Microsimulating Weekend Travel by Households in Calgary

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Abstract

A tour-based microsimulation of household weekend travel behaviour is being developed using data collected from the roughly 1,400 households assigned a weekend survey day in a household activity survey conducted in the Calgary Region in 2001. This paper describes the work being done, including the design of the system, the estimation process for the choice models used to establish the sampling distributions for the Monte Carlo processes used to assign states (simulating choices made) at various points in the microsimulation, and the calibration of the resulting system consistent with available aggregate targets.

Keywords: Weekend Travel; Personal Transportation Demand Modelling; Tour-based Modelling; Microsimulation

1 INTRODUCTION

The City of Calgary is located in the southern portion of the Province of Alberta in Canada. The Calgary Region had a population of approximately 1 million in 2001.

The City of Calgary operates an aggregate equilibrium model of household travel (Hunt *et al*, 2003) together with a tour-based microsimulation of commercial vehicle movements (Stefan *et al*, 2005) – both representing conditions on a typical weekday. Based on recognition of the need to consider the impacts of travel policy on weekend travel conditions – around shopping centres and weekend recreational facilities in particular – The City of Calgary has sponsored the development of a model of the transportation system on a typical weekend day. This paper describes the work being done in the development of this model, covering what has been accomplished to date at the time of writing and what will be done to completion.

Section 2 describes the data that have been collected. Section 3 describes the model design that has been developed based on the indications provided in these data and on experience with previous experience. Section 4 covers the model operation. Sections 5 and 6 discuss the model estimation and calibration, respectively and Section 7 offers some conclusions.

2 DATA

This section provides a description of the data on weekend travel in Calgary available for model development, to support model design, parameter estimation and subsequent model calibration.

2.1 Household Travel Behaviour

In 2001, the Household Activity Survey (HAS) was conducted in order to collect information on both in-home and out-of-home activities and resulting travel behaviour from a sample of households in the Calgary Region. Each participating household was assigned a survey day and asked to indicate in a subsequent interview the sequence of activities and related travel undertaken by each member of the household on that day.

A total of just over 8,400 completed interviews were obtained, with a total of 2,342 where the assigned day was a Saturday or Sunday – specifically 1,394 on Saturdays and 948 on Sundays – providing a sample of weekend activities and travel covering 0.60% of the total population.

The activity categories used to record responses are:

- Sleeping;
- Shopping;
- Work;
- School/Homework;
- Religious/Civic
- Volunteer;
- Medical/Financial;
- Travel;
- Drop Off Someone
- Exercise
- Entertainment/Leisure
- Social
- Eating
- Daycare
- Out-of-town
- Household Chores
- Park / Unpark Vehicle
- Pick Up Someone.

A range of household socioeconomic characteristics were also obtained, including the age, gender, employment and education status of each household member, and the total income and car ownership for the household. Network representations of the available transportation services were also developed – working with an existing Regional Travel Model (Hunt *et al*, 2003). These representations were used to establish quantified indications of the transport supply conditions and the accessibilities to various opportunities for each of a system of 1,447 geographic zones covering the Calgary Region, including those for the zone containing the home of each of the survey respondents. The resulting dataset of observations of weekend travel behaviour and corresponding household and travel system characteristics forms the sample of observations used in model development.

The observations of travel by households were organized into representations of the individual home-based tours made by groups of one or more household members. The result was a sample of 7,644 observations of individual tours containing a total of 19,635 stops made by all sizes of groups.

The tours in this sample are grouped into basic types to be treated separately in the modelling of the tour-related attributes, including the membership of the group making the tour, the mode for the tour, the number of stops on the tour and the specific activities to be undertaken at each stop. Other attributes of each stop, including the location of the stop and the duration of the activity at the stop, are also treated separately, but based on the activity at the stop rather than the type of tour.

Seven basic tour types are defined based on the nature of the activities undertaken on the tour and at the stops made in the tour:

- Serve Passenger (chauffeuring);
- Out-of-town;
- Work;
- School/Homework;
- Religious/Civic (also includes Volunteer and Daycare);
- Exercise; and
- SELSE (Shopping, Entertainment/Leisure, Social, Eating).

Each observed tour in the sample is designated to be one of these types using a cascading process starting at the top of the list. That is, the tour can only be a work tour if it does not include any element of serve passenger or any stops that are out-of-town. When there are multiple stops with different activities on the tour, the activity on the tour that appears highest in the list dictates the type for the tour. For example, a tour where someone exercises en route to work and then shops afterward is designed to be a 'Work' type.

