INCORPORATION OF STATE-OF-THE ART INTEGRATED MODELING METHODOLOGIES INTO FLORIDA'S STATEWIDE MODEL

Final Report: Executive Summary

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Executive Summary

The primary purpose of this document is to provide a detailed description of the modeling approach and methodology that the project team adopted in the development of the new Statewide Model for Florida. In addition to describing modeling methodologies, the document includes descriptions on the approaches adopted for developing the statewide model network and zone system in support of statewide modeling applications.

PROJECT OVERVIEW

The objective of the project was to develop a new Statewide Model for Florida that is capable of supporting a range of local/regional and statewide planning applications. Consistent with this vision, the new statewide model was developed so that it is consistent with local/regional models on the one hand and with statewide networks and support systems on the other. Some of the applications for the statewide model are envisioned to include, but not be limited to, the following:

Interface with Local/Regional Models at External Stations

Local/regional FSUTMS models need reliable and consistent information about external trips that enter and leave their model area. While one can easily obtain base year external trip information from ground counts and roadside/cordon line surveys, it is difficult to obtain future year external trip information in a reliable manner. It is envisioned that the statewide model, through its interface and consistency with local/regional models, will be able to offer future year estimates of external trips that local/regional modeling agencies can use for their planning purposes. While local/regional models do not necessarily have to use the estimates from the statewide model, agencies can use the estimates for conducting checks-and-balances on their own external trip forecasts.

Provide Information to the Statewide Highway Freight Model

The development of a statewide highway freight model (with intermodal connectors) was recently completed. The statewide highway freight model needs socio-economic data, network data, zonal data, and special generator data for running the models that produce estimates of statewide truck movements. It is envisioned that the new statewide model will serve as the custodian of this information (while maintaining consistency with local/regional models) and provide the information to the statewide highway freight model.

Provide Information to the FIHS Decision Support System

The new statewide model, in conjunction with local/regional models, will serve as the main source of traffic forecasts for the FIHS decision support system. The FIHS decision support system is used to develop the FIHS work program and it would be desirable to have the decision support system obtain traffic forecasts and volumes from travel demand models adopted in the state. In areas of the state where local/regional models are not able to provide traffic forecasts for FIHS facilities, the new statewide model would provide the forecasts. Thus, the statewide model needs to be consistent with the FIHS decision support system on the one hand and with local/regional models on the other.

Transportation Planning Studies in Rural Areas

The new statewide model will serve as a systems planning tool for such areas where local/regional model coverage is not available. Quite often, there is a need to conduct specialized transportation planning studies (corridor studies, IJR/IMR) in rural areas that are not covered by local/regional models.

The remainder of this document provides a description of the approaches and methodologies that were adopted in the development of the new statewide model. It is divided into the following sections:

- Statewide Model Network Development
- Zone Structure Development
- External Trips
- Trip Generation
- Trip Distribution
- Modal Split
- Traffic Assignment

Within the context of each section, data sources and data needs are identified and discussed. Therefore, there is no specific section dedicated to database management.

STATEWIDE MODEL NETWORK DEVELOPMENT

This document focuses on a description of the process and approach that were followed in developing a comprehensive statewide model network that is both consistent with local/regional model networks and capable of serving statewide planning needs.

As the FIHS decision support system is going to be heavily dependent upon the new statewide model for traffic forecasts, it was considered imperative that the statewide model network be consistent with the FIHS decision support system. The FIHS decision support system network is based on the Department’s state basemap that is constantly updated and maintained by the

Transportation Statistics office. Utilization of the state basemap as the backbone of the statewide model network will also make a host of statewide databases available for modeling purposes including the RCI data, work program data, and count station data.

However, the statewide model network must also be consistent with local/regional model networks. Therefore, the network derived from the state basemap was augmented and supplemented with information from local/regional model networks. Any discrepancies between the state basemap and the local/regional model networks will be resolved in consultation with the appropriate staff from the FDOT District office. Through this process, it is envisioned that the resulting statewide model network will be consistent, comprehensive, and coherent in its coverage of the state.

