UCI-ITS-AS-WP-00-6

An Activity-Based Travel Pattern Generation Model

UCI-ITS-AS-WP-00-6

Anup A. Kulkarni
Michael G. McNally

Department of Civil and Environmental Engineering and
Institute of Transportation Studies
University of California, Irvine, mmcnally@uci.edu

December 2000

Institute of Transportation Studies
University of California, Irvine
Irvine, CA 92697-3600, U.S.A.
http://www.its.uci.edu

DRAFT (UPDATED: 11/27/00 9:21 AM)

AN ACTIVITY-BASED TRAVEL PATTERN GENERATION MODEL

Anup A. Kulkarni
anup@translab.its.uci.edu

And
M. G. McNally
mcnally@uci.edu

Institute of Transportation Studies
University of California, Irvine
Irvine, California 92697
Phone/Fax: (949) 824-6571/ 824-8385

ABSTRACT

Activity-based approaches are perhaps the most promising alternative to the current travel forecasting methodology. This paper presents a pattern generation model that can serve as a link between activity and trip-based methodologies. The model uses a clustering approach to identify groups of similar activity-travel behavior and relates them to household socioeconomic attributes. Minimally, the pattern generation model is offered a possible replacement to the standard trip generation models. Moreover, it can serve as the core component of a proposed activity-based microsimulation model that constructs complete origin-destination tables using a wholly activity-based approach. The technique proposed clearly recognizes the complex nature of activity-travel behavior in terms of spatial and temporal constraints, household interactions, and the derived nature of such behavior. An application of the model is outlined using data from the 1994 Portland activity-travel survey.

1. OVERVIEW

The current travel demand modeling process is in the course of fundamental reassessment. Modified from a set of models developed in the 1950's to evaluate future network configurations, the procedure essentially consists of four sequential stages: trip generation, trip distribution, mode choice, and route assignment (see Jones, 1983 for an overview). The four-step forecasting methodology functions in an acceptable manner for the network planning purposes it was originally developed to analyze. However, federal requirements (Clean Air Act Amendments of 1970, 1977, and 1990; ISTEA; TEA-21) for transportation modeling have evolved from the original long-term forecasts to more short-term, policy sensitive forecasts without any necessary modification of the forecasting models. As a result, the four-step forecasting methodology has been the subject of increasing criticism from academics, practitioners, and environmentalists as being inadequate for forecasting needs.

A number of shortcomings in the methodology have been cited as particularly important. First, it lacks a behavioral foundation. As an example, current trip generation and destination choice models are calibrated and validated for a base year using zonal parameters such as trip generation rates and friction factors. Any policy change that results in a significantly altered transportation or land use environment (e.g., congestion pricing) are poorly reflected in these parameters and in the overall model forecasts. Second, the conventional methodology is trip-based. That is, unlinked trip productions and attractions are estimated at an aggregate level disregarding any links between destinations, modes, and chains inherent in trips. Third, spatial, temporal, and interpersonal constraints are not imposed. Fourth, limited feedback or equilibration exists between or within the four stages; only at the assignment stage is any equilibration considered. Final model outputs such as network volume and travel time are not equilibrated with the generation, distribution, or mode choice stages. Lastly, there is only a limited exogenous treatment of land use, economics, and demographics.

The activity-based approach has emerged from researcher's desire to model travel behavior by understanding the nature of activity participation that inspires it. It identifies travel as derived from the desire to participate in activities dispersed both in space and time, specified as daily or multi-day patterns of behavior (Hagerstrand, 1973). The following is a summary of the major characteristics of the activity-based approach (McNally, 1996):

a) Travel demand is derived from activity participation
b) Activity participation involves generation, spatial choice, and scheduling components
c) Activity and travel behavior are delimited by temporal and spatial constraints
d) Linkages exist between activities, locations, times, and individuals
e) A number of decision paradigms are probable

An activity-based model, for the purposes of this paper, is defined as a model that attempts to describe any or all aspects of activity participation and includes necessary constraints and linkages. Minimally, activity-based models must enumerate activity and travel start and ending times, durations, and locations in a time-dependent fashion (i.e., activity-travel patterns or multiple tours). A primary difficulty in developing activity models is trying to capture such complex behavior in a single entity for use as the primary unit of analysis (With conventional travel demand models, it is fairly easy to use the "trip" as the foundation.). A common approach has been to define and use as the basic unit of analysis the activity-travel pattern: "the revealed pattern of behavior represented by travel and activities over a specified time period." (McNally and Recker, 1987) A number of efforts have been successful in defining and using the activity-travel pattern, though little consensus has emerged as to a standard depiction.

This paper uses a modified version of the simultaneous, time-dependent representation of activity-travel patterns introduced by Recker et al. (1983) that discretized time into small intervals and identified activity-type and distance attributes at each interval. First, activity types are defined in the following manner: out-of-home work, out-of-home maintenance (dine out, shopping, etc.), out-of-home discretionary (visiting friends, social party, etc.), travel, and in-home

activities. Second, spatial dimensions are included through two variables: "distance from home" and "distance from last activity". Both the activity travel patterns are defined on these three variables over a 24-hour time period at 10-minute intervals (144 timesteps) for a total of 432 attributes per pattern. The advantages of this type of representation are that it is very straightforward to implement, can describe a large number of attributes along the temporal dimension, and once assigned to an individual, can be aggregated into trip tables or used as part of air-quality models (see McNally, 1999). The remainder of the paper will present the development of the pattern generation model as well as an illustration of the process for a subset of the 1994 Portland Activity Travel Survey.

2. FRAMEWORK FOR AN ACTIVITY-BASED GENERATION MODEL

The intent of this paper is to produce an activity pattern generation model that can serve as a bridge between the next generation of activity-based models and the current generation of travel forecasting models. The model constructed will also serve as the initial component of an ongoing effort at UC Irvine to produce an advanced activity-based microsimulation model aimed at replacing the entire conventional modeling process (see McNally, 1999). Specifically, this paper aims to develop a pattern generation model that may eventually serve as an alternative to the trip generation models used in current travel forecasting. The proposed model will be inherently activity-based and incorporate spatial and temporal dimensions alongside household interactions and lifecycle effects.

The activity pattern generation model uses as its foundation representative activity-travel patterns (RAPs), coarsely defined as groups of "similar" activity-travel patterns. Classification is involved in the categorization of individual activity-travel patterns into a limited number of RAPs. Underlying the use of classification of activity-travel patterns is the belief that there exist groups of individuals with similar travel behavior that can be captured in the RAPs. By distinguishing these patterns, it is possible to deal with the complete daily activity-travel patterns of individuals in a holistic manner. Both Recker et al.

(1983) and Pas (1983) have shown that much of the daily variation in activity-travel patterns can be captured through classification into a few pattern types and that "the choice of daily pattern type was closely related to socioeconomic characteristics describing household role, lifestyle, and lifecycle." (Vaughn et al. 1997) Recent work presented in McNally (1999) and Wang (1996) has bolstered the prospects for using RAPs as the basis of forecasting models by showing preliminary evidence that RAPs are stable over normal planning horizons (10 years).

Still, while a strong body of research has been built around RAPs, some questions still remain about applying the approach. Primarily, it is still unclear as to how the relationship between RAPs and socioeconomic characteristics should be constructed: should socioeconomic characteristics be related to RAPs or should RAPs be related to socioeconomic characteristics? Wang (1996) opted for the former by first specifying six lifecycle groups and clustering the groups independently to identify RAPs. The problem with this method is that some of the identified RAPs in the different lifecycle groups may be redundant and a full scale clustering more efficient. The advantage to this is that the patterns are more homogeneous when split first allowing for differences to be identified that may not originally be found. The other approach is to distinguish RAPs first and subsequently link them to RAPs. While efficient, many of the subtle differences between activity-travel patterns will be lost in the RAPs. Consequently, accuracy of any model developed on the results may suffer.

The proposed approach to develop a pattern generation model is a hybrid of the two described above. First, individuals are segmented by employment status and age into three groups: children, full-time employed adults, and adults not employed full-time. These categories are selected because previous research indicates that the age and employment status captures a significant portion of the variance in activity-travel behavior (e.g., Vaughn et al., 1997). Next, the individual activity travel patterns of each segment are classified to identify a number of distinct RAPs specific to each of the three defined categories. The advantage of this construction is that the homogeneous RAPs

are identified in a non-redundant manner. For instance, those adults that are employed full-time are likely to have very similar patterns regardless of their socioeconomic attributes. A possible drawback to this and similar classification methods is the question of focus: how detailed of a classification should be undertaken? With respect to the pattern generation model, more RAPs would likely lead to more accuracy. However, at some point, care must be taken to prevent adding too many RAPs that may result in the capture of more noise than differences in travel behavior. It is at this point where the classification shifts from "science" to "art" and the difficulty of finding good clusters becomes apparent. Finally, for each of the age and employment status segments for which there are RAPs identified, an additional socioeconomic dimension is applied, such as household lifecycle, number of cars, or additional commonly used variables in trip generation models. This allows the pattern generation model to be sensitive to socioeconomic changes in a target population. To keep consistent with Wang's approach for possible comparisons of results, the same six group lifecycle structure will be applied in a sample application: "Single Person Household", "Single Parent Household" (children under 18), "Couples without Children", "Single Worker Couples with Children", "Dual Worker Couples with Children", and "Unrelated Persons" (Note that couples include only Male-Female pairs that are either married or unmarried and that Work is defined as either full or part-time.).

