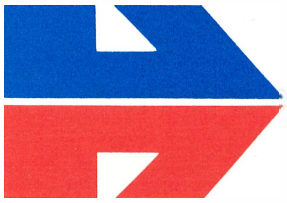

UNIVERSITY OF TORONTO
JOINT PROGRAM IN TRANSPORTATION

GTA SIMPLIFIED MODEL

Version 3.0

Users' Manual

Data Management Group
Joint Program in Transportation
University of Toronto

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GTA Simplified Model - Version 3.0 Users' Manual

CONTENTS

1.0 Introduction

The procedures used in the GTA Simplified Model were originally developed as part of a Regional Transportation Planning Model for the Regional Municipality of Durham and as a strategic planning tool for the Ministry of Transportation, Ontario. Versions 1 and 2 of the model were developed and calibrated using data from the 1986 and 1991 Transportation Tomorrow Surveys (TTS). Version 3 contains extensive revisions and has been recalibrated using data from the 1996 TTS. This guide has been written with the purpose of providing the necessary instructions needed to access and apply the model. Chapters 2 and 3 describe the structure and operation of the model. Chapter 4 contains recommendations regarding the values of input parameters to be used in simulating future transportation demand. Chapter 5 describes how the results from the model can be used for more detailed sub-area analysis. The appendices include the results of base year (1996) validation tests and the results of two test runs for the year 2021.

The model may be used to project and analyse traffic volumes and public transit ridership in the 3-hour peak period between 6 and 9 a.m. The geographic area represented by the model includes the new City of Toronto plus the Regional Municipalities of Durham, Halton, Hamilton-Wentworth, Peel and York. Trip calculations and travel assignments are based on the 1996 GTA traffic zone system and the transportation network data maintained at the Data Management Group. A number of external zones, and an external skeleton road network, have been added to ensure adequate representation of travel adjacent to and across the external boundary of the primary area covered by the model.

The model is divided into two main components. The first of these components consists of a set of spreadsheets that are used for inter-active input of land use, trip generation and mode split assumptions. Population based trip generation rates are used to project work trip origins, non-work trip origins for trips made by automobile and school trip origins for trips made by local transit. Employment based trip attraction rates are used to project work trip destinations. Base case trip generation and attraction rates have been developed using the 1996 TTS data. The rates are composite factors that, in the case of work trips, reflect labour force participation, propensity to work at home, daily trip making frequency and the proportion of trips that occur within the peak period. Each of these factors may be modified independently to reflect different scenarios for future conditions. A four way mode split (Auto, GO Rail, Local transit and other) is applied to the work trip component. The mode-split calculations use separate mode split factors for origins and destinations. The work trip generation rates and mode-split factors are adjusted to ensure that the total number of trip origins matches the total number of trip destinations for each mode. The user can select the relative weight given to the origin and destination totals.

The second major component of the model consists of an emme/2 databank and a set of macros. The macros duplicate the trip generation and mode split calculations performed in the spreadsheets and then perform trip distribution and assignment by mode. The model may be used to project future travel "demand", based on existing (1996) levels of service or a capacity restraint procedure can be used to modify the auto trip distribution to reflect projected changes in level of service on the road network. The emme/2 databank may be used to create and test alternative future network scenarios. Outputs from the emme/2 components of the model include values for an extensive list of performance indicators that can be used in the strategic assessment of land use and network alternatives.

A third component of the model consists of spreadsheets for the analysis and comparison of a number of standard outputs from of the model. Those outputs include the performance indicators, screen line crossings and a number of aggregated trip and travel time matrices.

2.0 Spreadsheet Components

The spreadsheet components of the model consist of the following workbooks.

- GEN_INP.xls - Trip generation rates
- Gen_mod.xls - Trip generation model including input of land use data
- MS_INP.xls - Modal split factors
- Ms_mod.xls - Modal split model
- D301.xls - Transfer of zone aggregations to emme/2.
- D311.xls - Transfer of land use, trip generation rates and mode splits to emme/2.

The contents and application of each workbook are described in the following sections. As a general rule individual worksheets are password protected to prevent accidental modification of the data and formulae. Exceptions, consisting primarily of the cells used to make selections and enter new data, are noted where applicable.

2.1 GEN_INP.xls - Trip Generation Assumptions

This workbook consists of a set of worksheets that are used to input trip generation rates for a standard set of zone aggregations. A plot of the zone aggregations is shown in appendix B. The workbook is self contained, (i.e.: Values can be analyzed and modified without requiring that other workbooks be open at the same time).

The following worksheets have a common form.

- Part_rt Employed labor force participation rate. i.e. ELF/Population
- WAH_rt Proportion of employed labour force that usually works at home.
- wk_tp_rt Daily first trips to work for each resident employed outside the home.
- pk_fac Proportion of daily first work trip origins that occur between 6 and 8.59 a.m.
- emp_rt Daily work trip destinations per job outside the home.
- emp_pk Proportion of daily first work trip destinations that occur between 6 and 8.59 am.
- nwau_rt Daily non-work trip origins (driver or passenger) per person.
- nwpk_fac Proportion of non-work auto trips that occur between 6 and 8.59 am.
- stud_part Proportion of total population that are full time students.
- sc_rt Total daily first trips to school per full time student resident.
- sc_pk_fac Proportion of first trips to school that occur between 6 and 8.59 a.m.
- sc_tr_fac Proportion of peak period first trips to school that are made on local transit.

The above worksheets are formatted as follows:

Column	Contents
A	Trip generation zone aggregation number
B	Observed value from the 1986 TTS
C	Observed value from the 1991 TTS
D	Observed value from the 1996 TTS
E	Values to be used in the current model run
F	Base case forecast value

G to Z	Available to the user for calculations, implementation of trip generation sub models and storage of the values used in different scenarios.
Row	
1	Scenario identifier (Columns G to Z)
2	Scenario description
3 to 75	Values for the GTA
76 to 85	External trip generation rates - See section 2.2
87 to 95	Aggregate values by regional municipality (Columns B to D).
97	Values for special aggregations (See note 4)

Notes:

1. Cell E1 and columns G through F are not protected from modification.
2. Cell E1 is used to select the column containing the values to be used in the current run. Enter the appropriate scenario identifier.
3. Values may be modified selectively. i.e. the values used in the current model run will default to the base case for any cell that is left blank or contains a zero value.
4. The base case has been set to the 1996 TTS values with the following exceptions:
   - The employed labour force participation rates have been reduced by 2.6% to correct for under reporting of population in the TTS relative to the census.
   - A common aggregate value has been used for all trip production factors from zone aggregations 315, 333, 351, 353, 355 and 356. These aggregations have too small a population for reliable calculation of individual rates.
   - A common aggregate value has been used for all trip attraction factors to zone aggregations 315, 333, 351, 356 and 440. These aggregations have too little employment for reliable calculation of individual rates.
   - Trip rates for external zone aggregations 570 (Brant) and 580 (Haldimand-Norfolk) have been chosen to reflect the 1996 observed rates for adjacent areas.
   - The observed TTS external trip generation rates to the GTA from Northumberland and Dufferin Counties have been adjusted downward by 20% and from Simcoe County by 25%. The TTS included only partial coverage of these 3 counties. The adjusted factors are applied to the total population of each county. The percent reduction is based on a comparison of simulated screen line volumes and traffic counts.
5. TTS work and school trip production rates are based on household location, not trip origin. Non work auto trip production rates are based on trip origins. All attraction rates are based on trip destination.

The worksheet "row" contains index values used in the lookup functions on the other worksheets. This sheet should not be modified.

The following worksheets contain the formulae that calculate the combined trip rates to be applied to the population and employment estimates.

- ampkwk_rt (a.m. peak period first work trips per capita of population.)
  = (part_rt * (1 - WAH_rt) * wk_tp_rt * pk_fac)
- ampkde_rt (a.m. peak period first work destinations per capita of employment)
  = (emp_rt * emp_pk)
- ampknwau_rt (a.m. peak period non work auto trip origins per capita of population)
  = (nwau_rt * nwpk_fac)
- ampktrsc_rt (a.m. peak period local transit first trips to school per capita of population)
  = (stud_part * Sc_rt * Sc_pk_fac * sc_tr_fac)

The previous worksheets have the following format:

Column	Contents
A	Trip generation zone aggregation number
B	Observed value from the 1986 TTS
C	Observed value from the 1991 TTS
D	Observed value from the 1996 TTS
E	Calculated values to be used in the current model run

2.2 External Trip Generation

Four components of external trip generation are included in the model.

a) A single factor, representing A.M. peak period work trips inbound to the GTA per capita of population is used for work trip generation from the external zones. The desired trip generation rates may be entered in rows 76 to 85 of the worksheet **"part_rt".** The external trip generation rates for t he other components of work trip generation (work at home, daily rate and peak period factor) have been preset to 1 or 0, as appropriate so that the total trip generation rate remains equal to the desired factor. The rates for the counties that were only partly covered by the TTS (Dufferin, Northumberland, Peterborough, Simcoe and Wellington) have been calculated on the basis of the population in the survey area but are applied to the total estimated population of the county. Base case generation rates for Brant county and the Regional Municipality of Haldimand-Norfolk have been estimated on the basis of the observed rates from the adjacent areas (Waterloo and Niagara) together with previously estimated rates based on 1991 Census POW data.

b) A single destination factor is used for A.M. peak period work trip attractions outbound from the GTA. The desired trip attraction rates may be entered in rows 76 to 85 of the worksheet **"emp_rt".** The destination peak factor has been preset to 1 for the external zones. The base case rates were calculated by dividing the reported number of trips in TTS by the total employment in each Regional Municipality or county regardless of the area covered by the TTS.

c) A.M. peak period trip generation for non-work automobile trips inbound to the GTA. The desired trip generation rates may be entered as factors in rows 76 to 85 of the worksheet **"nwau_rt".** The base case rates for the counties that were only partly covered by the TTS (Dufferin, Northumberland, Peterborough, Simcoe and Wellington) have been calculated on the basis of the population in the survey area but are applied to the total estimated population of the county. Base case generation rates for Brant County and the Regional Municipality of Haldimand-Norfolk have been estimated on the basis of the observed rates for the adjacent areas (Waterloo and Niagara).

d) Outbound auto non-work trips from the GTA are generated by the trip distribution component of the model. The number of trips is assumed to increase, or decrease, in proportion to the projected change in total non-work origins from each traffic zone from which the trips originate.

2.3 Gen_mod.xls - Trip Generation Model

The workbook is linked to the trip generation rates contained in the file **"GEN_INP.xls".** Both workbooks need to be open in order to perform the trip generation calculations in an efficient manner.

The worksheet **"model"** performs the trip generation calculations. The total number of work trip origins is calculated for each traffic zone. The following table describes the content of that worksheet.

Column	Contents
A	Traffic zone number (GTA96 zone system)
B	Planning District number (Used to create summary table - see note 1)
C	Trip generation aggregation number
D	Observed population - 1996 TTS
E	Observed employment - 1996 TTS
F	Population forecast (Note 2)
G	Employment forecast (Note 2)
I	Work trip origins calculated using the selected trip rates in "GEN_INP.xls"
J	Work trip destinations calculated using the selected trip rates in "GEN_INP.xls"
L	Work trip origins adjusted so that the origin and destination totals match.
M	Work trip destinations adjusted so that the origin and destination totals match.
O	Non work auto trip origins calculated using the selected trip rates in "GEN_INP.xls"
P	Local transit school trip origins calculated using the selected trip rates in "GEN_INP.xls"
Row	
1-8	Summary of totals by region.
9	Relative weights to be used in matching the work trip origin and destination totals (See note 3)
10	Adjustment factors applied to balance the work trip origin and destination totals.
17 onwards	Data by traffic zone

Notes:

1. The Planning District is assumed to be the zone aggregation number without the last digit.
2. Columns E and F are not protected and may be used to enter the current population and employment forecasts.
3. Cells I9 and J9 contain the weighting factors used in balancing the origin and destination totals. Cell I9 is not protected. The origin weight is set by entering the required value between 0 (balance origins to destination total) and 1 (balance destinations to origin total). The destination weight, (1 minus the origin weight) will appear automatically in cell J9.
4. Column C may be used to redefine the trip generation zone aggregations used in the model, but the tables contained in "GEN_INP.xls" have to be updated with new TTS tabulations in order to obtain observed time series data for the new aggregations.

The worksheet **"rates"** contains the final work trip generation rates for each zone aggregation. The factors have been rounded to four decimal places in preparation for the transfer of data to the emme/2 component of the model.

The worksheet **"pd_sum"** contains a summary of the trip generation results by planning district.

2.4 MS_INP.xls - Mode Split Input Assumptions

The workbook contains a set of worksheets that are used to input mode split assumptions as factors applied to a standard set of zone aggregations. A plot of the standard zone aggregations is shown in appendix B. Separate origin and destination mode split factors must be specified. The factors are applied to the projected work trip origin and destination totals for each zone in the aggregation. The workbook is self-contained, (i.e.: Values can be analyzed and modified without requiring that other workbooks be open at the same time).

The following worksheets have a common format for the input of modal split assumptions.

- other-o "Other" mode share of total a.m. peak period work origins.
- other-d "Other" mode share of total a.m. peak period work destinations
- GORail-o GO Rail mode share of total a.m. peak period work origins excluding "Other".
- GORail-d GO Rail mode share of total a.m. peak work destinations excluding "Other"
- transit-o Local transit share of a.m. peak work origins excluding Other and GO Rail.
- transit-d Local transit share of a.m. peak work destinations excluding Other and GO Rail

The format of the above worksheets is similar to those used in trip generation:

Column	Contents
A	Modal split zone aggregation number
B	Super aggregation code (See note 4)
C	Observed value from the 1986 TTS (GTA91 zone system aggregation)
D	Observed value from the 1991 TTS (GTA91 zone system aggregation)
E	Observed value from the 1996 TTS (GTA91 zone system aggregation)
F	Observed value from the 1996 TTS (GTA96 zone system aggregation)
G	Value to be used in the current model run
H	Base case forecast value
I to AB	Available to the user for calculations, implementation of modal split sub models and storage of the values used in different scenarios.
Row	
1	Numeric scenario identifier (Columns H to AB)
2	Scenario description
3 onwards	Data - 1 row per zone aggregation followed by super aggregation values

Notes:

1. Columns I through AB are not protected from modification.
2. Cell F1 is used to select the column containing the values to be used in the current run. Enter the appropriate scenario identifier.
3. Values may be modified selectively. The values used in the current run will default to the base case for any cell that is left blank or contains a zero value.
4. Super aggregations refer to modal split zone aggregations that have been aggregate further for the purpose of calculating base case values from the TTS data. The letters A through G are used to denote these aggregations. Those super aggregations are:
    - A - Rural municipalities without GO stations (Planning districts 17, 18, 19, 24, 25, 26, 34, 41, 43 and 44).
    - B - Zones in Metro (115 and 116) with insufficient 1996 data
    - C - Zones in York (293 and 300) with insufficient 1996 data
    - D - Zones in Peel (351, 352, 353, 354, 355 and 356) with insufficient 1996 data.

   The observed values for the individual mode split aggregations appear in columns C through F. Removing the super aggregation code from column B will cause the base case value to be replaced with the observed TTS value for 1996. The values for the super aggregations will not be re-calculated to reflect the change in zone aggregation.
5. Minor differences exist between the mode split zone aggregations based on the GTA91 zone system and the GTA96 zone system. The GTA96 zone system is used in the application of the model but 1986 and 1991 TTS data is not currently available on that zone base. The 1996 TTS mode shares are shown based on both zone systems in order to facilitate consistent time series analysis.
6. The base case mode split for external trips to and from the GTA is assumed to be 100% auto.

The worksheet **"row"** contains indices used in the lookup functions on the other sheets. This sheet should

not be modified.

2.5 MS_mod.xls - Mode Split Model

The workbook contains links to the mode split factors in the file **"MS_INP.xls"**, the trip generation rates in **"GEN_INP.xls"** and the trip generation calculations in **"GEN_MOD.xls"**. All four workbooks should be open in order for the mode-split calculations to be performed in an efficient manner. The mode-split calculations are performed sequentially by mode. The "other" mode consists primarily of walk trips. The "other" mode factors are applied to the projected work trip origin and destination totals for each traffic zone contained in each aggregation. Adjustment factors are applied so that the total number of origins matches the total number of destinations for the entire study area. The number of GO Rail work trip origins and destinations are calculated in the same manner by applying the GO Rail mode split factors to the remaining work trip origins and destinations after the "other" mode has been subtracted. The local transit trips are calculated after both the "other" mode and GO rail origins and destinations have been subtracted from the totals for each zone. The work trips that remain belong to the auto mode. The auto mode includes both drivers and passengers.

The worksheet **"input"** defines the zone aggregations to be used in the mode-split calculations. The sheet also shows by traffic zone the total work trip origins and destinations as calculated by the trip generation model. The entire sheet is protected.

Column	Contents
A	Traffic zone number (GTA96 zone system)
B	Mode Split zone aggregation number
C	GO Station number (Used to produce GO Rail ridership summary)
D	Calculated a.m. peak period work trip origins
E	Calculated a.m. peak period work trip destinations
G	GO Rail trip origins (output calculation)

The worksheet **"steps"** performs the mode split calculations and balances the total number of origins and destinations for each mode.

Column	Contents
A	Mode split zone aggregation number
B	Planning district number (Used to produce summary table - see note 1)
C	Total work trip origins by all modes
D	Total work trip destinations by all modes
F	"Other" mode origins prior to adjustment
G	"Other" mode destinations prior to adjustment
H	"Other" mode origins adjusted to match a common total
I	"Other" mode destinations adjusted to match common total
K	GO Rail origins prior to adjustment
L	GO Rail destinations prior to adjustment
M	GO Rail origins adjusted to match a common total
N	GO Rail destinations adjusted to match a common total
P	Local transit origins prior to adjustment
Q	Local transit destinations prior to adjustment
R	Local transit origins adjusted to match a common total
S	Local transit destinations adjusted to match a common total
U	Auto origins (The residual)
V	Auto destinations (The residual)
Row	
1-9	Totals by region.

11	Relative weights to be used in matching the origin and destination totals (See note 3)
12	Adjustment factors used to balance the origin and destination totals or each mode.
16 onwards	Data - 1 row per mode split zone aggregation

Notes:

1. The Planning District is assumed to be the zone aggregation number without the last digit.
2. Cells F11, K11 and P11 are not protected. These cells are used to enter the origin weight, between 0 and 1, to be used in balancing the origin and destination totals to a common total for each of the three modes. The destination weights, 1 minus the origin weights, will appear in cells G11, L11 and Q11. The default values have been set to 0.5 (mid-point) for all modes.

The worksheet **"factors"** contains the final mode split factors for each zone aggregation. The factors are shown as percentages of the total for all modes and have been rounded to two decimal places in preparation for the transfer of data to the emme/2 component of the model.