As mentioned earlier, the statewide model network also serves as the network for the statewide highway freight model. In order to serve the specific needs of the freight model, the network was further augmented with intermodal freight connectors and freight facilities (nodes) that have been identified by the Freight Stakeholders Task Force. These connectors are considered critical for the movement of freight to and from intermodal terminals and facilities.

Another step in the network development process involved the review of the network for inclusion (or lack thereof) of roadway facilities that have been missed in the state basemap and in the local/regional models. For example, there were roadway facilities in rural areas that were not covered by a local/regional model network and that had been excluded from the state basemap. In consultation with FDOT District office staff and through a thorough review against standard reference sources such as TIGER/Line files and USGS Quad Sheets, these network facilities were added.

The entire network that was thus developed was then thoroughly reviewed and checked for correctness and appropriate connectivity. Proper connectivity was established across links of the network so that intersections, interchanges, and turning restrictions can be accurately modeled. Dynamic segmentation based on traffic breaks offered a convenient point of departure for defining nodes and links. Then, each and every node and link was checked for correctness and proper connectivity to other links in the network. Nodes were added, deleted, or shifted in order to impart integrity to the network.

The above process is not envisioned to be a one-time effort. The process is dynamic as it will involve constant updates to the network. As the state basemap is continually updated by the Transportation Statistics office and local/regional model networks are continually refined by local agencies, the statewide model network will have to be continually enhanced as well. In addition to the issue of having to develop a dynamic updating process, there is also the issue of how best network edits and changes can be done. As the statewide model network is being developed from the perspective of the state basemap and RCI data, the network editing process may become more complex and may not be consistent with the FSUTMS network editing and modification process. Then, the distances and travel times obtained through an edit of the statewide model network may not be consistent with those that would have been obtained had the network been edited within a FSUTMS environment.

There are many new tools that make network editing and modification convenient, user-friendly, and accurate. GIS-TM, VIPER, and GIS environments (notably, ArcView) offer the capability of editing and modifying networks while preserving the integrity of the network and its link and node attributes. In developing the statewide model network, the project team has provided a set of procedures for network editing and modification.

The project team also subjected the statewide model network to a number of reasonableness checks. For example, the paths, travel times, and distances obtained from the new statewide model network were compared against those obtained from the 1990 Statewide Model network and the 2000 E+C Statewide Model network.

The statewide model network includes a host of attributes derived from the RCI data and the local/regional model network data. Several RCI data elements were used to define segments (breaks) in the state basemap network. Examples of such elements are noted in bold among the list of network attributes (provided below) that were included.

1. Beginning and ending mile posts
2. **Segment ID/US Road/County Road/Route/Section Identifiers**
3. **Functional class**
4. Area type
    a. **RCI area type**
    b. Local/regional model area type
5. Facility type
    a. **RCI facility type**
    b. Local/regional model facility type
6. All RCI variables/events, e.g.,
    a. **AADT**
    b. **Number of lanes**
    c. **Speed, both posted and free flow**
7. Capacity
    a. FIHS decision support system capacity (policy capacity)
    b. Model capacity
8. CONFAC
9. Traffic stream factors (K, D, T)

10. Seasonal factor
11. Tolls by vehicle class (auto, truck)
12. Lane and road use restrictions
13. All local/regional model network variables/events

By including all of the RCI variables, local/regional model variables, freight model network variables, and FIHS decision support system variables, the statewide model network is envisioned to be comprehensive and supportive of a host of statewide and local/regional planning applications.

Figure 1 provides a broad overview of the network development process.

