# FSUTMS-Cube Framework

*Standard Trip Generation and Distribution Models*

# Draft Technical Memorandum No. 1

# Trip Generation Review and Recommendations

*prepared for*

**Florida Department of Transportation Systems Planning Office**

*March 2009*

*draft report*

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## Trip Generation Review and Recommendations

*prepared for*

Florida Department of Transportation Systems Planning Office

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# 1.0 Introduction

The purpose of this report is to provide comments on the current FSUTMS trip generation model practice and provide recommendations on changes and improvements. A companion report is under development on the subject of trip distribution. The appendix to this report presents a brief literature review on the use of income as a trip generation variable and stratification of employment.

The next step would be to develop a prototype of this model structure. This step is not covered in this report.

# 2.0 Previous Work

This study is an outgrowth of an outline of a "new FSUTMS Framework" documented in the summer of 2008.[1] The outline recommended a closer review of several FSUTMS components, including trip generation. Observations from the Framework report include:

- A comprehensive review of zonal data variables should be conducted.
- An income variable should be added.
- The single/multi-family and auto ownership level stratifications should be re-examined.
- Adjustments of the standard trip purposes should be considered. There may be a need for separate school and university trip purposes, and realignment of the truck-taxi purpose to account for heavy trucks.
- If the models are to use truck trip purposes, data on truck special generators is needed.
- Attraction variables should be examined, and they should be defined in terms of NAICS instead of SIC.
- The structure of the model should be re-examined in light of the alternative methods used in Tampa Bay and Southeast Florida.
- The introduction of time-of-day modeling in Florida does not require trip generation modifications because most time-of-day models are implemented after trip generation.

In addition, trip generation recommendations have been provided in other reports such as the *FSUTMS Users Library, FSUTMS New Standards and Enhancements White Paper,* and the *FSUTMS Powered by Cube-Voyager Data Dictionary*. This report represents the third phase of the FSUTMS-Cube Framework with a focus on developing updated standards for trip generation and distribution modeling in Florida. Prior reports in this series have included *FSUTMS-Cube Framework Phase I: Transferable Model Parameters* and *FSUTMS-Cube Framework Phase II: Model Calibration and Validation Standards*.

It is also important to note that in addition to the models that have been developed for the MPOs in Florida, several regional models also have been developed. These models respond to the need to plan for transportation improvements that span single MPOs or urbanized areas, and to provide for more coordinated planning in areas where there are strong interactions between counties that would otherwise have models that would be independent of each other. In some cases the regional or districtwide models have

[1] *New FSUTMS Framework*, a report prepared by AECOM for the Florida Department of Transportation, Systems Planning Office, August 21st, 2008.

replaced the individual MPO models. Regional models that have been developed or completed include:

- District 1
  - District 1 Districtwide Model
  - Lee County MPO/Collier County MPO Model
  - Sarasota/Manatee MPO/Charlotte MPO Model
- District 2 - Northeast Regional Planning Model (NERPM)
- District 3 – Northwest Florida Regional Planning Model
- District 4
  - Southeast Regional Planning Model (SERPM)
  - Greater Treasure Coast Regional Planning Model (Palm Beach Martin, St. Lucie, Indian River, and part of Brevard Counties)
- District 5 – District 5 Districtwide Model
- District 6 – SERPM
- District 7 – Tampa Bay Regional Planning Model

# 3.0 Issues and Recommendations

The discussion of a new FSUTMS Framework (see reference 1) identified several issues that are important to moving FSUTMS forward in light of lessons learned, new software and hardware capabilities and advances in modeling practice since the standard GEN procedures was developed in the late 1970's. This section addresses these issues in detail, and puts forth recommendations.

## 3.1 Model Structure and Implementation

When FSUTMS was developed in the late 1970's, a useful trip generation procedure was not available in the UTPS mainframe-based modeling system. The most convenient way to implement a complicated model was FORTRAN. This worked well on the mainframe computer, as a FORTRAN compiler was available to everyone who had access to the mainframe computer, which was the only way to run the model.

At the transition to microcomputers in the mid-1980's, it was still true that the modeling platform, Tranplan, did not contain a suitable trip generation program. Thus, the mainframe GEN FORTRAN program was translated to Microsoft FORTRAN, which was a relatively simple task for modelers who knew FORTRAN.

While FORTRAN is a powerful programming language that adequately implements standard GEN, implementation in Voyager GENERATION is now a better choice. The Voyager GENERATION program contains powerful functions that simplify programming trip generation models. Furthermore, the GENERATION program handles a wide range of input and output files, including dbf files. Debugging and error-handling within Cube works much better with Voyager programs than with FORTRAN. Perhaps the most important reason to use GENERATION is that Voyager scripting is widely known and understood by modelers, it is relatively easy to add and modify program features, and no special software such as a FORTRAN compiler is needed. Thus, the first recommendation is to implement the new FSUTMS trip generation model entirely within Voyager using GENERATION, or some combination of GENERATION and MATRIX.

The next issue is the general structure of the model. All FSUTMS trip generation models use a household cross-classification model and apply trip rates for each trip purpose and household class to estimate daily trip productions. On the attraction side, the models use trip rates to estimate trip attractions by trip purpose. The trip rate equations do not contain additive constants or negative coefficients, so empty zones never have attractions and attractions cannot be negative. The models estimate daily trips, include routines to accommodate special generators, balance productions and attractions on output, and produce summary reports.

All Florida trip generation models have roots in common with the standard FSUTMS GEN model, but several variants of the model have been developed. Some involve only simple changes and others are substantially different. Examples of simple changes are options to turn-off balancing productions and attractions, the addition of school trip purposes, and the addition or modification of an independent variable. Some models supplement the GEN program with auxiliary programs to model additional trip purposes, such as tourist categories in Orlando. Models in southwest Florida have historically run a "dualgen" program that uses a different set of trip rates for seasonal and permanent residents. Other models, such as the southeast Florida life-style model and the Tampa Bay life-cycle model, implement larger changes while retaining many FSUTMS features.