The worksheet **"summary"** contains trip end and mode split summaries by Planning District and Region.

The worksheet **"stations"** contains GO rail trip origin summaries by station catchment area and line. Appendix B contains a plot of the pre-defined catchment areas.

2.6 *d311.xls - Transfer of Trip Generation and Mode Split Data*

The workbook is linked to the definitions of zone aggregation contained in the workbooks **"Gen_mod.xls"** and **"MS_mod.xls"**. It contains all of the necessary zone based information needed to repeat the trip generation and mode split calculations in emme/2. The workbook consists of a single worksheet containing three components of data:

a) Rows 2 through 32 are formatted as comment statements. The values provide a summary of the selected input parameters, land use data and adjustment factors. This summary may be referred to as a convenient means of checking the input selections for a given run. The inclusion of these values provides a permanent record as part of the input file to EMME2.

b) Cells A34, A36, A38, A40 and A42 contain parameters required by the EMME2 Macros for the trip distribution and assignment components of the model. These cells are not protected from modification. The function of each parameter is described in chapter 3. The recommended default value of each is shown as part of the matrix description on the previous line.

c) The remainder of the sheet consists of matrix data formatted for input to EMME2: The trip generation rates and mode-split factors contain the adjustment factors needed to match total origins and total destinations.

Matrix	Contents
mo2	A.M. Peak period work trip generation rates.
md2	A.M. Peak period work trip destination rates.
mo3	A.M. Peak period non-work auto trip generation rates.
mo4	A.M. Peak period generation rates for school trips by local transit.
mo5	Other origin mode share of total peak period work trips.
mo6	GO Rail origin mode share of total peak period work trips.
mo7	Local transit origin mode share of total peak period work trips.
mo8	Auto (Driver + Passenger) origin mode share of total peak period work trips.
md5	Other destination mode share of total peak period work trips.
md6	GO Rail destination mode share of total peak period work trips.

md7	Local transit destination mode share of total peak period work trips.
md8	Auto (Driver + Passenger) destination mode share of total peak period work trips.
mo1	Population forecast by traffic zone
md1	Employment forecast by traffic zone

Notes:

1. Trip generation and attraction rates are initialized to zero then read by zone group using zone ensemble gg.
2. Mode split factors are initialized to zero then read by zone group using zone ensemble gm.
3. The mode split factors differ from the ones used as input to excel in the splits for all modes have been recalculated as a proportion of total work trips. The factors used as input to the excel component of the model are applied sequentially to the trips remaining after the trips for the previous mode(s) have been subtracted from the total.
4. The trip rates and mode-split factors are rounded to four decimal places. The rounding may result in minor differences between the totals obtained in excel and emme/2.

Saving the worksheet as a space delimited text file will generate a fully formatted input file that can be read by emme/2 module 3.11. Reading the file is one of the functions performed by the emme/2 macro **"stage1"**. The filename, without the extension, is one of the calling arguments used to run the macro. The same name will be incorporated into the output file names and as the origin matrix name that is used to store the performance indicators. Emme/2 naming conventions restrict the name to a maximum of 6 alphanumeric characters. The extension **".prn"** is required by the macro.

2.7 d301.xls - Transfer of zone aggregations to emme/2

The workbook is linked to the definitions of zone aggregation contained in the workbooks **"Gen_mod.xls"** and **"MS_mod.xls"**. The information is formatted for input to emme/2 as the following zone ensembles:

Ensemble	Contents
gg	Aggregations for trip generation (as defined in "Gen_mod.xls")
gm	Aggregations for mode split (as defined in "MS_mod.xls")
gp	Planning districts (Based on the mode split aggregations defined in "MS_mod.xls")
gr	Regions (Fixed aggregations of the above Planning District definitions)

Saving the worksheet as a space delimited text file will generate a fully formatted input file that can be read by emme/2 module 3.01.

The transfer of data only needs to be made when there is a change in zone aggregations.

3.0 EMME2 Components

The EMME2 components of the model consist of an emme2bank, associated input and output files and two macros that perform all of the modeling functions. Standard output from a model run includes the list of performance indicators. The macro **"stage1"** repeats the trip generation and mode split calculations performed by the excel components of the model. Trip distribution and assignment are performed using 1996 levels of service and travel times to estimate unconstrained future travel demand. The macro **"stage2"** applies capacity constraint procedures to estimate the amount of travel and level of service that would occur on an assumed future network. The assignment procedures used in stage2 include provision for an additional link cost element that can be used to represent tolls, gasoline taxes, parking charge or other fixed link cost.

3.1 Contents of emme2bank

The emme2bank used in the development of the model contains 5 scenarios. Scenarios 1 and 2 are used by the macros **"stage1"** and **"stage 2"**. The remaining scenarios, used in the calibration and validation of the model, are optional.

	Scenarios
1996	1996 Combined network - TTS assignments
1	Stage 1 assignment - 1996 network
2	Stage 2 assignment - Future network
3	1996 TTS all or nothing assignment (using scenario 1996 link times)
4	Spare
	Scenario 1996 Special Attributes
us2	1996 Base case transit boardings from scenario 1
us3	1996 Base case transit volumes from scenario 1
@b1996	1996 Boardings by line (TTS assignment)
@t1996	1996 Transit link volumes (TTS assignment)
@bs1	1996 Base case boardings (from scenario 1)
@tvs1	1996 Base case transit volumes (from scenario 1)
@pd	The planning district in which each link lies
@reg	Region containing each link
@scree	Screen line codes
	Scenario 1 to 3 Special Attributes
vdf	99 for all links (fd99=ul1)
ul1	Auto link time (timau from scenario 1996)
@pd	Planning district containing each link
@reg	Region containing each link
@scree	Screen line codes (from scenario 1996)
@orvdf	Original vdf function numbers by link (from scenario 1996)
@v1996	1996 TTS auto volumes (volau in scenario 1996)
@cost	Fixed link cost (dollars)
	Modes
c	Car
w	Walk
t	Transfer
b	Bus

h	HOV 2+
m	Subway
r	Commuter rail
g	Coach-bus
s	Streetcar
l	LRT
I	HOV 3
f	Heavy truck
z	GO Rail auto access
	Zone ensembles
ga	Zone groups used to calibrate trip distribution model
gb	Reserved for zone aggregation/disaggregation in 2nd databank (See chapter 5 on sub-area analysis)
gg	Zone groups used for trip generation model
gm	Zone groups used for mode split model
go	Standard output aggregations (Maximum of 15)
gp	Planning districts
gr	Regions
gs	GO Station Catchment areas (Home end)
	Annotations
a	Zone group ga boundaries
d	Durham street network
g	Zone group gg boundaries
h	Halton street network
m	Zone group gm boundaries
p	Planning Districts
q	Peel street network
r	Regions
s	GO Rail station catchment areas
t	Toronto street network
w	Hamilton-Wentworth street network
y	York street network
z	GTA96 Zone Boundaries
	Scalars
ms1-90	Temporary storage of performance indicators
ms92	Factor to be applied to auto access matrix (Recommended default value 1)
ms93	Factor used to convert fixed link costs to minutes (Recommended default value 5)
ms94	Most recent origin matrix number used to store performance indicators (Set by macro **"stage1"** and read by macro **"stage2"**.
ms95	Scenario to be used by stage2 macro (Default value 2)
ms96	Elasticity coefficient used to modify auto work trip distribution in response to changes in auto travel impedance. (Recommended default value 0.03)
ms97	Global adjustment of auto occupancy factors (Default value set to 1)
ms98	Global factor applied to GO Rail forecast to account for non work trips (Recommended default value 1.07)
ms99	Unit value (1)
	Origin Matrices
mo1	Population forecast
mo2	A.M. Peak period work trip generation rates.
mo3	A.M. Peak period non-work auto trip generation rates.
mo4	A.M. Peak period generation rates for school trips by local transit.

mo5	Other origin mode share of total peak period work trips.
mo6	GO Rail origin mode split of total peak period work trips.
mo7	Local transit origin mode split of total peak period work trips.
mo8	Auto (Driver + Passenger) origin mode split of total peak period work trips.
mo9	Simulated total work trip origins
mo10	Simulated non work auto origins
mo11	Simulated local transit school origins
mo12	Simulated other work origins
mo13	Simulated GO Rail work origins
mo14	Simulated transit work origins
mo15	Simulated auto work origins
mo30*	1996 TTS auto work origins
mo32*	1996 TTS non work auto origins
mo33*	1996 TTS GO Rail work origins
mo34*	1996 TTS Transit work origins
mo35*	1996 TTS Transit school origins
mo43*	Row totals for GO Rail base matrix
mo44*	Row totals for local transit base matrix
mo47*	Balancing coefficients - Transit school trips
mo48*	Balancing coefficients - Non work auto
mo49*	Balancing coefficients - auto work
mo51-98	Available for storage of performance indicators
mo99*	Number of cells in ga group
	Destination Matrices
md1	Employment forecast
md2	A.M. Peak period work trip destination rates.
md5	Other destination mode share of total peak period work trips.
md6	GO Rail destination mode split of total peak period work trips.
md7	Local transit destination mode split of total peak period work trips.
md8	Auto (Driver + Passenger) destination mode split of total peak period work trips.
md9	Total work trip destinations
md12	Other work origins
md13	GO Rail work destinations
md14	Transit work destinations
md15	Auto work destinations
md30*	1996 TTS auto work destinations
md32*	1996 TTS auto non work destinations
md33*	1996 TTS GO Rail work destinations
md34*	1996 TTS transit work destinations
md35*	1996 TTS transit school destinations
md43*	Column totals for GO Rail base matrix
md44*	Column totals for local transit base matrix
md47*	Balancing coefficients - Transit school trips
md48*	Balancing coefficients - Non work auto
md49*	Balancing coefficients - auto work
md99*	Number of cells in ga group
	Full Matrices
mf1*	Auto work base distribution matrix
mf2*	Auto non work base distribution matrix
mf3*	GO Train base distribution matrix

mf4*	Local transit work base distribution matrix
mf5*	Local transit school base distribution matrix
mf6*	1996 Auto Trip Times (equilibrium assignment of mf6)
mf7*	Auto occupancy matrix
mf8	Auto vehicle hours (Stage 2 after capacity constraint)
mf9	Simulated auto person work
mf10	Simulated auto person non work
mf11	Simulated GO Rail
mf12	Simulated Local transit work
mf13	Simulated Local transit school
mf14	Total auto vehicle matrix
mf15	Total transit matrix
mf16	Total GO Rail matrix
mf17	Congested road time (stage 2)
mf18	Revised auto work base distribution & auto person hours (Stage 2)
mf19	Revised total auto vehicle matrix (Stage 2)
mf20*	1996 TTS a.m. peak auto driver transit access
mf21	1996 TTS a.m. peak auto home to first work destination
mf22	1996 TTS a.m. peak auto non work origin to destination
mf23	1996 TTS a.m. peak GO Rail home to first work destination
mf24	1996 TTS a.m. peak local transit home to first work destination
mf25	1996 TTS a.m. peak local transit home to first school destination
mf26	1996 TTS a.m. peak period auto driver origin to destination
mf27	1986 TTS Total a.m. peak auto person
mf28	1986 TTS Total a.m. peak auto driver
mf29	1986 TTS Total a.m. peak local transit
mf30	1986 TTS Total a.m. peak GO Rail

* Matrices that should be protected from accidental modification

3.2 *Initial Setup*

The easiest way to set up an emme2bank for a new application or project is to copy the emme2bank and support files that were used in the development of the model. These files are located in the directory **"/scr3/dalton"**. The files that need to be copied are:

emme2bank
annot* (optional)
stage1
stage2

The directories **"input"** and **"output"** need to be created as sub-directories of the directory where the model is to be run.

Alternatively an emme2bank can be created from scratch by executing the command "EMME2 newbank" in the directory to be used for the application. The advantage of using the newbank command, instead of copying the emme2bank file, is that the dimensions can be reduced. The following table compares the dimensions of the development emme2bank with the minimum recommended for running applications.

	Development emme2bank	Current usage (1996 Combined network)	Recommended minimum
Network scenarios	5	4	2
Zone centroids	1750	1703	1710
Nodes including zone centroids	10200	9846	10000
Directional links	34000	33058	33000
Turn table entries	2000	1615	2000
Transit vehicle types	15	10	15
Transit lines	600	566	600
Transit line segments	24000	22434	24000
Matrices of type mf	30	30	20
Matrices of type mo	99	-	99
Matrices of type md	99	-	99
Matrices of type ms	99	-	99
Functions per function class	99	-	99
Operators per function class	2000	-	2000
Words for log book	500	-	500
Demarcation entries per set	100	not used	100
Words for extra attributes	500000	-	500000
Node labels required	No	-	No
User data on transit segments	Yes	-	Yes
Class specific auto volumes	No	-	No
Disk space required	407MB	-	~ 300MB

Once the emme2bank has been created data may be imported directly from the development emme2bank using module 1.31 (New in emme/2 release 8). The data that must be imported are:

Scenarios 1 (current network) and 2 (Future network)
All zone group ensembles
Full matrices mf1 through mf7 and mf20
Scalar matrices ms93 through ms99
All functions

3.3 *Stage1 Macro*

The macro **"stage1"** must be called from the main menu, has two calling arguments and performs the following functions:

- Selects scenario 1.
- Stores the run identification code and performance indicator matrix number as the name and content of the scalar matrix **ms94**.
- Reads the input file, generated by excel, which contains the population and employment estimates, trip generation rates and mode split factors.
- Duplicates the trip generation and mode split calculations performed by the excel spreadsheets.
- Performs separate trip distributions for each of five combinations of mode and trip purpose (Auto work, auto non-work, GO Rail work, local transit work and local transit school). Work trips are balanced by 2 dimensional balancing of a base matrix to the desired origin and destination totals. Balancing is restricted to 3 iterations to prevent any excessive distortion of travel patterns that might be caused by regional imbalances in land use assumptions. Base matrices for non-work auto and local transit school

trips are scaled to match the desired row totals.

- The total auto driver matrix (mf14) is calculated by applying the occupancy factors (mf7), together with the global adjustment factor (**ms97**), and adding the TTS observed auto driver transit access matrix (mf20) factored by the global adjustment factor (**ms92**).
- The total GO Rail matrix (mf16) is calculated by applying the non-work adjustment factor (**ms98**) to the GO Rail work matrix (mf11).
- A minimum path auto assignment is performed in **scenario 1** using the 1996 equilibrium link travel times stored in ul1.
- A two-stage transit assignment is performed in **scenario 1.** The use of the GO Rail and GO Rail auto access modes is prohibited during the assignment of the local transit trip matrix (mf15). All transit and auxiliary transit modes are permitted during the assignment of the GO Rail trip matrix (mf16).
- The performance indicators applicable to stage 1 are computed and stored in the selected origin matrix.
- An output file is produced containing the assigned auto link volumes on all links coded as screen lines.
- Two output files containing standard aggregations of selected trip tables and travel times are produced.

The calling arguments are:

- arg1 - A 1 to 6-character string identifying the name of the input file. The same name will be used to identify the performance indicator origin vector and the output files. The input file must be located in the sub-directory "input" and must have the extension .prn. The output files will be saved to the sub-directory "output". Any previous output files of the same name are deleted prior to saving the new data.

- arg2 - An integer number, between 51 and 98, specifies the origin matrix number to be used to store the performance indicators. Any previous values stored in that array will be overwritten.

The macro takes approximately 20 minutes to run, or longer if the system load is heavy. It may be initiated interactively or in batch mode.

3.4 Stage2 Macro

The macro "stage2" is called from the main menu and performs the following functions:

- The most recent identification code and performance indicator matrix number are retrieved from **ms94**.
- The network scenario specified in **ms95** is selected.
- A generalized cost equilibrium assignment is performed on the auto network. The values stored in the extra link attribute **@cost** are used as the fixed link cost component and the current value of **ms93** as the weight factor.
- The performance indicators, which relate to the congested state equilibrium (vehicle km, hours and average speed) are calculated and saved.
- A new auto work base distribution matrix is calculated by comparing the equilibrium travel times, including any fixed link costs, with the 1996 travel times. The implied impedance in the base matrix (mf1) is adjusted using the elasticity factor specified in **ms96**. A factor of 0.03 gives results that are near the middle of the plausible range defined by the two extremes:
    a) average travel distance will remain the same regardless of trip time, and
    b) average travel time will remain the same regardless of trip length.
- The assigned link volumes are used to calculate minimum path travel times excluding the fixed link cost component. The resulting travel times are used to calculate the performance indicators for mean trip auto travel time and the travel times between specific origins and destinations.
- The auto work trip distribution is repeated and a revised total auto vehicle matrix calculated.
- The generalized cost equilibrium assignment is repeated using the revised auto vehicle matrix.
- The performance indicators that relate to the constrained state equilibrium (road utilization factors, vehicle km, hours and average speed) are calculated and saved.

- An output file is produced containing the assigned auto link volumes on all links coded as screen lines.
- The assigned link volumes are used to calculate minimum path travel times excluding the fixed link cost component. These travel times are used to calculate the constrained state performance indicators for mean trip auto travel time and the travel times between specific origins and destinations.
- Output files, containing the standard aggregations of selected trip tables, are produced.

The macro does not require any calling arguments. It may take several hours to run and can be initiated interactively or as part of a batch process.

3.5 Batch Processing

The GTA simplified model can be run in batch mode using a batch input file. The following is a listing of a typical batch input file:

```
 pmd
~<stage 1 91base 51
~<stage 2
~<stage1 21base 52
~<stage2
```

Line 1 contains the initials of the person initiating the run.
Lines 2 and 3 instruct EMME2 to run both stages of the model using the input file "96base.prn", from the input directory. The performance indicators will be saved in mo51.
Lines 4 and 5 instruct EMME2 to run both stages of the model using the input file "21base.prn", from the input directory. The performance indicators will be saved in mo52.
There is no limit to the number of test runs that can be performed in one batch process other than the number of origin vectors available to store the output.

The UNIX command to execute an EMME2 macro in batch mode is:

```
emme2 batch –m filein >&filout&
```

where:

filein is the batch input filename, and
fileout is the filename to which the EMME2 dialog is to be routed

3.6 Performance Indicators

The values of the performance indicators can be transferred to a pre-formatted spreadsheet for analysis and comparison with other scenarios. The row and scalar numbers are given to provide the documentation, which might be needed if the macros need to be modified in the future.