The result is a model that uses a three dimensional cross-classification table with the dependent variable being the likelihood of that type of individual participating in a particular RAP. Note that for each cell defined by age and employment status, a separate set of RAPs are defined. One advantage of the hybrid approach is that the classifications of activity-travel patterns are reduced without a substantial loss of detail in the defined RAPs. Once estimated, the application of the generation model to estimate patterns is straightforward. An individual's placement in a cell is deterministic as are the probabilities of participating in one of the identified RAPs for that cell. A RAP is assigned stochastically using standard techniques such as Monte Carlo Simulation.

Captured in the assigned RAP is a full spectrum of underlying activity-scheduling attributes (start times, durations, locations, and so on), which can be utilized in any subsequent processing. At minimum, the activity pattern generation model can replace conventional trip generation models by converting the assigned patterns to trips. More likely, the proposed model could replace both the trip generation *and* distribution models by producing origin-destination trip tables. This would be accomplished by simulating a fully specified activity-travel pattern with all activity-scheduling attributes, including activity locations that correspond to actual geographic locations. All patterns can then be reduced to an origin-destination trip table and be input into the mode choice and route choice stages of conventional models. A number of limitations of current approaches including unrealistic trip distributions and mode splits would be eliminated, while incorporation of household structure variables allow for household interactions on activity-travel patterns to be included. The model has the potential to serve as the input to an activity-based microsimulation model with the aim of replacing the conventional forecasting process.

3. CLASSIFYING ACTIVITY-TRAVEL PATTERNS INTO RAPS

3.1 SELECTION OF CLASSIFICATION DATA

The classification uses first day data from the 1994 Portland Activity-travel survey to construct individual activity-travel patterns. Only individual patterns that meet the following criteria are included: (1) complete data (location and times); (2) surveyed on a weekday; and (3) at least one out-of-home activity. Further, those individual patterns meeting the criteria were split into three sets based on the characteristics of the individual: full-time employed adults (17 years of age or older), non full-time employed adults (homemakers, part-time employment, retired, etc.), and children. The actual data used consisted of 1875, 1516, and 1061 activity-travel patterns.

3.2 CLASSIFYING METHODOLOGY

The classification is similar to the methodology applied previously by Recker et al. (1983). Modifications from the original approach were made in calculating the distance between an activity-travel pattern and a RAP as part of the k-means clustering algorithm. Specifically, at each timestep, each of the three attributes is treated as a nominal variable. When comparing two patterns, for each timestep the three attributes (activity type, miles from home, and miles from last activity) are compared. For each attribute that is "different", the distance measure is incremented (otherwise, the distance measure is not affected). The activity type attribute is nominal by definition. However, the "distance from home" and "distance from last activity" attributes must be converted into nominal variables in the similarity calculation. This is done at each timestep by considering the attribute as the same as the RAP centroid it is being compared to if it comes within a threshold of 20 percent of the RAP centroid's value. Therefore, the distance between a particular RAP and an activity-travel pattern will range from 0 to 432 (144 timesteps * 3 variables), corresponding from being exactly alike to very different. The advantage of this method is that it treats the activity and the distance attributes (miles from home and miles from last activity) with the same metric. Moreover, the weights associated with the three measures can easily be changed in the clustering procedure.

3.3 CLASSIFICATION RESULTS

ADULTS EMPLOYED FULL-TIME

Classification was started using the full-time employed adult subset. Clustering began with two groups and ended at ten groups. The RAP set selected for further analysis was determined based on the size of the groupings and a subjective analysis of their makeup. RAPs with equivalent activity-profiles and only small differences in distance were combined to avoid over defining the RAPs.

A six-group RAP set was selected for analysis. The six RAPs can be described as Standard Work, Power Work, Late Work, Work-Maintenance, Work-Discretionary, and Various Short Activities. Note that a seventh RAP, No Travel, was present in the data but not part of the classification procedure. **Figure 1** shows the activity and distance profiles for all RAPs in this data subset. **Figures 2 and 3** show the activity and travel profiles for RAP Standard Work. The activity profile identifies the proportion of the RAP members that are participating in each specified activity type (home, work, maintenance, discretionary, and travel) at each time step. The distance profile is composed of two parts. First, it shows the mean distance away from home of RAP members that are participating in any out-of-home activity at each time step. Second, it shows the mean number of miles from the last activity for all RAP members at each time step. A value of negative one symbolizes either that the activity is the first of the day or a return to home activity.

Tables 1 through 4 present the socioeconomic, activity, and travel statistics of each of the six RAPs as well as the overall group. For the overall group, the average age of the individuals is a little more than 40 years, 56/44 split between males and females, and 96 percent with driver's licenses. The household lifecycles of the individuals are primarily "Couples without Children" (31%), followed "Unrelated Persons" (20%), "Dual Worker Couples with Children" (18%), and "Single Person" households (16%). The households are primarily own their homes (74% vs. 26% renting), from upper middle income ($45 – $50K), and have an average household size of 2.6 (mostly two and three member households).

The Standard Work RAP consisted of the majority of activity-travel patterns (67%) and correlated very well with the overall group's socioeconomic statistics. Most members executed a traditional workday comprising of an AM-peak commute to a conventional 9 hour (8 hours work and 1 hour lunch) work activity, and a return home trip in the PM-peak. Roughly 10 percent of the RAP members exhibited some midday maintenance activity (lunchtime dining). The work activity's average distance from home is 7 miles.

The Power Work RAP consisted of 5 percent of the activity-travel patterns. Again, the individuals that made up the RAP are consistent with the overall average in most categories, though they have a higher proportion of the "Unrelated Persons" lifecycle group (28% vs. 20%) and a lower proportion of "Dual Worker Couples with Children" (13% vs. 18%). The typical work activity is 2 hours longer than the Standard Work RAP at 10 hours and the typical work day between 8 AM and 9 PM, including possible maintenance or discretionary activities while at work (possibly a lunch or dinner activity). The work activity's average distance from home is 7 miles.

The Late Work RAP consists of the least number (3%) of activity-travel patterns. It has the largest proportion of males (70%), individuals without licenses (98%), renters (49%), and the lowest income classification ($30K – $35K). A majority of the individuals have no children and consist mainly of "Single Persons" or "Unrelated Persons" lifecycles. Most members executed an 8-½ hour work activity duration that typically began at 3pm and lasted until midnight. The total number of trips for this RAP equaled 3.3 (lowest of all RAPs). The work activity's average distance from home is 7 miles.

The Work-Maintenance RAP consists of 7 percent of all activity-travel patterns. Demographically, the individuals that made up the RAP are very consistent with the overall average, though they have the highest median income ($50K – $55K). The typical workday is very similar to the Standard Work RAP at 8 hours between 8 AM and 5 PM. The main difference is that over 80 percent of all members engage in a noontime maintenance activity (most probably dining out) between noon and 1:30 PM. The work activity's average distance from home is 9 miles.

The Work-Discretionary RAP consists of 4 percent of all activity-travel patterns. Again, the individuals that made up the RAP are fairly consistent with the overall average, though they have the highest median income ($50K – $55K) and largest mean household vehicles. The typical workday is a little longer than the Standard Work RAP at 8-½ hours (8 AM and 5:30 PM) at an average distance of 10 miles from home. The main difference is that almost 100 percent

of all members engage in an after-work discretionary activity between 6 PM and 10 PM averaging 12 miles from an individual's home location.

Surprisingly, RAP Various Short Activities makes up the second largest group at 15 percent and is similar to the overall RAP socio-economics. The only statistic that stands out is the large proportion of "Dual Worker Couples with Children" lifecycle (22%) that makes up the RAP. The typical day consists of a number of different activities with short durations. Activity statistics suggest that likely activities include work, general shopping, personal business, social/recreational, dine out and serve and that dine out activities average1.1 hours. Normally, an individual in the RAP makes 4.4 trips, with the majority of them sandwiched between the AM and PM-peak hours and averaging less than 3 miles from home.