The first two types in the list require special treatments in the model, and thus are separated at the top of the list. The next four types include stops with a fairly high degree of fixedness in both time and location, and are put in order of decreasing degree of fixedness. This order is admittedly somewhat arbitrary - and difficult to justify based on the available data. But it is of relatively little consequence, as there are relatively few of some of these types of tours on weekends and also relatively few that include multiple activities.

The final type is called SELSE, which stands for <u>S</u>hopping, <u>E</u>ntertainment, <u>L</u>eisure, <u>S</u>ocial and <u>E</u>ating. These are the most frequent of all of the other out-of-home activities occurring at stops on tours – listed in relative order of frequency, with 'out-of-home household chores', 'medical' and 'financial' included in Shopping and 'out-of-home sleep' included in Social. These various activities are included together in the definition of tour types because of their similarity in terms of a comparatively low degree of fixedness in both time and space and the strong tendency for them to be done together on tours and also associated together generally. It is difficult to develop any sort of ordering among these activities that would serve as a basis for placing them at different levels in the hierarchy of tour types listed above. In some cases, eating out is a minor stop on a shopping trip; in others a quick errand is run en route to an important dinner at a restaurant or a friend's home. These activities are also frequently combined with the more fixed activities listed higher in the hierarchy: people are much more likely to stop off at the bank, store or coffee-house en route to or from work than they are to stop off at a church or a school.

Table 1 shows an analysis of conjoint activity selection in the sample of observed tours that supports the separation of SELSE from the more fixed activities higher in the list. In order to develop the values shown in Table 1, a listing of all the pairs of activities on tours with multiple activities was drawn from the full dataset. That is, the tour described above (with stops for exercise, work and shop in that order) was split into pairs of 'work-exercise', 'work-shop' and 'exercise-shop' and these pairs were added with other such pairs from other tours with multiple activities. These pairs were then sorted based on whether none, one or both of the activities was in the SELSE category (and thus relatively 'unfixed') The observed frequencies of these pairs were then compared with the corresponding expected frequency based on the observed relative frequencies of the activities themselves with no correlation among the activities. The ratios for these frequencies are included in Table 1.

Table 1: Observed and Expected Frequencies for SELSE and Non-SELSE Activity Pairs

Purposes	Observed	Expected	Observed/Expected
Non-SELSE – Non-SELSE	141	491	0.29
Non-SELSE – SELSE	1541	1777	0.87
SELSE – SELSE	1530	944	1.62

The tendency for SELSE activities to be undertaken relatively more frequently than expected (with a ratio greater than 1) and the tendency for non-SELSE activities to be undertaken relatively less frequently than expected (with a ratio less than 1) together support the designation of the tours including the SELSE activities as a single separate type lower than the set of other types each with just one of the non-SELSE activities.

Further analysis shows that the only pairing of SELSE activities to combine less frequently than expected was Entertainment/Leisure – Social, which combined at 96% the expected rate. Similarly, the combination of Serve Passenger – Religious/Civic (a ratio of 0.70) was the only pairing of non-SELSE activities to exceed a ratio of 0.50.

Considering the non-SELSE – SELSE pairs: School and Out-of-Town did not combine frequently with any SELSE activities, but Work, Serve Passenger and Religious/Civic did frequently combine with the SELSE activities, particularly with Shop and Eat.

The resulting frequencies of the types of tours in the expanded sample – indicating the relative frequencies on a typical weekend day – are shown in Table 2.

Table 2: Distribution of Expanded Weekend (both days) Tours in 2001 HAS in Calgary

Tour Type	Number	Relative Frequency
Serve Passenger (Chauffeuring)	962,600	0.146
Out-of-Town	59,300	0.009
Work	679,100	0.103
School / Homework	118,700	0.018
Religious / Civic	698,800	0.106
Exercise	92,300	0.014
SELSE	3,982,200	0.604
TOTAL:	6,593,000	1.000

2.2 Traffic Flows

Traffic flow counts were also conducted at selected locations near shopping centres and recreational facilities and along key screenlines over weekends, in order to provide information for subsequent model calibration.

The distribution of traffic volumes over time developed from an amalgamation of these counts is shown in Figure 1, along with the weekday distribution.

