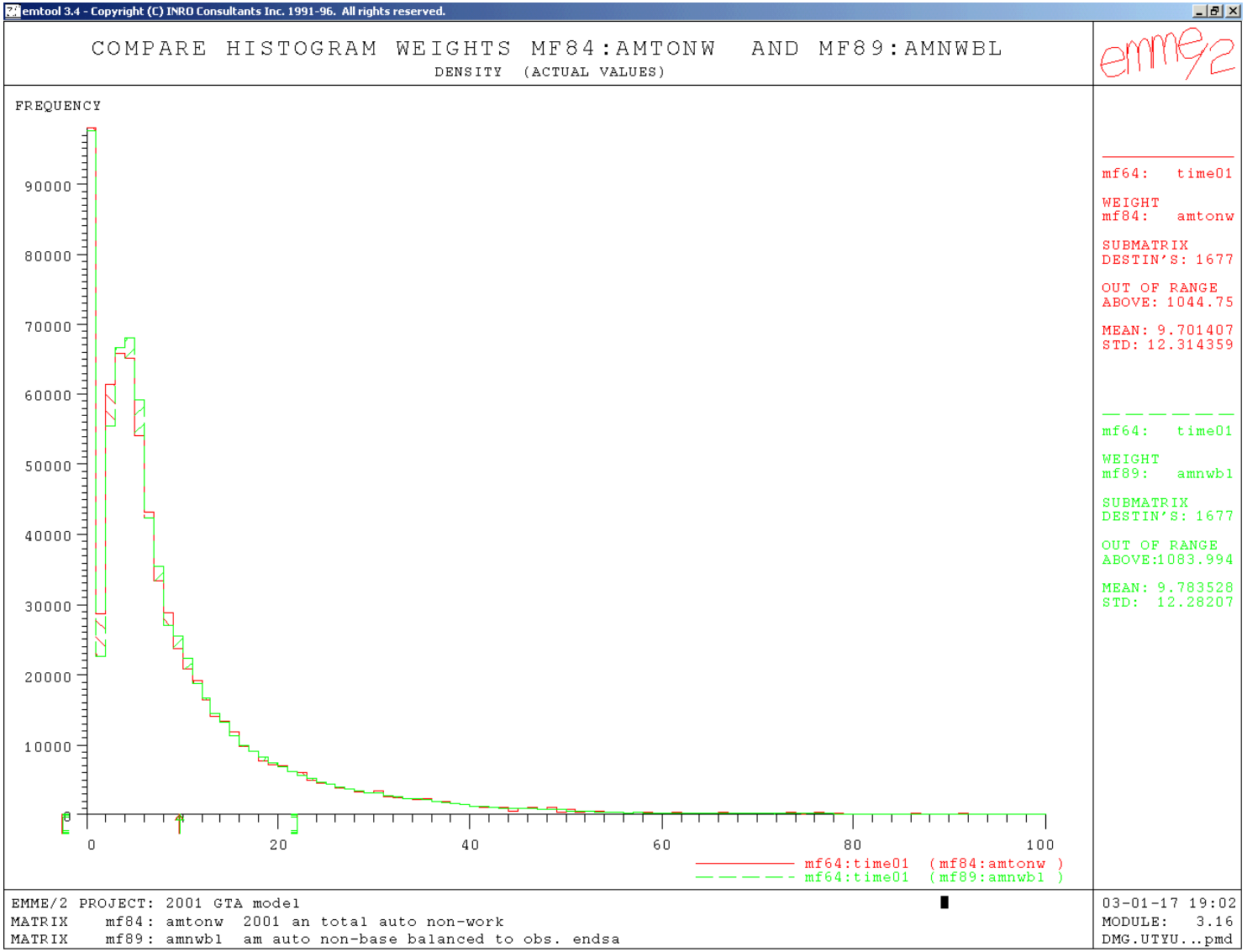
Appendix C – Trip Distribution Validation Plots