ADULTS NOT EMPLOYED FULL-TIME

A similar process to the one used to identify the groups for Full-time Working Adults was used to identify groups for the Adults Not Employed Full-time subset. A four-group RAP set was selected for analysis from the clustering process that started with two groups and ended at seven groups. The four RAPs can be described as Work/School, Maintenance, Discretionary, and Various Short Activities and make up 24, 12, 10, and 54 percent of the activity-travel patterns. Note that while some of the groups are name in a similar fashion to the groups identified for Adults Employed Full-time, the specifics of the RAPs are different for this data subset. Again, a No Travel RAP was present in the data but not a part of the classification procedure. **Tables 5 through 8** present the socioeconomic, activity, and travel statistics of each of the four RAPs. **Figure 4** shows a general snapshot of the activity and travel profiles for the four RAPs while **Figures 5 and 6** provides a more detailed look at the Work RAP activity and travel profiles.

The average individual is a little more than 50, likely female (62%), and has a driver's license (90%). The households lifecycles of the individuals are primarily "Couples without Children" (35%), followed by "Unrelated Persons"

(21%), "Single Person Households" (20%), and "Single Worker Couples with Children" (17%). The households have an average household size of 2-½ (mostly single and double person). The households tend to own their homes (77%), are primarily lower income ($35K – $40K), though a fair amount of middle and higher income groups exist. Keep in mind that the household statistics of the Adults Not Employed Full-time may overlap with Adults Employed Full-time and therefore should be analyzed with caution.

The Work/School RAP consisted of 24 percent of the patterns in the data segment. Almost an equal proportion of females (52%), much lower than the combined RAPs, and the youngest (40 vs. 51 years of age). Households have the highest income of all RAPs ($40K – $45K) as well as the largest household size. There is a larger than expected presence of the "Unrelated Persons" and "Dual Worker Couples with Children" lifecycle groups and a smaller than expected presence of "Couples w/o Children" when compared to all of the RAP member households. Most members executed a work or school pattern that included a 6 hour workday. This is three hours less than the standard work pattern that full-time workers typically execute. The data seems to indicate that around 15 percent of the RAP members exhibited some midday maintenance activity (lunchtime dining). The work or school activity's average distance from home is 6 miles.

The Maintenance RAP consists of 12 percent of all activity-travel patterns. 73 percent of the individuals in this RAP are female (much higher than overall) and average 56 years of age. Households makeup is different than the overall RAPs in that more “Couples without Children” and “Single Person” lifecycle groups are present at the expense of “Single and Dual Worker Couples with Children”. In addition, the average household size is lower than the combined RAPs (2.2 vs. 2.5) and the incomes are the lowest among all RAPs ($25K – $30K). The typical day is spent mostly at home with a number of maintenance activities around noon that cumulatively last more than 4-½ hours. The typical activities consist of those classified as shopping, personal business, and dining out in diminishing frequency. The activities' average distances from home

average 5-½ miles. The individuals that make up the RAP average 56 years, are largely from single person households or couples without children (also apparent in the household size figures where 1 and 2 member households dominate) and similar compared to the overall data subset.

The Discretionary RAP consists of 10 percent of all activity-travel patterns. The individuals are mostly female (61%, similar to all RAPs) and average in the late-50's. Household makeup is very similar to the combined RAPs, though household size is smaller at two and lifecycle membership is different. Specifically, "Couples without Children" is the largest lifecycle group, though a larger proportion of the "Single Person" lifecycle group is present at the expense of both "Single and Dual Worker Couples with Children". Interestingly, while some differences exist in the demographic makeup of the Maintenance and Discretionary RAPs, the differences between the two are very minor. The typical day is fairly similar to the Maintenance RAP with the main differences being that the main activity is discretionary, the average duration from home is an hour longer (5-½ hours), typically begin an hour earlier than in the Maintenance RAP, and average 9 miles from home with discretionary activities composing most of the out of home time. A small fraction of individuals participate in mostly discretionary activities in the evening as well, though it is less than 15 percent of the RAP members.

The Various Short Activities RAP consists of the majority (54%) of all activity-travel patterns and both the individuals and households that make up the RAP are very similar to the overall subset socio-economic characteristics, particularly the household size (2.5) and mean number of children (0.7). Minor differences include a higher mean age, lower proportion of high incomes, and lifecycle makeup. The typical pattern is somewhat similar to the Maintenance and Discretionary RAPs activity frequency composition, but varies widely with respect to the durations in the specific activities in that no activity duration is greater than an hour (**Table 8**). Specifically, the pattern executed typically engages in several different activities with a short duration and very near home (around 1 mile from

home). The activities are spaced throughout the day and are performed usually in one or two sojourns.

CHILDREN

Children made up the last category for classification. The classification was similar to the earlier clustering and started with two groups and ended at eight groups. The RAP set selected for further analysis was determined based on the size of the groupings and a subjective analysis of their makeup. RAPs with equivalent activity-profiles and only small differences in distance were combined to avoid over defining the RAPs. A final six-group RAP set was selected for further analysis. The six RAPs can be described as Standard School, Long School, School-Discretionary, Maintenance, Discretionary, and Various Short Activities. Note that a seventh RAP, No Travel, was present in the data but not part of the classification procedure. **Tables 9 through 12** present the socioeconomic, activity, and travel statistics of each of the four RAPs. **Figure 7** shows the activity and travel profiles for all the RAPs, while **Figures 8 and 9** shows the activity and travel profile of the Standard School RAP.

The average individual is 9 years, evenly split between female and male (51% to 49%), and does not have a driver's license (94%). The households lifecycles of the individuals are primarily "Single Worker Couple with Children" (56%), followed by "Dual Worker Couple with Children" (32%), "Single Parent" (14%), and "Unrelated Persons" (8%). The households have an average household size of 4.2. The households tend to own their homes (81%), are primarily middle income ($45K – $50K).

The Standard School RAP consisted of the majority of Children's activity-travel patterns (50%). Socioeconomically, this RAP is a little younger than (9 years) and more male (53%) than the overall averages, but is similar to the overall lifecycle, household size, and income statistics. Most members executed a 6-½ hour school activity between 8 am and 3 pm. Less than10 percent of the RAP members exhibited some midday maintenance activity (probably lunchtime

dining). The school activity's average distance from home is 2 miles. Around 12 percent of the RAP went out on a discretionary activity at around 7 pm.

The Long School RAP consisted of 5 percent of the activity-travel patterns. The Long School RAP is interesting in that households are made up of a substantially higher proportion of "Dual Worker Couples with Children" (52% versus 32%) and higher income households ($50K - $55K) than in the overall population. Mean age is 10, though there is a wide discrepancy in ages (both young and older children) and proportionally more females than males (68% versus 32%). It is likely that this group includes two types of children: children can not stay home without a parent who directly go to after school daycare centers and older children who stay after school to participate in school-related activities. The typical school activity is 2 hours longer than the Standard School RAP's school activity at 8-½ hours, somewhere between 8 AM and 4:30 PM. The averages durations indicate that both work (average 1-½ hours) and social/recreation (average1 hour) activities are common in this RAP, mostly during the evening hours. The school's activity's average distance from home is 5 miles.

The School-Discretionary RAP consists of 8 percent of activity-travel patterns. Children in the Discretionary RAP tend to be pre-teens (mean age of 12 years) older than the overall children from middle-income families ($45K - $50K) and two parent households (90% in "Single and Dual Worker Couples with Children"). It has a very interesting makeup in that the school activity is the same duration as the Standard School RAP (6-½ hours) with a relatively long social/recreational activity (3 hours). The school activity's average distance from home is 2-½ miles, while the social/recreational activity's average distance is 3-½ miles from home. A likely pattern example would be that of child that participates in a school activity during the day and then in a non-school related recreational sport in the afternoon.

The Maintenance RAP consists of the least proportion of all activity-travel patterns (4%). Children in this RAP tend to be younger (7 years) from households that are smaller than average, and have higher incomes ($50K -

$55K). The typical day is does not contain school and is rather similar to an adult's maintenance pattern with a day made up of mostly shopping, personal business, or dining out activities averaging 1, 3-½, and 2 hours, respectively. The Maintenance RAP is possibly a "tag-along" RAP with an adult parent where the child is essentially accompanying an adult throughout most of the day, though more analysis needs to be conducted to verify this statement. The average distance from home for the different activities ranges from 1-½ miles to around 3-½ miles.

The Discretionary RAP consists of 5 percent of all activity-travel patterns. This RAP makeup is similar to that of the children's Maintenance RAP in that it contains a disproportionate number of younger children. However it is different in that a large proportion of households come from the "Single Parent" lifecycle group and have lower income households compared to the overall data subset ($40K -$45K). The typical day does not contain a school activity and is rather similar to an adult's discretionary pattern with a day made up of an average of 2 social/recreational activities. The typical daily duration spent in social/recreational activities is 8 hours usually between the hours of 9 am and 6 pm. The average distance from home of these activities is 2 to 6 miles. Again, this is possibly a "tag-along" RAP with an adult parent.