Indicator	Aggregation	Source	Rows	ms
Stage 1 – Demand				
Population	Region & Ext.	Input data	1-8*	51-58
Employment	Region & Ext.	Input data	9-16*	59-66
Activity rate	Region & Ext.	Employment/population	17-24*	67-74
Total work trip origins	Region & Ext.	Trip generation model	25-32*	1-8**
Total work destinations	Region & Ext.	Trip generation model	33-40*	11-18
Non work auto origins	Region	Trip generation model	41-47	21-27**

Local transit school origins	Region	Trip generation model	48-54	31-37
"Other" work origins	Region	Modal split model	55-61	41-47**
GO Rail work origins	Region	Modal split model	62-68	51-57
Local transit work origins	Region	Modal split model	69-75	61-67
Auto work origins	Region	Modal split model	76-83	71-78
Other origin mode share	Region	Modal split model	84-90	
GO rail origin mode share	Region	Modal split model	91-97	
Local transit origin mode share	Region	Modal split model	98-104	
Auto origin mode share	Region	Modal split model	105-111	
Work trip self containment	Region	Trip distribution	112-118	81-87
Mean auto person min. (by origin)	Region	Trip distribution	119-125	81-87
Auto driver origins	Region	Auto occupancy model	126-132	31-37**
Mean auto occupancy	Region	Auto occupancy model	133-139	
Auto vehicle trips	Metro/in/out/ext.	Auto occupancy model	140-143	81-84
Vehicle km	Region	Minimum path assignment (1996 Network)	144-150	81-87
Freeway utilization	Region	Minimum path assignment (1996 Network)	151-157	51-57 81-87
Urban Arterial utilization	Region	Minimum path assignment (1996 Network)	158-164	51-57 81-87
Passenger boardings	Transit sub-mode	Transit assignment	165,170	79-84
Passenger km	Transit sub-mode	Transit assignment	171,176	86-90
Mean travel distance per boarding	Transit sub-mode	Transit assignment	177,182	

Stage 2 - Capacity constraint and Level of Service

Before trip length adjustment				
Mean auto trip time	Region	Equilibrium assignment	183,189	11-17
Auto vehicle km	Region	Equilibrium assignment (Future network)	190,196	11-17
Auto vehicle hours	Region	Equilibrium assignment	197,203	51-57
Mean auto speed	Region	Equilibrium assignment	204,210	
Select O-D times	10 Pairs	Equilibrium assignment	211,220	51-60
After trip length adjustment				
Work trip self containment	Region	Trip distribution	221,227	81-87
Auto vehicle trips	Metro/in/out/ext.	Auto occupancy model	228,231	81-84
Mean auto trip time	Region	Equilibrium assignment	232,238	11-17
Auto vehicle km	Region	Equilibrium assignment	239,245	11-17
Auto vehicle hours	Region	Equilibrium assignment	246,252	51-57
Mean auto speed	Region	Equilibrium assignment	253,259	
Freeway utilization	Region	Equilibrium assignment	260,266	51-57 81-87
Urban arterial utilization	Region	Equilibrium assignment	267,273	51-57 81-87
Select O-D Times	10 Pairs	Equilibrium assignment	274,283	51-60

* totals for 6 regions, external total and total excluding external

** referenced in stage2

The performance indicators may be retrieved from the emme2bank using option 1 (list a matrix) in module

3.14. Before selecting module 3.14 change the reports file name (reports=xxxxx) to something appropriate. Sub option 3 (several matrices by zones) permits the performance indicators for up to 7 runs to be tabulated at one time. Use the sub-matrix option to specify origin zones 1 to 283.

The file(s) containing the tabulations may be downloaded to a P.C. and opened in excel specifying fixed field width. Copy the resulting worksheet to the **"input1"** or **"input2"** worksheet of the file **"perf_ind.xls"**. The worksheet **"output"** has been pre-formatted to display the results with all of the appropriate headings and to provide comparisons with the assignment of the 1996 TTS data. The use of two input sheets (input1 and input2) permits comparisons to be made between a maximum of 14 runs in total.

3.7 Standard output files

- xxxxxx.rep — stage 1 EMME2 dialog.
- xxxxxx.sl1 — Auto screen line crossings from stage 1 (No capacity restraint)
- xxxxxxgo.mt1 — Aggregated matrices from stage 1 using zone group ensemble go
  - a.m. peak period auto person work
  - a.m. peak period auto person non work
  - a.m. peak period local transit work
  - a.m. peak period local transit school
  - a.m. peak period GO Rail work
  - a.m. peak period total auto vehicle
  - a.m. peak period auto person hours
  - a.m. peak period auto vehicle hours
- xxxxxxgp.mt1 — Aggregated matrices from stage 1 using zone group ensemble gp
  - same matrices as for xxxxxxgo.mt1
- xxxxxx.rp2 — stage 2 EMME2 dialog
- xxxxxx.sl2 — Auto screen line crossings from stage 2 (with capacity restraint)
- xxxxxgo.mt2 — Aggregated matrices from stage 2 using zone group ensemble go
  - a.m. peak period auto person work
  - a.m. peak period total auto vehicle
  - a.m. peak period auto person hours
  - a.m. peak period auto vehicle hours
- xxxxxgp.mt2 — Aggregated matrices from stage 2 using zone group ensemble gp
  - same matrices as for xxxxxxgo.mt2

xxxxxx denotes the run identification code used as the first calling argument for the macro "stage1". Both the macros "stage1" and "stage2" delete any previous output files with the same name prior to writing new output information.

The matrix output files (*.mt1 and *.mt2) may be downloaded to a P.C. and opened in excel specifying spaces and colons (:) as field delimiters. Copy the resulting worksheet from stage1 (*.mt1) to the "input1" sheet in formatgo.xls or formatgp.xls, depending on which zone aggregation is being used. Copy the resulting worksheet from stage 2 (*.mt2) to the "input2" sheet of the same file. Run the macro "format" in each of the two input spreadsheets. Excel macros are executed using the "tools" icon. The formatted trip tables will appear, ready for printing, on the appropriate worksheets. The formatting of the tables by planning district (formatgp.xls) may take a considerable amount of time. The other spreadsheet

(formatgo.xls) is smaller and should take only a few seconds to format. The zone aggregations currently defined in EMME2 as zone group ensemble "go" are:

- go1 Old Planning District 1
- go2 Old Planning Districts 2-6
- go3 Old Planning Districts 7-9 (Etobicoke)
- go4 Old Planning Districts 10-12 (North York north of Hwy 401)
- go5 Old Planning Districts 13-16 (Scarborough)
- go6 Regional Municipality of Durham
- go7 Regional Municipality of York
- go8 Regional Municipality of Peel
- go9 Regional Municipality of Halton
- go10 Regional Municipality of Hamilton-Wentworth
- go11 All external areas

The output sheets in "formatgo.xls" have been formatted to give sub-totals for the new City of Toronto as well as the above breakdown. Editing the zone ensemble "go" in EMME2 and the formatting of the output sheets in "formatgo.xls" can modify the zone aggregations. The maximum number of zone aggregations that can be conveniently accommodated is 15.

The files containing the screen line volumes before and after capacity restraint (*.sl1 and *.sl2) may be downloaded to a PC and opened in Excel specifying a space as the field delimiter. Copy the resulting worksheet to the "input" sheet of the file "screenl.xls".

4.0 Future Scenarios

The following assumptions are suggested as a base case future scenario.

4.1 Assumptions

The suggested forecasts are of the global, or average, net change relative to 1996.

	Annual rate of change between 1986 and 1996	Determining Factors	2001 Forecast	2011 Forecast	2021 Forecast (& Beyond)
Population	+ 1.95%	Natural Growth. Migration.	Hemson (see rationale)	Hemson (see rationale)	Hemson (see rationale)
Trip Generation Rates					
ELF Participation Rate	- 1.1%	Aging of the population. Female participation. Job availability Early retirement. Higher education.	+8%	+ 8%	+ 3%
Work outside the home	- 0.2%	Technology. Outside contracting.	-2%	- 5%	- 8%
Daily work trip rate	+ 0.6%	Absenteeism. Vacation time Proportion of part time work Nature of part time work.	No change	No change	No change
Peak period factor	- 0.8%	Flexible work hours. Part-time work. Congestion levels.	-2%	- 5%	- 5%
Net trip rate (Sum of last 4 factors)	- 1.5%		+3%	- 2%	- 9%
External commuting rate	> 5%	Job opportunities on the outskirts of the GTA. Tele-commuting. Semi-retirement.	+10%	+ 20%	+ 25%
Employment	N/A	Economic activity Labour force	Interpolate Hemson forecast of growth to match population based trip forecast		
Non work auto peak period trip generation rate.	+ 3.1%	Age distribution. Socio-economic trends.	+3%	+ 15%	+ 20%
a.m. peak transit school trip rate.	No change	School busing policies. Security (young females)	No change	No change	No change

Modal Split Factors					
Other work origins	No change. (Small local increase in downtown Toronto)		No change	No change	No change
Other work destinations	No change. (Small local increase in downtown Toronto)		No change	No change	No change
GO Rail origins 4 Regions	+ 1.5%	Growth in population relative to downtown employment.	No change *	*	*
GO Rail dest. PD 1	+ 5.0%	Growth in population relative to downtown employment.	No change *	*	*
Transit origins Metro 4 Regions Ham-Wen.	- 1.1% - 0.3% - 6.1%	Socio-economic trends. (Females & youths) Level of service. Environmental concerns. Financial constraints.	No change	No change	No change
Transit dest. Metro 4 Regions Ham-Wen.	- 1.6% - 0.4% - 6.3%	Socio-economic trends. Level of service. Environmental concerns. Financial constraints.	No change	No change	No change
Auto occupancy	No change	Auto availability Driver's licensing Cost of driving Environmental Policies	No change	No change	No change
GO Rail non work factor	-0.1%		No change	No change	No change

* See discussion in section 4.2 regarding GO Rail mode split and balancing factors.

4.2 Rationale

The following discussion focuses primarily on the forecasts for 2011 and 2021. It is recommended that the assumed trip generation rates and mode split factors remain constant beyond the year 2021 because of the high degree of uncertainty involved in all aspects of forecasting beyond a 25 year time horizon. The recommendations for 2001 have been included as an aid to addressing immediate, short term planning issues, and as a potential validation point against which future trends can be monitored and compared.

- Population

  Population growth rates have declined substantially since the 1960s when the annual growth rate for the GTA as a whole was more than 3%. Most of the decline can be attributed to lower fertility rates. Fertility rates currently remain well below long-term mortality replacement rates but, due to the age distribution of the population, there will continue to be a small amount of natural growth in population for the next 10 to 15 years. Unless there is an increase in fertility rates population growth beyond the year 2011 will be entirely dependent on in migration.

  The observed reduction in population growth rates since 1991 reduces the likelihood of the Hemson Scenario 2 forecasts being achieved within the time frame for which they are projected. Scenario 2 was used as the base in the application of the simplified model for the GTA Transportation Plan Study. Rather than make changes to these forecasts it is suggested that the fact that it may take longer to achieve them be recognized i.e.: that the forecast for 2011 may be applicable to 2014 and the forecast for 2021 may not be reached until 2025 or later.

- Labour Force Participation Rates

  Labour force participation rates reached an all time high shortly after the 1986 TTS. A booming economy, together with the age distribution of the population - all of the baby boomers were of working age, and high levels of female participation in the labour force were the significant factors in reaching those high levels of total labour force participation. The recent (since 1989) decline in labour force participation rates must be attributed, at least in part, to the economic recession and the resulting shortage of employment opportunity. It is not clear as to the extent to which these changes represent permanent re-structuring of the economy as opposed to being part of a prolonged economic cycle.

  The proportion of the population that is of working age will remain constant until the year 2011 and will then decline as the baby boomers start to reach retirement age in significant numbers. Male participation rates have declined since 1989 while female participation rates, in the middle and older age categories, have remained constant or declined only slightly. Participation rates for women remain below those for men in all but the youngest (15 to 24) age category. Future increases are therefore possible.

  The recent drop in labour force participation rates has been most noticeable in the 15 to 24 age range, where the 1996 rate was approximately half the 1986 rate for both sexes. In the 55 to 64 age category for men there was a 25% drop. In the same time period the proportion of the total population in the 20 to 24 age range that were full time students increased by 50%. The TTS data on its own does not permit any quantitative conclusions to be drawn as to the extent that these changes reflect personal aspirations and life style choices as opposed to being driven by the state of the economy and lack of available jobs. There is clearly potential for a reversal of these trends that could lead to the employed labour force expanding more rapidly than the population, should more jobs become available.

  The recommended future values are based on the assumption that there will be continued economic recovery leading to an increase in labour force participation rates by 2001 of half the amount lost since 1986. In the longer term it is assumed that the changing age distribution of the population will become the dominant factor resulting in a decline in labour force participation rates after the year 2011.

- Work at Home

  Although there has been much talk about the increased potential for people to work at home, and a significant percentage increase in the number of people who do, the effect on total trip making has been very minimal to date. It is suggested that the trend will continue and may increase slightly in pace.

- Daily work trip rate.

  The increase in daily work trip rate between 1986 and 1996 was due primarily to an increase in trip frequency for people who are employed part time. It could be that there are more people working 3 or 4 days a week, as opposed to 1 or 2, or that a number of people have more than one part time job. The TTS data does not identify people with more than one job. In either case there is limited potential for further increase. There could be a reversal of the previous trend as the economy recovers, although it is unlikely to result in significant change in total trip rate relative to the other factors.

- Peak period factor

  There has been a consistent trend towards a slight spreading of the peak period for work trips in all

regions. The 1991 TTS data generally lies mid-way between the 1986 and 1996 data. It is suggested that the trend will continue in the short term before leveling off at a constant value.

- Net work trip rate

  The effect of applying the suggested values in combination produces over all peak period work trip rates for 2011 and 2021 that are about 10% lower than were assumed for the GTA Transportation Plan Study and 18% to 25% below the 1986 levels used in the previous calibration of the full GTA model. These differences represent a significant change in the predicted need for new transportation facilities.

- External commuting

  The suggested future values for external, population based, trip generation rates for work trips to the GTA are similar in magnitude to those used for the GTA Transportation Plan Study. The 1996 TTS values are consistent with previous values derived from 1991 Census POW and traffic count data.

- Employment

  A substantial reduction is needed in the previously forecast totals in order for the base case employment forecasts to be consistent with the above population based assumptions. The previous totals (Hemson scenario 1) would need to be reduced by 20% for 2011 and about 30% for 2021. In the previous application of the simplified GTA model the discrepancy between the population and employment forecasts was resolved by using the population based work trip generation as the control total. A global reduction factor was applied to reduce the total number of work trip destinations to match the origin total. **An important question is whether it is better to factor total employment to obtain a balance, or the projected growth in employment. There is likely to be significant differences in the resulting travel patterns depending on which approach is adopted.** An alternative approach (used in the application of the full GTA model), is to factor to the mid-point of the calculated population and employment based trip totals.

  The recommended alternative (factoring the growth) avoids the need to generate new employment forecasts. The current forecasts (Hemson) are used to determine the distribution of future employment growth but the rate at which the growth is assumed to occur is adjusted so that the overall GTA job and work trip totals are consistent with the population based forecasts. It is suggested that the employment forecast for a given year be obtained by interpolating between the appropriate two years of the Hemson forecasts, to give a total GTA employment estimate that agrees with the population and labour force participation assumptions. The work trip destination totals are balanced to the origin total as a final adjustment.

- Non work auto trip generation

  The suggested adjustment factors for 2011 and 2021 are 15% higher than those used in the GTA Transportation Plan Study. The reason is that the observed increase between 1991 and 1996 was greater than the increase that was previously assumed for the entire period from 1991 to 2011. The assumed increase in work trip rates prior to 2001 is assumed to reduce the rate of growth in non-work related travel over the same time period.

- School trips by local transit

  Continued no change in the over all trip rates were the assumption used in the GTA Transportation Plan Study. Changes in school busing policy could affect future rates but such changes are hard to

predict and are likely to be localized.

- "Other" mode split factors

  The "other" mode-split factor has been highly consistent, both spatially and over time.

- GO Rail mode split factors

  The GO Rail mode share for work trip destinations to the downtown increased significantly between 1986 and 1989, remained constant between 1989 and 1996 and has been increasing again since 1996. The resulting increase in ridership may necessitate an increase in GO Rail service levels that could generate a further increase in mode share. The mode split factors suggested in the mode split tables (2011E and 2021E) are intended to reflect the increase in service on the existing GO Rail lines that would be necessary to accommodate the projected increase in ridership due to population growth in the GO Rail service area. Using these mode split factors with adjustment factors to balance to an over all trip total that is between the origin and destination totals reflects a continuation of both existing and long term historical trends. The use of an origin balancing factor of less than 0.5 (e.g.: 0.3) may be appropriate if GO Rail ridership is close to saturation of the downtown employment. A higher factor may be justified if the downtown catchment area expands or if the level of service on competing modes, particularly the auto mode, into the downtown deteriorate.

- Local transit mode split factors

  It was assumed in the GTA Transportation Plan Study that transit mode splits would increase from 1991 levels part way back to 1986 levels by 2011 and then would remain constant. The trend between 1991 and 1996, however, has continued downwards. In addition the elimination of provincial subsidies and the current financial constraints that could lead to further fare increases and cuts in service suggest that any significant increase in transit mode splits in the near future is unlikely. Future changes in the age distribution of the population could have a minor, but, beneficial effect. The increase in auto use and availability among younger women is likely to have a continued negative effect for at least the next twenty years as these women replace the women in the older age groups who were more transit dependent in their youth. Further declines in transit ridership are therefore possible, and likely, if current service levels cannot be maintained or improved. The assumption that transit mode splits can be maintained at 1996 levels implies some degree of renewed commitment to maintain public transit levels of service.

5.0 Sub-Area Analysis

The following procedure is recommended for the conduct of sub-area analysis that requires more detailed representation of the network and a finer zone system for a small area. The procedure is not specific to the GTA Simplified model and could also be used with the full GTA model.

The conversion process requires the establishment of two emme2banks referred to as bank "A" and bank "B".
Bank "A" contains the full GTA network and the 1996 GTA zone system. Bank "B" contains the network with the more detailed zone system and sub-area network representation. The detailed zone system must consist of GTA zone aggregations or sub-divided zones that can be aggregated to GTA zone boundaries. Zone ensemble gb is used to provide the link between the two emme2banks.

In bank "A" the ensemble gb is used to aggregate the GTA traffic zones that are remote from the area under study. Aggregation is not essential to the process but will improve the computational efficiency of the sub-area analysis. If zones are to be aggregated it is recommended that one of the GTA zone numbers in each aggregation be chosen as the zone centroid for the aggregated group and that the same zone number be used as the aggregated group number. The zone ensemble (gb) has been preset to provide a one to one correspondence between the GTA zone numbers and the group numbers. i.e. zone group gb1 consists of traffic zone 1, zone group gb2 consists of zone 2 etc. up to zone group gb4403 consisting of external zone 4403.

In bank "B" the ensemble gb is used to sub-divide the zones in the area for which more detailed analysis is required. The ensemble must contain one or more entries for each of the zone group numbers used as output from bank "A". An origin matrix (mon) and a destination matrix (mdn) are used to specify the proportions in which the origins and destinations are to be split between the zones that make up each zone group. The value 1 should appear in both matrices for the zones that are not being split.

