FAMOS: THE FLORIDA ACTIVITY MOBILITY SIMULATOR

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Abstract

The development of activity-based travel demand modeling systems ushers in a new era in transportation demand forecasting and planning. Many urban areas and regional agencies around the world are in the process of or are contemplating the initiation of transitioning to new activity-based travel demand models. Over the past few years, the authors have been working on a major effort to develop a multimodal comprehensive activity-based travel demand forecasting system for the State of Florida. The effort has resulted in the development of FAMOS, the Florida Activity Mobility Simulator.

FAMOS consists of two main modules that together comprise a microsimulation model system for modeling activity-travel patterns of individuals. They are:

- Household Attributes Generation System (HAGS): This module generates a synthetic population of a region together with location and household/person attribute information.
- Prism-Constrained Activity Travel Simulator (PCATS): This module consists of a series of models that simulate the activities and trips undertaken by an individual together with their respective attributes such as locations (destinations), modes, times, durations, and sequence. The key feature of this module is that activity-travel patterns are simulated while recognizing the presence of time-space prism constraints.

The model system has been developed and estimated using household activity and travel data collected in the Southeast Florida region of Florida in 1999. Results of the model development effort have been very promising and have demonstrated the applicability of activity-based model systems in travel demand forecasting practice.

This paper provides an overview of the model system together with a demonstration of its features and capabilities as a comprehensive transportation demand forecasting and policy analysis tool.

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1. Introduction

Over the past few decades, great strides have been made in understanding the derived nature of travel demand. Travel demand is derived from the human need to participate in activities that are distributed in time and space. Models that simulate travel demand using an activity-based approach have been gaining increasing attention in recent times due to their strong behavioral foundation and intuitive theoretical appeal.

In recognition of the growing interest in and importance of emerging activity-based models for travel demand forecasting, the Florida Department of Transportation sponsored a research project called the "Phased Implementation of a Multimodal Activity Based Travel Demand Modeling System for Florida". This multiyear research project has resulted in the development of a state-of-the-art activity based model system called *FAMOS: The Florida Activity Mobility Simulator*.

FAMOS simulates activity-travel patterns at the level of the individual decision-maker. Thus, not only is it an activity-based model system, but it is also a "microsimulation" model system. This is because activity-travel patterns are simulated at the "micro" level, i.e., at the most disaggregate level possible. By simulating activity-travel patterns at the level of the individual decision-maker, the model intends to provide a strong platform for modeling travel demand in a region along a continuous time axis. The output of FAMOS is essentially a series of activity-travel records for all people in the simulation. These activity-travel records can be aggregated both spatially and temporally to obtain zone-level origin-destination (O-D) matrices by trip purpose, mode, and time of day. These O-D matrices may then be fed into any static or dynamic traffic assignment routines for obtaining link volumes by time of day.

The state-of-the-art in activity-based modeling procedures has made great strides in the past decade. There are several different approaches for implementing activity-based concepts in a travel demand modeling context. One of the key aspects to activity-based modeling of travel demand is to recognize that people pursue their activities and trips within a constrained environment. People are constrained in time and space with respect to the locations they can visit at any given time. One must consider household, institutional (work and school), modal, financial, and situational constraints that limit the activity-travel choices of an individual. By reflecting constraints in the activity based modeling system, one can provide a framework where the activity-based model is responsive to a host of socio-economic, transportation system, and policy changes. FAMOS has been developed to explicitly account for such constraints and thus provide a robust platform for analyzing the impacts of alternative transportation policies on travel demand.

This paper describes the basic structure, framework, capabilities, and performance of FAMOS. The paper does not provide a detailed explanation of the model formulations, specifications, and methodologies. A series of references provided at the end of the paper contain the technical details of the model specifications and methodologies.

2. Structure of FAMOS

Figure 1 provides a broad schematic of the structure and logic of FAMOS.

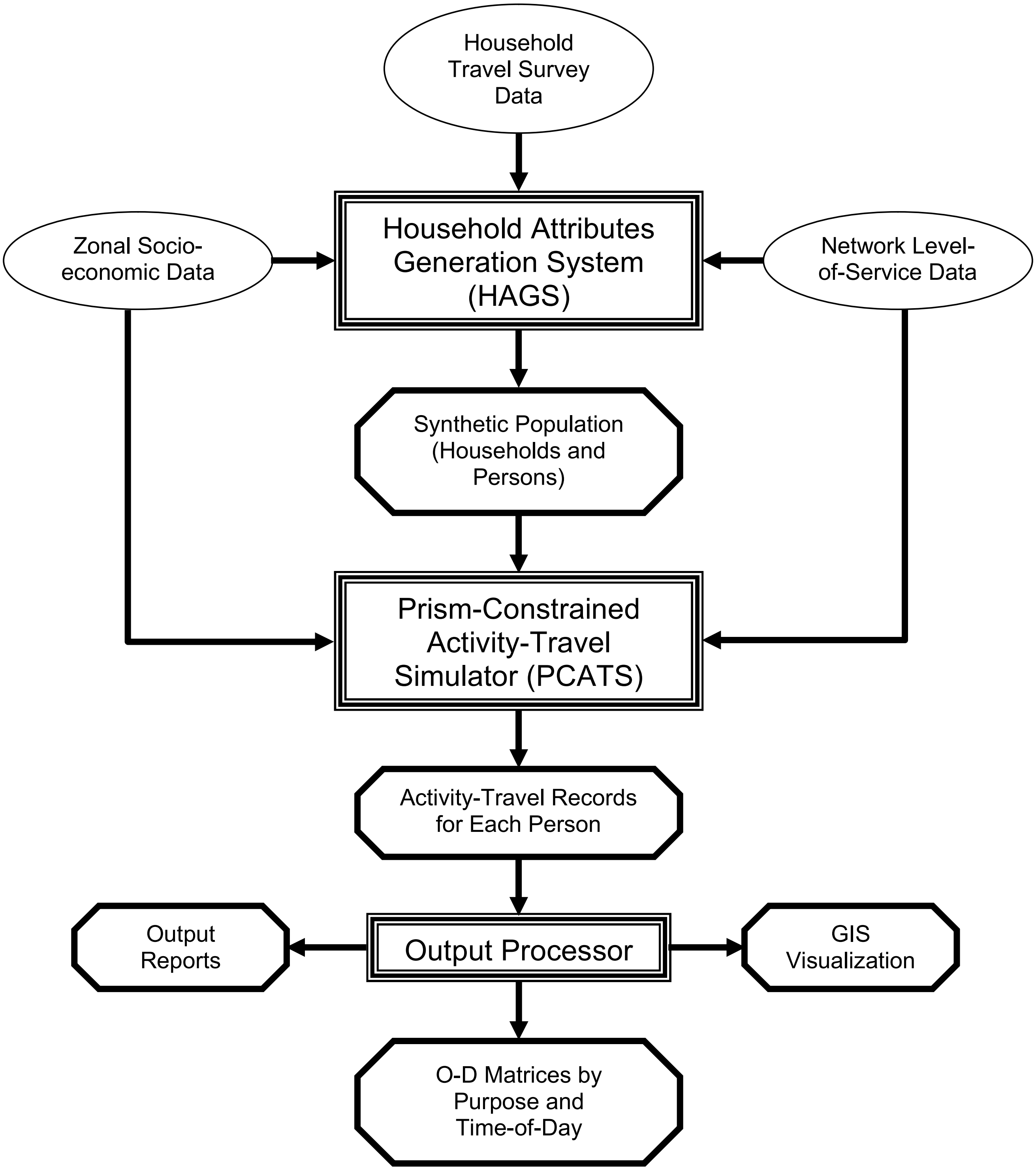

Figure 1. Structure and Logic of FAMOS

FAMOS includes two primary components. They are as follows:

1. *Household Attributes Generation System (HAGS)*: The Household Attributes Generation System (HAGS) is primarily a population synthesizer. Using zonal socio-economic data and household travel survey data, HAGS generates (synthesizes) households and persons within households. In addition to generating household and person attributes, HAGS also generates the agenda of mandatory or fixed activities that must be accomplished by each individual. For example, workers have to engage in work activities that generally tend to be fixed in time and space. The mandatory fixed activities are generated for each individual within HAGS. Thus, a basic skeleton around which the complete activity-travel agenda of a person will be formed is generated within this step. HAGS also includes work and school location choice models to identify the spatial locations of the fixed activities.

2. *Prism-Constrained Activity Travel Simulator (PCATS)*: The Prism-Constrained Activity Travel Simulator is a unique and comprehensive activity-based travel demand simulator that generates activity and travel records for each person synthesized by HAGS. The simulator utilizes the notion of Hagerstrand's time-space prisms to recognize the spatio-temporal constraints under which individuals must undertake their activities and trips. For each individual, PCATS determines the time-space prism boundaries and then simulates activity-travel records using a series of submodels that include activity type choice models, activity duration models, and destination and mode choice models.

Finally, FAMOS includes an output processor. The output processor is capable of aggregating the activity-travel records simulated by PCATS to generate origin-destination (OD) matrices by mode, trip purpose, and time of day. These matrices are then ready for network traffic assignment. In addition, the output processor includes a GIS visualization capability and a modest output reporter so that the user can examine trip length distributions by mode and purpose, aggregate trip rates, and overall modal splits. The output processor and report generator will be further enhanced in future versions of FAMOS.

FAMOS is a comprehensive activity-travel simulator that can be used in a stand-alone context as long as the databases needed to run it are available. However, in order to maximize the utilization of databases currently available at most public agencies and to facilitate a seamless transition from the traditional four-step model to the new activity-based models, FAMOS takes advantage of traditional four-step model databases, data preparation and computation capabilities, and network assignment routines. Figure 2 provides a broad schematic showing the relationship between FSUTMS and a standard four-step travel demand model.

