FSUTMS-Cube Framework

Standard Trip Generation and Distribution Models

Final Technical Memorandum No. 2

Trip Distribution Review and Recommendations

prepared for

Florida Department of Transportation Systems Planning Office

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Final report

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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 distribution model practice and provide recommendations on changes and improvements. This report is a follow up of an earlier report that examined trip generation, which included an appendix with 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 memo.

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 distribution. Observations from the Framework report include:

- Trip distribution should be performed for two time periods, peak and off-peak. Distribution by period is necessary to produce consistency in travel times and costs across all model steps. The peak distribution will require impedances from the peak period highway assignment from the previous model feedback iteration.

- Distribution also should be performed by income group; that is, distributing low-income productions to low-income attractions, medium-income productions to medium-income attractions, etc. This process will address one of the major issues with the current method of distribution: the grouping of all productions and attractions causes competition between low- and high-income households for the same attractions and low- and high-income jobs with the same households. A recent analysis on work-trip distribution examined the Census Transportation Planning Package (CTPP) 2000 results of seven urban areas, including Jacksonville, Atlanta, and Dallas/Forth Worth. It noted that blue- and white-collar workers tend to live and work in different areas within each city. Distributing productions and attractions by income group will help to alleviate this problem and improve traffic forecasts. This particular technique has been applied to the Orlando Urban Area Transportation Study (OUATS).

- The gravity model will continue to be used as the algorithm. It still is the most common algorithm used in models today. Calibration will continue to be performed according to average trip length curves, but it will be performed for each period, income level and travel purpose. In addition, the closure level for balancing attractions will be reviewed to determine a level that attempts to minimize skewing the results. An unfortunate consequence of using iterative matrix techniques is that they constrain the row and/or column totals. The balancing routines used in gravity model, destination choice and Fratar model all distort the final results.

- Alternatives to the gravity model should be explored. The destination choice formulation is very similar to the standard gravity model, but allows more explanatory variables to be used. It is not used in Florida, but has been applied to many urban areas around the country. New ways to perform trip distribution

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

beyond relying on transportation-related criteria should always be explored. Some areas distribute trips made by low-income or zero-car households by transit-only impedances. This approach is used in SERPM and helps to prevent the distribution of trips made by transit captives between TAZ's without connecting transit service. Other Districts and MPOs may want to explore this technique.

Research performed for the Florida Department of Transportation by the Lehman Center for Transportation Research at Florida International University explored the use of alternative distribution model structures, including intervening opportunity models, enhanced gravity models, and destination choice models. This study recommended further study of the use of income in the trip distribution process, improvement of the intrazonal trip distribution process, development of a CUBE-based destination choice program for use in Florida, and models of chained journeys rather than trips[2].

In addition, trip distribution 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*[3]. This memo 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*[4] *and Final Technical Memorandum No. 1, Trip Generation Review and Recommendations*[5].

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

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[2] *Refinement Of FSUTMS Trip Distribution Methodology, Final Report*, Contract No. BB942. Prepared for the Research Office of the Florida Department of Transportation by the Lehman Center for Transportation Research, Department of Civil & Environmental Engineering, Florida International University, September 2004.

[3] *FSUTMS New Standards And Enhancements – A User Oriented Approach*, A Florida Model Task Force White Paper, Systems Planning Office, Florida Department of Transportation, Tallahassee, FL, January 2006.

[4] *FSUTMS-Cube Framework Phase I: Transferable Model Parameters* and *FSUTMS-Cube Framework Phase II: Model Calibration and Validation Standards,* reports prepared by Cambridge Systematics, inc., for the Florida Department of Transportation, Systems Planning Office, 2007, 2008.

[5] *FSUTMS-Cube Framework Phase III: Standard Trip Generation and Distribution Models, Final Technical Memorandum No. 1, Trip Generation Review and Recommendations,* a report prepared by The Corradino Group, Inc., and Cambridge Systematics, Inc., for the Florida Department of Transportation, Systems Planning Office, 2009.