RAP Various Short Activities makes up the second largest group at 37 percent. This RAP contains the youngest children (mean age of 6 years), a large proportion of which are from "Single Worker Couples" and lower incomes ($40K – $45K). The typical day consists of a number of different activities with short durations and close to home. Activity statistics suggest that likely activities include general shopping and social/recreational activities that average ½ and 1-½ hours, respectively, and are around 1 mile from home.

The identification of the RAPs from the individual activity-travel patterns of subsets of the original data into adults employed full-time, adults not employed full-time, and children proved successful in identifying a small number of distinct patterns. Specifically, when individuals are segmented by employment status

and age first, differences between the activity-travel behavior of these pre-defined categories is increased and the differences within each group decreased.

3.4 IDENTIFYING CLASSIFICATION RULES

The descriptions provided above are only general in nature and there still is some variability as to the activity composition of the patterns. Thus to clarify the definition of the RAPs in each employment and age group, a set of classification rules was developed. The rules are expected to be useful in both developing a sense of the RAPs and for quickly classifying and comparing new, observed activity-travel patterns to those developed. The rules constructed are mutually exclusive, collectively exhaustive, and are applied in a hierarchical fashion. The rules are presented as a set of if-then-else statements that assign patterns to only one cluster and were developed after an empirical analysis of the cluster results for each of the previously examined subsets.

ADULTS EMPLOYED FULL-TIME

The classification produced six distinct RAPs that were described above. The six identified RAPs and the No Activity RAP excluded from the process.

1. If at least one (work or non-work) activity and a total work activity duration of less than 5 hours, then the pattern is classified as Various Short Activities.
2. If at least one work activity, the total work duration of greater than 5 hours, and the start time of the first work activity is after noon, then pattern is classified as Late Work.

If at least one work activity, the start time of the first work activity is before noon, and the duration of all work activities total between 5 hours to 10 hours:

   a. If any maintenance activity between 11 am and 2 pm, then pattern is classified as Work-Maintenance.
   b. Else if any discretionary activity after the work activity, then pattern is classified as Work-Discretionary.

c. Else, Standard Work activity.

3. If at least one work activity, the start time of the first work activity is before noon, and the duration of all work activities total more than 10 hours, then the pattern is classified as a Power Work.
4. If no out-of-home activities, then pattern is classified as a No Travel.

ADULTS NOT EMPLOYED FULL-TIME

For the adults not employed full-time, four groups were recognized from the clustering in addition to the No Activity group. The rules developed from the results follow based on the largest duration activity.

1. If no out-of-home activities, then pattern is classified as a No Travel.
2. If the largest duration out-of-home activity is maintenance and the maintenance duration is greater than 2 hours, then the pattern is classified as Maintenance.
3. If the largest duration out-of-home activity is discretionary and discretionary duration is greater than 2 hours, then the pattern is classified as Discretionary.
4. If the largest duration out-of-home activity is work or school and the activity is greater than 2 hours, then the pattern is classified as Work/School.
5. Else, the pattern is classified as a Various Short Activities.

CHILDREN

For the Children, six groups were recognized from the clustering in addition to the omnipresent No Activity group. The rules developed from the results follow based on the largest duration activity.

1. If no out-of-home activities, then the pattern is classified as a No Travel.
2. If a school activity is present, the school activity duration is greater than 3 hours, and is followed by a discretionary activity, then the pattern is classified as a School-Discretionary.

3. If a school activity is present with duration between 3 and 8 hours and not followed by a discretionary activity, then the pattern is classified as a Standard School.
4. If a school activity is present with duration greater than 8 hours and not followed by a discretionary activity, then the pattern is classified as a Long School.
5. If no school activity is present, the largest duration out-of-home activity is maintenance, and the maintenance duration is greater than 2 hours, then the pattern is classified as Maintenance.
6. If no school activity is present, the largest duration out-of-home activity is discretionary and the discretionary duration is greater than 2 hours, then the pattern is classified as a Discretionary.
7. Else, the pattern is classified as Various Short Activities.

The reasoning behind the Standard School Pattern's limit on school hours was to exclude children in part-time daycare and kindergarten from children in full-time school (grades 1 –12) with the belief that they affect (possibly guide) the activity-travel pattern of the child's primary caregiver.

4. ACTIVITY-BASED PATTERN GENERATION MODELS: TWO EXAMPLES

Tables 13 and 14 present two examples of pattern generation models for all adults. The pattern generation models are set up as category tables that specifies the likelihood that an individual of that age, employment status, and lifecycle will participate in a set of possible RAPs. Also provided for each cell are standard trip generation rates (though these rates are skewed upward since individuals without travel were not included in the analysis). Using the model in **Table 9**, consider an individual that fits into the category of employed adults in Single Parent Households. A conventional trip generation model using the same classification format would estimate 4.1 trips per day for each individual in the category. Rather than assigning 4.1 trips to the individual, the activity-based model estimates a 65.9 percent probability that the individual will participate in a Standard Work-like pattern. The probability of the individual executing a RAP

similar to the Power Work, Late Work, Work-Maintenance, Work-Discretionary, and Various Short Activities are 4.9, 5.2, 7.2, 3.6, and 13.1 percent.

The RAPs and their identified distributions can now serve as input to a two-stage Monte Carlo simulation (MCS) that generates activity-travel patterns. Starting with a given household and the classification results, each individual is assigned a RAP. The first-stage of the MCS synthesizes an individual's entire activity-travel pattern: the activity type, frequencies, start and end times, durations, sequencing, and distances. The process generates an activity ("an activity" minimally includes the activity type, its duration, and its distance from home) conditional on the distributions associated with the assigned RAP. Activities are generated in a time-dependent, sequential manner until an entire 24-hour period activity-travel pattern is constructed. The patterns output by this stage are provisional because travel times and distances are assigned only as general parameters. They are updated in the second-stage by executing each member's entire activity-travel pattern within a geographic information system in order to include information on the particular transportation network and activity distribution available to the household. Actual activity locations are selected from potential locations that satisfy the distance parameters of the simulated patterns. Once the locations are selected, the activity-travel patterns are updated to reflect the actual locations.

5. CONCLUSION AND FURTHER RESEARCH

This approach holds at least two distinct advantages over conventional trip generation models. First, because the conventional model produces trips as its standard output, a number of intermediate models and fixes are applied to address time-of-day and trip purpose. The process can be more accurate by introducing the full activity-travel patterns. The pattern generation model is robust enough to address this by specifying complete activity-travel pattern as output. Further, a microsimulation model that uses the pattern generation model as an initial stage is proposed that would redefine the entire travel demand-modeling framework using an activity-based approach. Moreover, this pattern

generation model can be used as a bridge to incorporate the activity-based approach to the current travel demand-modeling framework. The patterns generated can be converted into a trip origin-destination table and be input directly into mode choice and route choice models. By introducing the proposed pattern generation model alongside conventional trip-based models, the acceptance and understanding of activity-based models will be hastened. The model constructed will also serve as the initial component of an ongoing effort at UC Irvine to produce an advanced activity-based microsimulation model aimed at replacing the entire conventional modeling process (see McNally, 1999).

6. REFERENCES

Hagerstrand, T (1973). What about people in regional science?. Papers of the Regional Science Association, 24, 7-21.

Jones, P.M. (1983). Activity Approaches to Understanding Travel Behavior in P. Stopher, A. Myberg, and W. Brog (Eds.) New Horizons in Travel-Behavior Research, Lexington Books, D. C. Heath, Lexington, MA.

McNally, M. and W. Recker (1987). On the Formation of Household Travel-Activity Patterns: A Simulation Approach. Final Report, USDOT.

McNally, M. (1996). An Activity-Based Microsimulation Model For Travel Demand Forecasting. ITS Working Paper UCI-ITS-AS-WP-96-1, Irvine CA.

McNally, M. (1999). Activity-Based Forecasting Models Integrating GIS. Geographical Systems. Vol. 5, 163-187.

Pas, Eric I. (1983). Classification of Daily Travel-Activity Behavior. Transportation Science. Vol. 17, No. 4, 405 - 429.

Recker, W., G. Root, and M. McNally (1983). An Empirical Analysis of Household Activity Patterns. Final Report, USDOT, Report DOT/RSPA/DMA-50/83/19.

Vaughn, K. M., P. Speckman, and E.I. Pas (1997). Generating Household Activity-Travel Patterns (HATPs) For Synthetic Populations. Prepared For Presentation at the 76th Annual Meeting of the Transportation Research Board. Washington D.C.

Wang, R. (1996). An Activity-based Microsimulation Model. Ph.D. Dissertation. UC Irvine. Irvine, CA.