In the past, when the model was required to be programmed in a compiled language like FORTRAN, there was a strong reason to promote a single model. That reason no longer exists. Clearly the needs of south Florida, Tampa Bay, Orlando, Jacksonville, and smaller urbanized areas are different, and one size does not fit all. Thus, it makes sense to allow each MPO and District to use models tailored for its needs. But there should be commonality among the models to increase the availability and consistency in the data and to increase the understanding of how the trip generation models work. Several recommendations follow this idea:

- Until sufficient data become available to allow trip generation rates to be estimated by time-of-day, trip generation models should be developed and applied at the daily level. If time period specific trip tables are needed, they should be developed either by applying factors to the production and attraction vectors after trip generation, or factoring trip tables after trip distribution.
- Trip generation models that are customized to meet MPO needs should be encouraged, but these changes should be implemented in the Voyager GENERATION and MATRIX programs. The standard GEN model has been translated to a Voyager script in the Olympus model. Other models, including the life-style and life-cycle models should also be translated to Voyager scripts, where not already done. These models should include features to produce summary reporting similar to the reports in GEN, except when the reports would needlessly duplicate data that are easy to display in the Cube environment.
- Trip generation models should generally use a household cross-classification model and trip rates by classification and trip purpose for productions, and trip rates for attractions. This is the current FSUTMS practice.
- Trip generation models should be estimated from local surveys and data, where available. Florida DOT and the Model Task Force have funded an Add-On sample to the National Household Travel Survey (NHTS) that is presently underway. Once NHTS data become available later this year, a statistically valid sample will be available to develop new trip rates.

## 3.2 Subarea Balancing

Most trip generation models include a routine to ensure that the sum of attractions is equal to the sum of productions. The cross-classification trip production models and the trip rate attraction models usually do not result in this balance of productions and attractions, but most models use ratio and proportion to adjust attractions so the sum is equal to the sum of productions. The general rationale for adjusting attractions is there is generally a higher degree of confidence in household data than employment data, and trip rates for household-based productions are more readily available. This idea is reinforced by the fact that trip production rates are usually developed from household surveys, which are controlled at the household end. This balancing is done so that the effect of special generators can be controlled, adjusted or not adjusted, and so the modeler can clearly see the results of trip generation, which will be reflected in the results of the trip distribution model. In distribution, the gravity model will distribute as many trips as there are trip productions. Thus, in effect attractions are balanced to productions in distribution regardless of whether they are balanced in trip generation.

Balancing attractions in trip generation, however, allows the modeler to implement methods other than simple ratio and proportion. Some Florida models, including Tampa Bay, use a technique called subarea balancing. This means that instead of adjusting the sum of attractions for the entire region to the sum of productions for the entire region, the region is divided into subareas, and attractions are balanced to productions within each region. In the Tampa Bay Regional Planning Model (TBRPM) the subareas are counties. Different groupings of counties are used for each trip purpose. The rationale for subarea balancing is to dampen the impact on the model of variations in employment estimates and forecasts that result from different methods used throughout the region to make the estimates. These impacts can be large under some circumstances, such as:

- Large multi-jurisdictional models such as the TBRPM.
- Large models of a strip of counties along the coast (the Southeast Regional Planning Model, the Treasure Coast Model, and the Greater Treasure Coast Model).
- Models where one county is much larger than the others and dominates the zonal data. This was evident in the Northeast Regional Planning Model (NERPM) and the Greater Treasure Coast Model where the imbalance of productions and attractions in Palm Beach County was nearly as large as the number of attractions for some of the other counties (Martin, St. Lucie, Indian River, and parts of Brevard County). The model's attempt to balance productions and attractions caused unrealistically high volumes on north-south roads, including I-95.

The consultant was unable to find descriptions or discussions of subarea balancing outside of Florida.

Subarea balancing can mask actual travel behavior and travel patterns. For example, some subareas may be employment centers and others may be "bedroom communities." In this case, improperly chosen subareas would prevent the interactions between these areas

from being modeled correctly. Ideally, zonal data for all parts of the modeling area will have been developed in an accurate and consistent manner, eliminating the reason for subarea balancing.

Like many modeling issues, subarea balancing should be applied very carefully, only when it is needed, and only when a clear reason can be identified. Nevertheless, the technique should be available in the standard FSUTMS trip generation framework.

## 3.3 Area Type Variable

The SERPM and TCRPM models include area type in the attraction equations. The impact of area type for SERPM was estimated through an analysis of the 2000 Home-interview survey. A special attraction survey formed the basis of the area type impacts for Tampa Bay. Both models calculate area type based on development densities and the land use mix. Area type does not play a role in the standard GEN model.

The consultant reviewed available data from other models on the use of area type in trip attraction models. Other areas that have found area type to be useful in the estimation of trip attractions include:

- Dallas-Fort Worth, Texas
- Minneapolis, Minnesota
- Wyoming Department of Transportation
- Charlotte, North Carolina
- Kansas City, Kansas/Missouri
- Milwaukee, Wisconsin
- Pittsburgh, Pennsylvania
- Washington, D.C.
- Tucson, Arizona

NCHRP 365 also suggested separate attraction rates for retail employment in CBD and non-CBD areas.

The rationale for including area type is that businesses with the same or similar employment mix may have different trip attraction characteristics depending on their location. For example, a bank in a CBD may have almost no drive-up access trips by customers and may instead focus on data processing and record keeping, while a bank in the suburbs may have a large number of drive-up window trips. While there is ample evidence that area type influences trip attractions, a standard way of dealing with it was not found.

Recommendations for inclusion of area type in the new FSUTMS framework GEN model are:

- The model should include a method for incorporating area type in the trip attraction equations as a zonal variable.
- The model stream should include a method for dynamically estimating area type as the character of areas changes through time. Most areas with an area type model use some kind of density-based calculation.
- If possible, the impact of area type (coefficients) should be estimated from local data.
- The model should allow the area type feature to be turned off or set the coefficients to 1.00 if area type is not used.