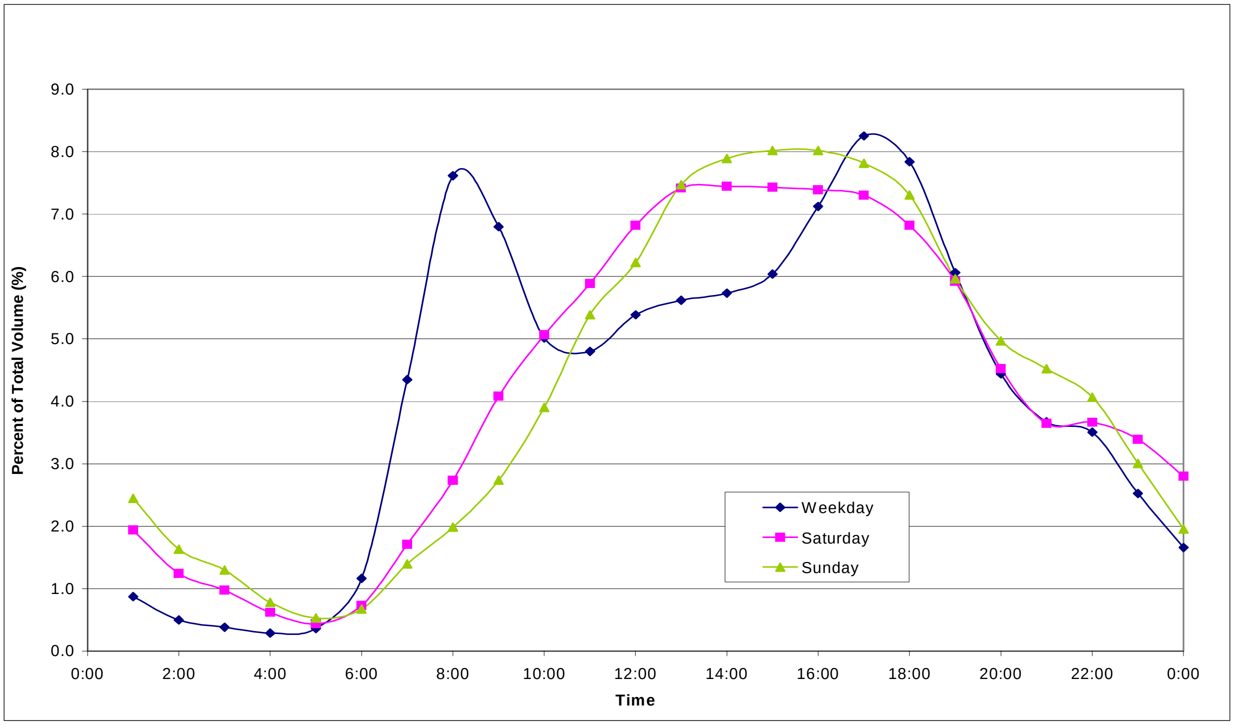

Figure 1: Diurnal Distributions of Traffic Flows in Calgary

3 MODEL FRAMEWORK

3.1 Tour-based Microsimulation Approach For Demand

The demand for travel arising at households is microsimulated at the level of each individual household and then aggregated to form zone-to-zone trip tables for assignment to the networks of available transportation services.

This microsimulation process is designed to simulate the demand for travel, representing how the attributes of the available alternatives and the characteristics of the households and its members give rise to the patterns of demand and how these patterns interact with the available supply. This is in contrast to the aggregate equilibrium approach often used in transport modelling, where the properties of the equilibrium solution for the interaction of supply and demand are identified *a priori* and the calculation process works to find this solution. With the microsimulation process the intention is to represent the nature of the demand at the level of the individual agents involved, and how it arises. Then the calculation process works to determine the aggregate result of this process over the full set of individual agents.

The benefits of this microsimulation process – which led to the decision to use it in this case – are:

- Reproducing behavioural processes rather than merely locating equilibrium;
- Finer resolution in representation of influences on behaviour;
- More complete accounting and representation of specific constraints;
- Potential for direct representation of variations in sensitivities;
- Reduced computation burden;
- Flexibility in aggregation of results; and
- Comparative ease in understanding basic model structure.

A tour-based framework is used in this microsimulation process. Individual tours starting from and returning to specific homes are considered one at a time, with the process identifying the attributes of the tour, including the membership of the group making the tour, the travel mode used for the tour, the number of stops made and their individual locations, the travel mode used for each trip between stops (largely conditioned by the mode for the tour), the start time for the tour and the type and duration of the activity undertaken at each stop. This is in contrast to the trip-based framework often used in transport modelling, where flows of trips are considered in isolation from the rest of the tours actually being made. The advantage of the tour-based approach is that it allows explicit representation of the factors acting to influence and even constrain the decisions being made – such as how the timing for a particular stop impacts the timing for all downstream stops, how the mode for the tour impacts the available mode or modes for the individual trips made on the tour, and how the attributes of one trip or one activity on the tour can impact decisions made regarding the entire tour that have further impacts on other decisions regarding other aspects of the tour.