ALL ADULTS EMPLOYED FULL-TIME

TABLE 1. Descriptive Statistics by RAP Group *

Variable/ RAP Group	Size		Sex			License			Homeownership		
	Freq.	Prop.		Freq.	Prop.		Freq.	Prop.		Freq.	Prop.
Standard Work	1261	67%	Female	556	44%	No	41	3%	Own	962	76%
			Male	705	56%	Yes	1219	97%	Rent	295	23%
Power Work	94	5%	Female	43	46%	No	3	3%	Own	64	68%
			Male	51	54%	Yes	91	97%	Rent	28	30%
Late Work	53	3%	Female	16	30%	No	4	8%	Own	25	47%
			Male	37	70%	Yes	49	92%	Rent	26	49%
Work-Discretionary	65	3%	Female	30	46%	No	2	3%	Own	46	71%
			Male	35	54%	Yes	63	97%	Rent	18	28%
Work-Maintenance	129	7%	Female	56	43%	No	7	5%	Own	96	74%
			Male	73	57%	Yes	122	95%	Rent	32	25%
Various Short Acts	273	15%	Female	116	43%	No	9	3%	Own	189	69.2
			Male	157	58%	Yes	264	97%	Rent	84	30.8
All RAPs	1875	100%	Female	817	44%	No	66	4%	Own	1382	74%
			Male	1058	56%	Yes	1808	96%	Rent	483	26%

* "Don't Know/Refused" replies not included in table.

TABLE 1. Continued

Variable/ RAP Group	Median Income	Mean Hh. Size (Sdev)	Mean Hh. Vehicles (Sdev)	Mean Age (Sdev)
Standard Work	$45K – $50K	2.6 (1.2)	2.1 (1.0)	41 (10.3)
Power Work	$45K – $50K	2.7 (1.4)	2.0 (1.0)	38 (11.3)
Late Work	$30K – $35K	2.3 (1.4)	1.6 (1.0)	39 (12.8)
Work-Discretionary	$50K – $55K	2.6 (1.6)	2.4 (1.6)	41 (9.9)
Work-Maintenance	$50K – $55K	2.7 (1.4)	1.9 (0.9)	41 (10.2)
Various Short Acts	$40K – $45K	2.7 (1.3)	2.0 (1.0)	40 (10.6)
All RAPs	$45K – $50K	2.6 (1.3)	2.0 (1.0)	41 (10.5)

ALL ADULTS EMPLOYED FULL-TIME

TABLE 2. Lifecycle by RAP Group : Frequency and Proportion

Group/ Lifecycle	Standard Work		Power Work		Late Work.		Work-Discretionary	
	Freq.	Prop.	Freq.	Prop.	Freq.	Prop.	Freq.	Prop.
Single Person	201	16%	15	16%	16	30%	11	17%
Single Parent	37	3%	3	3%	1	2%	1	2%
Couple w/o Child	404	32%	28	30%	10	19%	24	37%
Single Worker Couple w/ Children	147	12%	10	11%	3	6%	1	2%
Dual Worker Couple w/ Children	228	18%	12	13%	5	9%	13	20%
Unrelated Persons	244	19%	26	28%	18	34%	15	23%
All Lifecycles	1261	100%	94	100%	53	100%	65	100%

TABLE 2. Continued

Group/ Lifecycle	Work-Maintenance		Various Short Activities		All RAPs	
	Freq.	Prop.	Freq.	Prop.	Freq.	Prop.
Single Person	22	17%	40	15%	305	16%
Single Parent	6	5%	7	3%	55	3%
Couple w/o Child	37	29%	79	29%	582	31%
Single Worker Couple w/ Children	20	16%	37	14%	218	12%
Dual Worker Couple w/ Children	21	16%	60	22%	339	18%
Unrelated Persons	23	18%	50	18%	376	20%
All Lifecycles	129	100%	273	100%	1875	100%

ALL ADULTS EMPLOYED FULL-TIME

TABLE 3. Activity Statistics For RAP Group: Mean (Stdev)

Group/ Variable	Standard Work	Power Work	Late Work	Work-Discretionary	Work-Maintenance	Various Short Acts	All RAPs
Num Acts	5.1 (1.9)	5.6 (2.2)	4.9 (2.0)	6.4 (1.9)	6.4 (1.8)	5.5 (2.5)	5.3 (2.0)
Home Acts	2.4 (0.6)	2.4 (0.7)	2.3 (0.8)	2.5 (0.6)	2.4 (0.6)	2.7 (0.8)	2.4 (0.7)
Work Acts	1.5 (0.7)	1.8 (1.1)	1.5 (0.6)	1.4 (0.7)	2.0 (0.6)	0.4 (1.0)	1.4 (0.9)
Shop Gen. Acts	0.2 (0.5)	0.2 (0.4)	0.2 (0.4)	0.2 (0.9)	0.3 (0.6)	0.7 (0.9)	0.3 (0.6)
Shop Oth. Acts	0.0 (0.0)	0.0 (0.0)	0.0 (0.1)	0.0 (0.0)	0.0 (0.0)	0.0 (0.1)	0.0 (0.0)
PB Acts	0.1 (0.4)	0.2 (0.6)	0.1 (0.3)	0.1 (0.4)	0.1 (0.4)	0.4 (0.7)	0.2 (0.5)
Soc/Rec. Acts	0.2 (0.5)	0.2 (0.6)	0.2 (0.5)	1.4 (0.7)	0.2 (0.5)	0.7 (1.0)	0.3 (0.7)
Dine Out Acts	0.4 (0.6)	0.4 (0.6)	0.4 (0.6)	0.6 (0.7)	1.0 (0.6)	0.4 (0.6)	0.5 (0.6)
School Acts	0.0 (0.2)	0.3 (0.5)	0.0 (0.1)	0.0 (0.1)	0.0 (0.2)	0.0 (0.1)	0.0 (0.1)
Serve Acts	0.2 (0.5)	0.1 (0.5)	0.2 (0.7)	0.1 (0.4)	0.2 (0.6)	0.3 (0.7)	0.2 (0.5)
Chgtrvl. Acts	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)
Home Dur.	13.0 (1.8)	11.1 (2.3)	13.0 (1.9)	8.6 (2.1)	12.6) (1.8)	19.0 (3.4)	13.6 (3.2)
Work Dur.	8.5 (1.8)	9.8 (3.4)	8.6 (2.0)	8.2 (2.5)	7.9 (1.7)	0.9 (1.7)	7.4 (3.4)
ShopGen.Dur.	0.2 (0.4)	0.1 (0.5)	0.1 (0.5)	0.1 (0.4)	0.2 (0.4)	0.5 (0.9)	0.2 (0.5)
ShopOth.Dur.	0.0 (0.0)	0.0 (0.0)	0.0 (0.2)	0.0 (0.0)	0.0 (0.0)	0.0 (0.5)	0.0 (0.2)
Per. Bus. Dur.	0.1 (0.5)	0.1 (0.5)	0.1 (0.2)	0.1 (0.3)	0.1 (0.5)	0.3 (0.8)	0.1 (0.6)
Soc/Rec Dur.	0.3 (0.9)	0.4 (0.9)	0.4 (1.0)	4.5 (3.4)	0.4 (1.1)	1.3 (2.3)	0.6 (1.6)
Dine Out Dur.	0.4 (0.8)	0.4 (0.6)	0.4 (1.0)	0.5 (0.7)	1.1 (1.2)	0.5 (1.3)	0.5 (0.9)
School Dur.	0.1 (0.7)	0.9 (2.0)	0.1 (0.5)	0.0 (0.2)	0.1 (0.8)	0.0 (0.4)	0.1 (0.8)
Serve Dur.	0.0 (0.1)	0.0 (0.1)	0.0 (0.1)	0.1 (0.5)	0.0 (0.1)	0.1 (0.2)	0.0 (0.2)
ChgTrvl Dur.	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)
Travel Dur.	1.3 (0.7)	1.3 (0.7)	1.3 (0.9)	1.9 (0.9)	1.7 (1.0)	1.3 (0.8)	1.4 (0.8)

TABLE 4. Travel Statistics For RAP Group: Mean (Stdev)