To use FAMOS in conjunction with a traditional four-step model, the user may choose to utilize the zonal socio-economic data and the network level of service data (peak and off-peak modal level of service attributes) that are associated with the current four-step model in the region. The user should prepare these databases using existing four-step modeling procedures outside of the FAMOS software environment. Thus, FAMOS has been set up to utilize existing four-step model databases to the extent possible. Similarly, on the output end, FAMOS is capable of providing OD matrices by mode, purpose, and time of day. These OD matrices may be fed directly to any four-step model for network assignment. Thus, FAMOS version 2004.01 is capable of replacing the trip generation, trip distribution, and mode choice steps of the traditional four-step modeling process. In the future, a dynamic event-based network simulator will be added to FAMOS so that the network assignment step of the four-step modeling process can also be replaced by FAMOS. However, it should be noted that the generation of network level-of-service data currently requires one to run various steps of a four-step model.

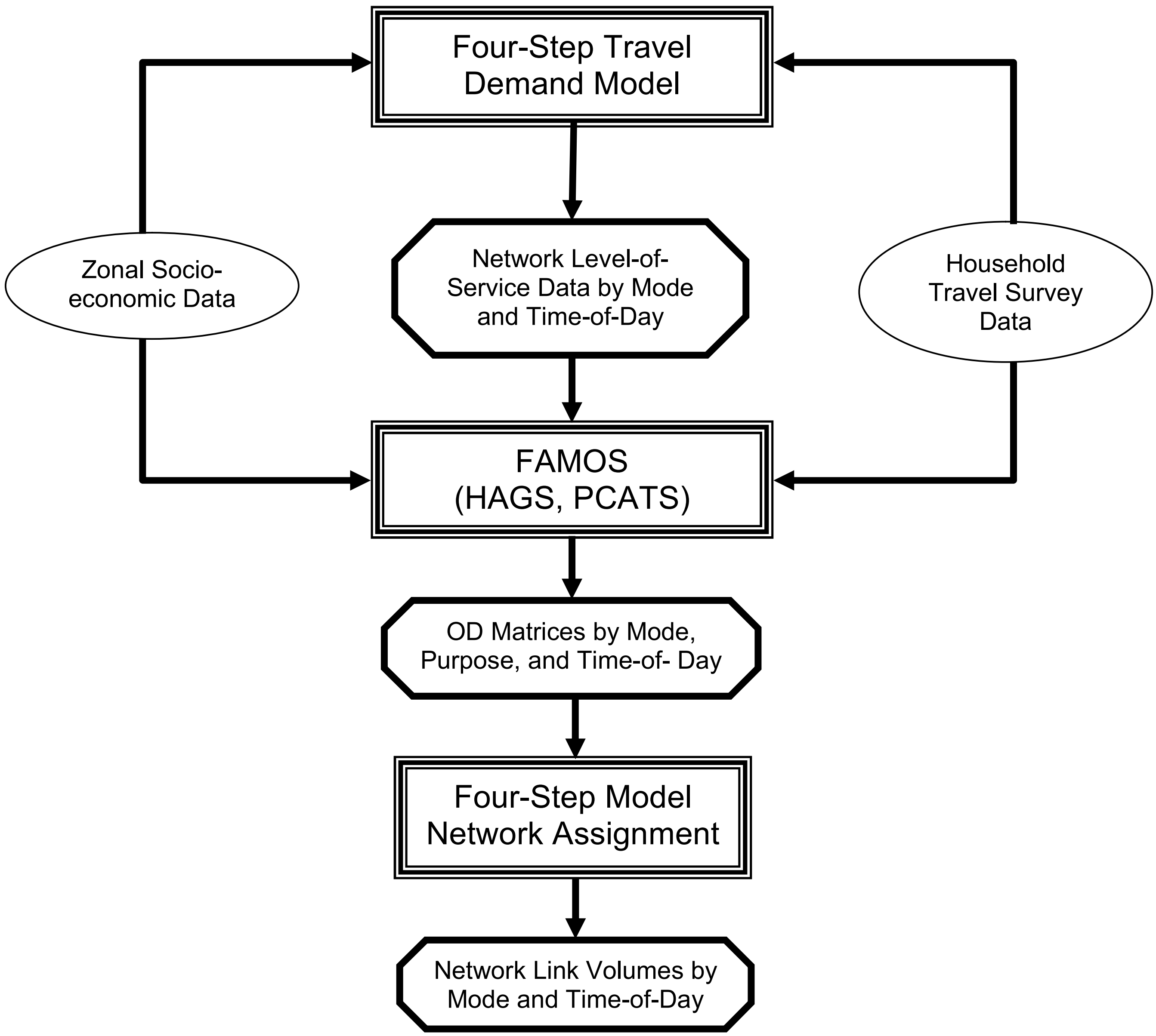

Figure 2. Using FAMOS in Conjunction with a Four-Step Travel Demand Model

Thus, the current version of FAMOS is complementary to, and is not yet a complete replacement for, traditional four-step travel demand models. On the other hand, it should be noted that the PCATS component of FAMOS is capable of replacing the trip generation, trip distribution, and mode choice steps of most traditional four-step travel demand models.

3. Data Needs and Flow

This section provides an overview of the database definitions and formats used in FAMOS. As mentioned previously, FAMOS makes maximum use of existing model databases that are commonly employed in the context of traditional four-step modeling procedures. At this time, FAMOS has been developed with a view to keeping input and output database formats simple and easy to use. Future versions of FAMOS will incorporate added flexibility, complexity, and detail in database definitions and formats. Microsoft Access® is used extensively for database management and handling in FAMOS.

The data sets needed to get started with FAMOS are the following:

- *Zonal Socio-Economic Data*: This includes population, household, and employment (by place of work) data for all traffic analysis zones in the model region. Most four-step travel demand models use zonal socio-economic data for estimating trip productions and attractions. These datasets are adequate for getting started with FAMOS.

- *Zonal Network Level of Service (LOS) Data*: This generally refers to the network skims that are associated with four-step travel demand models. Most four-step travel demand models are able to generate both free-flow and congested skims for a variety of level of service variables by mode of transport. These may include cost, travel time, and distance information by mode and time of day.

- *Household Travel Survey Data*: A household travel survey data set serves several purposes in the context of an activity-based microsimulation model system. First, it serves as the basis for all of the model specifications included in the system. While FAMOS offers a set of default submodels that comprise the activity-based microsimulation system, one may often choose to estimate a new set of models that are applicable to the particular context in which FAMOS will be applied. The household travel survey data allows the estimation of the various submodels that comprise FAMOS. In addition, however, the household travel survey data set (if sufficiently large and weighted) can provide information about the joint distribution of demographic characteristics in the population. These joint distributions are then used to generate a synthetic population of households and persons in HAGS. Any population census database may be used to provide information about joint distributions of characteristics in the population.

Figure 3 shows a schematic of the data flow in FAMOS. FAMOS first copies data files pertaining to a scenario to a working data directory.

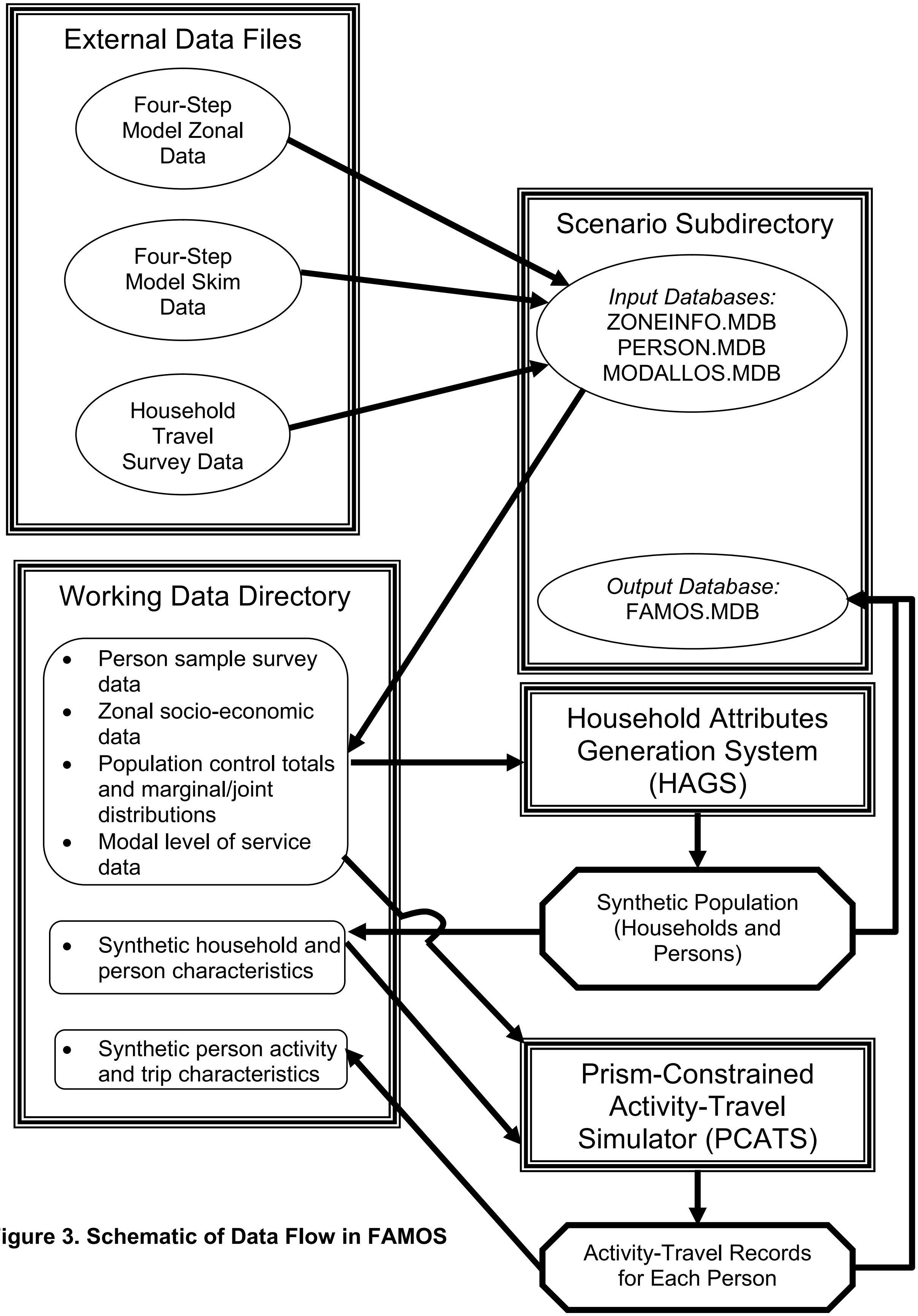

Figure 3. Schematic of Data Flow in FAMOS

HAGS uses the zonal data, household travel survey data, population census data, and modal level of service data to generate a synthetic population. The synthetic households and persons are written out to the output database (called FAMOS.MDB) and to a working data file in the working data subdirectory. PCATS then uses the output of HAGS together with the zonal and modal level of service data to simulate activity-travel patterns of individuals in the simulation. The activity-travel records corresponding to each person are written to the output database (FAMOS.MDB) in the scenario subdirectory and to a working data file in the working data subdirectory.