## 3.4 Trip Purposes

The previously referenced Framework outline recommended a reexamination of trip purposes. Issues that are important for the determination of what trip purposes should be used include the size of the trip market, whether the attractions are related to the same independent variables, whether there is a significant difference in the average trip length and frequency distribution, and whether the auto occupancy rates are similar. While it may be possible to combine home-based social-recreational (HBSR), home-based shopping (HBSH), and home-based other (HBO) trip purposes, there seems to be little reason to do this. In some instances more segmentation may be required. For example, SERPM separates home-based school trips from HBO as school trip patterns are usually different from the HBO trips, because their attractions are different – school enrollment for HB-school and employment and other variables for HBO, and their mode choice, auto occupancy and trip lengths are different. More recently, some models have separated university trips from the general school trip purpose, again because the attractions are different, and the trips lengths and choice modes – children versus adults – are quite different. Larger urbanized areas with large universities and significant mode choice issues may wish to use more detailed school and university trip stratifications.

The standard FSUTMS GEN model has a truck/taxi trip purpose. These seemingly unrelated trips, truck and taxi, were lumped together in early studies in many areas in the US (not just Florida), because these were trips that were not captured in the home-interview surveys. Since that time, the perception has become that the number of taxi trips is very small except perhaps in the largest cities and then mostly for airports. These trips more or less get lost in the NHB purpose, and eliminating taxis as a special purpose is probably justified. However, with the USDOT emphasis on freight, truck trips have become much more important than other commercial vehicle trips such as taxis.

Several large urban areas in Florida now model truck trip purposes. None of these models use commodity flow approaches, except the statewide model. The general issue here is to use truck trip purposes that produce results that can be compared to traffic counts, and

which may be related to measurable trip generation variables. Most areas use a variation of the "Quick Response Freight Manual" (QRFM) techniques which stratify trucks as four-tire trucks (generally indistinguishable from an auto in a tube count), single units with more than four tires, and combinations (semis). The QRFM method works fairly well, given that there is not enough data on local roads to judge whether the truck assignment is accurate. The recently released QRFM-II no longer recommends a default set of trip generation rates for trucks. But, the trip generation models are very similar to NHB models, and have little sensitivity to activities like major truck terminals. Thus, it is important to add truck special generators to the model to account for major truck generators, which cannot be accounted for with household and employment variables. Generally, these models ignore non-freight commercial vehicles.

Table 1 presents the trip purpose structure of a number of models in other states, with the original FSUTMS purpose appearing at the top of the table. Some areas use fewer trip purposes, and some use more.

## Table 1. Trip Purposes Used in Various Models

| | Home-based | | | | | | | | | | | | | Truck | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | School | | | | | | | | | By |
| **Model** | **Work** | **Shop** | **Rec.** | **Other** | **All** | **K-12** | **Grade** | **High** | **Univ.** | **NHB** | **NHBW** | **NHBO** | **Apt** | **All** | **Type** |
| FSUTMS | X | X | X | X | | | | | | X | | | | T/T | |
| Atlanta RC | X | X | | X | | X | | | X | X | | | | | |
| Baltimore MC | X | X | | X | | X | | | | | X | X | | | X |
| Boston | R | X | X | DO | X | | | | | | X | X | | | |
| Charlotte, NC | X | X | | X | X | | | | | X | | | | T/T | |
| Chicago | X | | | X | | | | | | | X | X | | | |
| Detroit | X | X | | X | | | | | | X | | | | | |
| Indianapolis | X | X | | X | X | | | | | X | | | | | X |
| Kansas City | X | X | X | X | | | | | | X | | | | | |
| Lincoln, NE MPO | X | X | X | X | | | | | | X | | | | | |
| Milwaukee | X | X | | X | | | | | | X | | | | | |
| Minneapolis | R | X | | X | | | | | | | X | X | | | |
| N. Jersey TPA | D/S | X | | X | | | | | X | | X | X | X | X | |
| NERPM (Florida) | X | X | X | X | | | | | | X | | | | TX | |
| NCTCOG | Q | | | X | | | | | | X | | | | | X |
| Pittsburgh | X | | | X | | | | | | X | | | | | |
| Puget Sound RC | X | X | | X | | X | | | X | | X | X | | | |
| Salt Lake City | X | X | PB | X | X | | | | | | X | X | | | |
| San Francisco MTC | X | | X | X | | | X | X | X | X | | | | | |
| SERPM (Florida) | X | X | X | X | | X | X | X | X | | X | X | X | | X |
| Southern Cal. AG | D/S | X | X | | | X | | | X | | X | X | | | |

Source: The Corradino Group

Notes:

| | | | |
|---|---|---|---|
| **Apt** | Airport | **Q** | Used but segmented by income quartile |
| **D** | Direct to work | **R** | Segmented by work/work-related |
| **DO** | Drop-off/pick-up | **S** | Work with intermediate stop |
| **J** | NHBW/journey at work | **T/T** | Truck and taxi |
| **P** | Shopping and personal business | **TX** | Taxi, light duty, heavy duty truck |
| **PB** | Personal business | **X** | Used |

In general, there would be little to gain from reducing or combining trip purposes. But, it would seem that there would be advantages to maintaining several more trip purposes, as has already been done for SERPM and TBRPM. Recommendations on trip purposes follow.