Group/ Variable	Standard Work	Power Work	Late Work	Work-Discretionary	Work-Maintenance	Various Short Acts	All RAPs
Number Trips	3.7 (1.8)	4.2 (2.3)	3.3 (2.1)	5.0 (2.0)	4.5 (2.2)	4.4 (2.4)	3.9 (2.0)
HBW Trips	1.7 (0.7)	1.8 (1.1)	1.8 (0.9)	1.4 (0.7)	1.7 (0.7)	0.7 (1.2)	1.6 (0.9)
HBO Trips	0.9 (1.2)	0.7 (1.1)	0.9 (1.4)	1.6 (0.9)	1.1 (1.2)	2.6 (1.9)	1.2 (1.4)
NHBNW Trips	0.2 (0.6)	0.3 (1.0)	0.2 (0.7)	0.7 (1.0)	0.3 (0.7)	0.8 (1.3)	0.3 (0.8)
NHBW Trips	0.8 (1.1)	1.0 (1.4)	0.4 (0.8)	1.2 (1.1)	1.4 (1.3)	0.2 (0.8)	0.8 (1.1)
HBS Trips	0.0 (0.3)	0.3 (0.9)	0.0 (0.7)	0.0 (1.1)	0.3 (0.7)	0.0 (1.3)	0.1 (0.3)
HBC Trips	0.0 (0.0)	0.0 (0.7)	0.0 (0.3)	0.0 (0.1)	0.0 (0.2)	0.0 (0.2)	0.0 (0.0)
Vehicle Trips	3.1 (2.4)	3.8 (2.4)	2.7 (2.2)	4.1 (2.0)	3.4 (2.3)	3.8 (2.5)	3.3 (2.0)
Transit Trips	0.2 (0.4)	0.1 (0.4)	0.3 (0.9)	0.2 (0.7)	0.4 (0.9)	0.1 (0.5)	0.2 (0.6)
Ped. Trips	0.3 (1.0)	0.3 (1.0)	0.3 (0.9)	0.7 (1.5)	0.7 (1.2)	0.5 (1.1)	0.4 (1.0)
Work Trips	1.3 (0.7)	1.8 (1.1)	1.2 (0.5)	1.4 (0.7)	1.6 (0.7)	0.4 (0.8)	1.2 (0.8)
Maint. Trips	0.8 (1.0)	0.7 (1.2)	0.7 (1.2)	0.9 (1.2)	1.3 (1.3)	1.7 (1.6)	0.9 (1.2)
Disc. Trips	0.2 (0.5)	0.2 (0.6)	0.2 (0.5)	1.2 (0.6)	0.2 (0.5)	0.6 (0.9)	0.3 (0.6)
Home Trips	1.4 (0.6)	1.4 (0.7)	1.3 (0.8)	1.5 (0.7)	1.4 (0.6)	1.7 (0.9)	1.4 (0.7)
AM Peak Trips	0.6 (0.6)	0.8 (0.7)	0.2 (0.5)	0.7 (0.6)	0.8 (0.6)	0.4 (0.7)	0.6 (0.7)
MIDDAY Trips	1.0 (1.2)	1.3 (1.3)	1.7 (1.5)	1.2 (1.4)	1.2 (1.1)	2.3 (1.9)	1.2 (1.4)
PM Peak Trips	1.1 (0.8)	0.9 (1.0)	0.3 (0.6)	1.4 (0.8)	1.5 (0.9)	0.9 (1.1)	1.1 (0.9)
Off Peak Trips	1.0 (1.0)	1.3 (0.7)	1.2 (0.8)	1.7 (1.0)	1.0 (0.9)	0.8 (1.0)	1.0 (1.0)

ALL ADULTS NOT EMPLOYED FULL-TIME

TABLE 5. Descriptive Statistics by RAP Group *

Variable/ Group	Size		Sex			License*			Homeownership*		
	Freq.	Prop.		Freq.	Prop.		Freq.	Prop.		Freq.	Prop.
Work/School	366	24%	Female	191	52%	No	29	8%	Own	263	72%
			Male	175	48%	Yes	335	92%	Rent	103	28%
Maintenance	182	12%	Female	133	73%	No	23	13%	Own	141	78%
			Male	49	27%	Yes	159	87%	Rent	40	22%
Discretionary	146	10%	Female	89	61%	No	22	15%	Own	113	77%
			Male	57	39%	Yes	123	84%	Rent	31	21%
Various Short Acts	822	54%	Female	527	64%	No	77	8%	Own	657	80%
			Male	295	36%	Yes	744	92%	Rent	163	20%
All RAPs	1516	100%	Female	940	62%	No	151	10%	Own	1174	77%
			Male	576	38%	Yes	1361	90%	Rent	337	22%

* "Don't Know/Refused" replies not included in table.

TABLE 5. Continued

Variable/ Group	Median Income	Mean Hh. Size (Sdev)	Mean Hh. Vehicles (Sdev)	Mean Age (Sdev)
Work/School	$40K-$45K	2.9 (1.3)	2.0 (1.0)	40 (17)
Maintenance	$25K-$30K	2.2 (1.0)	1.8 (0.9)	56 (19)
Discretionary	$35K-$40K	2.2 (1.2)	1.8 (1.2)	58 (20)
Various Short Acts	$30K-$35K	2.5 (1.2)	1.8 (0.9)	53 (19)
All RAPs	$35K-$40K	2.5 (1.2)	1.9 (1.0)	51 (20)

TABLE 6. Lifecycle by RAP Group: Frequency and Proportion

Group/ Lifecycle	Work/School		Maint.		Disc.		Various Short Acts		All RAPs	
	Freq.	Prop.	Freq.	Prop.	Freq.	Prop.	Freq.	Prop.	Freq.	Prop.
Single Person	49	13%	46	25%	44	30%	157	19%	296	20%
Single Parent	16	4%	5	3%	0	0%	19	2%	40	3%
Couple w/o Child	92	25%	74	41%	52	36%	308	38%	526	35%
Single Worker Couple w/ Children	67	18%	18	10%	17	12%	160	20%	262	17%
Dual Worker Couple w/ Children	35	10%	4	2%	2	1%	31	4%	72	5%
Unrelated Persons	107	29%	35	19%	31	21%	147	18%	320	21%
All Lifecycles	366	100%	182	100%	146	100%	822	100%	1516	100%

ALL ADULTS NOT EMPLOYED FULL-TIME

TABLE 7. Activity Statistics for RAP Group: Mean (Stdev)

Group/ Variable	Work/School	Maint.	Disc.	Various Short Acts	All RAPs
Number Acts	5.3 (2.1)	6.2 (2.4)	5.8 (2.2)	4.9 (2.3)	5.2 (2.3)
Home Acts	2.5 (0.6)	2.6 (0.8)	2.7 (0.9)	2.6 (0.9)	2.6 (0.8)
Work Acts	1.2 (1.0)	0.1 (0.3)	0.1 (0.4)	0.1 (0.4)	0.4 (0.7)
Shop Gen. Acts	0.2 (0.5)	1.4 (1.2)	0.4 (0.7)	0.7 (0.9)	0.7 (0.9)
Shop Oth. Acts	0.0 (0.0)	0.1 (0.3)	0.0 (0.0)	0.0 (0.1)	0.0 (0.2)
PB Acts	0.1 (0.5)	0.7 (1.1)	0.2 (0.5)	0.4 (0.7)	0.4 (0.7)
Soc/Rec. Acts	0.3 (0.5)	0.6 (0.8)	1.7 (0.9)	0.5 (0.0)	0.6 (0.8)
Dine Out Acts	0.3 (0.6)	0.5 (0.6)	0.3 (0.6)	0.2 (0.5)	0.3 (0.5)
School Acts	0.4 (0.6)	0.1 (0.3)	0.1 (0.4)	0.1 (0.3)	0.1 (0.4)
Serve Acts	0.3 (0.8)	0.2 (0.6)	0.2 (0.7)	0.3 (0.8)	0.3 (0.7)
Chgtrvl. Acts	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)
Home Dur.	13.7 (2.3)	17.2 (3.1)	15.6 (3.1)	20.5 (2.4)	18.0 (3.9)
Work Dur.	5.8 (3.8)	0.1 (0.5)	0.3 (1.1)	0.4 (1.3)	1.6 (3.1)
ShopGen.Dur.	0.1 (0.4)	1.6 (1.6)	0.3 (0.5)	0.5 (0.7)	0.5 (0.9)
ShopOth.Dur.	0.0 (0.0)	0.1 (0.4)	0.0 (0.0)	0.0 (0.1)	0.0 (0.2)
Per. Bus. Dur.	0.1 (0.4)	1.3 (2.5)	0.2 (0.6)	0.3 (0.8)	0.4 (1.1)
Soc/Rec Dur.	0.6 (1.3)	0.9 (1.8)	5.5 (3.0)	0.8 (1.4)	1.2 (2.1)
Dine Out Dur.	0.3 (0.8)	0.9 (1.6)	0.4 (0.8)	0.2 (0.7)	0.4 (0.9)
School Dur.	2.0 (3.1)	0.2 (0.7)	0.2 (0.9)	0.1 (0.7)	0.6 (1.8)
Serve Dur.	0.0 (0.2)	0.1 (0.5)	0.0 (0.1)	0.0 (0.2)	0.1 (0.3)
ChgTrvl Dur.	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)
Travel Dur.	1.4 (0.8)	1.5 (0.8)	1.6 (1.0)	1.0 (0.7)	1.2 (0.8)

TABLE 8. Travel Statistics for RAPs: Mean (Stdev)