4. Household Attributes Generation System (HAGS)

The Household Attributes Generation System (HAGS) is a model system developed to generate synthetic households. HAGS populates each geographical zone with synthetic households while observing marginal distributions of pertinent variables in census or zonal data. The current version of HAGS consists of two components: Household Distributor and Fixed Activity Generator.

Household Distributor determines the distribution of attributes of households in the respective zones based on data from the census, travel surveys and other sources. An iterative proportional fitting (IPF) method (Beckman et al., 1996) is applied to base-year marginal distributions of pertinent household and person attributes in each zone and their area-wide joint distribution, to yield a frequency distribution of households by their attributes for each zone. The base-year marginal distributions are obtained from the census and other data, while their area-wide joint distribution is obtained from base-year travel survey data. Each zone is then populated by cloning households from the travel survey data according to the distribution obtained for the zone.

As mentioned earlier, FAMOS explicitly recognizes the notion of Hagerstrand's time-space prism constraints in simulating individual activity-travel patterns. The Fixed Activity Generator determines the beginning vertex of the morning prism, the ending vertex of the evening prism, and the beginning and ending times of fixed activities, for each household member generated by the Household Distributor. For non-workers without any fixed activities, there will be just one prism for the entire day, and the Generator determines the beginning and ending vertices for this prism. The location of prism vertices are estimated using the stochastic frontier models developed by Kitamura et al. (2000) and Pendyala et al. (2000). These models incorporate as explanatory variables: person attributes, household attributes, land use characteristics, and attributes of commute trips. Since only work (including work-related business) and school activities are considered as fixed activities in the current version of FAMOS, work/school starting and ending times are generated probabilistically for each worker or student based on their distributions observed in the base-year travel survey data. Work/school zones are determined for respective workers/students using multinomial logit models of work/school location choice. The models may be viewed as a version of production-constrained gravity models. Their explanatory variables include land use characteristics, measures of separation between zones, and some of the variables used in the stochastic frontier models.

Thus, HAGS provides a means by which synthetic households can be generated and located, persons in each synthesized household can be simulated, and person work/school locations and schedules can be probabilistically determined. First, a joint distribution of selected population segment variables is developed for each zone. In the current implementation of FAMOS, vehicle ownership and household type are used as the segmentation variables. Using marginal distributions available for these variables at the regional and zonal level, the joint distribution of these segmentation variables can be developed

using marginal distribution we develop the joint distribution and we use Iterative proportional method for this.

using the iterative proportional fitting (IPF) method. If a joint distribution is already available at the zonal level, then the IPF method does not need to be applied. The IPF method is described in detail in the technical documentation and users guide (Pendyala, 2004) and closely follows that proposed by Beckman, et. al. (1996) for use in TRANSIMS.

Once the joint distribution of the market segmentation variables is ascertained for each zone, the synthetic households and personal attributes can be simulated.

Step 1: Draw households from the sample (sample data) with replacement to match the target population by segment for each zone (population data). At this step, the residential location of the sample draw is ignored, and changed to match the target population at each draw.

Step 2: The person records corresponding to the identical household identification number drawn in step 1 are extracted from the survey sample data, and the residential location is changed to that of the zone determined in step 1.

Step 3: For workers and students, the work/school location is determined using a multinomial logit model of work/school location choice. As the number of alternatives is large, the Monte Carlo Markov Chain (MCMC) algorithm is used to simulate choice sets for each individual with explicit consideration of time-space prism constraints (thus zones that are very far away are not drawn).

Step 4: The work/school beginning and ending times are preserved from the original sample data to be consistent with the observed distribution of work/school beginning and ending times. However, a small value of less than or equal to +/- 5 minutes is randomly added to reported start and end times to avoid round off problems that might lead to a large number of trips starting exactly at the same instant.

Figure 4 shows a screen shot of HAGS running while Figure 5 shows a typical output from HAGS. HAGS first writes the data files to the working data subdirectory and then simulates households, persons, and fixed activity schedules. These households, persons, and fixed activity schedules can be viewed in the HAGS visualizer of FAMOS.

HAGS also provides an interface to ArcView 3.2 or later so that the data can also be seen in a visual map format. One must have ArcView 3.2 or later in order to use this capability of FAMOS. Although FAMOS is a stand-alone package that will run without any problems even in the absence of ArcView, users will not be able to utilize the ArcView visualization capability without the ArcView package resident on the machine. One should also note that there are a host of visualization tools within the ArcView software package than can be utilized to further enhance and customize the views. Future versions of FAMOS will have enhanced mapping capabilities. Figure 6 shows such an ArcView display.