Procedure

1. Run the GTA model in bank "A" to produce the required "base case" trip tables based on the GTA traffic zone system.
2. Edit (module 3.01) zone ensemble gb in bank "A" to define the desired aggregation of zones remote from the study area.
3. Punch (module 3.14) each matrix to be transferred using aggregation gb for both origins and destinations.
4. Copy the full GTA network from bank "A" to bank "B" and edit in the extra detail and additional zone centroids required for the sub-area analysis. **(Note: It is not necessary to take out the superfluous centroids contained in the full network. They will be ignored in the assignment process if there are no trips).**
5. Edit zone ensemble gb in bank "B" to define the new zones that make up each of the GTA zones in the sub-area.
6. Input the matrices (module 3.11) from bank "A". The file does not require any editing unless the matrix numbers or descriptions are to be changed.
7. Create, or input, the origin and destination matrices (mon & mdn) containing the proportions in which the origins and destinations are to be split.
8. Perform the following matrix calculation (module 3.21) on each of the matrices to be used in the sub-area analysis mf(new) = mf(old) * mon * mdn
9. Proceed with the sub-area analysis.

Note: Local variations in land use can be analyzed by making the appropriate changes to the split factors (mon & mdn) or by applying additional adjustment factors to reflect the change in land use.

Appendix A - Training Exercises

General Notes:

1. The files required to perform this exercise, and to run the excel components of the model, are contained in the directory **/scr/gtamodel** on the UNIX system.

2. Use the main part of the simplified GTA model users guide as your reference manual.

3. When opening files in excel **do not** ask to re-establish links. The necessary links will be established automatically when the other files are opened. The time taken to establish links to un-opened files can be prohibitively long.

4. When copying spreadsheets that are newly formatted from text files it is best to do a simple copy of the entire spreadsheet (Click on the top left corner and press Ctrl+c). Copying the entire sheet will ensure that any previous values on the receiving sheet are deleted even if the new sheet contains less information.

5. When copying from a spreadsheet that contains formulae to another spreadsheet, either as input data (e.g.: population & employment) or to save and analyse results, it is necessary to do a Paste Special to obtain the values instead of the formulae. The keyboard sequence Alt+e,s,v,<enter>,Alt+e,s,t,<enter> can be used to paste both the values and formatting.

6. Most of the excel files are password protected so that only the necessary cells can be modified. I.e.: the formulae remain protected. For normal operation it should not be necessary to remove the protection. If, for any reason, you do decide to make modifications to the layout or formulae contained in the sheets the password is **PMD.** It is recommended that you make a copy of the original files before making any modifications.

Part A - Front End Excel components

1. Copy the file gtamod1.zip to your work area and unzip the contents.

2. Initiate excel

3. Open the file gen_inp.xls
   - Select one of the input attributes and create a column with a new set of values
   - Enter the same code as you used to identify the column into cell E1 in order to select the new values for the current run.
   - Check the other input attributes to ensure that the selection is consistent (e.g. representing the same year in all cases)

4. Open the files popemp.xls and gen_mod.xls
    - Select the desired population and employment data and copy the **values** to the model sheet of gen_mod.xls
    - Verify that you have your desired weighting of origin and destination totals.

5. Open the file ms_inp.xls
    - Select one of the mode choice input tables and create a column containing a new set of values
    - Enter the appropriate code into cell G1 to select the column you have just created.
    - Check the other mode choice input tables to ensure that the selections are consistent

6. Open the file ms_mod.xls
    - Review the weights assigned to the origin and destination totals for each of the first 3 modes. Make Modifications if desired.
    - Copy the **values** from either the summary or station worksheets to a new workbook so that they can be used for further analysis and comparisons.

7. Open the file d311.xls
    - Save as a space delimited text file using an appropriate name (xxxxxx.prn) that will identify the run in emme2 (maximum 6 alphanumeric characters not including the extension).

8. Repeat the previous exercise changing one or more of the following inputs
    - Land use (population and employment)
    - Trip generation rates
    - Relative weights given to work trip totals based on population Vs employment
    - Mode choice assumptions
    - Relative weights assigned to the origin Vs destination totals for each of the three modes

9. Compare the two sets of results.

Part B - Emme2 components

1. Upload the two files created in step 7 of Part A to the input sub-directory.

2. Create and execute a batch input file to run both stages of the model for each of the two scenarios.

3. Initiate emme2 in inter-active mode
    - Create an output (reports) file containing the performance indicators for both scenarios.
    - Compare the stage 1 and stage 2 road assignment results from the second

scenario. (The assignment results from the first scenario will have been over written)

4. Download the following files
   - the reports file containing the performance indicators
   - the matrix summary files (from the output sub-directory)
   - the screen line summary files (from the output sub-directory)
   - any other report or plot files you wish to generate

Part C - Excel Back End components

The file gtamod3.zip contains a set of emme2 output files that may be used as input to the part of the exercise without doing parts A and B first.

1. Copy the file gtamod2.zip (gtamod3.zip if required) to your work area and unzip the contents.

2. Initiate excel

3. Open the file per_ind.xls
   - Open the reports file containing the performance indicators using fixed field widths to define the columns (no blank columns)
   - Copy the resulting spreadsheet to one of the two input sheets of per_ind.xls
   - Review the results shown on the output sheet. Sections may be copied to a new workbook for further analysis.

4. Open the file screenl.xls
   - Open the emme2 output file containing the screen line volumes from stage 1 or stage 2 of one of the two scenarios (xxxxxx.sc1 or xxxxxx.sc2) as a space delimited text file.
   - Copy the resulting spreadsheet to the input sheet of screenl.xls.
   - Review the screen line totals shown on the results and major sheets. The workbook may be saved under another name or a copy made of the results sheets if they are needed for comparisons or further analysis.

5. Open the file formatgo.xls
   - Open the emme2 output file containing the standard matrix aggregations from stage 1 of the model (xxxxxxgo.mt1) as a space and colon (:) delimited text file.
   - Copy the resulting spreadsheet to the input sheet of formatgo.xls
   - Run the macro 'format' (from the Tools icon).
   - Review the formatted matrices - copy or print as desired.

Special notes re 5 above

   - The file formatgp.xls is available for formatting matrices generated using zone

ensemble gp (Planning districts) but is not included in the basic training package due to the amount of disk space (6 MB) required and the length of time it takes to format the results (15-20 minutes).

- The same files may be used to format stage 2 results (xxxxxxgo.mt2 and xxxxxxgp.mt2)

Appendix B - Zone Aggregations

GO Stations

Exhibit B1 shows the catchment areas that have been predefined for each GO Rail station.

Lakeshore West Line

2	Mimico
3	Long Branch
4	Port Credit
5	Clarkson
6	Oakville
7	Bronte
8	Appleby
9	Burlington
10	Aldershot
11	Hamilton

Lakeshore East Line

21	Danforth
22	Scarborough
23	Eglinton
24	Guildwood
25	Rouge Hill
26	Pickering
27	Ajax
28	Whitby
29	Oshawa

Milton Line

31	Kipling
32	Dixie
33	Cooksville
34	Erindale
35	Streetsville
36	Meadowvale
37	Milton

Georgetown Line

41	Bloor
42	Weston
43	North Etobicoke
44	Malton
45	Bramalea
46	Brampton
47	Georgetown

Bradford Line

51 Maple
52 King
53 Aurora
54 Newmarket
55 Bradford (Outside the GTA)

Richmond Hill Line

61 Oriole
62 Old Cummer
63 Langstaff
64 Richmond Hill

Stouffville Line

73 Agincourt
74 Milliken
75 Unionville
76 Markham
77 Stouffville

Exhibits B2 and B3 show the aggregations used for trip generation and mode split. The area not shown in exhibit B3 has the same aggregations as B2.

Exhibit B1 - GO Rail Station Catchment Areas

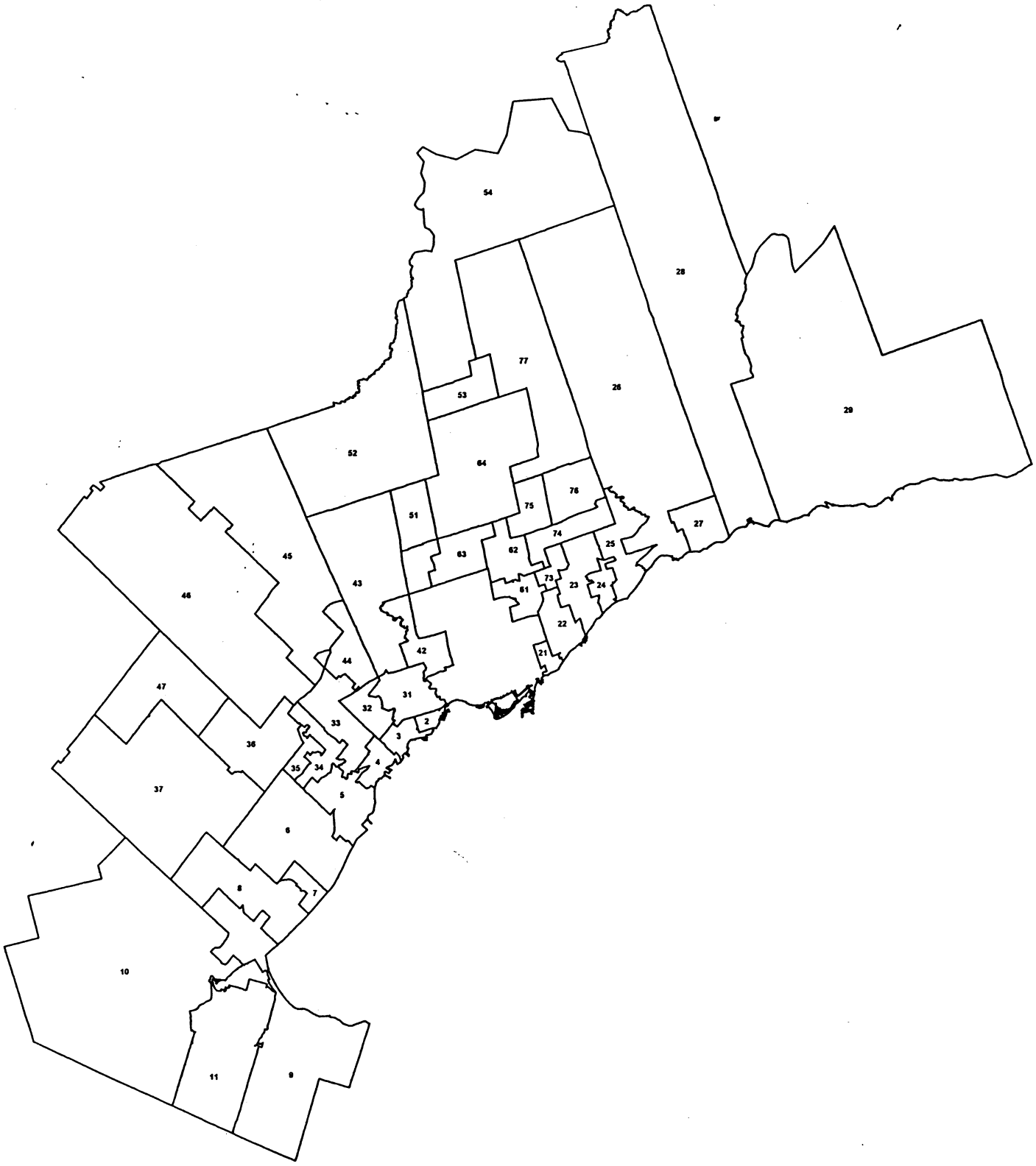


Exhibit B2 - Zone Aggregations Used for Trip Generation

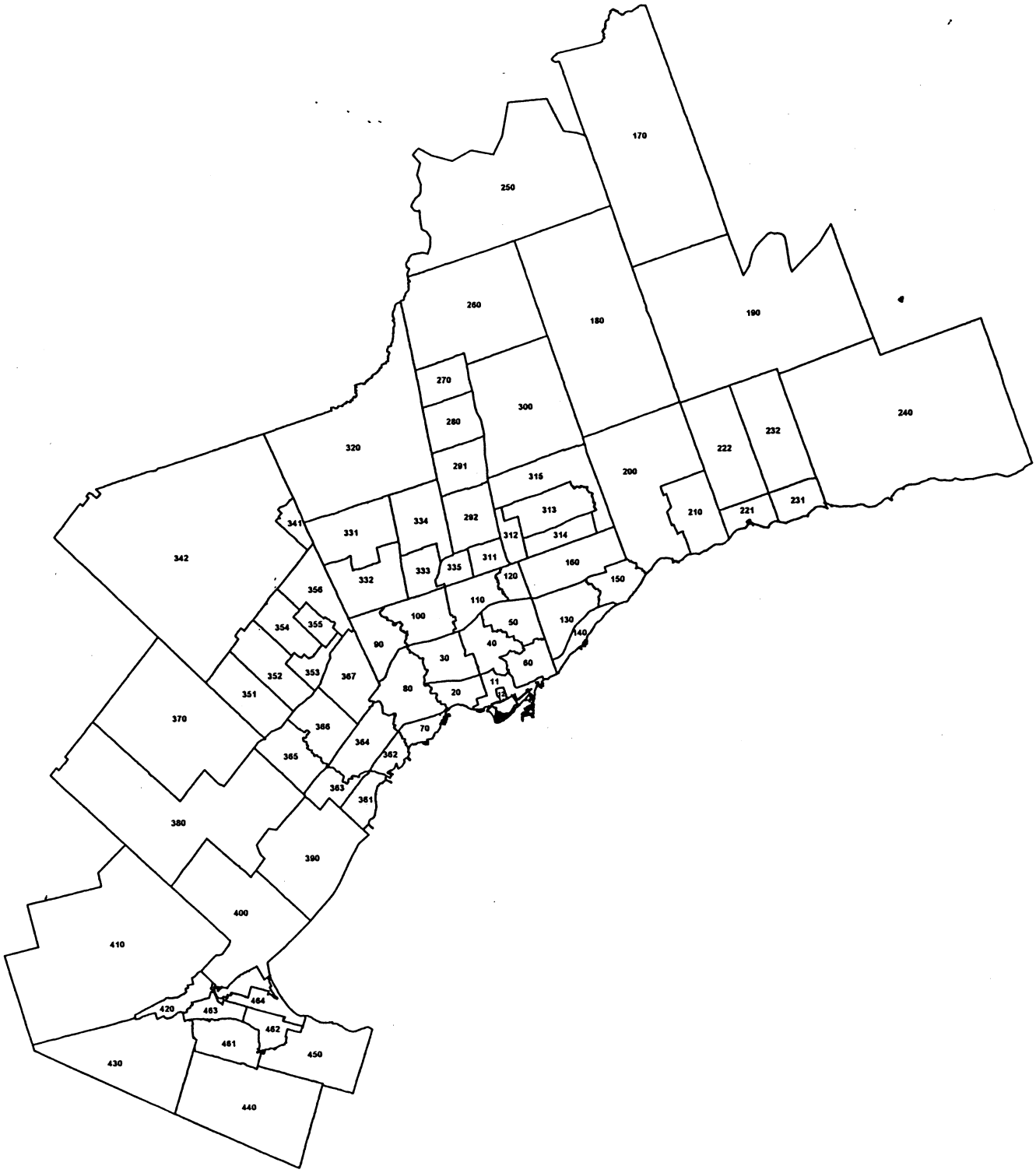
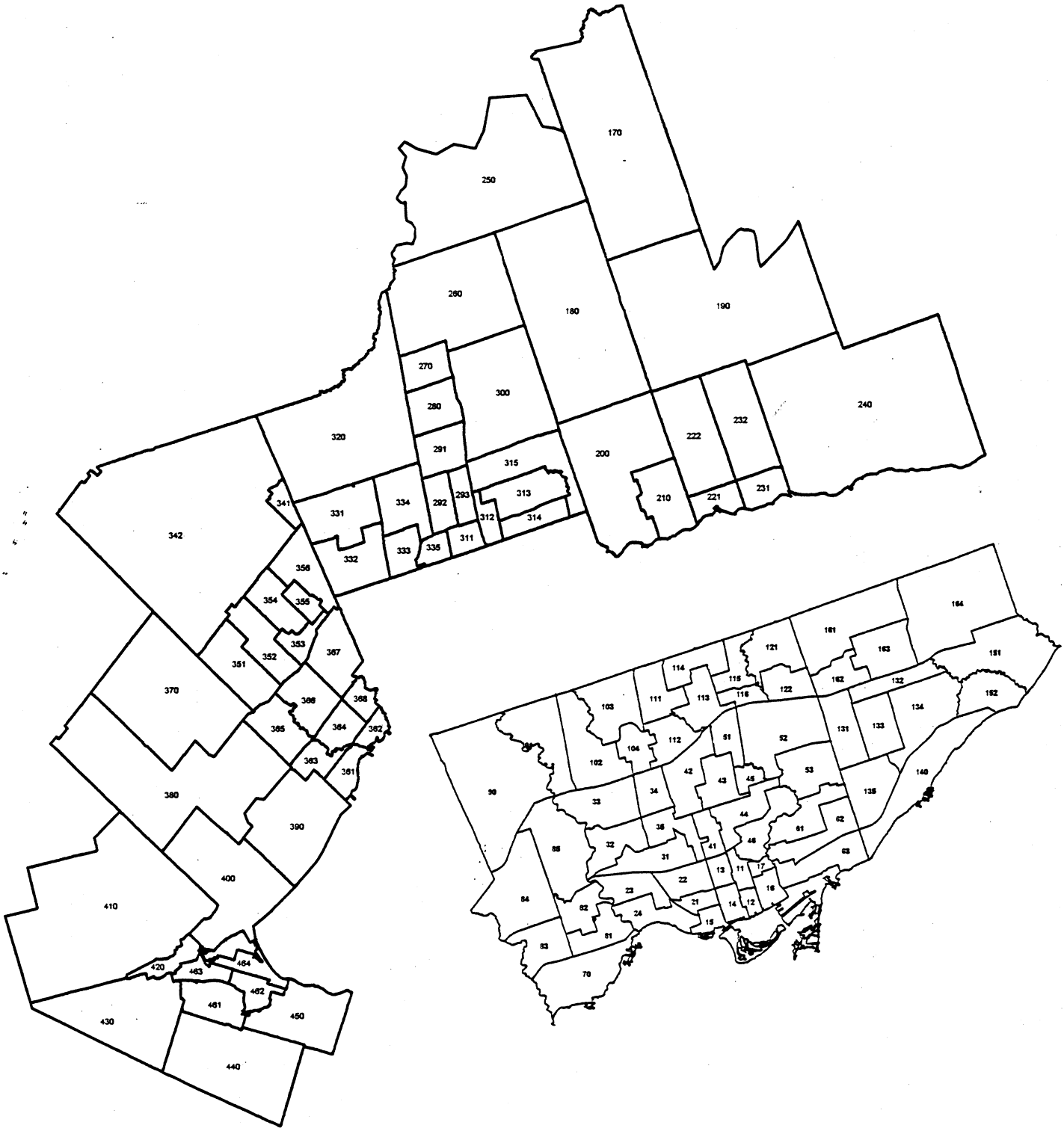


Exhibit B3 - Zone Aggregations Used for Mode Split



APPENDIX C - 1996 Validation

It was found that applying the TTS trip generation rates to the 1996 census population and employment data resulted in a discrepancy between the number of more work trip origins and destinations in the a.m. peak period. The number of origins was 7% higher than the number of destinations. Most of that discrepancy can be attributed to the following:

1. Differences between TTS and census population.

Relative to the census the TTS under reports the population of the GTA as a whole by 3.5%. The TTS validation report shows that 75% of the total under reporting of population occurs in the age zero and age 68 plus groups, neither of which would be expected to make any significant number of work trips. Applying the TTS work trip generation rates to the total census population would therefore be expected to lead to an over simulation of work trip origins. The base case labour force participation rates have been reduced by a global factor of 2.6% (3.5 x .75) to correct for this difference.