Group/ Variable	Work/School	Maint.	Disc.	Various Short Acts	All RAPs
Number Trips	4.1 (2.1)	5.1 (2.4)	4.6 (2.2)	3.9 (2.3)	4.1 (2.2)
HBW Trips	1.3 (1.1)	0.1 (0.4)	0.2 (0.6)	0.3 (0.7)	0.5 (0.9)
HBO Trips	1.0 (1.2)	3.0 (1.5)	3.1 (1.6)	2.8 (1.8)	2.4 (1.8)
NHBNW Trips	0.4 (0.9)	1.8 (1.8)	1.1 (1.4)	0.6 (1.1)	0.8 (1.3)
NHBW Trips	0.7 (1.3)	0.0 (0.3)	0.1 (0.3)	0.0 (0.2)	0.2 (0.7)
HBS Trips	0.6 (0.9)	0.1 (0.4)	0.1 (0.4)	0.1 (0.6)	0.2 (0.7)
HBC Trips	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)
Vehicle Trips	3.4 (2.3)	4.5 (2.8)	3.9 (2.4)	3.3 (2.3)	3.5 (2.4)
Transit Trips	0.3 (0.8)	0.3 (0.8)	0.2 (0.7)	0.1 (0.4)	0.2 (0.6)
Ped. Trips	0.4 (1.0)	0.4 (0.9)	0.4 (1.1)	0.5 (1.2)	0.4 (1.1)
Work/School/Scl. Trips	1.5 (0.8)	0.1 (0.4)	0.2 (0.4)	0.2 (0.4)	0.5 (0.8)
Maint. Trips	0.9 (1.3)	2.9 (1.7)	1.2 (1.2)	1.6 (1.4)	1.5 (1.5)
Disc. Trips	0.3 (0.5)	0.5 (0.7)	1.6 (0.9)	0.5 (0.7)	0.5 (0.8)
Home Trips	1.5 (0.6)	1.6 (0.8)	1.7 (0.9)	1.6 (0.9)	1.6 (0.8)
AM Peak Trips	0.9 (0.8)	0.3 (0.7)	0.6 (0.8)	0.4 (0.7)	0.5 (0.8)
MIDDAY Trips	1.4 (1.4)	3.6 (1.8)	2.5 (1.7)	2.3 (1.8)	2.3 (1.8)
PM Peak Trips	1.1 (0.9)	0.7 (0.9)	0.8 (1.0)	0.7 (0.9)	0.8 (0.9)
Off Peak Trips	0.7 (0.8)	0.5 (0.8)	0.7 (1.0)	0.5 (0.8)	0.6 (0.8)

CHILDREN

TABLE 9. Descriptive Statistics by RAP Group

Variable/ Group	Size		Sex			License			Homeownership		
	Freq.	Percent		Freq.	Percent		Freq.	Percent		Freq.	Percent
Standard School	537	51%	Female	252	47%	No	517	96%	Own	434	81%
			Male	285	53%	Yes	19	4%	Rent	102	19%
Long School	56	5%	Female	38	68%	No	44	79%	Own	47	84%
			Male	18	32%	Yes	12	21%	Rent	7	13%
School-Discretionary	83	8%	Female	47	57%	No	68	82%	Own	74	89%
			Male	36	43%	Yes	14	17%	Rent	9	11%
Maintenance	38	4%	Female	19	50%	No	36	95%	Own	30	79%
			Male	19	50%	Yes	2	5%	Rent	8	21%
Discretionary	57	5%	Female	28	49%	No	55	97%	Own	42	74%
			Male	29	51%	Yes	2	2%	Rent	15	26%
Various Short Acts	290	37%	Female	155	53%	No	281	97%	Own	228	79%
			Male	135	47%	Yes	8	3%	Rent	61	21%
All Groups	1061	100%	Female	539	51%	No	1001	94%	Own	855	81%
			Male	522	49%	Yes	57	5%	Rent	202	19%

* "Don't Know/Refused" replies not included in table.

TABLE 9. Continued

Variable/ Group	Median Income	Mean Hh. Size (Sdev)	Mean Hh. Vehicles (Sdev)	Mean Age (Sdev)
Standard School	$45K – $50K	4.4 (1.4)	2.1 (0.9)	11 (3.7)
Long School	$50K – $55K	3.8 (1.1)	2.3 (1.2)	10 (6.0)
School-Discretionary	$45K – $50K	4.1 (1.0)	2.3 (1.2)	12 (4.2)
Maintenance	$50K – $55K	3.6 (0.9)	1.9 (0.6)	6 (4.6)
Discretionary	$40K – $45K	3.8 (0.9)	2.3 (1.2)	7 (5.5)
Various Short Acts	$40K – $45K	4.3 (1.2)	2.1 (0.8)	6 (4.6)
All Groups	$45K – $50K	4.2 (1.3)	2.1 (0.9)	9 (4.8)

CHILDREN

TABLE 10. Lifecycle by RAP Group : Frequency and Proportion

Group/ Lifecycle	Standard School		Long School		School-Discretionary		Maintenance	
	Freq.	Prop.	Freq.	Prop.	Freq.	Prop.	Freq.	Prop.
Single Person	2	0%	0	0%	0	0%	0	0%
Single Parent	76	14%	10	18%	6	7%	7	18%
Couple w/o Child	2	0%	2	4%	0	0%	0	0%
Single Worker Couple w/ Children	218	41%	13	23%	41	49%	16	42%
Dual Worker Couple w/ Children	191	36%	29	52%	34	41%	12	32%
Unrelated Persons	48	9%	2	4%	2	2%	3	8%
All Lifecycles	537	100%	56	100%	83	100%	38	100%

TABLE 10. Continued

Group/ Lifecycle	Discretionary		Various Short Activities		All RAPs	
	Freq.	Prop.	Freq.	Prop.	Freq.	Prop.
Single Person	0	0%	2	1%	4	0%
Single Parent	16	28%	29	10%	144	14%
Couple w/o Child	0	0%	3	1%	7	1%
Single Worker Couple w/ Children	23	40%	172	1%	483	56%
Dual Worker Couple w/ Children	16	28%	58	59%	340	32%
Unrelated Persons	2	4%	26	20%	83	8%
All Lifecycles	57	100%	290	100%	1061	100%

CHILDREN

TABLE 11. Activity Statistics For RAP Group

Group/ Variable	Standard School	Long School	School-Disc.	Maint.	Disc.	Various Short Acts	All RAPs
Number Acts	4.3 (1.6)	5.2 (1.4)	5.9 (1.9)	4.7 (1.9)	5.1 (1.9)	4.7 (1.9)	4.6 (1.8)
Home Acts	2.3 (0.6)	2.4 (0.6)	2.4 (0.6)	2.2 (0.4)	2.4 (0.7)	2.5 (0.8)	2.4 (0.6)
Work Acts	0.0 (0.2)	0.3 (0.5)	0.0 (0.0)	0.1 (0.3)	0.0 (0.0)	0.0 (0.2)	0.0 (0.2)
Shop Gen. Acts	0.1 (0.3)	0.1 (0.3)	0.1 (0.4)	0.7 (1.3)	0.2 (0.5)	0.6 (0.9)	0.3 (0.6)
Shop Oth. Acts	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.1)	0.0 (0.0)
PB Acts	0.1 (0.3)	0.1 (0.4)	0.1 (0.2)	0.6 (0.6)	0.1 (0.2)	0.1 (0.4)	0.1 (0.4)
Soc/Rec. Acts	0.3 (0.6)	0.4 (0.7)	1.4 (0.8)	0.3 (0.9)	2.1 (1.2)	1.0 (1.0)	0.7 (0.9)
Dine Out Acts	0.2 (0.4)	0.3 (0.5)	0.4 (0.6)	0.5 (0.6)	0.3 (0.5)	0.1 (0.4)	0.2 (0.5)
School Acts	1.2 (0.4)	1.5 (0.8)	1.3 (0.5)	0.0 (0.2)	0.1 (0.3)	0.2 (0.5)	0.8 (0.7)
Serve Acts	0.1 (0.4)	0.1 (0.3)	0.2 (0.5)	0.3 (0.6)	0.1 (0.2)	0.2 (0.6)	0.1 (0.5)
Chgtrvl. Acts	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)
Home Dur.	15.8 (1.6)	11.4 (2.3)	12.8 (1.9)	15.4 (2.6)	14.2 (2.5)	20.4 (2.3)	16.4 (3.3)
Work Dur.	0.0 (0.6)	1.6 (2.7)	0.0 (0.0)	0.0 (0.5)	0.0 (0.0)	0.1 (0.7)	0.1 (0.9)
ShopGen.Dur.	0.0 (0.2)	0.1 (0.2)	0.1 (0.4)	1.0 (1.8)	0.1 (0.3)	0.5 (1.0)	0.2 (0.7)
ShopOth.Dur.	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)
Per. Bus. Dur.	0.0 (0.2)	0.1 (0.5)	0.1 (0.6)	3.5 (4.0)	0.0 (0.1)	0.1 (0.5)	0.2 (1.0)
Soc/Rec Dur.	0.5 (1.1)	0.9 (1.5)	2.9 (1.6)	0.5 (1.8)	8.0 (2.5)	1.4 (1.8)	1.3 (2.3)
Dine Out Dur.	0.2 (0.4)	0.3 (0.5)	0.3 (0.5)	1.9 (2.8)	0.3 (0.6)	0.1 (0.5)	0.2 (0.7)
School Dur.	6.5 (1.2)	8.5 (3.4)	6.4 (1.0)	0.1 (0.7)	0.2 (0.6)	0.3 (0.9)	4.3 (3.3)
Serve Dur.	0.0 (0.0)	0.0 (0.1)	0.0 (0.1)	0.4 (1.7)	0.0 (0.00	0.0 (0.1)	0.0 (0.3)
ChgTrvl Dur.	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)
Travel Dur.	0.9 (0.5)	1.1 (0.7)	1.2 (0.7)	1.0 (0.7)	1.21 (0.7)	0.9 (0.6)	0.9 (0.6)