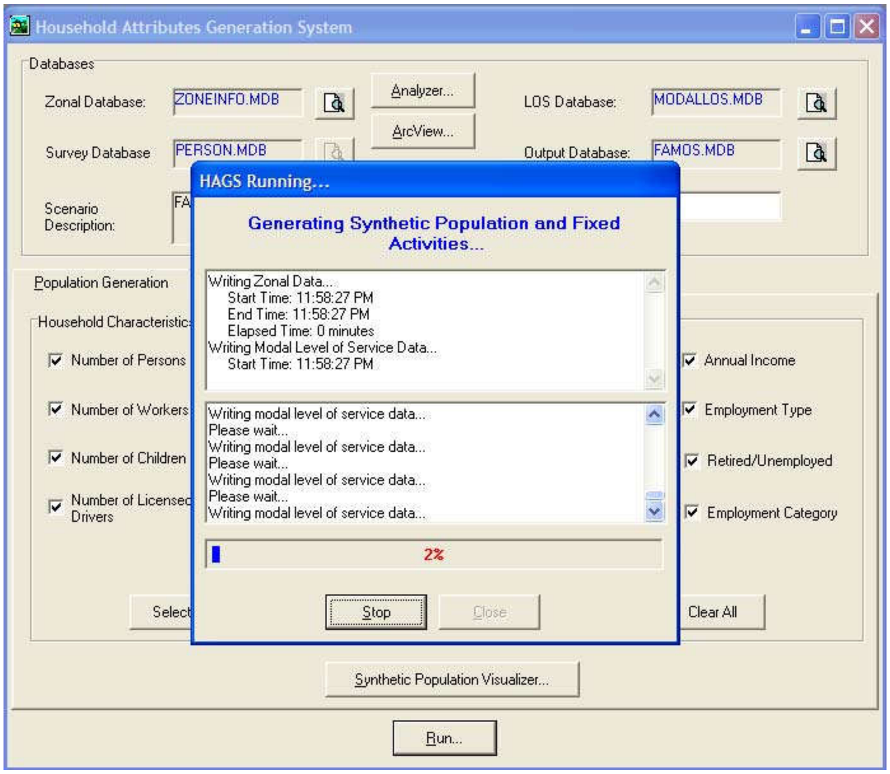

Figure 4. Screen Showing HAGS in Progress

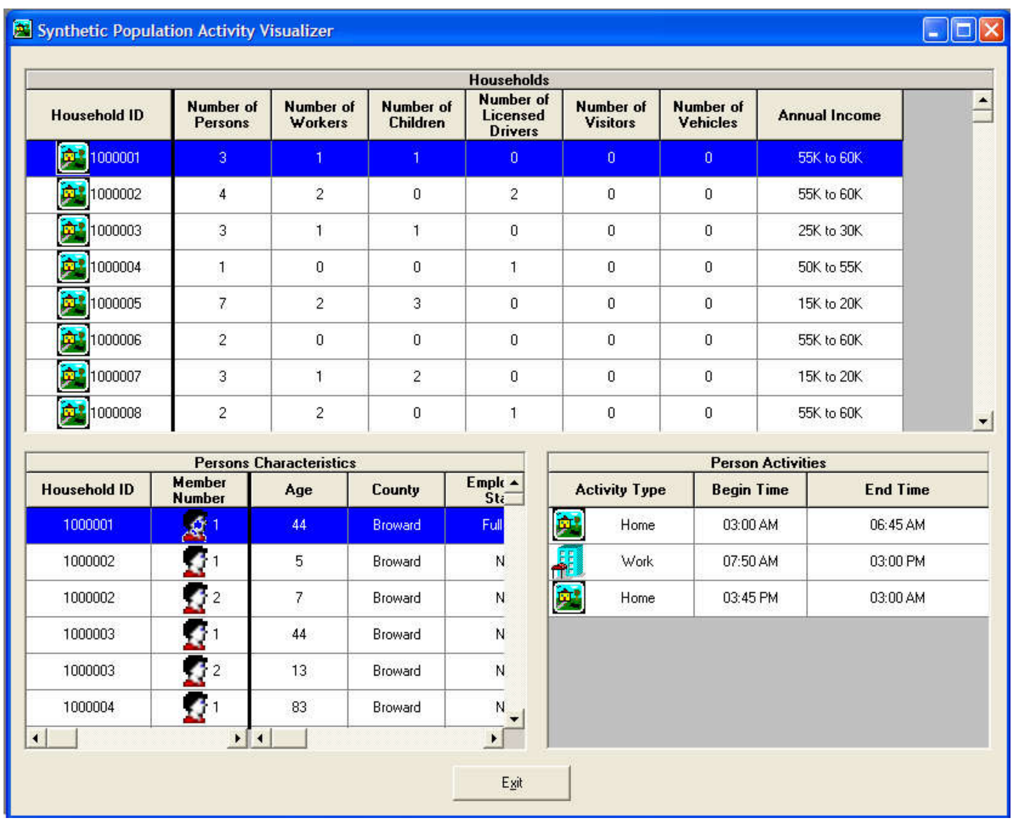

Figure 5. Screen Showing HAGS Output Visualizer

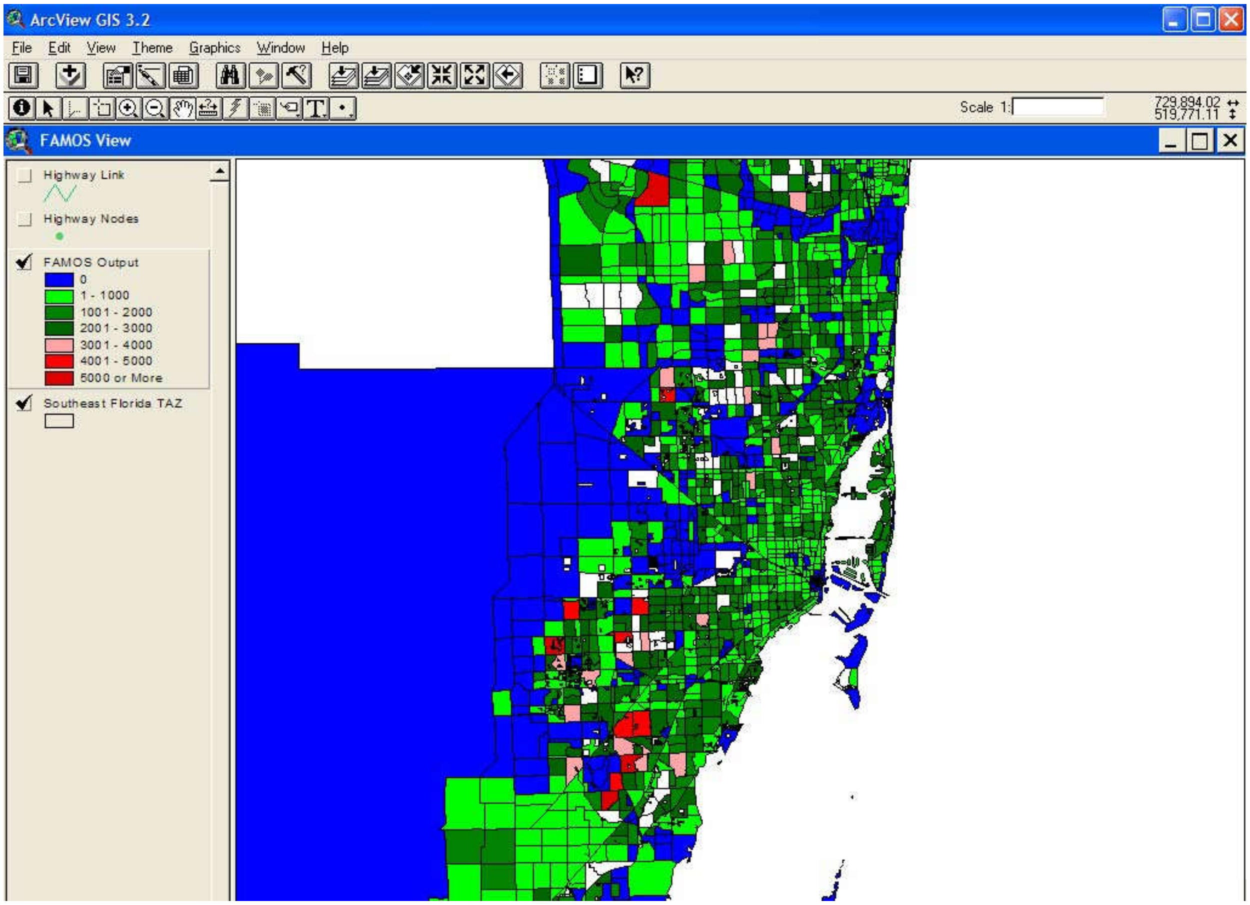

Figure 6. ArcView Display of HAGS Data for a Selected Variable

In Figure 6, a thematic map showing the number of households in each zone simulated by HAGS is shown. This map can be used to quickly evaluate the spatial distribution of households in a region and to check whether HAGS is simulating and locating households in a manner consistent with expectations and other known patterns of household location.

5. Prism-Constrained Activity-Travel Simulator (PCATS)

PCATS (Prism-Constrained Activity-Travel Simulator) is a system of behavioral models that together simulate individuals' activity and travel in urban space. All model components are statistically estimated and adjusted using household travel survey results. The PCATS within FAMOS is based on the 1999 Southeast Florida Household Travel Survey. It should be noted that the specification and estimation of PCATS submodels is limited by the availability of variables in the household travel survey. For example, the household travel survey does not include information about the sex of the person. Therefore, none of the models in PCATS include sex as an explanatory variable. The implementation of PCATS in other areas of the state may entail using the default models currently available within FAMOS or re-estimating PCATS submodels using locally available survey data. If local travel survey data is available, then one may develop and use very different model specifications and estimation results.

Although one would ideally like to develop PCATS submodels specific to a geographic area using locally available survey data, it may not be inappropriate to use the PCATS default activity-based submodels as a starting point when implementing FAMOS in a different area. In general, it is found that activity characteristics show lower variance across geographic areas indicating a greater possibility of transferability of activity-based models between areas. Activity-based models are considered to be more behavioral in nature and therefore fundamentally more transferable than traditional trip-based four-step models.

PCATS simulates behaviors of sample households in time and space over a one-day period. Results of the simulation may be visualized as a set of trip records for each household member, with information on trip purpose, starting and ending times, origin and destination zones, and travel mode. These data are accompanied by information on person and household attributes that are typically contained in travel survey data. An example of an individual's simulated daily travel pattern is shown in Figure 7.

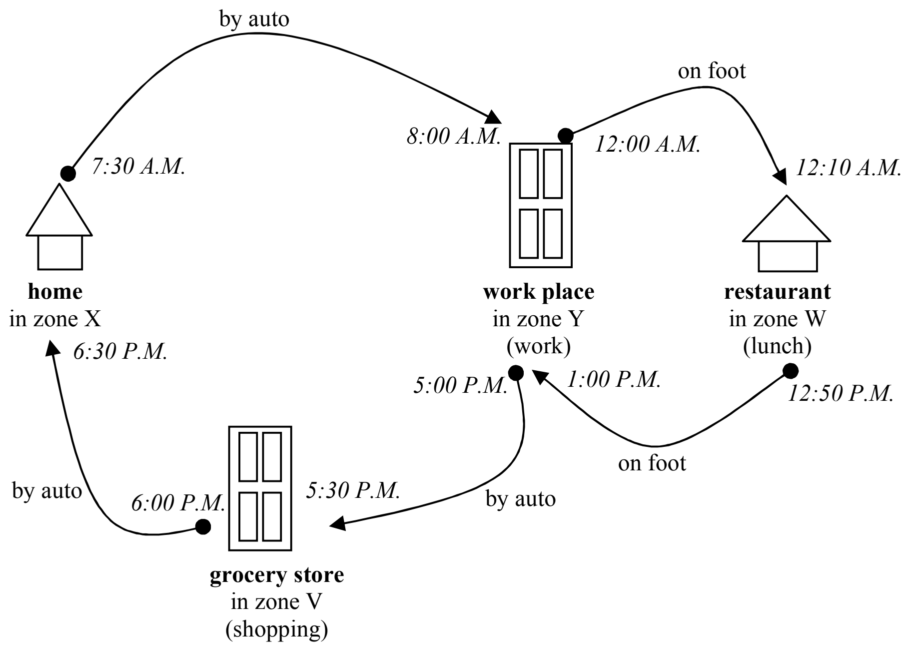

Figure 7. Example Daily Activity-Travel Pattern of an Individual Simulated by PCATS

Sample households may contain synthetic households, generated based on census data and travel survey results and distributed over the study area to represent its current, or future, population. The number of sample households can be adjusted to achieve desired levels of precision and spatial/temporal resolution in simulation results. In general, more precise results can be obtained by increasing the number of sample households by generating additional synthetic households. At this time, FAMOS simulates the entire population and thus provides a very high level of spatial and temporal resolution and accuracy. However, recognizing that full population simulation is computationally intensive and time-consuming, FAMOS incorporates the ability to undertake sample-based simulation where the user can specify the sampling fraction desired for the simulation run and then weight and expand the results to obtain regional origin-destination matrices. However, the user should recognize that sample-based simulation comes at the expense of accuracy and precision.

Though full population micro-simulation is done,to avoid longer processing time we use select a sub-sample of the sample population to estimate the model.