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) covering Palm Beach, Broward and Miami-Dade Counties.
  - Treasure Coast Regional Planning Model (TCRPM) covering Martin, St. Lucie, and Indian River Counties.
  - 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
  - West Central Florida Regional Planning Model covering urbanized portions of Hernando, Hillsborough, Manatee, Pasco, Pinellas, Polk and Sarasota Counties.

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 DISTRIB procedure was developed in the early 1980s. This section addresses these issues in detail, and puts forth recommendations.

3.1 Model Structure and Implementation

When FSUTMS procedures were developed in the 1970s and 1980s, a gravity model trip distribution procedure was present in the UTPS mainframe-based modeling system. Gravity models are by far the most common method for performing trip distribution, and all software, micro-computer and mainframe, have included gravity models. This includes the Tranplan and Cube software used in Florida. As with other aspects of the modeling software, Cube provides more options and flexibility than did Tranplan, but the Tranplan gravity model program had gravity model capabilities that are not found in Cube without extensive scripting, most notably in its ability to produce a "smoothed" set of friction factors.

The original FSUTMS DISTRIB models were designed for daily models and typically used a single set of travel time skims. These skims were subsequently "updated" to include terminal times at both ends of each trip, and an estimate of intrazonal time. Most often, terminal times were established, without the benefit of data, as a function of the area type of the TAZs. CBD terminal times were set at four or five minutes, rural terminal times were set at one minute, with terminal times for the other areas types set at minute increments between the CBD and rural times. Again, this usually was done using "conventional wisdom," meaning that it wasn't supported by local data. The most common assumption for intrazonal travel time was half the travel time to the nearest neighboring TAZ. This was easy to implement using a convenient function in Tranplan.

Friction factor curves usually were "borrowed" from earlier models as presented in the early FSUTMS reports, generally because new data on which to base friction factors was not available. Sometimes the friction factors were adjusted to match average travel times as reported in Census tabulations or other data. Full calibration of the gravity model is problematic even with the presence of the "small sample surveys" common over the past ten years or so, because the sample size of these surveys is generally specified to estimate trip rates for trip generation, and may be too small to reliably estimate a friction factor curve. The inadequacy of data is exacerbated by the need to estimate separate curves for each trip purpose. While Tranplan and Cube (as well as UTPS) are able to incorporate "K-factors", their use has been considered bad practice in Florida, and thus they are almost never used.

Some models include special techniques implemented outside the gravity model to improve distribution as may be indicated by comparing traffic counts and assigned volumes on specific links and at screenlines and cutlines. Two common procedures were to assign time penalties to links to reduce volumes, and to perform subarea balancing of productions and attractions (addressed in the memo on trip generation). Finally, most models include a balancing step to ensure that the output trip table contains the same number of trip attractions (generally column totals), as were input to the model from trip generation. Thus, most FSUTMS models apply a standard gravity model by trip purpose, distribute with updated free-flow travel time skims and friction factors, and iteratively balance attractions.

Some newer models have included other features made available in the newer Cube software and some best suited to faster hardware. These changes may or may not produce desirable results and could include:

- Replacement of empirical friction factor curves with gamma functions. While NCHRP 365 contains a set of suggested default values, this document will soon be updated using data from the 2008 National Household Travel Survey (NHTS).
- Use of peak skims for work trips and free-flow skims for nonwork trips.
- Some models with time-of-day elements may include an iterative process so that trip distribution, mode choice and trip assignment all use the same time values within each time period.
- While early FSUTMS may have run a small number of iterations to balance attractions, say five or ten iterations, newer models may run many more, up to the Cube limit of 99.
- Subarea balancing.
- Use of K-factors for special situations.
- Redevelopment or adjustment of friction factors based on available data.
- Use of multiple friction factor curves as a function of the production zone. This is most common for regional models encompassing several counties.