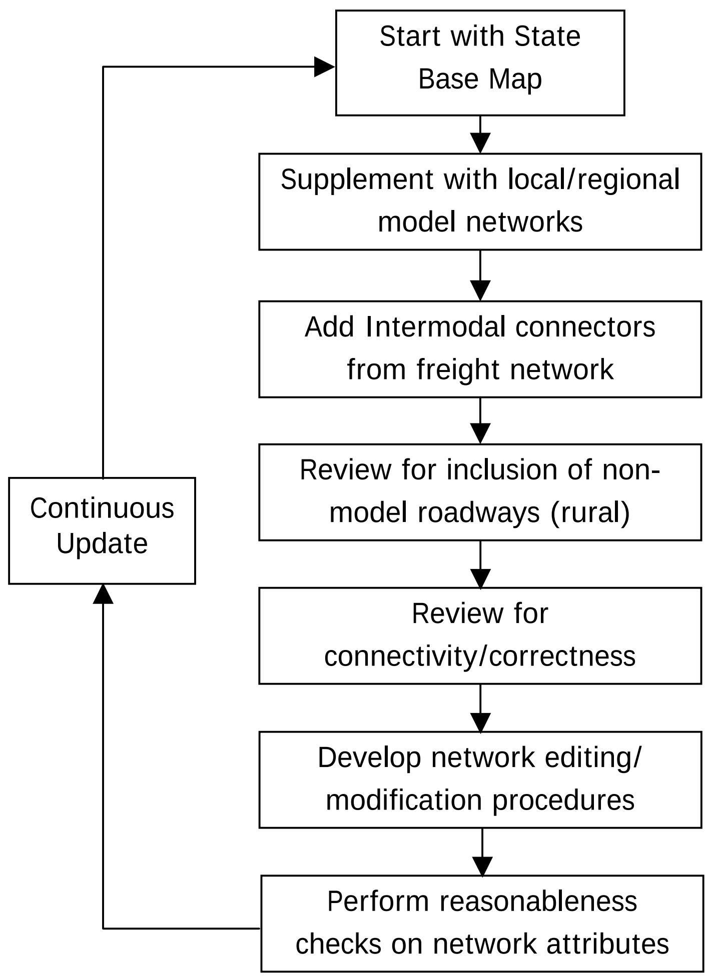

Figure 1. Statewide Model Network Development Process

ZONE STRUCTURE DEVELOPMENT

The zone structure used for the statewide model must support the modeling of both auto and truck traffic traveling on the states tourist and trade routes. At the same time, however, the zonal structure must also be refined and detailed enough to model the distribution and assignment of these trips on local road networks.

The 1990 statewide model contained a zone system of 540 TAZs. Previous experience validating the 1990 statewide model and applying the model for future year forecasts showed this to be an inadequate zone structure for achieving desired levels of model validation accuracy and resulted in "lumpy" traffic assignments. With a small supply of TAZs and centroid connectors, too many trips were loading on to the network in too few locations. A recommendation was made to increase the number of zones to approximately 2,500 TAZs.

An initial recommendation for a revised TAZ system was to use census tracts to define zones for the new statewide model since the state of Florida contains approximately 2,500 census tracts. A first cut review of the census tracts indicated that urbanized areas contain the greatest number of census tracts and seem to benefit the most from the use of census tracts as the basis for TAZ designations. Validation of network links in urbanized areas, however, is not a focal point of the statewide model development effort as more detailed and validated local/regional FSUTMS models already exist in these areas.

Conversely, the areas that need additional zones most for model validation are rural in nature, and the census tract-based TAZs in these areas are even larger than the original statewide model rural zones, which were based on census enumeration districts. Therefore, use of census tracts for TAZ boundaries did not provide the added zones in the places where they were needed most for enhanced model validity. As an example, Jefferson County and Wakulla County consist of four zones each in the 1990 statewide model but contain only two census tracts each. If census tracts were synonymous with TAZs, each of these two counties would then have 50 percent less zones than the 1990 model. It had already been established from previous model validation and application efforts using the statewide model that the 1990 rural zone system was inadequate. Reducing the number of zones in rural areas is not going to improve model validity.