Monte Carlo techniques are used to identify the attributes of each tour. There are two basic categories of attributes relevant with the use of these Monte Carlo techniques: discrete and continuous.

Discrete attributes are those with discrete states – such as the travel mode for the tour or the activity at each stop. With this category of attributes the Monte Carlo technique are set-up to use some form of logit choice model to assign the selection probabilities to the discrete states, with the utility functions for the alternatives representing the behavioural influences of the characteristics of the alternatives and the individual decision-makers. Part of the development of this component of the overall modelling system is the estimation and later the calibration of the logit model using observations of the relevant discrete choice behaviour.

Continuous attributes are those whose states are expressed with continuous values – such as the start time for a tour or the duration of an activity. With this category of attributes the Monte Carlo techniques are set-up to sample directly from a cumulative distribution function for the full range of possible values for the attribute based on either an observed distribution of such values or a parameterized distribution function that has been fit to such an observed distribution of values. Again, part of the development of this component of the overall modelling system is the setting up of these observed frequency distributions, with the estimation and later calibration of the parameterized versions being used.

The microsimulation process complements the tour-based framework, and the tour-based microsimulation approach is the current state-of-the-art in transport demand modelling.

Most practical urban transport demand models still use the aggregate equilibrium approach; and models of urban travel demand on the weekend are very unusual. It seems likely that the model described here is the first of its kind as a tour-based microsimulation model of urban weekend travel. Differences in the patterns of travel on weekends have led to some differences in the representations in this model relative to those in the tour-based and more general activity-based models of weekday urban travel that have emerged recently (Vovsha and Bradley, 2005).

3.2 Treatment of Space

The study area is divided into 1,447 geographic zones, which act as the locations of homes for households and stops on tours. A system of nodes-and-links networks is used to represent the multi-modal system of transportation services connecting these geographic zones, including the times spent in different states (in-vehicle, walking, waiting) and the money costs faced in traversing these links along the paths going between the zones. This is the same set of zones and networks used in the City's existing aggregate equilibrium model of household travel demand (Hunt *et al*, 2003).

The output of the tour-based microsimulation is a list of individual tours and the trips within these tours, including the states established for each of these tours and trips. These trips are aggregated and sorted into origin-destination matrices (also called 'trip tables') that are assigned to the network representations using equilibrium assignment.

3.3 Treatment of Time

The assignment of trip tables to network representations described above is done for specific time periods. The results of this assignment provide a static representation of conditions indicative for the entire time period in each case.

Selecting the number of time periods to be considered involves making a tradeoff between temporal resolution and computing resource requirements. A 'compromise' value of four time periods has been selected – based for the most part on the general organization of computing resources at the City of Calgary. The tour-based microsimulation calculation of travel demand can be distributed across processors, but the assignment of the trip tables is only appropriately done with one time period considered in full on one computer. The computing time required to do an assignment is long enough that all assignments must be done in parallel on different processors in order to avoid unacceptably long run times overall. The existing models at the City of Calgary are run on sets of four single-processor computers, so it make sense to organize the weekend model to work on similar sets of four computers.

Alternative forms of design with four assignments done in parallel on four computers are:

- Peak and Offpeak assignments on each of Saturday and Sunday;
- Four assignments spanning a single combined weekend day; and
- Peak on Saturday, Peak on Sunday and two Offpeak assignments spanning the rest of a single combined weekend day.

The use of four assignments spanning a single combined weekend day is selected because the general nature of travel behaviour and the resulting aggregate patterns are more similar at the same times on Saturdays and Sundays than they are during reasonably separate times on either day. In many locations, travel conditions for 8:00 to 9:00 on Saturday are fairly similar to travel conditions for 8:00 to 9:00 on Sunday and are dramatically different from travel conditions for 13:00 to 14:00 on Saturday. The biggest differences between Saturdays and Sundays concern the prevalence of religious/civic activities on Sunday mornings, and the increase in social, entertainment and leisure activities on Saturday evenings. The peaks on weekends arise largely because of shopping, and this is common to both Saturdays and Sundays.

In an attempt to separate differing travel conditions as much as possible using four continuous periods, and to also match the uni-modal peaking pattern for traffic volumes on weekends, the selected time periods are:

- AM shoulder; 9:00 – 13:00; with moderate traffic volumes generally; high religious/civic activity, low entertainment and social activity; contains 0.294 of all weekend trips (based on time at mid-point of trips);
- Peak; 13:00 – 17:00; with high traffic volumes generally; high shopping activity; contains 0.346 of all weekend trips;
- Evening shoulder; 17:00 – 21:00; with moderate traffic volumes generally; high travel for eating and social activities; contains 0.218 of all weekend trips; and
- Offpeak; 21:00 – 9:00; low traffic volumes generally; low activity across all purposes; contains 0.142 of all weekend trips.