2. Differences between TTS and census employment.

Total employment in the GTA, as reported in the TTS, was 1.5% higher than the total given by the census. In addition the TTS employment figures do not include non-residents of the survey area. The trip generation rates that have been assumed for the Regional Municipality of Haldimand-Norfolk, Brant county and the parts of Wellington, Dufferin, Simcoe, Peterborough and Northumberland counties not covered by the TTS add an additional 32,000 a.m. peak work trip destinations to the GTA - 2.2% of the total - increasing the total discrepancy between the TTS and census to approximately 3.7%. Seasonal variations and the difference in timing between the census and TTS would account for some of this difference. If that is the major cause of the difference, and assuming that it is desirable for the model to represent fall conditions when travel demand is highest, using the TTS estimates of employment would be more appropriate than the census data. Employment data based on the census, however, is more likely to be used as the base for future estimates. A 1996 base case simulation was therefore produced using census based control totals for both population and employment but with an adjustment factor applied to work trip destinations in order to match the work trip origin total. The adjustment factor adds 4.4% to the work trip destinations in each zone, having the same effect as applying a global adjustment to the employment figures. The differences in Employment totals by Regional Municipality are summarised below.

Toronto - The TTS employment total is 4% higher than the totals given by both the census and Toronto's own employment surveys. Work trips from outside the survey area are not likely to be a significant factor

Durham - The TTS employment is 6% higher than the census before any allowance is made for trips from outside the survey area.

York - The TTS employment is 3% higher than the census before any allowance is made for work trips from outside the survey area.

Peel - The TTS and Census employment totals match within 1%. Work trips from outside the TTS area are not a significant factor. Applying the 4.4% adjustment may therefore over represent actual employment in Peel. The Region of Peel's own employment data gives totals that are 13% to 14% higher than either the census or TTS but these numbers are based on past projections, not actual counts.

Halton - The TTS employment total for Halton is 5% lower than that given by the census. The region's own employment data is in close agreement (within 1%) with the census. Work trips from outside the survey account for about half of the discrepancy.

Hamilton-Wentworth - The TTS employment number is 2% lower than the census but the addition of about 15,000 work trips from outside the TTS results in a total that is 5% higher than the census. The Region's own employment data is in close agreement with the census.

Exhibit C1 - Validation Performance Indicators

	Observed		Simulated		
	1986 TTS	1996 TTS	96tts-excel	96tts-emme2	96base
Population					
1 Toronto	2,134,251	2,305,558	2,305,554	2,305,554	2,386,217
2 Durham	317,890	450,354	450,359	450,359	458,622
3 York	345,256	567,689	567,689	567,689	592,445
4 Peel	577,057	812,512	812,511	812,511	852,519
5 Halton	266,422	328,264	328,266	328,266	339,882
6 Ham.-Wen.	423,403	461,990	461,993	461,993	467,799
7 Total GTA	4,064,279	4,926,367	4,926,372	4,926,372	5,097,484
8 External	n/a	1,358,776	1,358,776	1,358,776	1,846,161
Employment					
9 Toronto	1,331,435	1,257,004	1,257,005	1,257,005	1,213,271
10 Durham	121,769	149,553	149,552	149,552	141,118
11 York	177,550	275,774	275,724	275,724	268,704
12 Peel	283,856	389,276	389,275	389,275	392,543
13 Halton	113,974	141,383	141,390	141,390	148,830
14 Ham.-Wen.	194,176	181,216	181,219	181,219	181,252
15 Total GTA	2,222,760	2,394,206	2,394,165	2,394,165	2,345,718
16 External	n/a	548,347	539,716	539,716	724,490
Activity Rate (employment per 1000 population)					
17 Toronto	624	545	545	545	508
18 Durham	383	332	332	332	308
19 York	514	486	486	486	454
20 Peel	492	479	479	479	460
21 Halton	428	431	431	431	438
22 Ham.-Wen.	459	392	392	392	387
23 Total GTA	547	486	486	486	460
24 External	n/a	n/a	397	399	392
Work origins					
25 Toronto	711,004	616,694	616,693	616,727	621,596
26 Durham	91,374	118,262	118,263	118,261	117,299
27 York	110,277	162,785	162,793	162,793	165,471
28 Peel	195,851	246,615	246,637	246,635	251,748
29 Halton	82,726	98,914	98,914	98,915	99,833
30 Ham.-Wen.	110,320	105,312	105,313	105,303	103,992
31 Total GTA	1,301,552	1,348,582	1,348,614	1,348,634	1,359,939
32 External	n/a	n/a	41,565	41,560	70,176
Work Destinations					
33 Toronto	814,295	745,692	744,385	744,402	750,511
34 Durham	63,943	74,582	76,537	76,536	75,438
35 York	108,004	163,232	163,152	163,147	166,086
36 Peel	167,255	224,704	223,315	223,318	235,230
37 Halton	65,191	76,902	77,847	77,846	85,597
38 Ham.-Wen.	104,970	94,034	93,821	92,517	98,200
39 Total GTA	1,323,658	1,379,146	1,379,057	1,377,765	1,411,061
40 External	n/a	n/a	11,122	11,499	18,162
Non work auto origins					
41 Toronto	153,460	216,913	218,269	218,238	225,844
42 Durham	32,399	58,795	55,640	55,633	56,653
43 York	33,905	85,382	82,722	82,720	86,438
44 Peel	56,121	110,647	105,817	105,821	110,812
45 Halton	28,521	47,335	45,498	45,502	47,128
46 Ham.-Wen.	34,138	52,958	49,695	49,693	50,352
47 Total GTA	338,543	572,031	557,642	557,606	577,226

Exhibit C1 (Continued)

	Observed		Simulated		
	1986 TTS	1996 TTS	96tts-excel	96tts-emme2	96base
Transit school origins					
48 Toronto	84,617	95,594	95,536	95,560	98,972
49 Durham	4,695	5,935	5,915	5,910	6,019
50 York	6,613	7,278	7,242	7,240	7,588
51 Peel	4,063	9,450	9,482	9,487	9,978
52 Halton	7,767	1,210	1,210	1,202	1,241
53 Ham.-Wen.	5,516	6,092	6,092	6,098	6,133
54 Total GTA	113,270	125,558	125,476	125,497	129,931
Other mode work origins					
55 Toronto	31,763	34,097	34,239	33,898	34,378
56 Durham	2,586	2,323	2,589	2,565	2,567
57 York	2,287	1,828	2,021	2,001	2,050
58 Peel	4,019	3,112	3,225	3,190	3,292
59 Halton	1,632	1,788	1,757	1,742	1,774
60 Ham.-Wen.	5,983	5,019	5,347	5,296	5,214
61 Total GTA	48,269	48,167	49,179	48,692	49,275
GO Rail work origins					
62 Toronto	5,506	6,678	6,813	6,655	6,789
63 Durham	4,336	7,430	7,164	7,057	6,998
64 York	1,645	3,613	3,615	3,560	3,620
65 Peel	8,954	12,257	12,376	12,196	12,490
66 Halton	5,391	7,765	7,887	7,769	7,816
67 Ham.-Wen.	520	846	719	707	699
68 Total GTA	26,353	38,588	38,574	37,944	38,412
Transit work origins					
69 Toronto	228,709	173,436	172,620	172,666	173,611
70 Durham	3,103	2,185	2,296	2,296	2,277
71 York	9,989	11,770	11,742	11,743	11,967
72 Peel	15,528	14,544	14,684	14,686	15,009
73 Halton	1,762	1,224	1,224	1,222	1,227
74 Ham.-Wen.	10,752	5,468	5,675	5,674	5,565
75 Total GTA	269,842	208,626	208,243	208,287	209,656
Auto work origins					
76 Toronto	445,026	402,483	403,022	403,508	406,818
77 Durham	81,349	106,324	106,213	106,344	105,458
78 York	96,356	145,574	145,414	145,489	147,833
79 Peel	167,350	216,703	216,352	216,563	220,957
80 Halton	73,942	88,138	88,046	88,181	89,016
81 Ham.-Wen.	93,065	93,979	93,572	93,626	92,514
82 Total GTA	957,088	1,053,201	1,052,618	1,053,711	1,062,596
83 External	33,227	302,733	74,601	41,559	70,176
Work trip self containment (% of origins)					
112 Toronto	85	81		82	81
113 Durham	62	53		55	53
114 York	39	43		45	44
115 Peel	51	54		55	56
116 Halton	46	44		45	46
117 Ham.-Wen.	80	74		73	72
118 GTA Mean	77	66		67	66
Mean auto person minutes (at 1996 Level of service)					
119 Toronto	14.7	13.8		13.8	13.8
120 Durham	20.0	20.7		23.5	23.7
121 York	21.4	18.6		20.7	20.7
122 Peel	16.9	16.4		16.5	16.4
123 Halton	19.7	19.0		19.7	19.9
124 Ham.-Wen.	13.1	14.8		15.6	16.3
125 Total GTA	16.4			16.9	17.0

Exhibit C1 (Continued)

		Observed		Simulated		
		1986 TTS	1996 TTS	96tts-excel	96tts-emme2	96base
	Auto Driver Origins					
126	Toronto		496,817		510,733	518,187
127	Durham		139,402		143,496	142,635
128	York		191,652		195,944	200,271
129	Peel		269,966		275,509	283,343
130	Halton		115,115		119,198	122,068
131	Ham.-Wen.		122,033		118,871	120,633
132	Total GTA		1,334,985		1,363,752	1,387,137
	Mean auto trip occupancy (Excluding passengers under 11)					
133	Toronto		1.25		1.22	1.22
134	Durham		1.18		1.13	1.14
135	York		1.21		1.16	1.17
136	Peel		1.21		1.17	1.17
137	Halton		1.18		1.12	1.12
138	Ham.-Wen.		1.20		1.21	1.18
139	Total GTA		1.22		1.18	1.18
	Auto Vehicle Trips					
140	Within Toronto	408,511	394,910		403,986	409,573
141	Inbound to Toronto	145,169	201,419		206,982	213,338
142	Outbound from Toronto	93,201	113,645		106,747	108,614
143	External to Toronto	423,418	669,913		692,567	732,496
	Total		1,379,887		1,410,282	
	Vehicle km					
144	Toronto		8,084,567		8,636,490	8,846,478
145	Durham		2,472,125		2,441,054	2,625,561
146	York		4,362,569		3,601,306	3,916,395
147	Peel		4,514,404		4,524,893	4,842,854
148	Halton		2,581,862		2,317,679	2,530,357
149	Ham.-Wen.		1,707,780		1,493,227	1,861,040
150	Total GTA		23,723,307		23,014,650	24,622,684
	Passenger Boardings by Mode					
165	Subway	289,349	232,673		251,927	253,783
166	Streetcar	53,791	39,218		42,248	43,168
167	Bus	501,760	398,844		381,848	388,753
168	GO Bus	27,971	25,278		30,151	30,403
169	GO Rail	27,785	38,963		32,594	33,118
170	Total all modes	900,656	734,987		738,812	749,271
	Passenger km by Mode					
171	Subway	1,974,168	1,597,047		1,691,313	1,705,677
172	Streetcar	139,304	109,268		107,982	109,245
173	Bus	2,039,345	1,679,171		1,675,227	1,709,846
174	GO Bus	409,538	400,643		548,208	541,939
175	GO Rail	826,521	1,238,111		1,006,916	1,018,246
176	Total all modes	5,388,908	5,024,251		5,029,721	5,085,024
	Mean Travel Distance per Boarding (km)					
177	Subway	6.8	6.9		6.7	6.7
178	Streetcar	2.6	2.8		2.6	2.5
179	Bus	4.1	4.2		4.4	4.4
180	GO Bus	14.6	15.8		18.2	17.8
181	GO Rail	29.7	31.8		30.9	30.7
182	Total all modes	6.0	6.8		6.8	6.8

Exhibit C1 compares the results of 2 simulation runs with trip totals and assignments of the raw TTS data. The first of the two simulation runs uses TTS population and employment data as input together with the observed TTS trip generation rates. Comparable results are shown for both the spreadsheet and emme/2 components of the model. The second simulation (the 1996 base case) uses population and employment data supplied by the regions and trip generation rates that have been adjusted to reflect the differences in population between the 1996 TTS and Census data. Comparable data from the 1986 TTS is included to show the magnitude of the change that has taken place over a ten year period relative to the difference between the observed and simulated results for 1996.

Since the 1996 TTS trip generation rates, modal split, population and employment data, were was used as direct input to the first of the two runs it is not surprising there is an almost exact match in origin and destination trip totals for all modes. The small differences that occur can be attributed to rounding, minor differences in zone assignment, arising from the switch to the 1996 GTA zone system, and the application of multiple factors based on different zone aggregations. The significantly lower activity rates shown in the base case simulation reflect the higher population and lower employment numbers used relative to TTS. The origin and destination trip totals, however, are very close to the TTS observed and simulated values because of the adjustment in work trip rate and the balancing to the origin total. The most significant difference between the two simulation runs is in the number of external trips. Both the TTS and TTS simulated have incomplete representation of external trips, whereas the base case simulation should, theoretically, have total representation.

The potential for differences between the TTS and simulated data are substantial in the trip distribution and assignment stages of the model. Each TTS record represents, on average, 20 trips that are all assigned to the same cell in the trip matrix. The seeding process, used in the calibration of the trip distribution model, re-distributes these "blocks of trip" between adjacent cells, thus reducing the number of cells which have zero value. Exhibit C2 compares the number of non-zero cells in the base matrices used for trip distribution with the number of non zero cells in the observed TTS matrices. Where as the TTS matrices show an average of about 25 trips (one and a quarter observations) in each non zero cell the simulated non zero values are mostly less than 1. Clearly neither matrix can provide an accurate representation of real life trip movements between individual traffic zones. Comparisons must be done at a more aggregate level. Exhibit C1 shows the comparison by region of work trip self containment, mean auto trip time and auto occupancy.

Exhibit C2 - Non Zero Cells

Matrix	Observed trips (TTS)	Non zero cells (TTS observed)	Non zero cells (Simulated)
Auto Work	1,098,542	42,353	1,715,141
Auto non work	577,125	16,671	862,276
GO Rail work	39,278	1,574	108,505
Local transit work	209,285	8,585	443,790
Local transit school	125,659	4,279	148,037

Note: Number of possible non-zero O-D pairs is 1677 x 1729 = 2,899,533 cells

The comparisons of auto vehicle km and transit ridership, also shown in exhibit C1, are obtained from the trip assignments. The use of the minimum path "all or nothing" ensures that the same routing between a given O-D pair is used in all cases thus providing a better comparison of the similarity of actual trip patterns than might be obtained with an equilibrium assignment. The biggest differences in the base case auto assignment, relative to both the TTS observed and TTS simulation, can be attributed to the more complete representation of external trips. The transit assignments show 12% to 15% fewer GO rail boardings in the simulation runs compared to the assignment of the raw TTS data. A potential deficiency in the modeling process is that trips in the GO Rail matrix are not compelled to use GO Rail if the travel time using other transit routes is calculated to be faster. All transit modes have to be included in the GO Rail assignment in order to provide local transit connections at the origin and destination. The trips most likely to be affected

are from areas with local transit connections to the subway. The output from the mode-split component of the model is therefore likely to produce better estimates of total GO Rail ridership than are obtained from the assignment. The many to one nature of GO Rail, with more than 90% of trips going to Union station, enables the GO Rail ridership to be summarized by station and line, as is done in the excel spreadsheets, without the use of the emme/2 components of the model.

Other comparisons between the TTS and simulated results are possible using the graphic display capabilities of emme/2. Exhibits C3, C4 and C5 compare the observed and simulated travel time distributions for total auto trips, local transit trips and GO Rail trips. In all cases the travel time matrix from an equilibrium assignment of TTS auto driver trips is used to determine the travel time intervals. Actual travel times, by local transit or GO Rail, could be significantly different. Auto travel times are used as a convenience to determine the similarity in trip distribution of two trip matrices. The differences in both mean travel time and standard deviation are small for each of the three modes.

Exhibit C6 compares the assigned link volumes obtained from the simulation with the volumes obtained from the assignment of TTS data. The differences are small demonstrating that the simulation procedures are able to reproduce the observed travel patterns from TTS with a high degree of accuracy.

The 1996 validation included a review of assigned volume to capacity ratios throughout the network. This part of the validation proved to be more a test of the adequacy and accuracy of the network representation than of the model itself. The few minor problems that were identified have since been corrected.

The final validation test, shown in exhibit C6, is a comparison between assigned link volumes across sceen lines and actual road counts. Unfortunately no count information was readily available for the same time period as the TTS. The 1995 Cordon Count data has been used. The data is not only for a different year but also for a different time of year (early summer instead of fall). The summary is by inter-regional boundary using screen lines defined by agency staff. Each non-external screen line appears twice but not necessarily with the same volume. In the cases where two different volumes are shown the regions on either side of the boundary have selected different links in the network to represent that boundary. In reviewing the screen line data a number of problems and inconsistencies were identified as to the manner in which the screen line data were coded in the emme/2 network. Recommendations have been made as to how the coding might be improved but, due to these, and other problems associated with the use of cordon count data, it was not possible to draw any conclusions as to how well the assigned volumes from either the TTS or the simulation runs represent actual traffic volumes.

Exhibit C6 shows the screen line volumes obtained from both equilibrium and a minimum path assignment of TTS data. The differences are small suggesting that the minimum path assignment technique can be used with confidence to compare volumes across major screen lines. Both stages of the model were run for he base case simulation with the resulting screen line volumes shown under the headings 96Base/1 (stage 1) and 96Base/2 (stage 2). The capacity constraint procedure should not have a significant effect since the assigned volumes and travel times should not have changed. The results confirm that no significant change does occur. The difference in volume that do occur could well be the result of different routings resulting from very small changes in travel time. The base case volumes are mostly within a few percentage points of the volumes that result from the assignment of the TTS data. There are significant differences in the volumes crossing the external screen lines but those volumes are only partially represented by the TTS data. The more complete representation of external trips is also likely to have been a contributing factor resulting in the higher volumes simulated across some of the internal screen lines, most notably York to Toronto, Halton to Peel and Hamilton-Wentworth to and from Halton.