- **HBW –** This trip purpose should be kept as it is now being used in FSUTMS. This trip purpose requires home to be one end of the trip and work to be the other. Trips with an intermediate stop are not HBW. While not part of the overall recommendation for the revised FSUTMS trip generation model, larger urbanized areas should consider segmenting the HBW purpose by income level. This would require the estimation of both productions and attractions by income level. The impact of this improvement would be seen in improved trip distribution.
- **HBSH (shopping) –** This trip purpose should be kept as it is now being used in FSUTMS.
- **HBSR (social-recreational) –** Again, this trip purpose should be kept as it is now being used in FSUTMS.
- **Home-based school –** This would be a new purpose. In some areas this is important for the analysis of transit. Furthermore, although a distribution issue, for public schools it may be better to distribute these trips to conform to the school board's student zoning plan instead of using a gravity model. Some latitude should be given to allow for local needs. In some areas, a single K-12 school purpose and a university purpose would suffice. To fully account for trip movements and student zoning, it may be necessary to use grade school, middle school, high school and university, especially where these types of trips are an issue for mode split.
- **Non-work Airport –** This would be a new trip purpose for persons traveling to the airport who do not work at the airport. The reason to allocate a special purpose rather than to lump them in with HBO is that airport trip lengths are typically different from most HBO trips. Unless there is more than one good airport option, the travel time is not a factor in distribution. But all of these trips will not come from households. Some will come from businesses and hotels. Trips to the airport by airport workers should already be covered by the HBW purpose. Some areas use FAA forecasts of enplanements as the independent variable for airport trips. Landside person trip rates are available from *ITE Trip Generation* for airports.
- **HBO –** These trips are all other home-based trips minus school and airport purposes.
- **NHBW –** This new purpose, nonhome-based work oriented, is a partial replacement for NHB. It requires that one trip end be a work location, and neither end be home. Often, these trips are part of a complex commute (e.g., HBO-NHBW for dropping off children at school or day care).
- **NHBO** - This new purpose, nonhome-based other, is also a partial replacement for NHB. It requires that neither end be a work or home location. NHBW and NHBO usually have different trip length frequency distributions.
- **Commercial vehicles –** This new purpose would account for four-tire service or commercial vehicles, including taxis, delivery vehicles, and utility trucks.

- **Medium and heavy trucks** – This new purpose would account for trucks carrying goods. Most new models contain truck trip purposes. The *QRFM* would serve as a source of data for this trip purpose, but the long range goal would be to develop special generators of freight terminals and other areas, such as ports, with high levels of activity.

## 3.5 Zonal Data Variables

The standard FSUTMS GEN model had a fixed set of zonal data, which thirty years ago were deemed to be a good set of data for Florida models, and which were required by the rather inflexible GEN FORTRAN program. As noted earlier, variations of this procedure have evolved over the past 30 years, and if trip generation models are implemented in Voyager script through GENERATION and MATRIX, MPO's will have much more flexibility in specifying their trip generation model. Some file formats and names have recently changed as part of the implementation of FSUTMS-Cube/Voyager.

Obviously, the zonal data variables must be available to support the chosen model. Furthermore, there must be a way to forecast these data. This paper comments on the need to forecast the independent variables, but a complete treatment of this subject is far beyond the scope of this paper, involving land use models and other issues.

### 3.5.1 Trip Production Variables

In FSUTMS, production variables were previously stored in a file called ZDATA1. This file has since been combined with the ZDATA2 file into a single dbf file named ZONEDATA. Production variables are usually household data that are available from the Census. For future years, MPOs forecast these data, and generally reflect control totals published by the Bureau of Economic and Business Research (BEBR) at the University of Florida. The standard GEN model uses the production variables shown in Table 2 below. The variables used by other major Florida models, such as Tampa Bay and Southeast Florida, are also shown. Please note that in the Southeast Florida models, a special Census tabulation, STP60, supplements the aggregate data listed in the table, and provides the basis for disaggregating the data for the household model to each occupancy and auto ownership level from the aggregate rate. Similar tables have been requested by FDOT as part of the next American Community Survey (ACS) since requests for special Census tabulations will no longer be supported.

## Table 2. Trip Production Data in Florida Models

| Standard FSUTMS | | Tampa Bay | | Southeast Florida |
|---|---|---|---|---|
| **Autos** | | **Autos** | | |
| Zone number | | Zone number | | Zone |
| Sector or district number | | Sector or district number | | Transit Summary District |
| Single family DUs | | Single family DUs | | Reference TAZ (for STP60) |
| % vacant & transient SF DUs | | % Vacant and Non-Permanent | | HHs w/Children |
| % vacant SF DUs | | % Vacant and Non-Permanent | | HHs wo/Children |
| Permanent pop. in SF DUs | | Permanent DU Population | | Vehicles in HHs w/Children |
| % SF DUs | 0 | % DUs retired | 0 | Vehicles in HHs wo/Children |
| % SF DUs | 1 | % DUs working w/children | 0 | Workers in HHs w/Children |
| % SF DUs | 2+ | % DUs working wo/children | 0 | Workers in HHs wo/Children |
| Multi-family DUs | | % DUs retired | 1 | Pop. in HHs w/Children |
| % vacant & transit MF DUs | | % DUs working w/children | 1 | Pop. in HHs wo/Children |
| % vacant MF DUs | | % DUs working wo/children | 1 | Occupied hotel rooms |
| Permanent pop. in MF DUs | | % DUs retired | 2 | County Code |
| % MF DUs | 0 | % DUs working w/children | 2 | |
| % MF DUs | 1 | % DUs working wo/children | 2 | *** Note STP60 |
| % MF DUs | 2+ | % DUs retired | 3+ | |
| Hotel Units | | % DUs working w/children | 3+ | |
| % occupied hotel units | | % DUs working wo/children | 3+ | |
| Hotel occupants | | Business Hotel Units | | |
| | | Economy Hotel Units | | |
| | | Resort Hotel Units | | |
| | | Group Quarters Population | | |
| | | Enivron. Justice Flag | | |
| | | Urban Area Flag | | |

Comments and recommendations regarding production variables follow.