Throughout the microsimulation process, times of day and quantities of time are treated as continuous values rounded to the nearest minute.

3.4 Treatment of Behaviour

The representations of behaviour in the model are contained in the choice models and parameterized distributions used in the Monte Carlo processes to establish the states for the tour attributes. The model simulates the tours made by each household by first identifying a tour, its start time and its type (from those listed in Table 1 above) and then determining the states for the relevant tour attributes. This is done using a two stage approach.

In the first stage, called ‘tour generation’, the model uses a time-based approach. The model day is split into intervals of equal and short duration (currently 15 minutes) starting at 3:00. The model considers the first time interval, determining if a tour is generated, and if one is generated, then determining its type and the precise start time (to the nearest minute) it starts. It then determines the states for the attributes of the tour, including who goes on the tour, if a vehicle is used, and when those on the tour return home – as described in more detail below. The model then updates the information for the household regarding which members and vehicles are present during each interval.

The model repeats this process for the first time interval until it determines that no more tours are generated in this interval. The model then moves to consideration of the next time interval, starting this process again for this next interval. Of course, for most intervals, particularly those in the early morning, no tour will be generated and the model will simply move to consideration of the next time interval. This process continues until the entire model day is covered, ending at 3:00 of the next calendar day.

Monte Carlo processes are used to determine if a tour is generated, and if it is, to determine its precise start time and type. The probability of a tour starting is determined using a logit model with a utility function for the start alternative that includes the time of day, the number of people in the home at the time and their characteristics, the number of vehicles present, the accessibility of the home location and the composite utility for the set of tour type alternatives. The probabilities for the alternative tour types are similarly determined using a logit model with utility functions that include time of day, the characteristics of the people at home, and the number and types of tours made previously in the model day by people in the household. The precise start time is drawn from a uniform distribution spanning the time interval.

In the second stage, called ‘tour refinement’ the model determines the states for the attributes of a generated tour in a series of steps that vary with tour type. Table 3 shows the tour attributes considered along with the category (discrete or continuous), available states and input variables for each of these attributes for each tour type. In general, when refining a tour of a particular type, the model proceeds by selecting the state for each subsequent tour attribute by working from left to right across the relevant row in Table 3.

Table 3: Summary of the Models and their Inputs for Determining the Attribute State of Each Tour Attribute for Each Tour Type: Each column in the table concerns one of the models used in simulating tours; the first set of rows indicate the tour types where the models are used and the second set of rows indicate the inputs to the models