The development of PCATS was motivated by the recognition that various constraints imposed on individuals' activity and travel are not well represented in conventional models of travel behavior. Emphasized in PCATS, therefore, are the constraints imposed on the individual's movement in geographical space along time. Because the speed of travel is finite while the time available for travel and activity is limited, the individual's trajectory in time and space is necessarily confined within "Hägerstrand's prism." This is shown in Figure 8. In the figure, point A represents the time point through which the individual must stay at location H. For example, this may be the earliest possible time that a commuter can leave home. Point B represents the time point by which the individual must be at location W. This may be the time by which the commuter must report at his or her work place. If urban space can be represented one dimensionally as in the figure, and if the commuter can travel at speed v, then the domain in time and space that the commuter can occupy can be represented by the parallelogram as shown in the figure. This parallelogram is representative of Hägerstrand's prism.

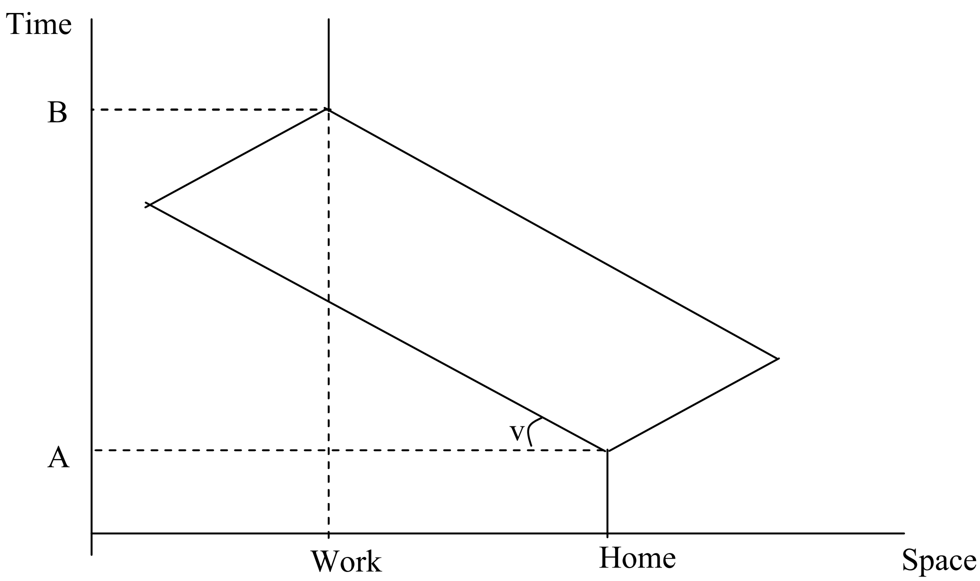

Figure 8. Hägerstrand's Prism

Prior to the simulation of activity-travel behavior, PCATS identifies the set of prisms that govern an individual's behavior, then generates activities and trips within each prism while observing constraints involving private travel modes and operating hours of public transit. Prisms are defined over a system of traffic zones (TAZs). PCATS first determines for each individual the periods in which the individual is committed to engage in a certain activity, or a bundle of activities, at a predetermined location. These periods are called "blocked periods". For example, a worker's work hours may constitute blocked periods.

The complement of a set of blocked periods for an individual is a set of "open periods." For example, the lunch break of a worker constitutes an open period. A Hägerstrand's prism is established for each open period that an individual has. This is done through the following procedure. Given the mode of travel being used, it is determined for each zone whether the zone can be visited within the open period and, if so, how much time can be spent in the zone before starting to move to the location of the next committed activity. This is repeated for all zones to identify the earliest possible arrival time at, and the latest possible departure time from, each zone. These arrival times and departure times comprise a prism for the open period.

Blocked periods for workers are typically determined by work schedules, e.g., between 8:00 A.M. and 12:00 noon and between 1:00 P.M. and 5:00 P.M. would be typical blocked periods (see Figure 9). Then, a worker's day may be assumed to include three prisms: one before work, one during the lunch break, and one after work (Figure 9). The beginning time of the first prism before work and the ending point of the last prism after work are not well defined. In FAMOS, stochastic frontier models have been developed to estimate such unobserved prism vertices or end points.

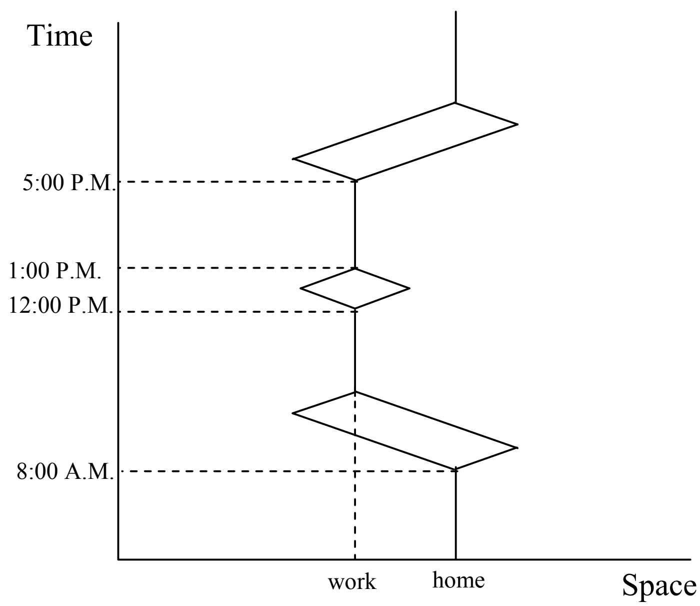

Figure 9. Typical Worker's Prisms

Another set of constraints incorporated into PCATS is concerned with the availability of travel modes. As noted earlier, the availability of public transit is determined by its operating hours. Outside the operating hours, public transit is eliminated from the choice set of the destination-mode choice models. PCATS also tracks the location of private travel modes such as the automobile and bicycle. For example, if a private automobile is not located at the origin of a trip, then it will be eliminated from the choice set of the destination-mode choice models.

5.1 Generation of Activities

In PCATS, the probability that a particular daily activity-travel pattern will be made is decomposed into a series of conditional probabilities, each associated with one activity bundle and the trip to reach the location where it is pursued. The conditional probability of an activity bundle is further decomposed to yield the following three sets of model components: 1) activity type choice models, 2) destination and mode choice models, and 3) activity duration models. These models are applied repeatedly to simulate activities and trips one by one within each open period. This is shown in Figure 10.

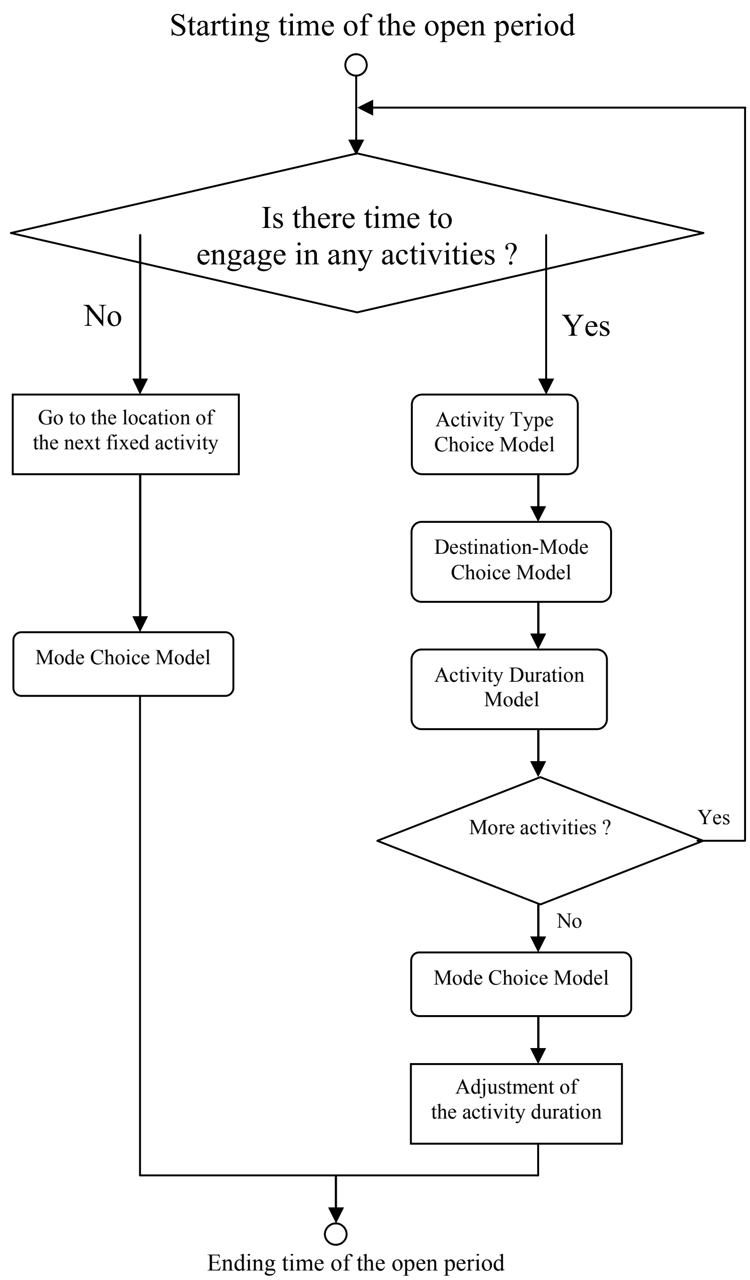

Figure 10. Structure of PCATS

Table 1 shows the segments on which these models were developed in the current version of PCATS that has been implemented in FAMOS.

Table 1. Segmentation Adopted in Model Development

Models	FAMOS Segmentation
Activity Type Choice Models	{Workers, Students, Others}
Destination-Mode Choice Models	{Work, Non-work} × {Workers, Students, Others}
Activity Duration Models	{Social-Recreational, Shopping, Other Non-work} × {Workers, Students, Others}

after generating activity schedule after population synthesis, we apply discrete choice models for activity type choice,mode choice etc.