Finally, while Cube and Tranplan both implement standard gravity models, which produce very similar results, there is a major difference in that Tranplan produced integerized trip tables, while Cube's trip tables can be floating point. The use of Cube's floating point matrices is the preferred method, as it avoids problems which can arise from rounding procedures. There is no apparent benefit to rounding the matrices to stay consistent with Tranplan results unless the goal is simply to be consistent with the old software.

The recommendation for software is to use Cube's DISTRIBUTION program to produce floating point trip tables. In all but the most unusual cases DISTRIBUTION will provide the features needed by FSUTMS models. However, there are other changes that should be considered, as detailed in subsequent sections.

3.2 Subarea Balancing

This issue pertains to both trip generation and trip distribution, and was treated completely in the preceding trip generation report. The conclusion in the trip generation report was that 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 framework.

3.3 Trip Purposes

This too was addressed in the preceding trip generation memo. The conclusion was to use the following trip purposes.

- **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 enhancement 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 for most models in Florida. In some areas this is important for the analysis of transit. Furthermore, it may be better to distribute public school 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.
- **Nonwork 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, and thus this trip purpose is a combination of home-based and nonhome-based trips. 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*[6] 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. The *Quick Response Freight Manual II*[7] contains suggestions for developing gravity model friction factors.
- **Medium and heavy trucks** – This new purpose would account for trucks carrying goods. Most new models contain truck trip purposes. The *QRFM* contains suggestions for developing gravity model friction factors for these trips as well.

An obvious impact of this is that surveys and data will be required for the added and modified trip purposes. It is expected that the 2008 NHTS Florida Add-On Sample will supply sufficient data for most of these new trip purposes except for the commercial vehicle and truck purposes, which would require a survey of commercial vehicles. Also, there might be an insufficient sample of airport travelers in the NHTS, requiring supplemental airport surveys or borrowing friction factors from other airports surveyed.

■ 3.4 External Trips

Again, this issue was addressed in the earlier trip generation model memo. The conclusion was that the EI trip purpose should be retained. But on the internal end of trips, separate

[6] *Trip Generation, 8th Edition*, Transportation Research Board, Washington, D.C., 2000, ISBN-13:978-1-933452-43-2, ISBN-10: 1-933452-43-9.

[7] Quick Response Freight Manual II, U.S. Department of Transportation, Federal Highway Administration, Office of Freight Management and Operations, Publication #FHWA-HOP-08-010 EDL #14396, September 2007.

trip production (home end) and attraction (non-home end) equations should be developed. Effectively, this results in distinct EI and IE trip purposes. These trips would be distributed by a gravity model. A Fratar model is best suited for the distribution of external-external trips.

3.5 Use of K-Factors

K-factors have long been part of the standard gravity model specification. They have not often been used in Florida, and their use has not been considered good practice, primarily because it is not possible to judge whether values should remain constant in future years. Many modelers consider K-factors to be "catch-all" factors that attempt to compensate for model deficiencies that may include unexplained differences in trip generation rates, unaccounted for travel times and delays, socio-demographic differences such as incomes of workers and type of jobs, and other issues.

The recommendation for K-factors is to continue the current FSUTMS practice of using K-factors only when there is a clear reason for doing so, and only after all other modeling options have been exhausted. Clear reasons for using K-factors should be directly related to regional trip distribution patterns and could include a lack of sufficient data to calibrate friction factors or an inability to conduct distribution separately by income or auto ownership categories (whether this be time, budget, or MPO preference). K-factors were originally defined as "socioeconomic correction factors" back in the 1960s, and were intended to fix income-related distribution issues. K-factors could be considered as an alternative to other approaches aimed at correcting for distribution anomalies such as subarea balancing and coding of travel time penalties. As such, rationale for their use could include lack of clear physical features for implementing penalties (usually only recommended for bridges and steep grades) or concerns over use of subarea balancing.