Tour Types / Attributes of Tour	Tour group leader	Primary stop location	Other tour group members	Tour mode - primary stop location	Tour mode - no primary stop location	Include intermediate stop outbound	Intermediate stop purpose	Intermediate stop location	Trip mode to intermediate stop	Intermediate stop duration	Trip mode to primary stop	Primary stop duration	Next stop purpose	Next stop location	Trip mode to next stop	Next stop duration	Group size change at stop	Destination type for departing tour member	Destination zone for departing tour member	Trip mode to destination for departing tour member	Origin type of arriving tour member	Origin zone for returning tour member	Trip mode from origin for arriving tour member	Portion of tour to include
Serve Passenger (Chauffeuring)	X		X										X	X		X	X	X	X	X	X	X	X	
Out-Of-Town	X		X	X																				X
Work	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X								
School	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X								
Religious/Civic	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X								
Exercise	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X								
SELSE	X		X		X								X	X	X	X								
Model Inputs / **Models** / **Attribute Category; Alternative States**	Discrete: Household members present	Discrete: Model zones	Discrete: Remaining household members present	Discrete: Private Vehicle, Bicycle, Transit/Walk	Discrete: Private Vehicle, Bicycle, Transit/Walk	Discrete: yes or no	Discrete: Activities	Discrete: Model zones	Discrete: Private Vehicle, Bicycle, Transit, Walk	Continuous	Discrete: Private Vehicle, Bicycle, Transit, Walk	Continuous	Discrete: Return home; Activities	Discrete: Model zones	Discrete: Private Vehicle, Bicycle, Transit, Walk	Continuous	Discrete: none, +1, +2, -1, -2	Discrete: re-join group, home separately, other	Discrete: Model zones	Discrete: Private Vehicle, Transit, Walk	Discrete: home separately, other	Discrete: Model zones	Discrete: Private Vehicle, Transit, Walk	Discrete: Outbound, Return, Both
person characteristics	X	X	X																					
person prior tours on model day	X		X																					
household demographics						X	X					X	X								X			
household prior tours on model day			X			X	X			X		X				X	X	X			X			
zone-to-zone travel disutilities		X		X				X	X		X			X	X				X	X		X	X	
home location accessibilities	X		X		X												X	X			X			
primary destination location accessibilities			X	X		X				X		X	X			X								
other location accessibilities		X						X		X		X	X	X		X	X	X	X		X	X		
population distributions		X						X						X					X			X		
employment distributions		X						X						X					X			X		
time of day			X	X	X	X			X	X	X	X	X		X	X		X		X	X		X	X
tour group size				X	X	X	X		X	X	X	X	X		X	X	X	X						
tour member demographics				X	X	X	X	X		X		X	X	X		X	X							
tour member prior stops on model day						X	X					X	X			X	X							
tour member total elapsed time by activity on model day																X								
vehicles per driver remaining at home				X	X																			
travel time home to primary destination						X							X											
travel distance home to primary destination						X							X											
tour mode						X	X	X	X		X		X	X	X									
availability of transit pass				X	X				X		X				X			X		X	X		X	
enclosed angle with subsequent stop location								X						X										
stop purpose								X		X		X		X		X								
prior stops on tour													X			X								
total elapsed time on tour													X			X	X	X						
total elapsed travel time on tour													X			X	X	X						
departing tour member characteristics																		X	X	X				
destination type for departing tour member																			X	X				
arriving tour member characteristics																					X	X	X	
origin type for arriving tour member																						X	X	

SELSE tours, appearing last in the list of tour types, are the most common, constituting about 60% of the total. The states for the attributes of SELSE tours are developed using a 'growing' approach: When a tour starts and the group making the tour leaves the home, each subsequent stop on the tour is considered as the tour progresses. A 'return home' alternative is available for each next stop purpose; if the next stop purpose is not 'return home', then the tour extends by one more stop. This 'growing' approach is more consistent with the nature of weekend-style tour-making involving a mix of shopping, eating, leisure, social and entertainment activities – where there are a comparatively large number of equally important stops in many tours. This contrasts with the 'rubber-banding' process typically used in tour-based modelling, where a primary destination for the tour is established and then one or two intermediate stops on the trips between the base and this primary destination are identified – analogous to first stretching a rubber-band between two points and then pulling it wider along the lengths in-between.

The attributes of the four types of tours listed immediately above SELSE (Work, School, Religious/Civic and Exercise) are developed using a hybrid form of the 'rubber-banding' process – where the outbound portion to the primary destination is considered as in the rubber-banding process, but the portion after departure from the primary destination is considered using the growing approach. This retains the main advantage of the rubber-banding process, in that a primary destination is identified and the attributes of the journeys between home and this primary destination can be used in the selection of a tour mode, but also allows for a larger number of stops after the primary destination consistent with what was observed in the data.

The attributes of out-of-town tours are determined using a rubber-banding process with the entry/exit point (model boundary, airport and coach station) selected as the primary destination. The duration determined for the stop at this primary destination is then used to identify those tours lasting longer than the simulated day – in which case only the outbound or return portion, selected randomly, is considered in the model.

Serve passenger tours are the most complex type, involving at least one change in the size of the group (pick-up or drop-off) and potentially more. The complexities arise with consideration of the subsequent pick-up of those dropped-off on the same or a subsequent tour, the further travel by those picked-up or dropped-off, and the potential for both household members and non-household-members to be included. A helpful simplification, at least in the Calgary context, is that mode use for serve passenger tours is limited to auto. The attributes of these tours are determined using a complex tracing of the range of possibilities for the tour that employs the growing process described above as a starting point and branches to further consideration of the travel for each person leaving or joining the group in the auto.

The method of tour generation used in the first stage is different from the current state-of-the-art being used in some of the most recently developed activity-based models of household travel on weekdays, where there is a more complete consideration of the activity pattern spanning the entire model day (sometimes jointly over the full set of household members) (Vovsha and Bradley, 2005). Such approaches rely in part on the relative fixedness of work and school activities to help reduce the range of possible options and associated complexity that is taken into account. This would seem to be appropriate when considering weekdays, given the prevalence of work and school activities. The more straightforward time-based approach used in this work is more appropriate when considering weekends, with the very low amount of school and work and the much greater prevalence of SELSE-type activity patterns.