While census tracts provided a good starting point for a revised TAZ system and, in fact, provided a satisfactory zone structure in urbanized sections of the model, it became clear that additional effort and refinement was required in defining TAZs for rural areas. Census 2000 Block Groups, TIGER 2000 files, urban/regional model TAZs, and street networks were used to identify potential zone splits in locations where census tracts do not provide for enough statewide TAZs. TIGER 2000 coverages were stitched together for each FDOT District area to evaluate the splitting of census tracts into smaller TAZs as well as aggregation of tracts in other instances.

One concern over using census tracts to define TAZs is the fact that census tract boundaries do not always follow major highway corridors and often include heterogeneous land uses. Standard practice in establishing TAZs includes the use of major streets and highways as zone boundaries and the separation of heterogeneous land uses into different TAZs. Furthermore, census tracts often form irregular and elongated polygons. Standard practice generally recommends against irregular and elongated TAZs as this impacts the loading of trips on to a highway network. Once again, the use of census block groups and urban/regional TAZs as a mechanism for refining tract-based TAZ definitions was recommended. In addition, approximately 60 special generator TAZs were introduced for generation of truck trips at airports, ports, truck terminals, and rail yards. The entire process resulted in a new zonal system for the statewide model with approximately 3500 zones.

Closely related to the establishment of a TAZ system was the addition of zone centroids and centroid connectors to the highway network. The 1990 statewide model centroid connectors were initially added using a computerized routine; however, during validation of the statewide model, it was determined that most of these computer-generated connectors failed to reflect actual loading points based on established development and access patterns on roadways near the TAZs. In some cases, centroid connectors crossed water bodies since there was no sort of barrier file included in the program execution. Centroid connectors were reevaluated and modified as necessary at the start of model validation.

The concept of using a similar program to define initial placement of centroids and connectors was therefore considered only as a starting point. Each zone centroid was evaluated individually by one or more members of the model development technical team for proper placement based on local knowledge of land use patterns. Likewise, centroid connectors were evaluated on an individual basis considering roadway accessibility. The program used to set the initial centroids and connectors was constructed so as to prohibit the placement of centroid connectors on limited access facilities and at existing roadway intersections. The program also accounted for physical barriers to zonal access such as rivers, bays, and rail corridors. A preliminary set of centroids and connectors were coded based on these criteria. In this stage, centroid connectors were connected to highway links at traffic break locations, wherever feasible.

Once a preliminary set of centroids and connectors were coded, the project team reviewed the results in consultation with FDOT district staff to reflect local knowledge and experience with validating travel demand models. TIGER 2000 files and USGS quad sheets were used during the review process. Any necessary changes and adjustments deemed appropriate were implemented. Centroid locations and centroid connectors were evaluated on an iterative basis throughout the model validation process to ensure proper loading of trips on to the highway network.

The database approach to model network development had to incorporate the addition of centroid connectors. Unlike highway links in the FIHS decision support system database, where beginning and ending milepost information is available, link distances for centroid connectors have to be calculated through use of some other process similar to the FSUTMS NETPRO program. Also, the

FIHS decision support system database had to be segmented to allow for centroid connectors to tie in with the highway network at specific locations. During model validation, this required additional breaking of FIHS decision support system segments to accommodate the need for accurate model replication of ground counts through model simulation.

Figure 2 provides a schematic depicting the zone development process.