5.2 Activity Type Choice Models

The activity type choice models are two-tier nested logit models. The upper tier comprises two categories of activity bundles: (A) in-home activities, and (B) out-of-home activities. The alternatives nested under (B) may include the following activity types: social-recreational and shopping. These are defined in terms of the trip purposes identified in the travel diary data used for model specification and estimation.

The type of the first activity bundle in an open period is determined using an activity type choice model. In the models, the probability that a given activity type will be selected decreases as the time available in the prism becomes shorter relative to the distribution of activity durations for that type of activity. In other words, the models reflect the tendency that activities tend not to be pursued if there is not enough time for them. The time of day is another important factor that affects the choice of activity type. The explanatory variables used in the activity type choice models in the FAMOS implementation of PCATS are: age, sex, household auto ownership, household size, and the time of day.

the sequence of the submodels discussed here

Given the activity type, a destination-mode pair is next determined using a destination and mode choice model. Following this, the duration of the activity at the destination is determined. At this point, the time of day when, and the location where, the next activity ends can be determined. The activity type choice model is applied again to simulate activity engagement in the remainder of the open period, using updated amount of time available. This process is repeated until all available time is exhausted in the open period.

5.3 Destination-Mode Choice Models

The destination and mode choice models are also nested logit models. Alternative destinations constitute the upper-level alternatives, and available travel modes are nested under each destination alternative. An example set of explanatory variables is presented in Table 2.

Geographical zones are used in the current version of PCATS to represent location. As noted earlier, the geographical extension of the prism is evaluated for each travel mode, and destination-mode pairs are excluded from the choice set if they do not fall in the prism. The amount of time available at the destination is one of the determinants of the choice probability along with the attributes of the destination zone and the trip to the destination by respective travel modes. Travel modes are classified into auto drive alone, auto multi-occupant vehicle (driver and non-driver), public transit, and walk and bicycle.

Given a travel mode, PCATS evaluates travel time to the destination zone. If the automobile or public transit is used, a zone-to-zone travel time is obtained from the modal level-of-service database depending on the time of day (peak or off-peak). Travel times by bicycle or walking are computed using an assumed mean speed of travel (12.0 mph for bicycle and 4.0 mph for walking) and the zone-to-zone distance. Given a travel time, the starting time of the activity at the destination is determined.

Table 2. Explanatory Variables of Destination-Mode Choice Model: For Workers, Non-work Activities

Zone Attributes
zone size
population density
commercial employment
Household/Person Attributes
age
auto ownership
Trip Attributes
travel cost
travel time
number of transfers
Activity Attributes
current time of day
location type of current activity
location type of next fixed activity

5.4 Activity Duration Models

Following these, the duration of the activity at the destination is determined using the activity duration model corresponding to the activity type. The activity duration models in PCATS are hazard-based, split population survival models. In these models, the maximum possible activity duration is first determined based on the size of the prism, which is a function of the speed of travel, the location of the trip origin, the location of the current activity, and the location of the next fixed activity. Then, an individual is assumed to decide whether he or she allocates all the time available in the current open period to a single activity, or to two or more activities. Binary logit models are developed to represent this binary choice.

If a person chooses the former option, the activity duration is the maximum possible activity duration in the current open period. If the person chooses the latter option, the duration of the next activity is determined using a hazard-based duration model. A set of hazard-based duration models is deployed in PCATS. A model is developed for each activity type, and the parameters of the distribution (the mean and a shape parameter) are formulated as functions of personal attributes and other explanatory variables. Weibull distributions are exclusively used in the current version of PCATS. The examples of explanatory variables used in the duration models are person and household attributes, time of day, time availability, location type indicator (see Table 3). The distribution as given by the duration model for the activity type is right truncated, i.e., a probability mass equaling to the probability that the activity duration will exceed the maximum available time is placed at the maximum. The resulting mix distribution is used to generate activity durations in the simulation. The two sub-models, the binary logit model and hazard-based duration model, are estimated simultaneously for each activity type.

Table 3 Example Explanatory Variables of Split Population Survival Models: For Workers, Shopping

Household/Person Attributes
age
license
household size
car ownership
Activity/Prism Attributes
current time of day
the possible maximum activity duration
location type of current activity
location type of next fixed activity

As noted earlier, once the attributes of an activity bundle are all determined, the procedure is repeated for the next activity bundle in the same prism. Activity and travel in each open period is thus simulated by recursively applying these model components, while considering the history of past activity engagement. Activity starting and ending times are determined based on simulated activity durations and travel times (from the modal level-of-service tables). The procedure is repeated until each open period is filled with activities.

Estimating the components of PCATS and simulating an individual's activity-travel pattern in the target area, requires the following data:

- Household/person attributes (e.g., age, sex, license, household size, car-ownership) usually obtained from running HAGS
- Attributes of blocked periods (e.g., the beginning time, ending time, type, and location of each fixed activity within each blocked period) usually obtained from running HAGS
- Level of service data by mode for each zone pair in the study area (e.g., travel time, travel cost, and number of transfers) usually obtained from a traditional four-step model
- Zone characteristics (e.g., area, population, population density, number of employees, and number of commercial establishments) usually associated with current four-step models

Figure 11 shows a screen of PCATS in progress where activity-travel patterns are simulated for each individual in the simulation by repeatedly applying the submodels described in this section. Figure 12 shows a screen in which the output of PCATS can be visualized at the level of the individual traveler. The activity travel records for each person are displayed together with a graphic of the activity-travel pattern.