TABLE 12. Travel Statistics For RAPs

Group/ Variable	Standard School	Long School	School-Disc.	Maint	Disc	Various Short Acts	All RAPs
Number Trips	2.9 (1.4)	3.8 (1.4)	4.1 (1.7)	3.6 (1.9)	3.7 (1.7)	3.7 (1.8)	3.3 (1.6)
HBW Trips	0.0 (0.2)	0.4 (0.8)	0.0 (0.0)	0.1 (0.3)	0.0 (0.0)	0.0 (0.3)	0.0 (0.2)
HBO Trips	0.7 (1.0)	0.7 (0.8)	1.6 (1.0)	2.2 (0.9)	2.8 (1.2)	2.7 (1.6)	1.4 (1.5)
NHBNW Trips	0.3 (0.8)	0.9 (1.1)	1.3 (1.4)	1.1 (1.6)	0.9 (1.2)	0.7 (1.0)	0.6 (1.0)
NHBW Trips	0.0 (0.2)	0.1 (0.3)	0.0 (0.0)	0.0 (0.2)	0.0 (0.0)	0.0 (0.1)	0.0 (0.1)
HBS Trips	2.0 (0.5)	1.7 (1.0)	1.2 (0.7)	0.2 (0.4)	0.0 (0.3)	0.3 (0.8)	1.3 (1.0)
HBC Trips	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)
Vehicle Trips	1.5 (1.6)	3.0 (1.7)	2.6 (2.0)	2.9 (2.3)	3.0 (1.8)	3.1 (1.9)	2.2 (1.9)
Transit Trips	0.9 (1.0)	0.3 (0.5)	0.7 (0.9)	0.4 (0.8)	0.1 (0.6)	0.2 (0.5)	0.6 (0.9)
Ped. Trips	0.6 (1.1)	0.4 (1.0)	0.8 (1.2)	0.3 (0.8)	0.6 (1.3)	0.4 (0.9)	0.5 (1.0)
Work/Scl. Trips	1.1 (0.3)	1.5 (0.6)	1.1 (0.3)	0.1 (0.3)	0.0 (0.3)	0.2 (0.5)	0.8 (0.6)
Maint. Trips	0.3 (0.7)	0.5 (0.8)	0.5 (0.8)	2.0 (1.4)	0.5 (0.7)	1.1 (1.1)	0.6 (0.9)
Disc. Trips	0.3 (0.6)	0.4 (0.6)	1.1 (0.9)	0.3 (0.8)	1.8 (0.9)	0.9 (0.9)	0.6 (0.9)
Home Trips	1.3 (0.6)	1.4 (0.6)	1.4 (0.6)	1.2 0.4()	1.4 (0.7)	1.5 (0.8)	1.4 (0.6)
AM Peak Trips	0.9 (0.4)	0.8 (0.5)	1.0 (0.5)	0.8 (0.9)	0.4 (0.5)	0.3 (0.6)	0.7 (0.6)
MIDDAY Trips	1.2 (0.7)	0.8 (1.1)	1.1 (0.9)	1.7 (1.9)	1.6 (1.4)	2.1(1.6)	1.4 (0.2)
PM Peak Trips	0.5 (0.8)	1.2 (0.8)	1.4 (1.0)	0.8 (0.7)	1.0 (0.9)	0.8 (0.9)	0.7 (0.9)
Off Peak Trips	0.3 (0.6)	1.0 (0.7)	0.5 (0.8)	0.2 (0.4)	0.7 (0.8)	0.5 (0.8)	0.4 (0.7)

TABLE 12. An Activity-based Pattern Generation Model for Adults Segmented by Employment Status and Lifecycle Group

Employment Status / Lifecycle Group	Adults Employed Full-time	Adults Not Employed Full-time
1: Single Person Household	Standard Work: 66% Power Work: 5% Late Work: 5% Work-Maintenance: 7% Work-Discretionary: 4% Various Short Acts: 13% *Trips/adult: 4.1 (2.2)*	Work/School: 17% Maintenance: 16% Discretionary: 15% Various Short Acts: 53% *Trips/adult: 4.1 (2.4)*
2: Single Parent Household (children under 18)	Standard Work: 67% Power Work: 6% Late Work: 2% Work-Maintenance: 11% Work-Discretionary: 2% Various Short Acts: 13% *Trips/adult: 4.0 (2.0)*	Work/School: 40% Maintenance: 13% Discretionary: 0% Various Short Acts: 47% *Trips/adult: 4.5 (2.2)*
3: Couples* w/o Children	Standard Work: 70% Power Work: 5% Late Work: 2% Work-Maintenance: 6% Work-Discretionary: 4% Various Short Acts: 14% *Trips/adult: 3.8 (2.0)*	Work/School: 18% Maintenance: 14% Discretionary: 10% Various Short Acts: 59% *Trips/adult: 3.8 (2.0)*
4: Single Worker Couples* w/ Children	Standard Work: 67% Power Work: 5% Late Work: 1% Work-Maintenance: 9% Work-Discretionary: 1% Various Short Acts: 17% *Trips/adult: 3.6 (1.8)*	Work/School: 26% Maintenance: 7% Discretionary: 7% Various Short Acts: 61% *Trips/adult: 4.9 (2.6)*
5: Double Worker Couples* w/ Children	Standard Work: 67.3% Power Work: 3.5% Late Work: 1.5% Work-Maintenance: 6.2% Work-Discretionary: 3.8% Various Short Acts: 17.7% *Trips/adult: 4.1 (2.1)*	Work/School: 48% Maintenance: 6% Discretionary: 3% Various Short Acts: 43% *Trips/adult: 4.2 (2.5)*
6: Unrelated Persons	Standard Work: 65% Power Work: 7% Late Work: 5% Work-Maintenance: 6% Work-Discretionary: 4% Various Short Acts: 13% *Trips/adult: 3.8 (1.9)*	Work/School: 33% Maintenance: 11% Discretionary: 10% Various Short Acts: 46% *Trips/adult: 4.0 (2.2)*

* Couples includes only Male-Female pairs that are either married or unmarried.

TABLE 13. An Activity-Based Pattern Generation Model for Adults Segmented by Employment Status and Household Vehicles

Employment Status / Vehicles	Adults Employed Full-time	Adults Not Employed Full-time
1: No Household Vehicles	Standard Work: 53% Power Work: 4% Late Work: 13% Work-Maintenance: 4% Work-Discretionary: 2% Various Short Acts: 26% *Trips/adult: 3.4 (1.8)*	Work/School: 23% Maintenance: 17% Discretionary: 10% Various Short Acts: 50% *Trips/adult: 3.5 (1.8)*
2: One Household Vehicle	Standard Work: 62% Power Work: 6% Late Work: 4% Work-Maintenance: 9% Work-Discretionary: 3% Various Short Acts: 16% *Trips/adult: 4.2 (2.2)*	Work/School: 17% Maintenance: 13% Discretionary: 13% Various Short Acts: 57% *Trips/adult: 4.0 (2.3)*
3: Two Household Vehicles	Standard Work: 71% Power Work: 4% Late Work: 3% Work-Maintenance: 7% Work-Discretionary: 3% Various Short Acts: 12% *Trips/adult: 3.8 (1.9)*	Work/School: 26% Maintenance: 12% Discretionary: 7% Various Short Acts: 55% *Trips/adult: 4.2 (2.4)*
4: Three or more Household Vehicles	Standard Work: 67% Power Work: 6% Late Work: 2% Work-Maintenance: 5% Work-Discretionary: 5% Various Short Acts: 16% *Trips/adult: 3.9 (2.0)*	Work/School: 30% Maintenance: 11% Discretionary: 10% Various Short Acts: 49% *Trips/adult: 4.2 (2.2)*

* Couples includes only Male-Female pairs that are either married or unmarried.