3.5 List of Synthetic Households

The microsimulation requires a list of all the households in the Calgary Region, including for each household the socio-economic characteristics of the household and its members used as inputs to the models in the microsimulation. Specifically, these characteristics are:

For Households

- Income
- Number of autos owned;
- Home location zone;
- Lifecycle category;
- List of (Link to) household members;

For Persons (Household Members)

- Gender;
- Age;
- Employment Status;
- School Status;
- Driver Status;
- Transit Pass Status.

Such a list for the actual households for 2001 is not available for reasons of both cost and privacy concerns. A list of synthetic households has been developed instead. A simulated annealing process (Kirkpatrick *et al*, 1983; Williamson *et al*, 1998) was used, where individual household records in the HAS sample were drawn repeatedly at random and kept or rejected according to the fit of the resulting list to aggregate distributions regarding a range of variables known from other census sources, including dwelling type, household size, person age and gender and average income in collections of the model zones.

A list of the households for future years to be considered by the microsimulation will be synthesized in the same way, using expected marginal distributions and the HAS sample of individual households as inputs.

4 MODEL OPERATION

The model completes a 'run' of the tour-based microsimulation, producing an estimate of the travel demand on a typical weekend day, by considering each household in the list of synthetic households in turn. The travel demand from the tour-based microsimulation is assigned to the available transportation supply using an iterative process as shown in Figure 2.

Based on experience with a similar tour-based microsimulation in Calgary – concerning urban commercial movements on a typical weekday; (Stefan *et al*, 2005) – it is expected that the 'large loop iterations' will converge to a solution where the trip tables and travel times are consistent from one iteration to the next with as few as 5 repeated runs of the tour-based microsimulation within each 'large loop'. When the 'large loop' iterations have converged the tour-based microsimulation is run 30 times in order that the resulting expectation estimators (the final average values) have good statistical properties.

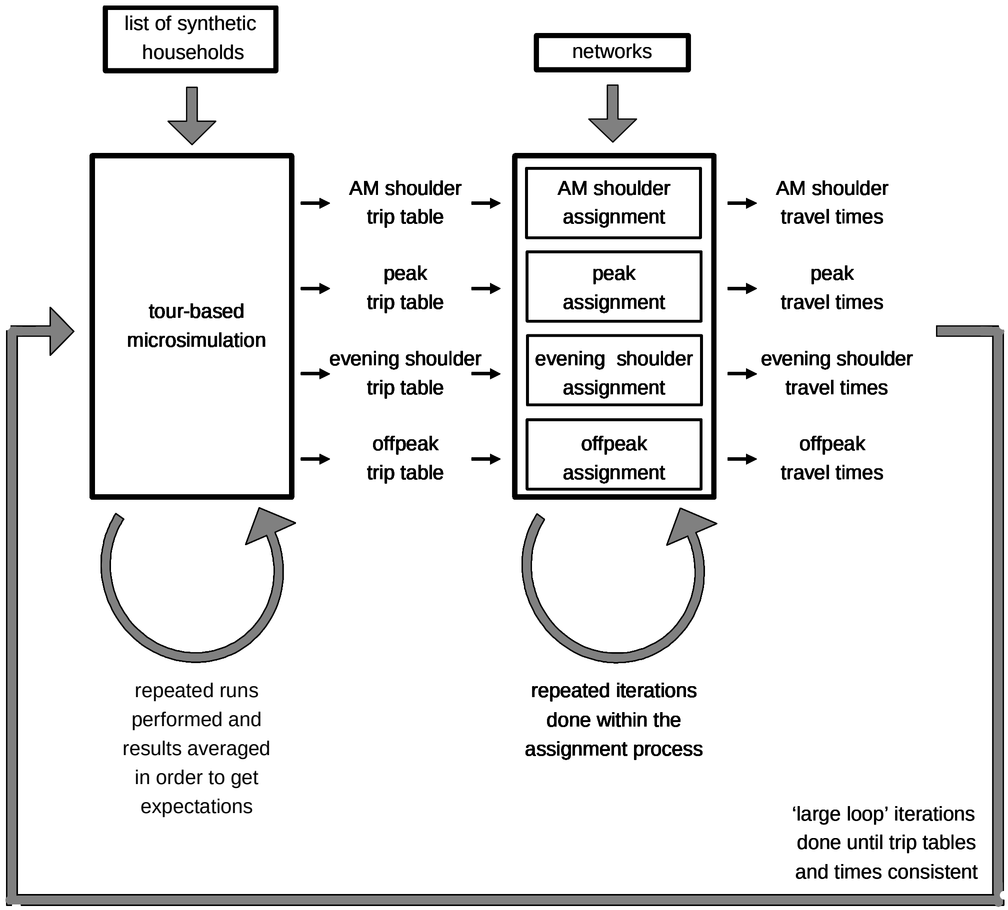

Figure 2: Model Operations

5 ESTIMATION

The discrete choice models and continuous duration models to be developed as part of the development of the tour-based microsimulation are all summarized in Table 3.