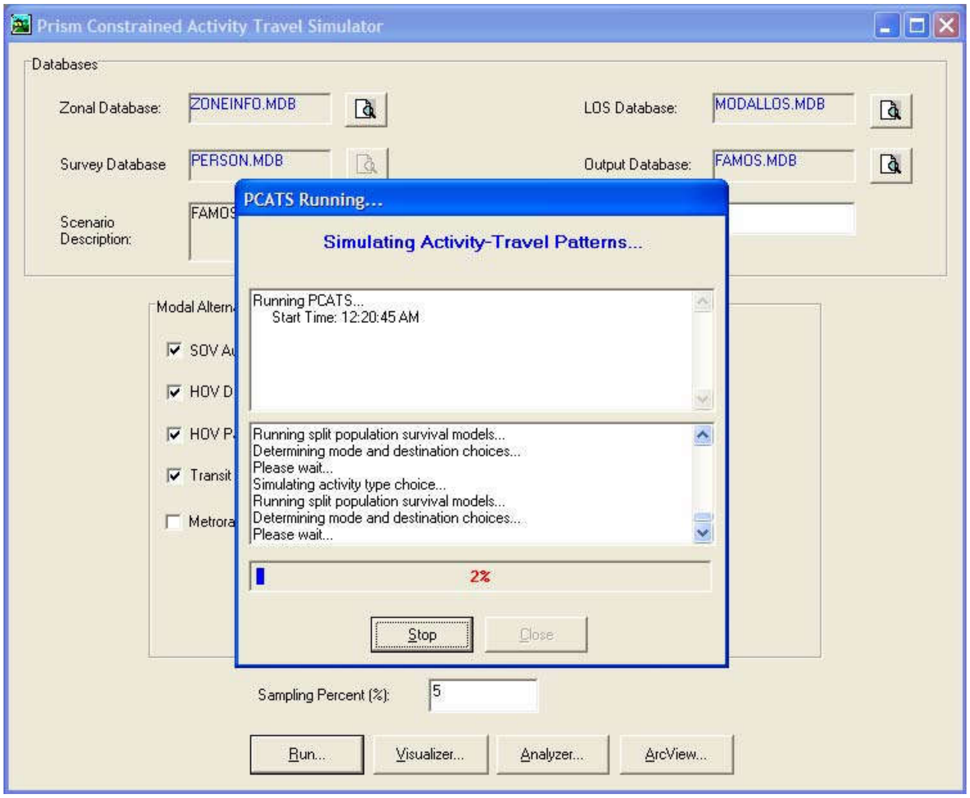

Figure 11. Screen Showing PCATS in Progress

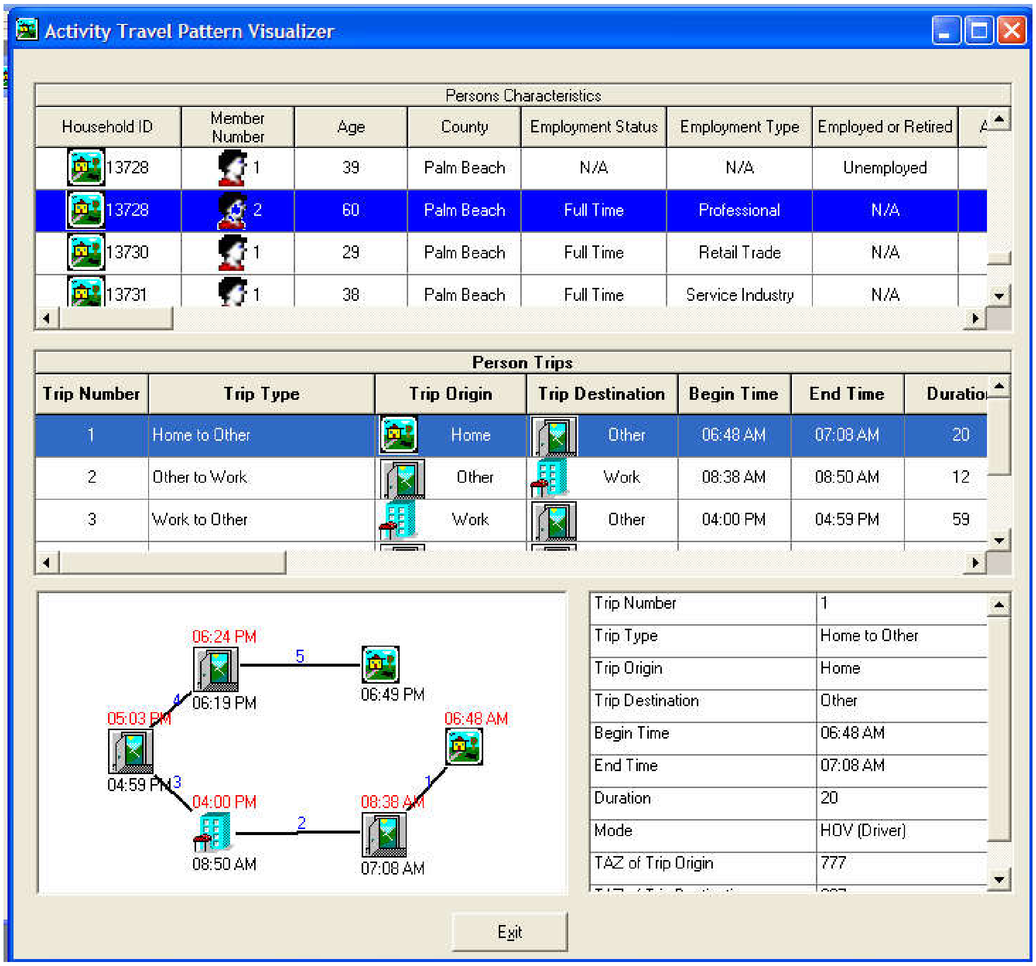

Figure 12. Screen Showing PCATS Simulated Activity-Travel Records

PCATS allows the user to view the output at the aggregate or zone level so that the user may view reports, perform reasonableness checks, and obtain aggregate measures of travel demand in the region. For example, one may obtain trip length distributions by mode, purpose, and time of day to study the overall spatial distribution of travel demand in a region. Figure 13 shows a screen where the trip length distribution obtained from a simulation is depicted.

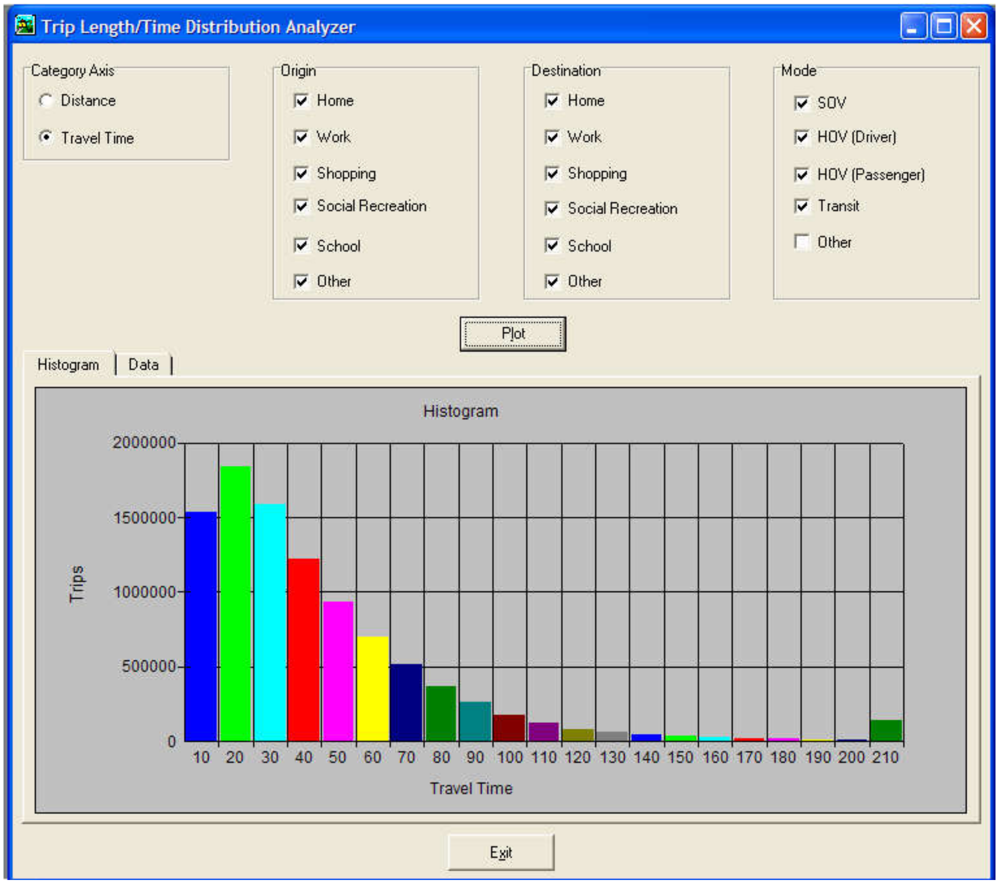

Figure 13. Screen Showing PCATS Output Trip Length Distribution Analyzer

PCATS also provides the ability to view the output in aggregate form within a GIS environment. Currently, FAMOS provides an interface to ArcView 3.2 or higher. The GIS output viewer allows the user to visually display a thematic map showing the density of trip exchange from an origin zone to all possible destination zones or vice versa. Thus, the thematic display can show daily trip exchanges from an origin zone to all possible destination zones or show daily trip exchanges from all possible origin zones to a destination zone. The display can be done by trip purpose and mode (but not by time of day at this time).

The GIS interface requires the user to have a zonal shape file in an ArcView subdirectory within the FAMOS directory. The zonal shape file is a standard ArcView shape file that has the map of the traffic analysis zone structure. The associated DBF file should contain the zone IDs and any other zonal attributes that the user wishes to have in the ArcView DBF file. Whenever the user requests an ArcView display of a particular piece of information, FAMOS will automatically (dynamically) append information to the zonal DBF file in the ArcView subdirectory and produce the desired display. Figure 14 shows a screen display of this feature of FAMOS.

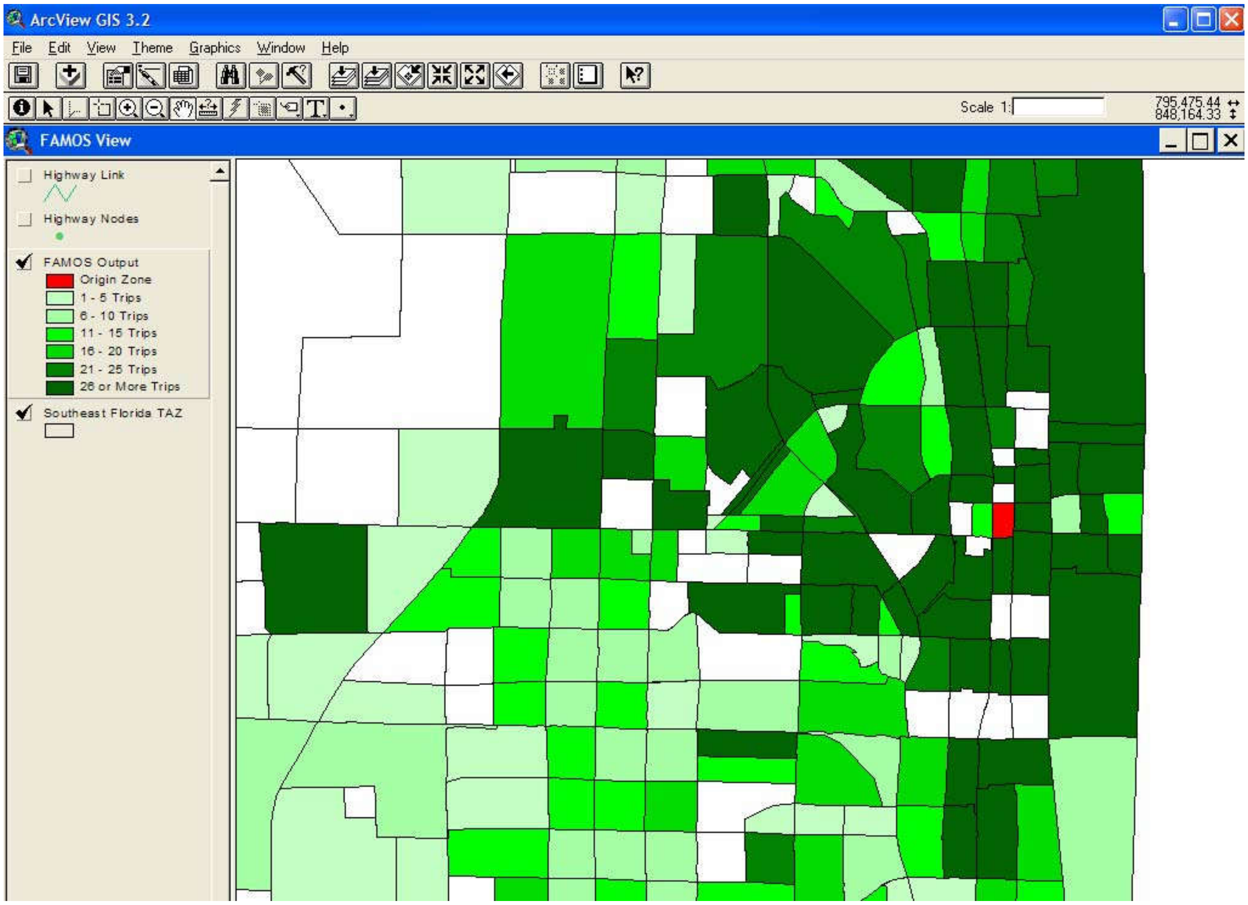

Figure 14. ArcView Visual Display of Daily Trip Exchanges Output by PCATS

6. O-D Matrix Creator

FAMOS produces individual activity-travel records for each person in the simulation region. In order to generate origin-destination matrices suitable for traffic assignment in FSUTMS, one needs to aggregate across the individual activity-travel records according to selected criteria. FAMOS incorporates an O-D matrix creator to allow the user to generate custom O-D matrices on the fly. Figure 15 shows a screen depicting the O-D matrix creation process in progress in FAMOS.