Exhibit C3 - Auto Time Distribution

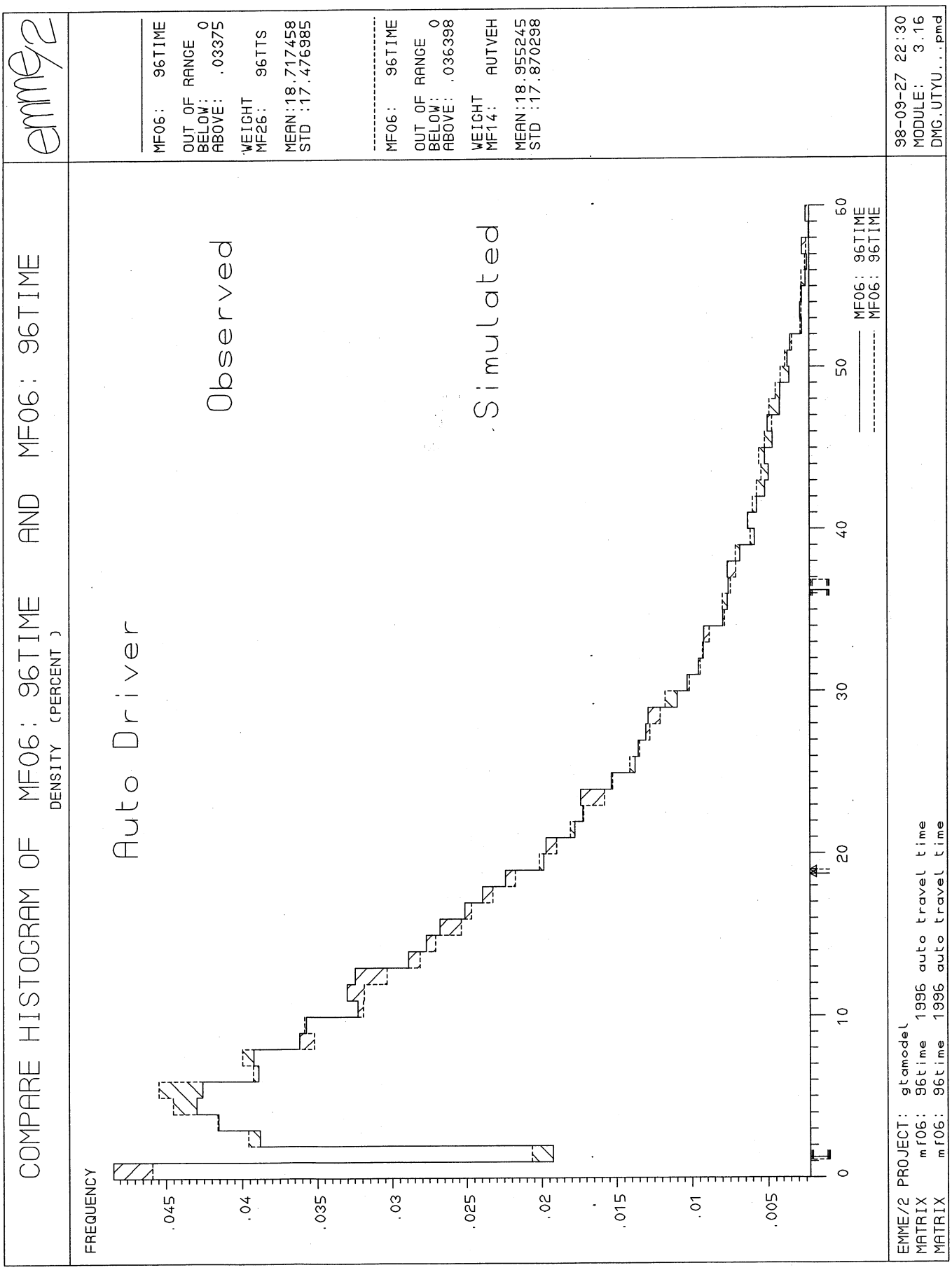


Exhibit C4 - Local Transit Time Distribution

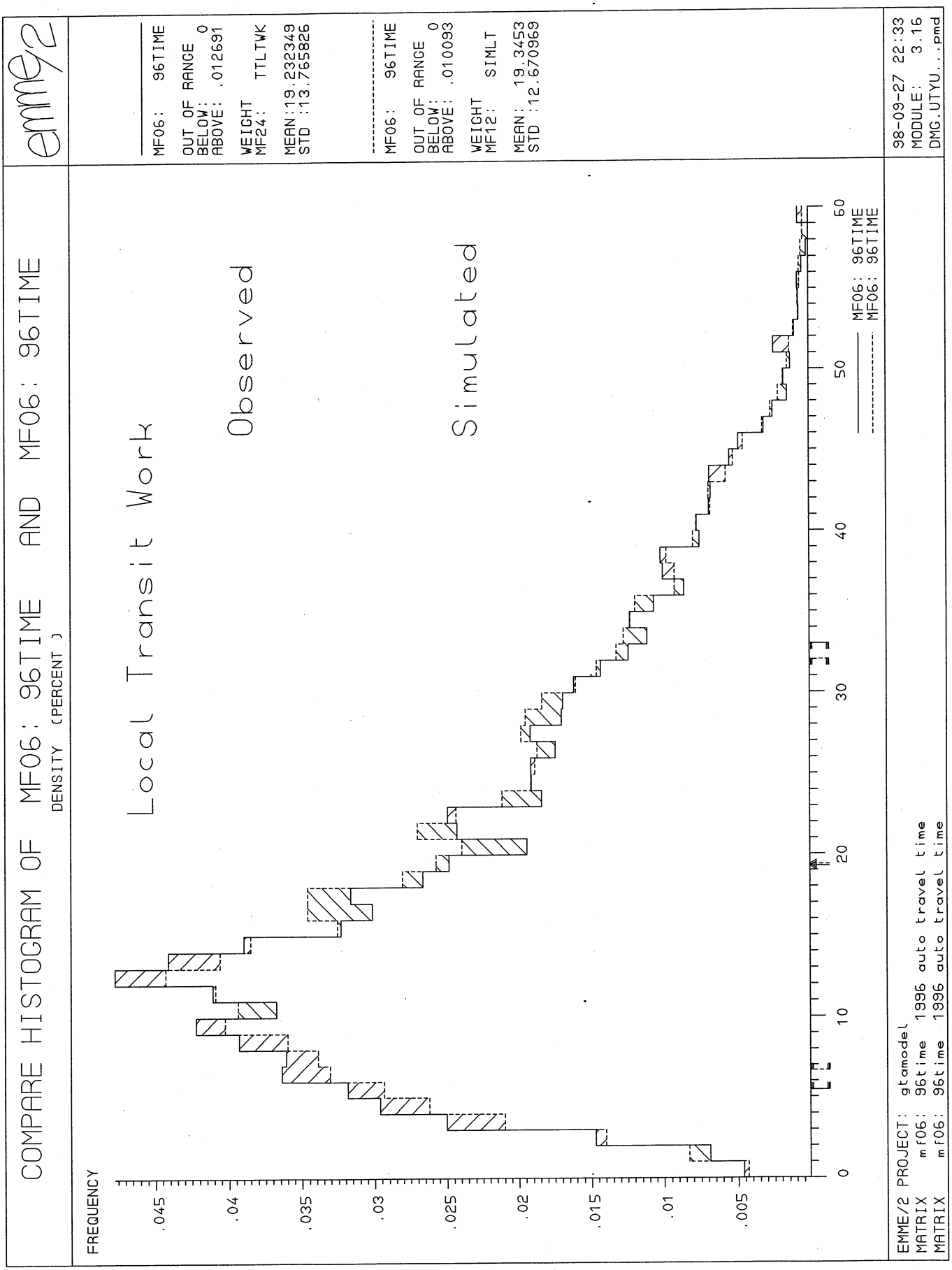


Exhibit C5 - GO Rail Time Distribution

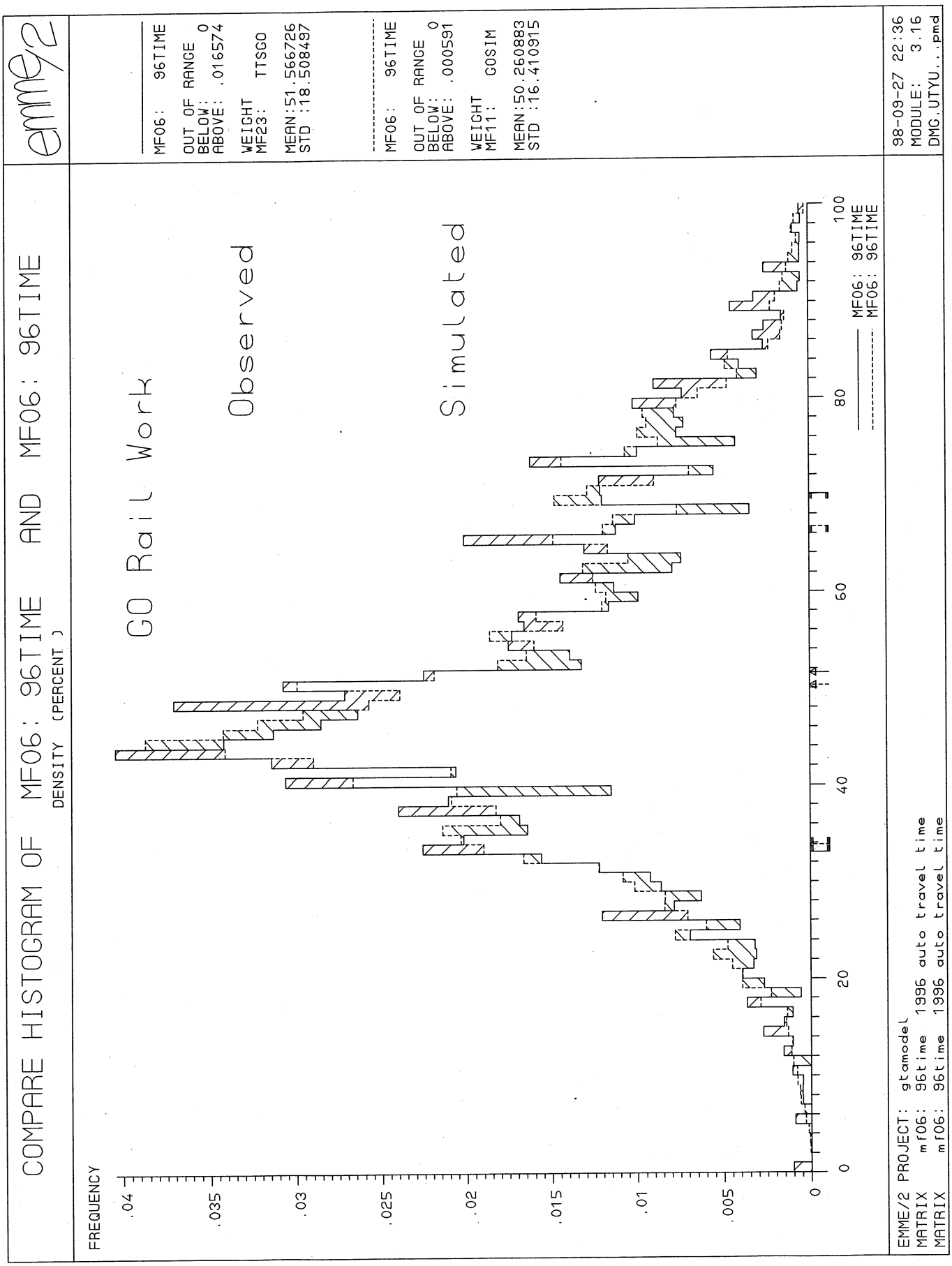


Exhibit C6 - Link Volumes

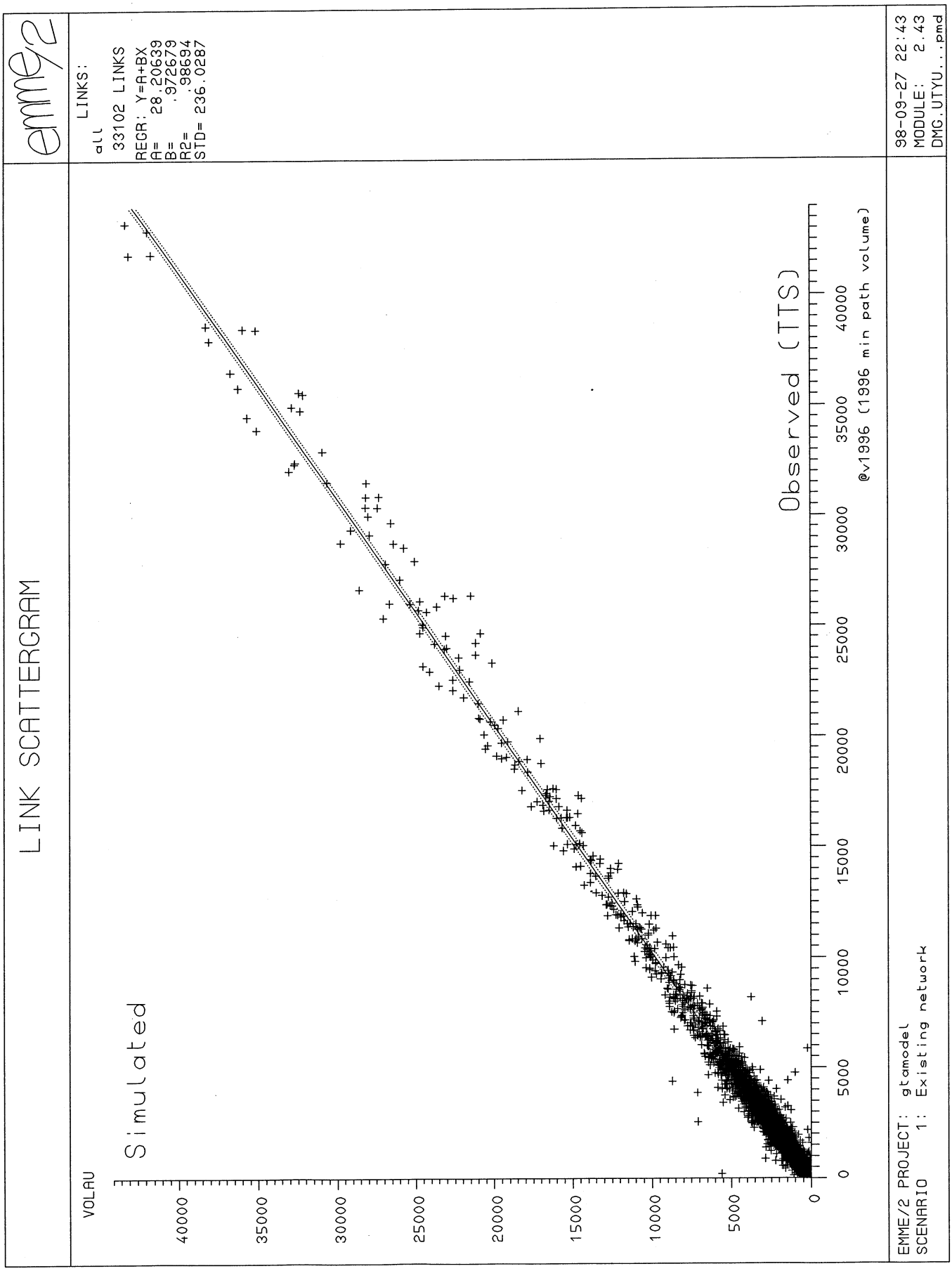


Exhibit C7 - Screen Line Volumes

Screen Line	95 Cordon Count	TTS Assignments Equilibriu	TTS Assignments Min. Path	Simulations 96TTS	Simulations 96Base/1	Simulations 96Base/2	TTS/Count 96Base/Count	96Base/TTS 96Base/Count	
Peel > Toronto	89523	108250	108729	106394	108102	107782	121%	120%	100%
York > Toronto	94231	104009	102285	101921	108971	109933	110%	117%	106%
Durham > Toronto	31714	35795	36695	38311	39072	38036	113%	120%	106%
Toronto in	**215468**	**248054**	**247709**	**246626**	**256145**	**255751**	**115%**	**119%**	**103%**
Toronto > Peel	62478	71977	71098	67389	71515	71428	115%	114%	99%
Toronto > York	63922	66068	65831	64972	65671	65521	103%	103%	99%
Toronto > Durham	9934	9173	9076	8042	7936	8010	92%	81%	87%
Toronto out	**136334**	**147218**	**146005**	**140403**	**145122**	**144959**	**108%**	**106%**	**98%**
Toronto > Durham	9934	9173	9076	8042	7936	8010	92%	81%	87%
York > Durham	3714	1954	2045	1949	2016	2002	53%	54%	102%
External > Durha	5858	4813	4823	5409	9226	9210	82%	157%	191%
Durham in	**19506**	**15940**	**15944**	**15400**	**19178**	**19222**	**82%**	**99%**	**121%**
Durham > Toronto	31714	35795	36695	38311	39072	38036	113%	120%	106%
Durham > York	9714	12509	11512	13146	14256	16456	129%	169%	132%
Durham > Externa	5496	2624	2606	2148	2730	2731	48%	50%	104%
Durham out	**46924**	**50928**	**50813**	**53605**	**56058**	**57223**	**109%**	**122%**	**112%**
Peel > York	12245	11254	11771	10389	11142	11961	92%	98%	106%
External > York	14094	12401	10519	8666	15037	15158	88%	108%	122%
Durham > York	9765	12045	11138	12880	13974	15634	123%	160%	130%
Toronto > York	73048	66068	65831	64972	65671	65521	90%	90%	99%
York in	**109151**	**101768**	**99259**	**96907**	**105824**	**108274**	**93%**	**99%**	**106%**
York > Peel	7814	4868	5293	5526	6455	6168	62%	79%	127%
York > External	4054	3639	3486	1877	2858	2870	90%	71%	79%
York > Durham	3631	2679	2599	2917	2998	3759	74%	104%	140%
York > Toronto	104713	104009	102285	101921	108971	109933	99%	105%	106%
York out	**120212**	**115195**	**113663**	**112241**	**121282**	**122730**	**96%**	**102%**	**107%**
Halton > Peel	50857	52466	51528	49716	53855	54046	103%	106%	103%
External > Peel	7493	8686	10388	7899	10941	**11499**	116%	153%	132%
York > Peel	7429	5602	5123	6168	6968	7370	75%	99%	132%
Toronto > Peel	62478	66501	66307	61603	65304	65167	106%	104%	98%
Peel in	**128257**	**133255**	**133346**	**125386**	**137068**	**138082**	**104%**	**108%**	**104%**
Peel > Halton	23714	22579	22475	21236	23560	23619	95%	100%	105%
Peel > external	2160	1859	1815	1603	2123	2136	86%	99%	115%
Peel > York	12286	12496	14863	14284	15109	13039	102%	106%	104%
Peel >Toronto	89523	103255	103545	101416	102740	102599	115%	115%	99%
Peel out	**127683**	**140189**	**142698**	**138539**	**143532**	**141393**	**110%**	**111%**	**101%**
Peel > Halton	23714	27174	26818	25578	28665	29045	115%	122%	107%
H-W > Halton		22806	22993	24620	26528	26076		n/a	114%
External > Halton		7902	7323	7796	10333	9658		n/a	122%
Halton in	**23714**	**57882**	**57134**	**57994**	**65526**	**64779**		**273%**	**112%**
Halton > Peel	50857	56926	56211	55367	58658	58932	112%	116%	104%
Halton > H-W		24704	23180	23082	26268	27872		n/a	113%
Halton > External		5628	5680	4262	5062	6026		n/a	107%
Halton out	**50857**	**87258**	**85071**	**82711**	**89988**	**92830**		**183%**	**106%**
Halton > H-W		24704	23180	23082	26268	27872		n/a	113%
External > H-W		12511	12473	13166	25809	25800		n/a	206%
H-W in	**0**	**37215**	**35653**	**36248**	**52077**	**53672**		n/a	**144%**
H-W > Halton		22806	22993	24620	26528	26076		n/a	114%
H-W > External		9496	9223	7185	10912	11136		n/a	117%
H-W out	**0**	**32302**	**32216**	**31805**	**37440**	**37212**		**n/a**	**115%**

Appendix D - Year 2021 Test Runs

The trip generation and mode split factors recommended in chapter 4 were used for two test runs identified as "21base" and "21m_1". The Ministry of Transportation and the City of Toronto supplied the population and employment estimates for the first run. Municipal control totals agree with Hemson Scenario 1. Exhibit D1 provides a summary of the input selections and the resulting adjustment factors applied in the spreadsheet components of the model. In order to match the work trip origin and destination totals the destinations were reduced globally by about 16%. Reducing the work trip destinations is equivalent to assuming a similar reduction in the employment forecasts.