5.1 Discrete Choice Models

Observations of the relevant choice behaviour for developing the logit choice models include a listing of the characteristics of the available alternatives and of the decision-maker in each case, along with an indication of the selection made. These observations will be put together from the household travel behaviour data described in Section 2.1 above. The corresponding utility functions will then be developed and the sensitivity parameters and alternative specific constants in these functions estimated using disaggregate logit estimation techniques (Daly, 1992; Ben Akiva and Lerman, 1985). The results of these estimations will guide in the determination of the final forms of these utility functions, which may contain inputs that differ some from what is listed in Table 3.

5.2 Continuous Duration Models

Observations of the distributions of stop durations for developing the continuous duration models will be drawn from the household travel behaviour data described in Section 2.1 above. Initially, non-parametric distributions will be established for each tour type, with further segmentation within each type based on groupings of the model input variables listed in Table 2 as permitted by the available data. The intention is then to develop hazard duration models (Bhat, 2000; Hensher and Mannering, 1994) in order to parameterize the influences of the model inputs and replace the non-parametric distributions with these parameterized versions where possible.

6 CALIBRATION

After all of the discrete choice and continuous duration models in the elements of the microsimulation have been assembled and the values for the various coefficients established as described above, including all the sensitivity parameters and alternative specific constants, the microsimulation will then be calibrated to appropriately match various aggregate targets.

An iterative approach will be used where the microsimulation is run, the match of the output values to specific aggregate targets assessed and the associated alternative specific constants adjusted in order to improve the match. With Monte Carlo processes like the one being described here, in general the results are different with each run. So multiple runs will have to be done and the results averaged in order to get values that indicate the expectations, or central tendencies, of the outputs.

The elements of the microsimulation are interdependent, which means that adjustments to the values of the coefficients in one model can alter the output values for other models. For example, if the tour generation is adjusted, then the membership in subsequent tours is changed, which affects the decision to return home and therefore tour lengths. This necessitates the use of an approach in calibration where the matches to different sets of targets are considered consecutively over a series of iterations until the adjustments to the coefficients and the resulting changes in the output values are small enough to be of no consequence. The sets of aggregate targets to be considered include, but will not be limited to:

- Tour generation by household type, geographic area and time period;
- Mode split by household type and time period;
- Distribution of stops by purpose, tour type and time period;
- Number of stops per tour by tour type;
- Total trip destinations in each of 13 superzones by stop purpose, adding superzone-specific attractors to the stop location utility functions as required; and
- Intra-superzonal proportions of trips in each of 13 superzones; adding intra-superzonal factors to the stop location utility functions as required.

This initial list of targets reflects the general experience in previous similar work that the geographic distribution results require some of the greatest post-estimation adjustments in order to get adequate model performance overall.

7 CONCLUSIONS

This paper reports on work in progress to develop a tour-based microsimulation model of weekend travel in Calgary. This work is not complete at the time of writing, but much of the essential elements of the design have been identified – based in large part on analysis of the travel behaviour data collected for this purpose and on previous experience. It is useful to a wider audience of those considering such modelling to see this design, and how it is tailored to fit weekend rather than weekday behaviour.

The differences in weekend behaviour, including a greater prevalence of more complex tours by family groups that include larger numbers of stops for combinations of shopping, entertainment, leisure, social and eating activities (called 'SELSE' in the paper), along with the reduced instances of work and school activities, has led to the design here of a more flexible 'growing' approach to the representation of tours and a time-based tour generation process with group size as one of the attributes – rather than the more restricted 'rubber-banding' approach to tours and the more complex consideration of the entire day of activities around work and school and joint across household members now emerging as the 'state-of-the-art' in models of weekday travel.

The simulated annealing process used to develop the list of synthetic households was straightforward to implement and worked well.

The dataset of observations of household travel behaviour on weekends is not very large. At this point it appears to be sufficient to perform the model estimation work as outlined, but with some joint estimation across tour types and with some supplementing from the observations of analogous weekday behaviour where the sample sizes are particularly small. The work will progress on this front in the time before the conference, and results will be included in the conference presentation.

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