One of the most powerful aspects of FAMOS is its simulation of activity-travel patterns along the continuous time axis. Thus, it offers a powerful time-of-day modeling capability that has been missing in traditional trip-based travel demand models. Coupled with a robust activity-based simulation model system that is behavioral in nature, the time-of-day modeling capability makes FAMOS a powerful policy analysis tool for addressing such issues as induced demand, trip re-scheduling, trip chaining, and changes in destination choice. The O-D matrices created using this feature of FAMOS are now ready to be imported in FSUTMS for performing time-of-day based traffic assignment.

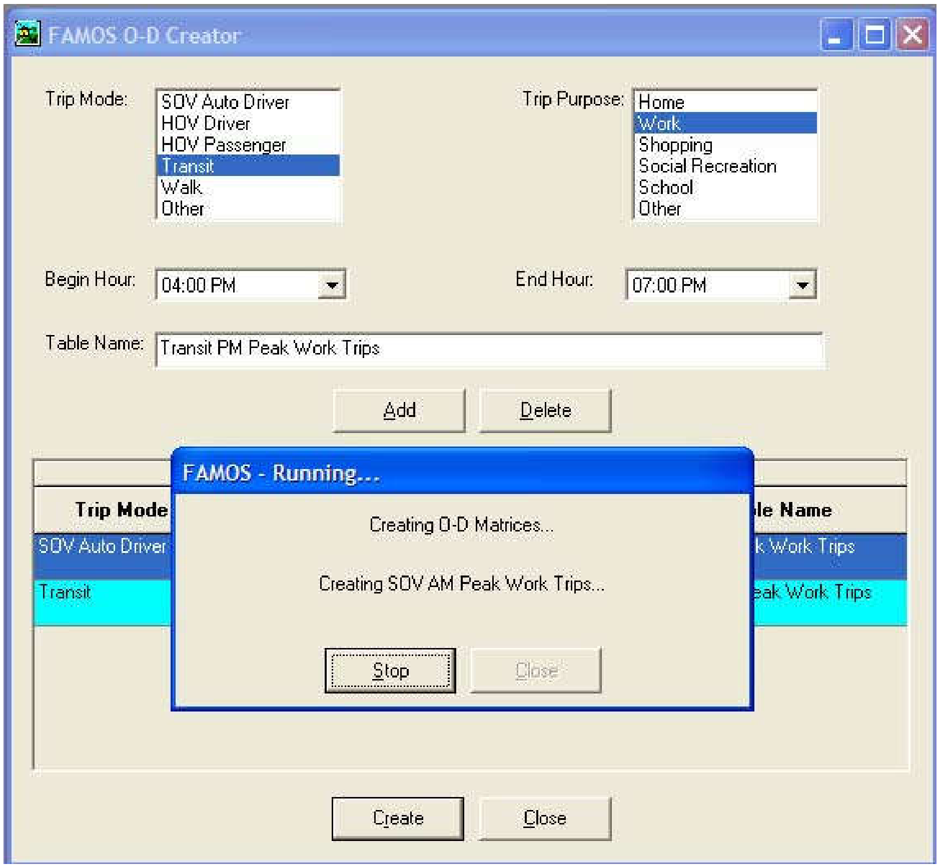

Figure 15. O-D Matrix Creator Window

7. FAMOS Software and Validation Results

FAMOS is a user-friendly software package that runs under the windows operating system in a PC environment. As FAMOS is a computationally intensive program, it is recommended that the software be run on a high-end computer that is at least a Pentium-4 machine running at 2 GHz or faster and with at least 512 MB RAM and 4 GB of free hard disk space. The software has been applied and several runs have been made in the context of the application to the Southeast Florida region. The Southeast Florida region consists of about 3000 TAZ's and has a population of about 3 million. In the current implementation of FAMOS, HAGS takes about 3 hours to generate a synthetic population and fixed activity agenda for the entire region. PCATS takes about 2 hours for every 5% sampling fraction requested by the user. Thus, a full 100% population simulation may take about 36-45 hours to run. Run times will vary depending on the hardware configuration. Future versions of FAMOS will be enhanced to make run times more efficient.

Selected summary validation results are furnished here to illustrate the ability of FAMOS to replicate observed travel behavior data. It should be noted that these validation results were obtained with absolutely no adjustments, special calibration procedures, or adjustment factors. These validation results were obtained from a raw complete run of FAMOS from beginning to end. Given that absolutely no special calibration procedures were employed to "fit" FAMOS output to observed travel survey data, the validation results show that comprehensive activity-based models such as FAMOS are able to replicate observed travel behavior. It is to be noted that additional validation studies within specific market segments, modes, and geographical areas need to be undertaken to fully understand the feasibility of applying activity-based model systems.

The validation results are based on comparisons between travel measures provided by FAMOS and those found in the Southeast Florida Travel Survey data using which the model system was developed. Table 4 compares average daily trip rates while Table 5 compares average number of daily fixed and flexible activities. It is found that FAMOS replicates the overall observed averages quite closely.

Table 4. Comparison of Observed and Predicted Average Daily Trip Rates

Group	Observed	FAMOS
Worker	3.9	4.3
Student	3.0	3.3
Other	4.2	3.8

Table 5. Comparison of Observed and Predicted Average Daily Fixed and Flexible Activities

	Fixed Activities		Flexible Activities	
Group	Observed	FAMOS	Observed	FAMOS
Worker	1.2	1.2	2.4	2.2
Student	1.0	1.0	2.0	1.8
Other	0.0	0.0	2.7	2.2

Table 6 provides a comparison of observed and predicted first departure time and final arrival time (at home).

Table 6. Comparison of Observed and Predicted First Home Departure Time and Final Home Arrival Time

	First Home Departure Time		Final Home Arrival Time	
Group	Observed	FAMOS	Observed	FAMOS
Worker	470	440	1075	1192
Student	472	496	986	1055
Other	627	498	962	967

This comparison shows that FAMOS is able to capture the temporal aspects of travel behavior quite well, while recognizing the spatio-temporal constraints governing these aspects of behavior. In this table, time is represented in continuous clock minutes with 12:00 midnight being zero and 12:00

midnight at the end of the day being 1440 minutes. Thus, 6:00 AM would be 360, 6:00 PM would be 1080, and so on.

Finally, Table 7 provides validation results for modal split. The modal split validation is given for each market segment considered in FAMOS. The model system is found to provide reasonable mode split validation results.

Table 7. Mode Split Validation Results by Market Segment

Mode	To Fixed Activities		To Flexible Activities	
	Observed	FAMOS	Observed	FAMOS
Workers				
SOV	79.3%	66.9%	63.1%	69.1%
HOV Driver	12.0%	24.0%	26.6%	19.9%
HOV Passenger	5.4%	6.5%	7.2%	7.1%
Transit	1.4%	1.1%	0.7%	1.1%
Other	1.9%	1.5%	2.4%	2.9%
Students				
SOV	13.6%	17.2%	18.2%	18.4%
HOV Driver	6.4%	10.0%	14.1%	11.0%
HOV Passenger	54.6%	47.0%	60.5%	57.1%
Transit	17.6%	13.7%	1.3%	8.3%
Other	7.9%	12.2%	5.9%	5.2%
Others				
SOV	39.1%	50.0%	42.2%	42.0%
HOV Driver	26.1%	25.3%	28.9%	31.8%
HOV Passenger	28.0%	21.1%	23.4%	16.7%
Transit	1.7%	2.6%	1.4%	1.1%
Other	5.1%	1.1%	4.1%	8.4%

8. Conclusions

This paper describes the structure, framework, and paradigm underlying FAMOS, a comprehensive activity-mobility simulator that has been developed for implementation in Florida. The model comprises two major components: a Household Attributes Generation System (HAGS) that generates synthetic households and persons and simulates a fixed activity agenda around which more discretionary activities and trips can be scheduled, and a Prism-Constrained Activity-Travel Simulator (PCATS) that simulates detailed activity-travel records for each person in the simulation.

FAMOS is able to simulate activity-travel patterns along the continuous time axis while accounting for the inter-dependency among trips due to trip chaining. It has been found in recent travel surveys that trip chaining (linking of trips) is very common among travelers and that trip chains are becoming increasingly complex over time. By accounting for trip chaining and recognizing the inter-dependency among trips that trip chaining entails, FAMOS is able to realistically simulate modes, destinations, and trips/activities while recognizing the spatio-temporal and modal constraints that exist in daily activity-travel patterns. The other major benefit of using FAMOS is its inherent time-of-day modeling capability. As activity-travel patterns are simulated along the continuous time axis, FAMOS is capable of providing time-of-day based origin-destination matrices by mode and purpose suitable for time-of-day based traffic assignment and policy analysis.

FAMOS has been designed to work with readily available databases. The data sets needed to get started with FAMOS are the following:

- Zonal socio-economic data (commonly available with all traditional four-step models)
- Zonal-level network level of service (LOS) data (commonly available with all traditional four-step models)
- Household travel survey data set

Although FAMOS is quite comprehensive in its treatment of activity-travel patterns, it does not currently model:

- Freight and goods travel
- Taxi travel
- E-I and E-E travel
- Visitor/tourist travel

Information about these trips should be obtained from the traditional four-step model to augment the output obtained from FAMOS.

The current version of FAMOS has been estimated and calibrated using the 2000 Southeast Florida Household Travel Survey data set. Initial validation results are very encouraging and demonstrate the feasibility of developing and applying an activity-based microsimulation model system for regional travel demand forecasting. A fully functional user-friendly software package called FAMOS has been developed. The software is available on a CD with a comprehensive users guide and technical documentation that together describe the operation of the software and the technical background of the model formulation and estimation.

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