- Note that income is not used in any of these models. This is probably because models that would use it were not developed because of the lack of data, rather than from a determination that income is not a significant variable. It should be noted that income fell out of favor in the 1970's and 1980's when high rates of inflation made it difficult to compare income data developed in different years. Concerns regarding the accuracy of income reporting has also been questioned.
- Income is used in many models developed for cities and regions in other states, as noted in Appendix A. Income is used in many mode choice models, and can be helpful in the development of an auto ownership model. Income might be found to be a better or equal variable to auto ownership for trip generation. Thus, it is recommended that

median family income be added to ZDATA1. This variable will have to be forecast, but this is a common variable and techniques for forecasting income are available.

- Other states and urbanized areas may simply categorize by income quartiles for the base year and assume that quartiles will not change, unless there is special information that may suggest that income levels will change. Others may rely on statewide, university or other special studies which may actually estimate income levels. Others may get income data from third party sources like Global Insight or Regional Economic Models, Inc. (REMI), or models using these sources, to produce estimates of future year incomes or quartiles for use in travel demand modeling.
- Note that the Tampa Bay and Southeast models do not use the single/multi-family stratification. It is possible to classify a household as single versus multi-family from the 2000 Census, but these variables might not be available in the future. Furthermore, some studies (Ewing, et. al.) suggest it is not highly correlated with trip rates. These variables could be dropped once new trip production rates are calculated from the Florida NHTS Add-On.
- Auto ownership is used in the original FSUTMS GEN, as well as Tampa Bay and Southeast. Many areas have moved in other states to an auto ownership model, which is easier to estimate if income data are available. It is recommended that auto ownership be retained as an informational variable. But for use in the model, auto ownership should be replaced by an auto ownership model derived from income, accessibility, and other variables that may be found to be significant.
- Tampa Bay and Southeast Florida use the children/no children classification. This variable has been found to be significant in many areas. Thus, it should be included. Forecasts of zonal data variables would have to include this stratification.
- Southeast Florida uses workers instead of persons for work trip purposes. Tampa Bay uses retired households in all home-based trip purpose production methods. Both are useful variables, yet can be a challenge to forecast. In a sense, the number of workers and presence of retired persons measure similar phenomena. There is no information that suggests that one variable works better than the other, and the best method might be dependent on the local area. Nevertheless, the number of workers is probably easy to extract from the Census, has a very logical connection with work trips, and has been proven to be effective in the District 4 models. Thus, number of workers is recommended for HBW trips.
- A more detailed hotel model would be good if the data are available. A more detailed model, similar to the Tampa Bay method was developed for Southeast Florida, but the MPO's generally did not want to develop the data – hotels by type. Thus, the simpler GEN method should be retained along with the option of categorizing hotel-motel units where desired.

### *Trip Attraction Variables*

In FSUTMS, attraction variables were previously stored in a file called ZDATA2, which generally contains zonal place-of-work employment data and place-of-school enrollment. The standard GEN model requires five attraction variables (ZDATA2):

- Industrial employment;
- Commercial employment;
- Service employment;
- Total employment (sum of the preceding three); and,
- Total school enrollment.

Tampa Bay uses the same variables, but subdivides each employment category to local and regional. NERPM uses modified definitions of the existing categories with the addition of a new category called manufacturing industrial employment. It appears that this stratification provides a better alignment with the trip purposes, and allows the models to do a better job of estimating trip attractions from employment data, particularly for commercial vehicles. SERPM adds a SCHOOL file, which requires school enrollment by type of school: grade, middle, high, and university, along with the school board's student zoning plan school zone locations for each home TAZ and type of school.

It is recommended that each MPO estimate trip attraction equations for local data, and specify trip attraction rates to fit its unique situation. In locations where local surveys are not available, trip rates should be borrowed from other areas that do have surveys and have estimated the rates. It is recommended, however, that most areas adopt the employment classification used by NERPM. Table 3 below lists the employment categories, the "old" SIC classification and the new NAICS classification for the standard FSUTMS GEN and NERPM.

## Table 3. Employment Categories Used in Florida Models

| Employment Variable | Code | |
|---|---|---|
| | **SIC** | **NAICS** |
| **Standard GEN** | | |
| Industrial | 1-39 | 1, 21, 23, 31-33 |
| Commercial | 50-59 | 42, 44-45, 722 |
| Service | 40-49, 60-99 | 22, 48-49, 51-56, 61-62, 71, 721, 81, 99 |
| Total | 1-99 | 11-99 |
| **Northeast Regional Planning Model (recommended)** | | |
| Manufacturing Industrial | 20-51 | 22, 31-33, 42, 48-49 |
| Other Industrial | 1-19 | 11, 21, 23 |
| Commercial (retail trade) | 52-59 | 44-45 |
| Service | 60-67, 70-89, 99 | 52, 53, 51, 81, 99 |

| | | |
|---|---|---|
| Total | 1-99 | 11-99 |

Use of the revised employment classifications would require re-estimation of the standard trip attraction equations from local survey data.

FAA base year estimates and future year forecasts of enplanements are recommended as the independent variable in the special generator file for the new airport trip purpose.

## 3.6 Special Generators

Major changes for special generators are not recommended. The standard GEN uses a special generator dbf SPECGEN file (formerly a text file called ZDATA3) that is extremely flexible, and this flexibility should be retained. However, there are several minor modifications:

- MPOs are encouraged to review special generator rates and values. Collection and use of locally determined data on person trip rates and purposes are strongly encouraged. Documentation of trip rate assumptions is crucial to proper model application.
- In most areas, special generators are used for the analysis of development impacts. Thus, it is desirable to adopt a procedure whereby special generator productions and attractions are not modified in the process of balancing productions to attractions. Several FSUTMS models already do this, such as NERPM, and it should become the standard procedure to enhance site impact modeling.

## 3.7 External Trips

External trips are dealt with differently in various FSUTMS models. Some maintain external-internal (EI) trips as a separate purpose. Others integrate EI trips with internal trips. Some models in other states use separate EI and IE trip purposes.