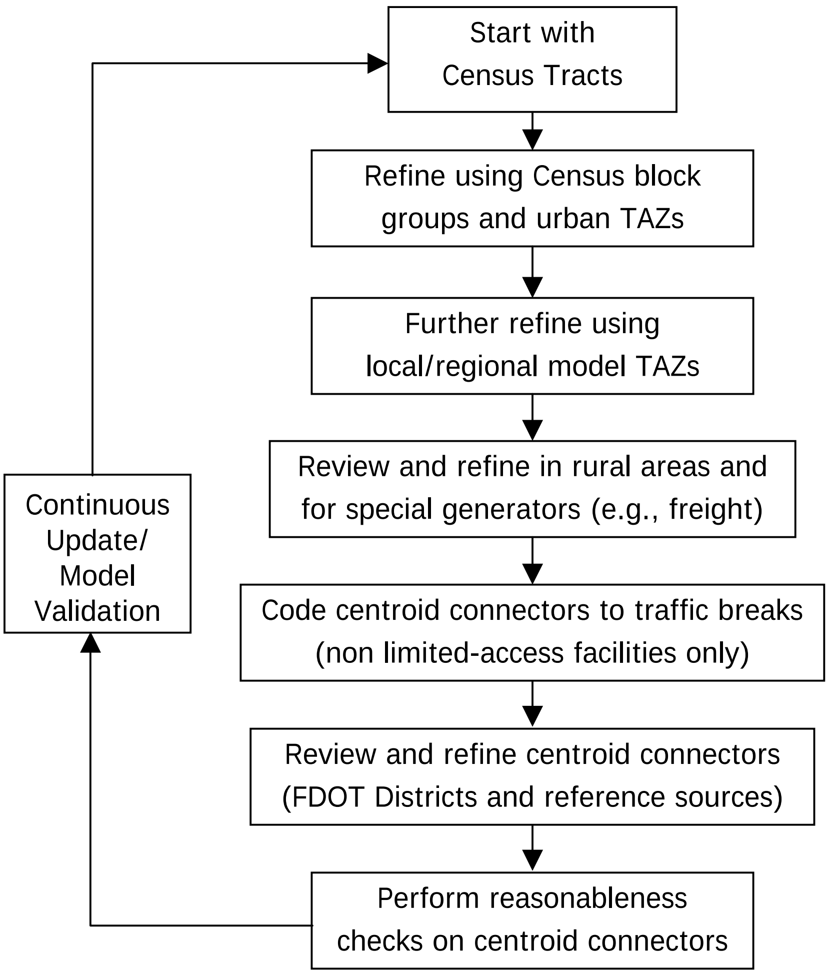

Figure 2. Statewide Model Zone Structure Development Process

In summary, in generating the new statewide model zone structure, the project team strived to maintain consistency with three levels of geography:

- Data geography: Census block, block group, and tract boundaries
- Political geography: District, city, county, metropolitan area boundaries
- Regional model TAZ geography: Local/regional model TAZ boundaries

For purposes of model development, the Year 2000 was adopted as the “Base Year”.

EXTERNAL TRAVEL DEMAND

External travel demand for the statewide model is comprised of trips with one or both trip ends being located outside the state of Florida. The statewide freight model will provide information to estimate truck travel into and out of the state. However, with respect to auto trips, national travel surveys and other sources of data do not provide sufficient specific data to determine the origin and destination patterns of travel into and out of the state. This particular step of the modeling process may be refined further as more detailed data become available in the future.

External zones were established for each state highway crossing at the state line as well as "dummy" external zones for planned facilities such as the I-10/I-65 connector, the Dothan-Panama City corridor, and the Valdosta-Madison corridor. The 1990 external zone system for the statewide model was a good starting point as most of the external roadways that should be in the new statewide model were already in the 1990 model.

The approach used in the 1990 statewide model for simulating external trip movements was based on an early 1990s Statewide Origin-Destination (O/D) Survey. The geocoded trips were input to a TRANPLAN BUILD TRIP TABLE format with origin zone, destination zone, number of trips, and expansion factors. During validation of the 1990 statewide model, it was determined that there were geocoding errors in the O/D database that caused illogical travel movements to be simulated in the model. While the original database does exist in some form, it was not recommended that this same approach be used to distribute external trips in the updated statewide model.