In the second run (21m_1) the same population forecasts were used but reducing the projected growth in employment subsequent to 1996 by 30% in all zones modified the employment forecasts. The 30% reduction in growth gives approximately the same work trip destination total as in the base case run but with a different distribution. The selection of inputs and adjustment factors is shown in exhibit D2.

Exhibit D3 contains the performance indicators produced in emme/2 by the stage 1 macro. Stage 1 projects "travel demand" with the assumption that 1996 levels of service on the road and transit networks are maintained at 1996 levels. The GO Rail mode split assumptions do reflect increased service frequency to accommodate the projected growth in demand in the GO Rail service area. The performance indicators from the 1996 base case are included in the table as a base for comparison.

The activity rate calculation demonstrates the magnitude of the change in labour force participation rates, more than a 20% increase from the average 1996 value for the GTA, which would be required if values comparable to the Hemson Scenario 1 population and employment forecasts are to be achieved. The different employment assumptions in test run 21m_1, relative to the base case, result in a larger number of work trips to destinations in Toronto and Hamilton-Wentworth with a corresponding reduction to the other regions.

There is little difference in the mode splits between the 2 runs and the 1996 base case. The lack of change is a direct reflection of the input assumptions. The Regional municipality of York is shown as having an increase in GO Rail mode share reflecting the increased service levels implied in the mode split assumptions. The local transit mode share for the GTA as a whole is shown as declining from 16.4% in 1996 to 13.5%, a result of the growth being concentrated in areas with below average existing transit mode splits.

Durham, York and Halton all show significantly higher work trip self-containment in the 2021 base case relative to 1996. There is little change for Peel and Toronto and a decrease for Hamilton-Wentworth. These changes are consistent with the assumed trends in employment growth. The differences between the 21m_1 and 1996 base case are smaller reflecting the greater similarity in employment distribution.

The increase in total vehicle km of auto travel between 1996 and 2021 is projected to be 56% for the GTA as whole. The biggest percentage increase (110%) occurs in the Regional Municipality of Durham. Absolute growth is highest in the Regional municipality of York (3.1 million km) followed by Durham (2.9 mkm), Peel (2.8mkm), Toronto (2.4 mkm) and Halton (1.9 mkm). Local transit ridership is projected to grow by 15% and GO Rail ridership by 57% for the GTA as a whole. Test 21m_1 shows a slightly greater increase in GO Rail ridership (62%).

Exhibit D4 shows the performance indicators from Stage 2 of the model. The capacity constraint procedure gives an indication of what might reasonably be expected to happen if no additions or improvements are made to the transportation network other than increased service frequency on the GO Rail system. Total auto travel is reduced by about 10% relative to stage 1. Growth in auto travel between 1996 and 2021 is reduced from 56% to 46%. Average auto operating speed for the GTA as a whole is estimated to decline from 55 kph to 42 kph. Average auto trip length is 3% shorter than in 1996 but mean trip time is projected to increase from 18 minutes to 22 minutes, a 22% increase resulting from increased congestion. The reduction in auto trip length results in an increase in work trip self-containment for all Regions. 68% of all work trips are projected to have their origin and destination in the same region compared to 64% in the unconstrained assignment and 66% in the 1996 simulation.

The 21m_1 results, compared to the 2021 base case, show greater work trip self containment for the City of Toronto and the Regional municipality of Hamilton-Wentworth reflecting the increase in the proportion of total employment allocated to those two areas. The other Regional municipalities become less self contained but the differences in total vehicle km, auto operating speed and mean travel time are minor.

Exhibit D5 provides a comparison of projected auto vehicle volumes across the inter-regional and external boundaries. Comparing the 2021 base case with 1996 shows that the biggest absolute increase in demand (Stage 1) occurs between York and Toronto, an increase of 71,000 vehicles, or 65%, in the a.m. peak 3 hours. The projected increases across the York-Durham and York-Peel boundaries, although smaller in absolute terms, are in excess of 100% in both directions. The application of the capacity constraint procedure (stage 2) reduces the total projected increase inbound to Toronto from 52% to 37% and outbound from 23% to 10%. The 21m_1 simulation produced volumes inbound to Toronto that are about 6% higher than the base case, as would be expected with the higher proportion of employment growth assigned to Toronto.

Exhibit D1 - 21Base Input Selections

```
t matrices
c  Trip Generation Selections (0 = Base case)
c       Participation rate - 2021
c       Work at Home - 2021
c       Work trip rate - 0
c       Peak Factor - 2021
c       Employment trip rate - 0
c       Destination peak factor - 0
c       Non work auto trip rate - 2021
c       Non work peak factor - 0
c       Student participation rate - 0
c       School trip rate - 0
c       School peak factor - 0
c       School local transit mode share - 0
c Land Use and Trip generation adjustments
c       Population & employment - 2021 Base
c       Work trip origin adjustment factor - 1
c       Work trip destination adjustment factor - 0.8388
c Mode choice selections (0 = Base case)
c       Other mode origins - 0
c       Other mode destinations - 0
c       Other mode origin adjustment factor - 0.9843
c       Other mode destination adjustment factor - 1.0161
c       GO Rail origins - 2021E
c       GO Rail destinations - 2021E
c       GO Rail origin adjustment factor - 0.8391
c       GO Rail destination adjustment factor - 1.0895
c       Local Transit origins - 0
c       Local Transit destinations - 0
c       Local Transit origin adjustment factor - 1.0338
c       Local Transit destination adjustment factor - 0.9683
c
m matrix=ms92 autbac 1 Auto background trip factor
 all:all 1
m matrix=ms93 mindol 5 Minutes per dollar link cost conversion
 all:all 5
m matrix=ms96 timcof 0.03 Work trip time elasticity factor
 all:all 0.03
m matrix=ms97 occadj 1 Auto occupancy adjustment factor
 all:all 1
m matrix=ms98 gonwfc 1.07 GO Rail non work adjustment
 all:all 1.07
```

Exhibit D2 - 21m_1 Input Selections

```
t matrices
c  Trip Generation Selections (0 = Base case)
c        Participation rate - 2021
c        Work at Home - 2021
c        Work trip rate - 0
c        Peak Factor - 2021
c        Employment trip rate - 0
c        Destination peak factor - 0
c        Non work auto trip rate - 2021
c        Non work peak factor - 0
c        Student participation rate - 0
c        School trip rate - 0
c        School peak factor - 0
c        School local transit mode share - 0
c Land Use and Trip generation adjustments
c        Population & employment - 2021M
c        Work trip origin adjustment factor - 1
c        Work trip destination adjustment factor - 1.0051
c Mode choice selections (0 = Base case)
c        Other mode origins - 0
c        Other mode destinations - 0
c        Other mode origin adjustment factor - 0.9945
c        Other mode destination adjustment factor - 1.0054
c        GO Rail origins - 2021E
c        GO Rail destinations - 2021E
c        GO Rail origin adjustment factor - 0.8674
c        GO Rail destination adjustment factor - 1.0700
c        Local Transit origins - 0
c        Local Transit destinations - 0
c        Local Transit origin adjustment factor - 1.0525
c        Local Transit destination adjustment factor - 0.9524
c
m matrix=ms92 autbac 1 Auto background trip factor
 all:all 1
m matrix=ms93 mindol 5 Minutes per dollar link cost conversion
 all:all 5
m matrix=ms96 timcof 0.03 Work trip time elasticity factor
 all:all 0.03
m matrix=ms97 occadj 1 Auto occupancy adjustment factor
 all:all 1
```

Exhibit D3 - Performance Indicators

Matrix	mo63	mo64	mo65
Run ID	96base	21base	21m_1
Population			
Toronto	2,386,217	2,702,002	2,702,002
Durham	458,622	949,996	949,996
York	592,445	1,100,007	1,100,007
Peel	852,519	1,255,003	1,255,003
Halton	339,882	650,005	650,005
Ham.-Wen.	467,799	566,445	566,445
Total GTA	5,097,484	7,223,458	7,223,458
External	1,846,161	2,654,723	2,654,723
Employment			
Toronto	1,213,271	1,800,000	1,565,299
Durham	141,118	370,005	278,451
York	268,704	580,007	455,492
Peel	392,543	686,008	568,624
Halton	148,830	330,042	257,558
Ham.-Wen.	181,252	253,213	224,431
Total GTA	2,345,718	4,019,275	3,349,855
External	724,490	1,044,717	916,625
Activity Rate (employment per 1000 population)			
Toronto	508	666	579
Durham	308	389	293
York	454	527	414
Peel	460	547	453
Halton	438	508	396
Ham.-Wen.	387	447	396
Total GTA	460	556	464
External	392	394	345
Work origins			
Toronto	621,596	633,313	633,313
Durham	117,299	218,195	218,195
York	165,471	277,285	277,285
Peel	251,748	334,214	334,214
Halton	99,833	171,532	171,532
Ham.-Wen.	103,992	114,836	114,836
Total GTA	1,359,939	1,749,376	1,749,376
External	70,176	125,356	125,356
Work Destinations			
Toronto	750,511	854,069	890,158
Durham	75,438	154,962	139,167
York	166,086	273,748	257,949
Peel	235,230	317,177	314,629
Halton	85,597	146,319	136,683
Ham.-Wen.	98,200	106,057	112,408
Total GTA	1,411,061	1,852,332	1,850,995
External	18,162	21,322	22,336
Non work auto origins			
Toronto	225,844	305,692	305,692
Durham	56,653	138,895	138,895
York	86,438	186,218	186,218
Peel	110,812	184,199	184,199
Halton	47,128	110,292	110,292
Ham.-Wen.	50,352	73,565	73,565
Total GTA	577,226	998,860	998,860

Matrix	mo63	mo64	mo65
Run ID	96base	21base	21m_1
Transit school origins			
Toronto	98,972	112,425	112,425
Durham	6,019	12,721	12,721
York	7,588	13,034	13,034
Peel	9,978	14,456	14,456
Halton	1,241	2,362	2,362
Ham.-Wen.	6,133	6,709	6,709
Total GTA	129,931	161,708	161,708
Other mode work origins			
Toronto	34,378	40,917	41,348
Durham	2,567	4,541	4,589
York	2,050	3,208	3,239
Peel	3,292	4,211	4,247
Halton	1,774	3,200	3,232
Ham.-Wen.	5,214	5,099	5,153
Total GTA	49,275	61,175	61,809
GO Rail work origins			
Toronto	6,789	6,758	6,984
Durham	6,998	12,140	12,548
York	3,620	9,291	9,610
Peel	12,490	17,926	18,523
Halton	7,816	13,433	13,882
Ham.-Wen.	699	637	657
Total GTA	38,412	60,185	62,204
Transit work origins			
Toronto	173,611	182,255	185,545
Durham	2,277	4,091	4,167
York	11,967	17,395	17,704
Peel	15,009	18,256	18,582
Halton	1,227	2,118	2,154
Ham.-Wen.	5,565	5,677	5,776
Total GTA	209,656	229,790	233,927
Auto work origins			
Toronto	406,818	403,384	399,436
Durham	105,458	197,423	196,891
York	147,833	247,391	246,732
Peel	220,957	293,822	292,862
Halton	89,016	152,782	152,264
Ham.-Wen.	92,514	103,424	103,251
Total GTA	1,062,596	1,398,226	1,391,436
External	70,176	125,356	125,356
Other origin mode share (%)			
Toronto	3.6	3.9	3.9
Durham	1.4	1.2	1.2
York	0.8	0.7	0.7
Peel	0.9	0.8	0.8
Halton	1.2	1.1	1.1
Ham.-Wen.	3.2	2.6	2.6
Total GTA	2.4	2.1	2.1

Exhibit D3 (Continued)

Matrix	mo63	mo64	mo65
Run ID	96base	21base	21m_1
GO Rail origin mode share (%)			
Toronto	0.7	0.6	0.7
Durham	3.9	3.3	3.4
York	1.4	1.9	2.0
Peel	3.4	3.4	3.5
Halton	5.3	4.7	4.9
Ham.-Wen.	0.4	0.3	0.3
Total GTA	1.9	2.1	2.1
Local transit origin mode share (%)			
Toronto	28.8	28.0	28.3
Durham	4.6	4.5	4.6
York	7.5	6.4	6.5
Peel	6.7	6.1	6.2
Halton	1.7	1.6	1.6
Ham.-Wen.	7.3	6.3	6.4
Total GTA	16.4	13.5	13.6
Auto origin mode share (%)			
Toronto	66.8	67.4	67.1
Durham	90.1	90.9	90.8
York	90.3	91.0	90.9
Peel	89.1	89.7	89.5
Halton	91.9	92.6	92.4
Ham.-Wen.	89.0	90.7	90.6
Total GTA	79.3	82.4	82.1
Work trip self containment (% of origins)			
Toronto	81	80	81
Durham	53	60	55
York	44	49	47
Peel	56	56	56
Halton	46	51	48
Ham.-Wen.	72	64	67
GTA Mean	66	64	63
Mean auto person minutes (at 1996 Level of service)			
Toronto	13.8	13.3	13.2
Durham	23.7	22.6	23.5
York	20.7	19.5	20.0
Peel	16.4	16.7	16.9
Halton	19.9	18.4	18.9
Ham.-Wen.	16.3	16.6	16.4
Total GTA	17.0	17.2	17.5
Auto Driver Origins			
Toronto	518,187	579,472	576,350
Durham	142,635	291,950	288,966
York	200,271	364,008	363,936
Peel	283,343	404,342	404,003
Halton	122,068	230,746	230,786
Ham.-Wen.	120,633	146,616	147,645
Total GTA	1,387,137	2,017,135	2,011,687

Matrix	mo63	mo64	mo65
Run ID	96base	21base	21m_1
Mean auto trip occupancy (Excluding passengers under 11)			
Toronto	1.22	1.22	1.22
Durham	1.14	1.15	1.16
York	1.17	1.19	1.19
Peel	1.17	1.18	1.18
Halton	1.12	1.14	1.14
Ham.-Wen.	1.18	1.21	1.20
Total GTA	1.18	1.19	1.19
Auto Vehicle Trips			
Within Toronto	409,573	454,934	459,577
Inbound to Toronto	213,338	322,992	342,542
Outbound from Toro	108,614	124,538	116,773
External to Toronto	732,496	1,250,749	1,228,981
Total	1,464,021	2,153,213	2,147,873
Vehicle km			
Toronto	8,846,478	11,213,602	11,480,692
Durham	2,625,561	5,534,769	5,468,529
York	3,916,395	7,035,629	7,029,717
Peel	4,842,854	7,615,342	7,639,995
Halton	2,530,357	4,384,729	4,328,505
Ham.-Wen.	1,861,040	2,523,737	2,564,391
Total GTA	24,622,684	38,307,804	38,511,828
Passenger Boardings by Mode			
Subway	253,783	288,857	294,934
Streetcar	43,168	52,493	52,997
Bus	388,753	453,090	458,419
GO Bus	30,403	53,106	53,717
GO Rail	33,118	48,949	50,564
Total all modes	749,271	896,846	910,896
Passenger km by Mode			
Subway	1,705,677	1,961,395	2,002,169
Streetcar	109,245	130,151	131,329
Bus	1,709,846	1,993,479	2,017,062
GO Bus	541,939	945,807	968,971
GO Rail	1,018,246	1,581,997	1,636,588
Total all modes	5,085,024	6,613,428	6,756,590
Mean Travel Distance per Boarding (km)			
Subway	6.7	6.8	6.8
Streetcar	2.5	2.5	2.5
Bus	4.4	4.4	4.4
GO Bus	17.8	17.8	18.0
GO Rail	30.7	32.3	32.4
Total all modes	6.8	7.4	7.4