The standard FSUTMS method maintained EI trips as a separate trip purpose, with all trip attractions generated at internal TAZs in the GEN program, and all productions specified as exogenously calculated values at external stations and input in the ZDATA4 file, now called EIPRODS within INTEXT file. The attraction equations usually include both household and employment data. EI productions and attractions are then distributed using a standard gravity model. Several deficiencies have been identified with this method.

- This method sometimes overestimates trip making in zones located near the study area boundary and forces all home-based trips to be attracted internally.

- There is no way to track the actual trip purpose.
- This method does not account for asymmetrical travel, where, for example, fewer trips may be sent out from the area than attracted to the area. This generally would be the case for an isolated city that is an employment center. On the other hand, if a model is a satellite to a larger area, many trips may leave the area in the morning to work in the nearby city, while attracting few work trips. This issue is especially important when dealing with directional and time-of-day travel.

An alternative method for modeling EI trips has been adopted for the southeast Florida models. Similar methods are used in some models in other states. This method eliminates the EI trip purpose and allows trips entering and exiting the study area to compete with internal trips. Thus, for each trip purpose, both productions and attractions are specified for each external station in INTEXT (named before ZDATA4). These trips are distributed as part of the standard internal-internal gravity model for each trip purpose. To prevent trips from entering by one external station and exiting at another (effectively an external-external trip), either special "K" factors are specified to prohibit these trips, or the external-external travel times are specified to be very large so that no interaction occurs. Also, some models place an extra time on the external centroid connectors to represent the average external trip travel time, so the external productions and attractions compete fairly with the internal productions and attractions in the gravity model. There are issues with this method too.

- In some cases, external trips appear to be too short, and do not penetrate far enough into the study area.
- The external time is difficult to estimate and actual data are unlikely to exist.
- This method does not recognize that EI trips for the work purpose may have different trip-making characteristics than internal-internal trips (e.g., EI HBW trips may be longer than internal-internal HBW trips).

While not recommending changes in models where these issues have been studied extensively and suitable methods have been developed, for the revised FSUTMS framework, the following method is recommended.

- The EI trip purpose should be retained. But on the internal end of trips, separate trip production (home end) and attraction (non-home end) equations should be developed. Effectively, this results in EI and IE trip purposes.
- In the absence of external station roadside interview origin-destination studies, which are generally not permitted in Florida, it is difficult to estimate trip rates for trips with their home end outside the study area. Inmost cases the Census Journey to Work data will be useful for estimating the work portion of the typical EI/IE trips. Home interview surveys would be expected to provide the required data for IE trips produced in the study area. In most cases, planning judgment will have to be used to estimate the split between IE and EI trips. Please note that IE trips are generally produced at household locations and sent to external stations, while EI trips are produced at external stations and sent to trip attraction locations, which generally are

employment locations. Also, note that the split between EI and IE trips will be important only when there is an imbalance between the two types of trips.

- Consideration should be given to implementing procedures used in NERPM whereby external trips are categorized by auto occupancy and vehicle class based on roadside travel surveys to enhance the modeling of managed lanes.
- Each external station should be provided both EI productions and IE attractions according to the travel characteristics of the region. In most cases, the number of productions and attractions will not be equal at a given station, although on a daily basis, the number of origins and destinations at the station will be the same.

# 4.0 Revised Standard Trip Generation Model Specification

This section describes the recommended trip generation model for the new FSUTMS framework, and recaps preceding sections. While changes from GEN are recommended, the changes are generally consistent with procedures used in different Florida models. Furthermore, it is recognized that many areas have developed methods that work well, and for these areas changes should not be mandated.

## 4.1 Model Structure and Implementation

The trip generation model for the new FSUTMS framework should be implemented in the Voyager GENERATION program, eliminating the use of FORTRAN procedures. Both NERPM and the Olympus training model use Voyager scripting for trip generation. Production models should continue to include a household cross-classification approach. Attraction models should be "zero intercept" trip rate models.

## 4.2 Subarea Balancing

While caution in the use of subarea balancing is urged, the generation model for the new FSUTMS framework should allow each trip purpose to use subarea balancing to subsets of TAZ's. Different subsets should be allowed for each trip purpose. Assumptions for subarea districting should be documented (compared against travel surveys, CTPP, etc.).

## 4.3 Area Type Variable

The generation model for the new FSUTMS framework should include a method for including area type in the trip attraction equations as a zonal variable. Furthermore, the model should include a dynamic method for estimating area type so that its value will change between base and future years as may be appropriate for some zones (Tampa Bay and SERPM contain possible methods for implementing this procedure). The impact of area type on attractions, by purpose, should be determined from local origin-destination

survey data. In the absence of such data, or confidence that data can be borrowed from another similar area, use of area type in trip generation should be omitted. Thus, the model should allow the area type feature to be turned off if area type is not used.

## 4.4 Trip Purposes

Several new trip purposes are recommended. This also requires the realignment of several existing trip purposes.

- **Home-based school** – This would include at least two new purposes: K-12 and university. Furthermore, although a distribution issue, for public schools it may be better to distribute these trips to conform to the school board's student zoning plan instead of using a gravity model. Some latitude should be given to allow for local needs. For many smaller areas, a single K-12 school purpose and a university purpose would suffice. To fully account for trip movements and student zoning, it may be necessary to use grade school, middle high school, high school and university, especially where these types of trips are an issue for mode choice.
- Implementation of a home-based school trip purpose is predicated on knowing where students in each TAZ attend school. In areas without a student assignment plan, and for enrollment in charter schools, private schools, magnet schools, and other special cases, the current gravity model procedure should be used. Please note that this procedure requires school enrollment to be tabulated by school grade, and by whether the school has an assigned student assignment plan district.
- **Non-work Airport** – This would be a new trip purpose for persons traveling to the airport who do not work at the airport. These trips are generally airport passengers, or persons traveling to the airport to pick-up or drop-off passengers. Trips to the airport by airport workers should already be covered by the HBW purpose. FAA forecasts of enplanements are a good independent variable for estimating airport trips. Person trip rates are available from *ITE Trip Generation*.
- **HBO** – These trips are the residual home-based trips not included in the new trip purposes. It may be necessary to adjust HBO attractions due to the realignment of the other trip purposes.
- **NHBW** – This new purpose, nonhome-based work oriented, is a new purpose and a partial replacement for NHB. It requires that one or trip ends be a work location, and neither end be home. Often, these trips are part of a complex commute: HBO-NHBW.
- **NHBO** – This new purpose, nonhome-based other, is a new purpose and a partial replacement for NHB. It requires that neither end be a work or home location. NHBW and NHBO usually have different trip length frequency distributions, and may use different variables in trip generation.
- **Commercial vehicles** – This new purpose accounts for four-tire service and other non-freight trucks and commercial vehicles.