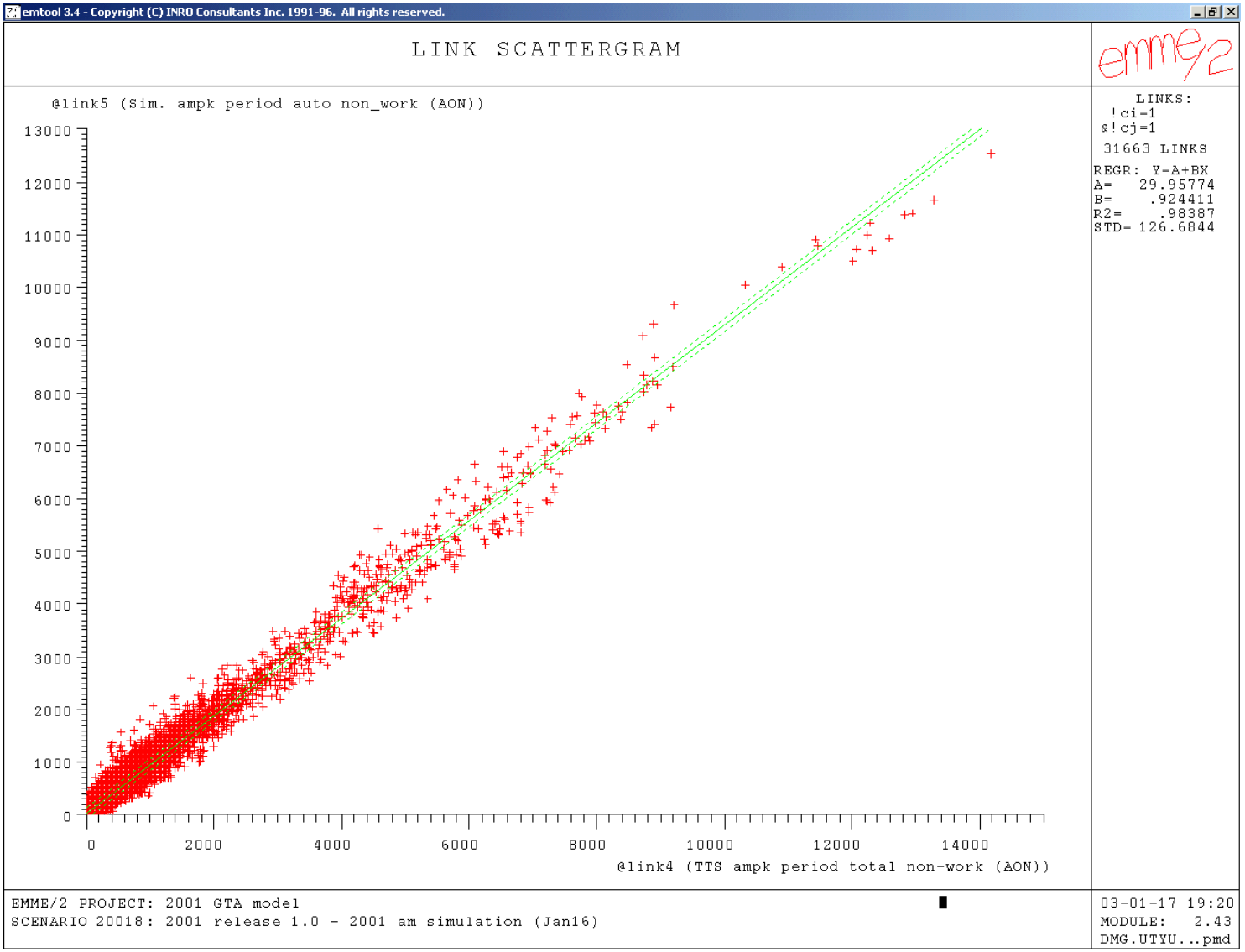
Appendix C – Trip Distribution Validation Plots