Exhibit D4 - Stage 2 Performance Indicators

Run ID	96base	21base		21m_1	
		Prior to Capacity Constraint	After Constraint	Prior to Capacity Constraint	After Constraint
Auto vehicle km					
Toronto	8,906,394	11,355,528	10,402,198	11,570,010	10,535,190
Durham	2,636,981	5,766,284	4,885,818	5,697,700	4,724,664
York	3,956,365	6,924,874	6,317,492	6,964,894	6,301,231
Peel	4,874,668	7,831,364	7,246,382	7,880,129	7,275,796
Halton	2,579,698	4,360,216	3,771,652	4,320,011	3,740,982
Ham.-Wen.	1,868,169	2,725,969	2,496,746	2,759,627	2,539,255
Total GTA	24,822,276	38,964,232	35,120,284	39,192,372	35,117,116
Auto vehicle hours					
Toronto	182,592	307,575	251,641	331,557	266,412
Durham	43,072	175,574	116,191	179,925	111,471
York	72,671	223,487	185,139	236,009	191,529
Peel	80,859	183,526	157,661	190,687	163,608
Halton	43,377	123,444	87,404	121,334	86,473
Ham.-Wen.	32,369	55,977	48,499	57,079	49,811
Total GTA	454,940	1,069,583	846,536	1,116,591	869,304
Mean auto speed (kph)					
Toronto	49	37	41	35	40
Durham	61	33	42	32	42
York	54	31	34	30	33
Peel	60	43	46	41	45
Halton	60	35	43	36	43
Ham.-Wen.	58	49	52	48	51
Total GTA	55	36	42	35	40
O-D Travel times by road (mins)					
Oshawa to Union Sta.	78	150	115	161	118
Scarb. T.C to Union Sta.	35	43	40	47	42
North Yonge to Union	30	38	37	40	39
Square 1 to Union Sta.	37	53	47	57	50
Burlington to Union Sta.	72	118	94	122	97
Burlington to North Yonge	76	122	97	123	98
Oshawa to North Yonge	62	131	95	138	97
Newmarket to North Yonge	42	79	71	83	73
Markham to Brampton	51	82	72	84	73
Brampton to Markham	50	73	66	73	67
Work trip self containment (% of origins)					
Toronto	81	80	84	81	86
Durham	53	60	61	55	56
York	44	49	54	47	52
Peel	56	56	61	56	60
Halton	46	51	55	48	52
Ham.-Wen.	72	64	62	67	65
GTA Mean	66	64	68	63	67
Auto Vehicle Trips					
Within Toronto	409,573	454,934	477,826	459,577	485,185
Inbound to Toronto	213,338	322,992	296,772	342,542	313,157
Outbound from Toronto	108,614	124,538	114,437	116,773	106,224
External to Toronto	732,496	1,250,749	1,255,369	1,228,981	1,234,062
Total	1,464,021	2,153,213	2,144,404	2,147,873	2,138,628
Mean auto trip time by origin (mins)					
Toronto	14		15		15
Durham	24		28		28
York	22		30		31
Peel	17		22		23
Halton	20		23		24
Ham.-Wen.	17		17		17
Total GTA	18		22		23

Exhibit D5 - Screen Line Volumes

	96Base	21base		21m_1		Growth in demand	Increase from 96Base		
						21base-	21Base	21Base	21m_1
	Stage 1	Stage 1	Stage 2	stage1	Stage 2	96base	Stage 1	Stage2	Stage 1
Peel > Toronto	108102	145444	131286	149971	135245	37342	35%	22%	39%
York > Toronto	108971	179959	167545	190053	176689	70988	65%	52%	74%
Durham > Toronto	39072	63229	50865	69833	53862	24157	62%	34%	79%
Toronto in	**256145**	**388632**	**349696**	**409857**	**365796**	**132487**	**52%**	**37%**	**60%**
Toronto > Peel	71515	82298	71642	84294	72311	10783	15%	0%	18%
Toronto > York	65671	84433	79182	78390	72366	18762	29%	21%	19%
Toronto > Durham	7936	11886	8284	9967	6585	3950	50%	3%	26%
Toronto out	**145122**	**178617**	**159108**	**172651**	**151262**	**33495**	**23%**	**10%**	**19%**
Toronto > Durham	7936	11886	8284	9967	6585	3950	50%	3%	26%
York > Durham	2016	4681	4600	4165	4174	2665	132%	130%	107%
External > Durham	9226	16820	18482	16447	17758	7594	82%	101%	78%
Durham in	**19178**	**33387**	**31366**	**30579**	**28517**	**14209**	**74%**	**63%**	**59%**
Durham > Toronto	39072	63229	50865	69833	53862	24157	62%	34%	79%
Durham > York	14256	29804	24371	30167	24671	15548	109%	48%	112%
Durham > External	2730	4137	4861	4229	4937	1407	52%	78%	55%
Durham out	**56058**	**97170**	**80097**	**104229**	**83470**	**41112**	**73%**	**40%**	**86%**
Peel > York	11142	24712	20398	24939	20920	13570	122%	71%	124%
External > York	15037	27224	26285	27224	26159	12187	81%	73%	81%
Durham > York	13974	29213	22145	29557	22328	15239	109%	42%	112%
Toronto > York	65671	84433	79182	78390	72366	18762	29%	21%	19%
York in	**105824**	**165582**	**148010**	**160110**	**141773**	**59758**	**56%**	**37%**	**51%**
York > Peel	6455	13941	11910	12862	11250	7486	116%	93%	99%
York > External	2858	4545	3996	4669	4185	1687	59%	39%	63%
York > Durham	2998	6411	9525	5903	9174	3413	114%	153%	97%
York > Toronto	108971	179959	167545	190053	176689	70988	65%	52%	74%
York out	**121282**	**204856**	**192976**	**213487**	**201298**	**83574**	**69%**	**57%**	**76%**
Halton > Peel	53855	92131	71635	93837	73520	38276	71%	33%	74%
External > Peel	10941	20156	22295	20405	22505	9215	84%	94%	87%
York > Peel	6968	15132	12580	14357	11963	8164	117%	71%	106%
Toronto > Peel	65304	74154	62989	75927	63063	8850	14%	-3%	16%
Peel in	**137068**	**201573**	**169499**	**204526**	**171051**	**64505**	**47%**	**23%**	**49%**
Peel > Halton	23560	32920	27348	31664	25577	9360	40%	16%	34%
Peel > external	2123	3434	3960	3378	3901	1311	62%	85%	59%
Peel > York	15109	25405	16426	25834	16878	10296	68%	26%	71%
Peel >Toronto	102740	136860	124444	141415	128387	34120	33%	21%	38%
Peel out	**143532**	**198619**	**172178**	**202291**	**174743**	**55087**	**38%**	**22%**	**41%**
Peel > Halton	28665	41424	37640	40358	36073	12759	45%	30%	41%
H-W > Halton	26528	40287	31447	40309	31799	13759	52%	21%	52%
External > Halton	10333	19485	14152	19271	13888	9152	89%	47%	86%
Halton in	**65526**	**101196**	**83239**	**99938**	**81760**	**35670**	**54%**	**28%**	**53%**
Halton > Peel	58658	98885	79315	101690	81550	40227	69%	35%	73%
Halton > H-W	26268	36467	34386	36030	34083	10199	39%	23%	37%
Halton > External	5062	8739	8932	8541	9104	3677	73%	48%	69%
Halton out	**89988**	**144091**	**122633**	**146261**	**124737**	**54103**	**60%**	**32%**	**63%**
Halton > H-W	26268	36467	34386	36030	34083	10199	39%	23%	37%
External > H-W	25809	41357	43305	42324	44183	15548	60%	68%	64%
H-W in	**52077**	**77824**	**77691**	**78354**	**78266**	**25747**	**49%**	**45%**	**50%**
H-W > Halton	26528	40287	31447	40309	31799	13759	52%	21%	52%
H-W > External	10912	14072	14743	14539	14881	3160	29%	32%	33%
H-W out	37440	54359	46190	54848	46680	16919	45%	24%	46%

Appendix E - Durham Transportation Planning Model

The Durham Regional Transportation model was created using the procedures for sub-area analysis described in chapter 5.

Emme2banks

The operation of the Durham Regional Model requires the creation of two emme2bank based on different zone systems. The first emme2bank contains the full GTA zone system and is used to run the simplified, or the full, GTA model. The second emme2bank, containing more detailed network and zone system for the Region of Durham, is used to run the Regional model. The common link between the two emme2banks is obtained by using the zone ensemble "gb" for the transfer of matrix data between them. In the GTA emme2bank "gb" defines the zone aggregations to be used outside the Region while in the Regional emme2bank it defines how the zones within the Region are sub-divided.

Zone System

The geographic coverage provided by the Regional model can be divided into 3 distinct areas in which different approaches were adopted to create a composite zone system:

1. An area, consisting of the Regional municipality of Durham plus the counties of Northumberland, Peterborough and Victoria, in which the zones used in the GTA model are subdivided for greater detail
2. An area, corresponding to the old city of Scarborough, the townships of Whitchurch-Stouffville and Georgina, most of the city of Markham and most of the township of East Gwillimbury, in which the zones used in the GTA model are retained.
3. In the remaining area covered by the GTA model the GTA zones are aggregated to form larger zones.

Zone numbering

In each aggregation of GTA traffic zones one of the original zone centroids was selected as the centroid of the aggregated zone number. The zone number and centroid location are retained as the zone number and location of the new centroid. In most cases centroids close to major freeway interchanges were selected. The following zone aggregations were used:

Zone number	Description
5	Etobicoke south of Dundas
28	Etobicoke between Dundas & Hwy 401
61	Etobicoke north of Hwy 401 (PD 9)
80	Old Planning District 3
86	Old Planning District 10
152	Old Planning District 2
225	Old Planning District 1
287	Old Planning District 4
309	Old Planning District 11
337	Old Planning District 12
348	Old Planning District 5
367	Old Planning District 6
1061	City of Vaughan
1144	Town of Richmond Hill
1157	Markham west of Hwy 404
1246	Town of Aurora
1265	Town of Newmarket
1284	Township of King plus Simcoe county
1324	East Gwillimbury west of Woodbine Ave.

1338	Georgina west of Woodbine Ave.
1512	Mississauga north of ? and west of ?
1552	Mississauga south of ?
1609	Pearson airport (East of ?)
1643	City of Brampton
1692	Caledon plus Dufferin county
2027	Cities of Oakville & Burlington
2122	Milton & Halton Hills, City of Guelph and Wellington county
2503	Regional Municipalities of Hamilton-Wentworth, Niagara, Haldimand-Norfolk and Waterloo, county of Brant.

The required zone equivalence table was created in the GTA emme2bank and is designated as zone ensemble gb. To create the ensemble a zone group calculation was performed in Module 3.21 to set the initial value of gb for each zone equal to itself (i.e.: equation value = p) so that there is a one to one correspondence. Module 3.01 was then used to specify the zones to be aggregated. In most cases this could be done by specifying zone groups that represent planning districts or municipalities (zone ensemble gp in the emme2bank) or as a range of consecutive centroid numbers. The zone ensemble, excluding the zone numbers within the region of Durham, was exported and used as input to the program azoneb to create an annotation file containing the aggregated zone boundaries (annotc).

An extra digit was added to the zone centroid numbers within the Regional Municipality of Durham. Zeros were added to those zones that were not to be split. (e.g. zone 501 in the GTA model became zone 5010 in the Regional model). Subdivided zones were numbered consecutively by adding a one to the end of original zone number for the first zone in the sequence. (e.g. zone 508 in the GTA model was sub-divided into four zones numbered 5081 through 5084). An excel spreadsheet was used to create a list of the new zone numbers together with population and employment data. Custom formulae were used in excel to format a zone ensemble input file for emme2 using the same ensemble designation (gb) as was to define the zone aggregations in the GTA emme2bank.

The 5 external zones in the GTA model that represent the area East and North of Durham (zones 4001 through 4005) were subdivided into 21 zones numbered 4001 through 4021. A text editor (Norton Editor) was used to add these zones to the equivalence table created in excel. The file was read into the Regional emme2bank but not until all of the new centroids were defined in the network and the zone ensemble (gb) had been initialised, using the matrix calculator, to provide a one to one equivalence for the zones outside the Region. **Note: adding or deleting centroids in the network after the zone ensemble has been created will create errors in the zone ensemble definition. The zone calculation must be repeated and the zone equivalence file re-imported.**

Transfer of network data.

Network data were transferred from the GTA model databank using extra attributes to flag the nodes and links to be exported. The extra (@nflag and @lflag) were initialised to zero and then changed to 1 for the required selection of nodes and links using the network calculator (module 2.41). The required links were identified (@lflag=1) using a combination of link functional classification (vdf) and spatial classification (link type). The selected links satisfied one, or more of the following criteria:

- all links in the regional municipality of Durham (type=200,299)
- all links in Scarborough (type=113,116)
- all links in Whitchurch-Stouffville (type=330)
- all links except centroid connectors in Georgina, East Gwillimbury and Markham (type=325 or 326 or 331and vdf=100,699)
- required centroid connectors in Georgina, East Gwillimbury and Markham (i or j=1160,1229 or 1327,1331 or 1343,1353)
- all freeways and freeway ramps (vdf=10,29)
- controlled access and high capacity arterials in York region (type=300,399 and vdf=30,49)
- controlled access, medium and high capacity arterials in Planning Districts 1, 4, 5,6, 11 and 12 (type 101 or 104,106 or 111,112 and vdf=10,59

The jnodes (@nflagj) of the identified links were set to 1 (maximum value of @lflag) and then the inodes were identified by adding the maximum value of @lflag to the current value of @nflag.

The selected nodes and links were punched (module 2.14) and the resulting file was imported into excel where custom formulae were used to change the zone numbers within the Region of Durham and to create the additional centroids for the zones that had been split. The first centroid in a split zone was given the same co-ordinates as the original centroid and the remaining centroids located at 100 metre intervals in an easterly direction. In the link section of the file the defining node numbers for centroid connectors within the region of Durham were changed to match the first centroid number in the sequence. The new centroids that were generated were subsequently moved to appropriate locations, and centroid connectors added, by inter-active editing in module 2.12 of emme2.

The centroid locations for the aggregated zones were exported from the GTA emme2bank as a separate file to the one containing the rest of the node and link data. The required centroid connectors were subsequently added by inter-active editing in the Regional emme2bank. The external zones (4001 through 4021) and their centroid connectors were added by inter-active editing.

Transfer of Matrix Data

Matrix data can be transferred from the GTA emme2bank to the Regional emme2bank by using the punch option in module 3.14 and specifying the aggregation "gb" for origins and/or destinations as appropriate for the type of matrix. The matrix data most likely to be transferred are population (mo1 in the simplified model), employment (md1) and total vehicles (mf19). The punched output files can be edited, to change the matrix numbers, names or descriptions, but is otherwise ready for input to the regional emme2bank using module 3.11. Importing data by zone group results in the same value, the original GTA zone total, being entered for each of the sub-divided zones. To obtain appropriate values for the individual zones it is necessary to perform a matrix calculation. The recommended approach is to split the origin total in proportion to population and the destination total in proportion to employment. The required equation to create a total vehicle O-D matrix is

mf19 * mon2 * mdn2 / (mon1 * mdn1)

where:

mf19	is the total vehicle matrix (type - full) from the GTA emme2bank
mon1	is the population matrix (type - origin) from the GTA emme2bank
mdn1	is the employment (type - destination) from the GTA emme2bank
mon2	is the population matrix (type - origin) for the Regional zone system
mdn2	is the employment matrix (type - destination) for the Regional zone system

Population and Employment data for the regional zone system (mon2 and mdn2) has to be entered, from a spreadsheet or other external source, but only for the zones in Durham plus the external zones that have been split. The values for the other zones can be set equal to GTA zone totals (mon1 and mdn1) using the matrix calculator. To avoid the possibility of errors resulting from division by zero it is suggested that a full matrix be created, containing the values of the "mon1 * mdn1" component of the equation. This matrix can be used as a constraint matrix, excluding zero values.

The total number of trips in the regional trip matrix will equal the total in the GTA matrix provided that the population and employment numbers in the sub-divided zones always sum to the total population and employment in the GTA zone. If there are significant differences additional adjustment factors can be applied to adjust the trip totals. This adjustment should not be made unless it is felt that the regional population and employment data is significantly less reliable than the GTA data (i.e.: the data should only be used to proportion trips between sub zones and not control the over all total).

Regional Model

Modifying the population and employment data for the regional zone system then repeating the calculations shown in the previous section can test local variations in land use. More substantial changes in land use, such as changes in horizon year or different growth scenarios for the GTA as a whole, can be tested in one of two ways.

a) run the full GTA model for the new land use scenario and then repeat the zone aggregation/disaggregation procedure, or

b) Using the same procedure as for testing local variations in land use but with an additional adjustment factor to account for the over all change in land use totals. Without that adjustment the factoring of trips on the basis of changes in population and employment will result in over estimation of the change in the number of trips as a result of a genera change in land use. E.g.: a 10% area wide increase in population coupled with a similar 10% increase in employment would produce a 21% increase in trips. The recommended additional adjustment factor is to divide the calculated number of trips by the geographic mean of the change in population at the origin end and the change in employment at the destination end, both measured at an aggregate level (municipality). The formula, shown in the previous section, is revised as follows:

mf19 * sqrt (mon3 * mdn3 / (mon4 * mdn4)) * mon2 * mdn2 / (mon1 * mdn1)

Where:

mf19	is the base case total vehicle matrix from the GTA emme2bank
mon1	is the base case population matrix from the GTA emme2bank
mdn1	is the base case employment matrix from the GTA emme2bank
mon2	is the forecast population matrix for the Regional zone system
mdn2	is the forecast employment matrix for the Regional zone system
mon3	is the base case population matrix aggregated by municipality
mdn3	is the base case employment aggregated by municipality
mon4	is the forecast population matrix aggregated by municipality
mdn4	is the forecast employment matrix by municipality

The zone ensemble "gp" in the Regional emme2bank contains the zone equivalence necessary to aggregate to municipality within the Region of Durham and the other areas in the GTA where the GTA zone has been retained. In the areas, which have been aggregated there, is a one to one equivalence to the aggregated zones. The external zones are treated as one aggregated zone.

To do checklist

1996 Base Case

- Centroid numbers agree with zone boundaries
- Compare Durham land use numbers with census and TTS
- Check assignment for obvious errors
    - missing links
    - lanes & vdf
    - centroid connectors
- Decisions
    - What land use to use for t he rest of the GTA excluding Durham - I recommend staying with the existing 1996 base case numbers

2021 Base Case

- Additions to the network
- Population data
    - Durham
    - Rest of the GTA
    - External

- Employment data
    - Durham
    - Rest of the GTA
    - External
- Decisions
    - What data to use for the rest of the GTA - particularly employment

Note: There are currently two sets of population and employment data for 2021. The first was developed from Hemson scenario 1 by the MTO and has since been converted from the 1991 to 1996 zone system. If the recommendations in chapter 4 are accepted re future labour force participation and trip generation at the home end it is necessary to reduce employment, or employment trip attraction rates, by 14% in order to balance the totals. The second set of employment numbers reduces the growth in employment by 40% (giving approximately the same total as when total employment is reduced by 14%). The second method results in more employment within Toronto relative to the regions resulting in more cross boundary commuting and generally heavier loading on the network. The 40% reduction in employment growth must be reconciled with the available estimates for the sub-divided zones in Durham.

Recommended Tests

It is recommended that initially the full GTA model only be run for 1996 and 2021. The in between years can be obtained by factoring the trip totals by the projected changes in population and employment as described in the section on the regional model. Linear interpolation can be used to generate the population and employment numbers for all areas except Durham. As an initial test the numbers from the 1996 GTA base case model run can be factored to match the 2021 projected population and employment for comparison with the results of the 2021 GTA base case model run.