3.6 Definition of Skims for Trip Distribution

Traditionally, Florida models have used only travel time, updated to account for intrazonal and terminal times, and the time value of tolls for the gravity model impedance. Earlier Tampa Bay and SERPM models used a highway and transit composite impedance, but the composite impedances have been dropped from these models to make them more understandable and intuitive. The current Tampa Bay and SERPM models consider toll plaza service time and tolls in the calculation of the path impedance, and the gravity model impedance includes the time value of the tolls and service times.

SERPM uses transit skims in the distribution of transit-captive trips, which are defined as trips made from zero-auto households. The reason here is to prevent the distribution of trips from zero-auto households to locations other than those served by transit. The only special requirement here is that production files must be stratified by those from households with autos, and households without autos. This generally has been found to improve model results, and the only complication is that there are some zero-auto households with no transit services, and use of autos must be assumed for these TAZs.

Another common procedure in other states, Ohio for example, is to include distance in the assignment model impedance calculation. Please note that distance is not used in the impedance calculation for trip distribution. Use of a distance impedance is not recommended for Florida, but is mentioned here for completeness. The consultant believes that consistent methods for determining paths and skims should be used in all model steps requiring an impedance calculation: trip distribution, mode choice, and traffic assignment.

Thus, it is recommended that most FSUTMS models continue the practice of using updated highway travel time skims for trip distribution. For areas with toll facilities, service time and tolls also should be included in the impedance. Each area should carefully consider the value of time – usual practice is to relate the value of time to income, which could be done if income is added as a zonal variable as recommended in the trip generation memo, and to use a different value of time for each trip purpose. Most studies find that tolls have less impact on work trips, but result in a higher impedance for nonwork trips. A good source of value of time data for Florida is the *Southeast Florida Road and Transit User Cost Study*.[8]

For areas that have a high investment in transit services, or are considering such an investment, using transit skims to distribute trips from zero-auto (or perhaps low income) households should be considered.

Larger urban areas and areas that experience significant congestion should use congested skims to distribute peak period trips, and free-flow skims to distribute off-peak trips. The issue of distributing trips with congested skims, and iterating between distribution and assignment is part of the larger issue of modeling by time of day, and thus should be coordinated with this issue.

■ 3.7 Balancing Attractions – Singly or Doubly Constrained

The gravity model formulation ensures that the resulting trip table (row sum) contains the same number of trips leaving each TAZ, as the number of productions given to the model. This is a certainty because it can be proven mathematically. But, the same is not true for attractions (column sum). With only one iteration of the gravity model, the trip table is not likely to have the same number of trips attracted to each TAZ as in the attraction file. Most

[8] *Florida Road and Transit User Cost Study*, a report prepared by Cambridge Systematics, Inc., for the Florida Department of Transportation, District 4, 2008.

models use an iterative method to adjust the modeled attractiveness so that the trip table contains the correct number of attractions for each TAZ. In the original FSUTMS model, it was common to perform ten attraction iterations. Most models reach convergence in ten iterations, or come "close enough." But often the level of convergence was not examined closely. In newer models, for example SERPM, many more iterations are applied, and the iterations continue until close convergence is reached, or the maximum number of iterations allowed by the software, 99 for Cube, has been performed.

A high number of iterations to force convergence of attractions implies that the modeler is confident that the model is correctly estimating attractions. In fact, forcing convergence implies that the trip attraction estimate is more important or reliable than the travel time effects of the gravity model. It is certain that if many iterations are applied to reach convergence the trip length frequency distribution of the resulting trip table is different from what is implied by the friction factors.

For work trips, this may be a good assumption. It is a reasonable assumption that there will be a little less than two HBW trips attracted for each employee (less than two because of days off, and linked HBO-NHB instead of HBW), and the work location is largely immaterial to the travel behavior.