Appendix C – Trip Distribution Validation Plots

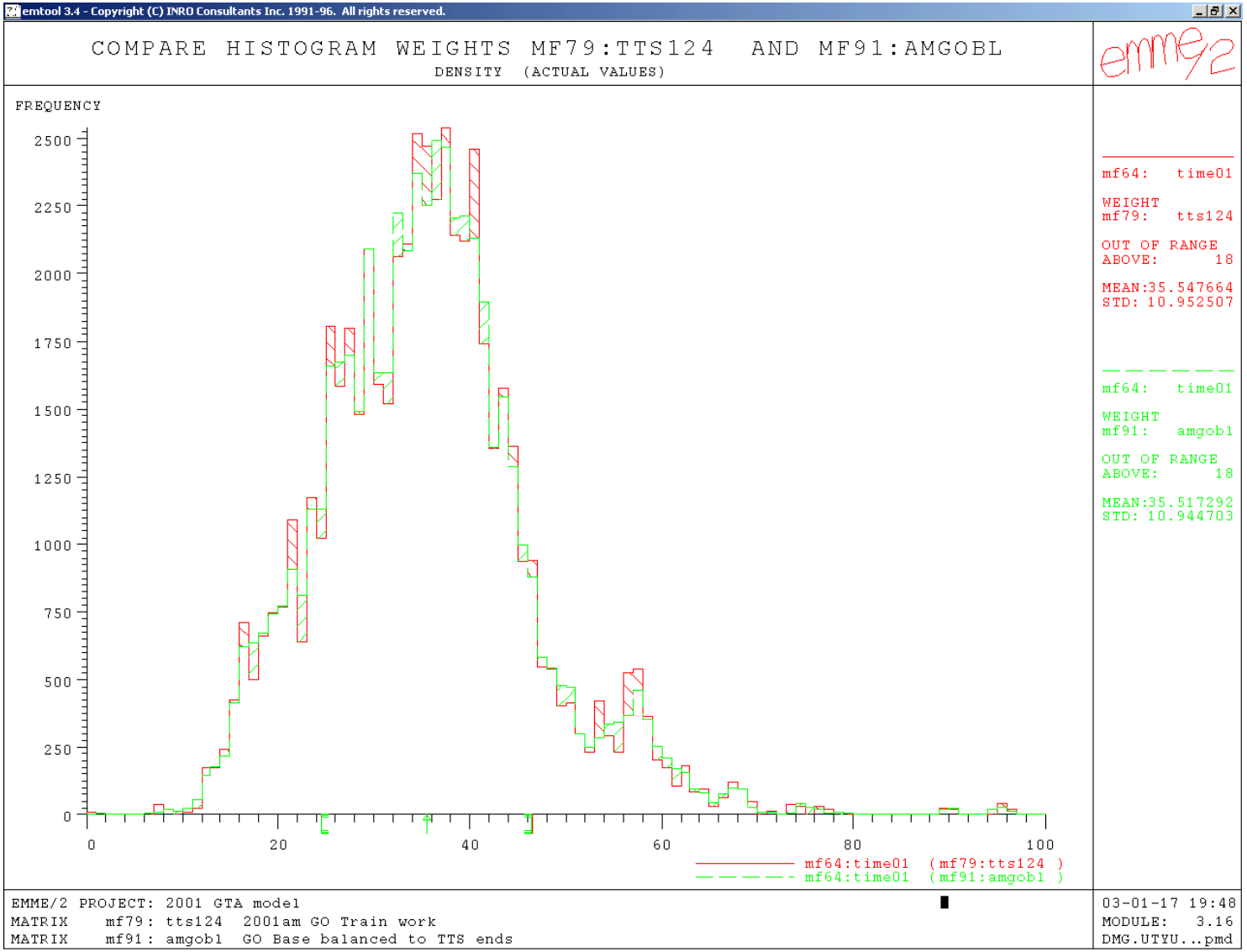


Appendix C – Trip Distribution Validation Plots



q

Appendix C – Trip Distribution Validation Plots



Appendix C – Trip Distribution Validation Plots