- **Medium and heavy trucks** – This new purpose would account for trucks carrying goods. Four-tires that are indistinguishable from autos in traffic counts should be in the standard trip purposes. Most new models contain truck trip purposes. The *QRFM* could serve as a source of data for this trip purpose, but the long range goal would be to develop special generators of freight terminals and other areas, such as ports, with high levels of activity.

## 4.5 Zonal Data Variables

For trip production data, several changes are recommended. The changes are the addition of income, a recommended children/no-children stratification and the number of workers in a household. The single/multi-family stratification could be dropped once updated NHTS trip rates are calculated. Auto availability variables should be replaced with an auto ownership model. Recommendations are explained further below.

- The lack of income data in Florida has been a limiting factor in the implementation of several modeling improvements. It is recommended that median family income be added to ZDATA1. This variable will have to be forecast, but income is a common variable and techniques for forecasting it are available. The availability of zonal income would allow for better modeling of trip distribution, mode choice, and other parts of the model, and the development of an auto ownership model.
- It is recommended that the single-family/multi-family stratification be dropped from the new FSUTMS framework trip generation model once new NHTS trip rates become available.
- It is recommended that auto ownership be retained as an informational variable, but that for the model, auto ownership should be replaced by an auto ownership model derived from income, accessibility, and other variables that may be found to be significant.
- A children/no children classification should be included in the ZONEDATA file. Forecasts of zonal data variables would have to include this stratification.
- The new FSUTMS framework trip generation model should use the number of workers in the household in the estimation of HBW productions.

For trip attractions (ZDATA2), several changes are recommended. First, employment data should be realigned to include:

- Manufacturing Industrial (NAICS 22, 31-33, 42, 48-49)
- Other industrial (NAICS 11, 21, 23)
- Commercial (retail trade) (NAICS 44-45)
- Service (NAICS 52, 53, 51, 81, 99)
- Total (NAICS 11-99)

To support the school model, the place-of-school K-12 enrollment, and university enrollment will be required. If the model is to use a student zoning plan instead of a gravity model for trip distribution, the assigned school zone for each home zone also will be required.

FAA forecasts of enplanements are recommended for the airport trip purpose.

## 4.6 Special Generators

The existing special generator method should be retained with a minor modification. The procedure should be modified so special generator productions and attractions are not modified in the process of balancing productions to attractions.

## 4.7 External Trips

A change to the external- internal (EI) model is recommended. The EI propose should be split into EI and internal-external trips (IE). Studies of available survey data, journey-to-work data, local knowledge, and the statewide model should provide input to the development of the data required to support this model.

- EI productions should be estimated for external station (exogenous).
- EI attractions should be estimated for each internal TAZ from attraction data, generally employment and households. EI productions should be balanced to match the attractions.
- IE productions should be estimated for each internal TAZ from household data.
- IE attractions should be estimated for external station. IE attractions should be balanced to match the productions (exogenous).
- The number of external-external trips (EE) at each external station should be determined from the exogenously determined station volumes, roadside travel surveys, minus the EI and IE trips.

# Appendix A

*Literature Review on Income as a Variable Employment Stratification*

# Income Stratification

- **Atlanta Regional Commission (ARC)**: The model is structured as a logit model estimating the daily trip frequency a person would make. The socio-economic independent variables, specified as information for the household, are as follows:

  - HH size (1, 2, 3, 4+)
  - HH income group (under $20K, $20 – 50K, $50 – 100K, over $100K)
  - Number of workers (0, 1, 2, 3+)
  - Number of children (0, 1, 2, 3+)
  - Number of autos (0, 1, 2, 3+)

  For each of the three home-based and the non-home based trip purposes (work, other, shop, and NHB) there were four individual income groups resulting in 16 home-based trip purposes. University and home-based school based trips were maintained as single trip purposes.

- **Baltimore Metropolitan Council (BMC)**: Trip distribution is performed separately by income for the home-based purposes. Twenty-nine separate gravity models are run.

  Income groups are: lowest 10%, next lowest 15%, next lowest 20%, and highest 55%. These are referred to as Travel income groups 1, 2, 3, and 4, respectively.

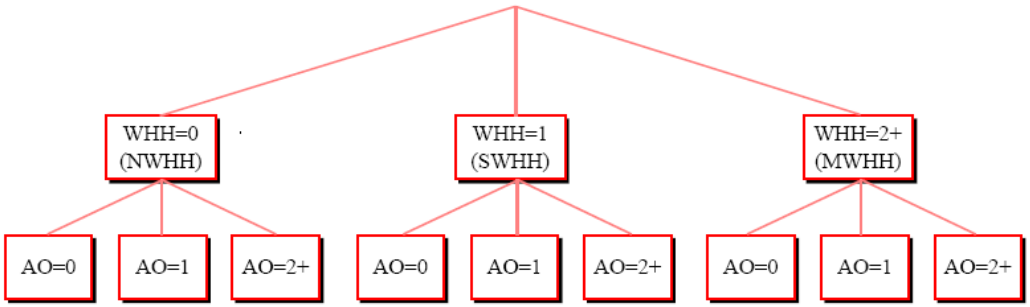
  The joint distribution is determined by household size, by income, and by workers. In this model, two joint distributions are used: the HHs in a zone is stratified separately by size and income, and then by workers and income. The same procedure is used for each joint distribution. In the trip production procedure, the worker/income stratification (16 cells) is used for the HBW, JTW, and JAW purposes. The size/income stratification (20 cells) is used for the SCH, HBS, HBO, and OBO purposes.