For other trip purposes, trip rates are much less certain. Take for instance two identical business establishments, one with a convenient location, and the other much less accessible. It is likely that the less accessible business will have fewer shopping trip attractions. The same would seem to be true for other nonwork trip purposes. But, if many iterations of the gravity model are applied to force convergence on attractions, then both businesses will get the same number of trips despite the difference in accessibility. Some modelers have recognized this and recommend forcibly balancing attractions (a doubly constrained model) only for HBW trips. An example is the recommended procedure in the *Virginia Travel Demand Modeling Policies and Procedures Manual*.[9] Some modelers contend that this is a trip generation issue, and that the trip attraction model should take into consideration the difference in accessibility, and thus forcing convergence is always correct. But this issue will be present until a different trip generation model procedure is developed which considers accessibility.

The consultant's recommendation is to continue using a doubly constrained gravity model for the HBW trip purpose. But for other trip purposes it might be advantageous to use a singly-constrained gravity model that is not iterated to force convergence on attractions, or to run only a few iterations (perhaps five or less). Additional testing of this approach should be conducted prior to assuming this relationship for all Florida models.

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[9] *Virginia Travel Demand Modeling Policies and Procedures Manual*, a report prepared by the Virginia Department of Transportation, 2007.

3.8 Stratification by Income Level

Again, this issue was addressed in the earlier trip generation model memo. Conclusions were that models in larger urbanized areas should consider segmenting the HBW trip purpose by income level. For these models, separate distribution models will be required for each income level. Furthermore, separate friction factor curves should be developed for each income segment if sufficient stratified household survey samples are available. The primary advantage of this approach is that workers in each income class will be paired with more likely employment locations, which should significantly improve model results. Stratifying the HBW trip purpose by income was found to improve models in a study of trip distribution methods performed by the Lehman Center at Florida International University using Florida data.[10]

3.9 Destination Choice Models

Destination choice models have received a lot of attention in recent years, particularly in connection with activity-based and tour-based models, where a disaggregate approach is required. The *Refinement of FSUTMS Trip Distribution Methodology* cited above (see reference 8) also developed and tested destination choice models for Palm Beach, Broward and Volusia counties. These were aggregate models. The results of these tests were mixed. For HBW trips, better spatial accuracy was observed for inter-district trips, but intrazonal trips were significantly underestimated. For nonwork trip purposes, the destination choice models matched the survey average trip length better than the gravity model, but did worse with the trip length frequency distribution and intrazonal trips. It is interesting to note that the destination choice models contained income data, which the gravity models did not. In fact, the study's primary finding was that it is important to stratify trips by income both in trip generation and trip distribution.

Thus, while continued research on disaggregate destination choice models is in order, the consultant recommends the continued use of gravity models, but with income stratification for the larger models.

[10] *Refinement of FSUTMS Trip Distribution Methodology*, Final Report, Contract No. BB942. A report prepared by the Lehman Center for Transportation Research, Department of Civil & Environmental Engineering, Florida International University, for the Florida Department of Transportation, District 4, 2004.

4.0 Revised Standard Trip Distribution Model Specification

This section describes the recommended trip distribution model for the new FSUTMS framework, and recaps preceding sections. While changes in trip distribution procedures 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 recommendation for software is to use Cube's standard gravity model DISTRIBUTION program to produce floating point trip tables. In all but the most unusual cases, DISTRIBUTION will provide the features needed by FSUTMS models. Inputs to the model will be production and attraction files, highway skims, and friction factors.

4.2 Subarea Balancing

This issue impacts both trip generation and trip distribution. Consistent with the trip generation report, it is recommended that subarea balancing should be applied very carefully, only when it is needed, and only when a clear reason can be identified. Nevertheless, subarea balancing should be available in the standard FSUTMS framework.

4.3 Trip Purposes

Consistent with the preceding trip generation report, FSUTMS trip purposes should be:

- **Home-based work (HBW),** in larger urbanized areas stratified by income.
- **HBSH** (shopping).

- **HBSR** (social-recreational).
- **Home-based school,** with possible stratifications by public/private, and by grade school, middle school, high school, and university consistent with local conditions. Furthermore, using student assignment districts to assign public school trips should be considered.
- **Nonwork Airport**.
- **HBO (other)**.
- **NHBW** (nonhome-based work-oriented).
- **NHBO** (nonhome-based other).
- **Commercial vehicles**.
- **Medium and heavy trucks**.

■ 4.4 External Trips

Consistent with the earlier trip generation model memo, it is recommended that the external-internal (EI) and external-external (EE) trip purposes should be retained in FSUTMS. A gravity model should be used to distribute EI trips. A Fratar model should continue to be used to distribute external-external trips. As discussed in the earlier report on trip generation, consideration should be given to implementing procedures used in the NERPM and Alachua County models whereby external trips are categorized by auto occupancy and truck category based on roadside travel surveys to enhance the modeling of managed lanes.

■ 4.5 Use of K-Factors

The recommendation for K-factors is to continue the current FSUTMS practice of using K-factors only when there is a clear reason for doing so, related to trip distribution patterns, and only after all other reasonable modeling options have been considered or exhausted. K-factors can be implemented, where necessary, as an alternative to other approaches used in Florida such as subarea balancing and coding of travel time penalties.

■ 4.6 Definition of Skims for Trip Distribution

It is recommended that most FSUTMS models continue the practice of using updated highway travel time impedances for trip distribution. For areas with toll facilities, skims should include toll plaza service time and the time value of tolls. Each area should carefully consider the value of time. For areas that have a high investment in transit services, or are considering such an investment, using transit skims to distribute trips from zero-auto (or perhaps low income) households should be considered. Larger urban areas and areas that experience significant congestion should use congested skims to distribute peak period trips, and free-flow skims to distribute off-peak trips. This issue should be coordinated with the larger issue of time of day modeling.

Some models, including the latest version of SERPM, calculate another set of highway skims for vehicles that can use HOV lanes. Generally, these skims are used as an input to the mode choice models, and allow travel times on HOV lanes and managed lanes to impact the choice of drive-alone versus carpools (usually two or three occupants). In an area where some lanes are restricted to vehicles with two occupants and other must have three or more occupants, the model may develop a set of highway skims for each occupancy level. The usual practice, however, is to use only the drive-alone skims in the distribution model, under the assumption that the travel time advantages of higher-occupancy will not affect trip distribution. For areas where HOV and managed lanes serve a large number of trips and offer a significant travel time advantage, it may be useful to consider carrying the vehicle occupancy stratification to trip distribution in a feedback loop. An alternative would be use the log sum of the occupant-specific skims in the distribution step. This more complicated procedure would be used only in models that had extensive HOV or HOT lane facilities, and when data and results suggested that it would be necessary.

4.7 Balancing Attractions – Singly or Doubly Constrained

Doubly constrained gravity models should continue to be used for the HBW trip purpose. But for other trip purposes modelers should consider the use of a singly-constrained gravity model that is not iterated to force convergence on attractions, or to run only a few iterations (perhaps five or less). Additional testing of the singly-constrained approach should be conducted prior to assuming this standard for all Florida models. Such testing should cover a wide spectrum of Florida models, including small “highway only” models and large regional models, and assess the impacts to distribution, mode choice (where applicable), and assignment.

4.8 Stratification by Income Level

Consistent with the earlier trip generation model memo, the recommendation is that models in larger urbanized areas should consider segmenting the HBW trip purpose by income level. While this could effectively double the run times for HBW distribution, used of singly-constrained approaches for other trip purposes could potentially offset this difference. In all likelihood, a single set of friction factors would be used for low- and high-income households unless a statistically valid survey sample is available for lower income households.

■ 4.9 Destination Choice Models

The recommendation is that while continued research on destination choice models is in order, gravity models should continue to be used, but with income stratification for the larger models. Continued research on destination choice should consider disaggregate approaches, unlike previous studies in Florida. Case studies of other models around the U.S. should also be included to better understand the rationale used in selecting this approach.