- **San Francisco MTC**: The market segments used in the BAYCAST model system are:

  - Household by workers in the household (WHH=0, 1, 2+);
  - Households by autos available in the household (AO=0, 1, 2+); and,
  - Households by household income quartile (Income=<$25K, $25K-45K, $45K-75K, >$75K).

  The MTC workers and vehicles in household model (WHHAO) is a nested logit choice model applied at the zone-of-residence level. The input to the WHHAO model application is number of households stratified by household income quartile level. The

home-based work trip distribution model is actually four sets of friction factors applied to HBW trip ends stratified by household income quartile level.




*Non-Working Household Theta = 0.7451 (t=3.0)*
*Single-Worker Household Theta = 0.4477 (t=2.7)*
*Multiple Worker Household Theta = 0.1968 (t=1.8)*
*AO = auto ownership level*
*WHH = workers in household level*
*NWHH = non-working household*
*SWHH = single worker household*
*MWHH = multi-worker household*

- **North Central Texas Council of Governments (NCTCOG)**: Trip attraction is stratified by area type, employment type and number of households, and, in the case of the HBW trip purpose, income quartile.

- **Puget Sound Regional Council (PSRC)**: Households are grouped into income quartiles relative to the income distribution at the entire regional level at any point in time. Income group is determined by 1999 Annual Household Income from the 2000 Census defined as categories:

  - Low – Under $25,000;
  - Low/medium – $25,000 to $45,000;
  - Medium/high – $45,000 to $75,000; and
  - High – Over $75,000.

  The vehicle availability model is the application of a cross-classification model that is based upon the income, household size, and worker characteristics. Cross-classification tables are developed as four-way classification tables (households by income, household size, workers, and vehicles available) for each of 20 subareas.

- **The North Jersey Transportation Planning Authority (NJTPA)**: The NJRTME also structured the estimation of trips by income. The previous model had four income quartiles defined in relatively equal magnitudes. In contrast, the NJRTME has 5 income groups which were defined based on mode share characteristics. This approach was adopted since several of these groups had significant variation in transit usage and the NJ Transit Mode Choice Model utilizes income as a market segmentation variable.

- Group 1 – equal or less than $14,999
- Group 2 – between $15,000 and $34,999
- Group 3 – between $35,000 and $74,999
- Group 4 – between $75,000 and $149,999
- Group 5 – $150,000+

- An iterative proportional fitting (IPF) algorithm was used to estimate the joint distribution of households by size, income and life cycle in each zone.

- For the work-based trip purposes, the production cross-classification process utilizes the number of workers as a predictive variable. In order to estimate households by number of workers, a submodel was used to disaggregate households into several worker categories. These estimates are derived using the zonal joint distribution of households by household size, income group and life cycle previously calculated.

# Employment Stratification

- **Atlanta Regional Commission (ARC)**: The trip attraction part in this model uses the SMARTRAQ data which came from the home interview survey performed in 2001. The employment class is only used in the Home Based Work purpose because utility coefficients are based on the employment class of workers.

  Employment Class

  - Finance, Insurance, Real Estate (FIRE)
  - Retail
  - Government
  - Transportation, Communications, Utilities (TCU)
  - Wholesale
  - Construction

- **Baltimore Metropolitan Council (BMC)**: The independent variables are drawn from the list of available zonal socioeconomic data items, as well as other secondary statistics that can be derived from those items.

  - RE: Retail employment
  - OFF: Office employment
  - IND: Industrial employment
  - OTH: Other employment
  - ENROLL: School enrollment
  - Office and Services

- **Puget Sound Regional Council (PSRC)**: Employment is divided into five industry sector groups based on the extent to which they exhibit roughly similar trip generation/land use characteristics. The sectors used are:

  - Manufacturing (SIC 19 to 39);
  - Wholesale Trade, Transportation, Communications, and Utilities (WTCU) (SIC 40 to 42, 44 to 51);
  - Retail Trade (SIC 52 to 59);
  - Finance, Insurance, Real Estate, and Services (FIRES) (SIC 07, 60 to 67, 70 to 76, 78 to 81, 83 to 84, 86, and 89); and,
  - Government and Education (SIC 43, 82, 92 to 97).

- **The North Jersey Transportation Planning Authority (NJTPA)**: Employment was supplied in 10 sectors corresponding to the Standard Industrial Classification (SIC) codes.

  - AGMINE: Agriculture, Forestry, Fishing Employment, and Mining (01-14)
  - CONST: Construction Employment (15-17)
  - MFG: Manufacturing Employment (20-39)
  - TRANS: Transportation, Communications, Electric, Gas, And Sanitary Services Employment (40-49)
  - WHLSE: Wholesale Trade Employment (50-51)
  - RET: Retail Trade Employment (52-59)
  - FIRE: Finance, Insurance and Real Estate Employment (60-67)
  - SER: Services Employment (70-89)
  - GOV: Government - Public Administration Employment (91-97)
  - MIL: Military Employment (99)
  - BASIC: AGMINE + CONST + MFG + TRANS + WHLSE Employment (01-51)
  - RETAIL: RET Employment (52-59)
  - SERVICE: FIRE + SER + GOV + MIL Employment (60-99)

- **Mid-Ohio Regional Planning Commission (MORPC)**:

  - Agriculture, Forestry, Fisheries
  - Primary Metals (Steel)
  - Light Industry
  - Heavy Industry
  - Transportation Equipment (Auto)
  - Wholesale
  - Retail
  - Hotel
  - Construction
  - Health
  - Transportation Handling
  - Utilities
  - Other Services
  - Grade School Education
  - Post-Secondary Education
  - Government