Instead, it was recommended that a more typical FSUTMS approach be used to distribute external trips. First, base year traffic counts were compiled for external zone locations to establish a control total for external trips at each location. Next, an estimate was made of the internal-external (I-E)/external-external (E-E) split at each external zone. In addition to the previously mentioned O/D survey, travel characteristics information has been collected along I-95, US 1, and US 319 at the state line. The project team obtained data from the FIHS planning group in FDOT Central Office to help identify an I-E/E-E split.

It was felt that the number of E-E trips is fairly small as the state of Florida is not a major location for multi-state through trips. There are a small number of trips originating in South Georgia and Alabama that use I-10 as a travel route for trips destined for South Georgia and Alabama. In addition, there are some trips that begin or end on I-10 outside Florida and travel to the I-95 state line crossing. As sufficient survey data was not available to ascertain the I-E/E-E split, estimates were made based on local knowledge and the importance of each facility and adjusted during model validation. Once an I-E/E-E split was determined, a simple E-E trip table was estimated with the number of E-E trips between pairs of external zones. A Fratar model was then used to scale the table to match the E-E portion of the traffic counts at the external stations. The Fratar model was also used for obtaining future year estimates.

I-E trips were divided into categories of routine and occasional based on the proximity of external zones to urbanized areas. Routine trips would occur primarily along external zones near Jacksonville, Tallahassee, Pensacola, Valdosta (Georgia), and Dothan (Alabama). These routine trips would constitute work, school, and shop-oriented trips that occur on a regular basis. Conversely, the occasional trips are more vacation-oriented trips where people are traveling to Florida to visit tourist attractions, family, or friends. The reason for separating I-E trips into these components within the Statewide Model is that trip lengths will be notably longer for the occasional trips than for the routine trips.

As in the case of I-I trips, a gravity model was used to distribute I-E trips. As expected, the I-E trips followed the FSUTMS paradigm, with all productions at the Alabama and Georgia State line, and all attractions at the internal zones. Different friction factors and power/gamma functions were developed for the two I-E trip components. K-factors were needed to direct the linkages between certain external zones and select urbanized areas based on an evaluation of trip table origins and destinations and application of logic/local knowledge.

Another consideration was to lump the I-E trip ends with the I-I trip ends, and distribute them to internal zones as well as external zones. This is the practice, for example, in the District 4 urban models. In this way, for any impedance-based distribution method, a Miami trip would be less likely to end out-of-state than one from Jacksonville. Under this scheme, the I-E trip purpose would disappear.

Using this approach, the I-E trip productions and attractions at internal zones would be accounted for within the internal trip generation. It is reasonable to believe that identical businesses and residences would generate the same number of trips regardless of their location in the state. If, as noted above, I-E productions and attractions were partitioned into local and long-distance trip ends, then the I-E trips would be a subset of the long-distance trip ends. On the out-of-state end of the trips, it would be necessary to estimate the number of I-E trip productions and attractions, by internal trip purpose, at each external station. Special friction factors would not be required because the trips would be distributed as part of the I-I model. During calibration it might be necessary to adjust the length of the external centroid connector to achieve proper distribution. The new statewide model provides options to implement both of these methods for external travel modeling.

As noted earlier in this section, a separate truck trip table for external trips was developed as part of the Florida Statewide Highway Freight Model development effort. These truck trips are subtracted from the I-E and E-E trips in order to properly match ground counts taken at the state line.

TRIP GENERATION

The statewide highway freight model provides methodologies and data for long-distance truck trip generation. The statewide model shoulders the responsibility of generating auto trips for the entire state. Over the last 10 to 15 years, FSUTMS trip generation models around Florida have been customized to meet the travel forecasting needs of local planning agencies. Many of these local adaptations of FSUTMS resulted in creative and technically sound enhancements to the FSUTMS trip generation step that have been adopted in whole or part in various areas around the state. A well-known example of such an enhancement includes the adoption of life-style considerations in trip generation cross-classification matrices. These enhancements have made trip generation models more reliable and useful to local decision makers.

While these enhancements have proven valuable to local planners, they provided challenges to the development of a statewide trip generation model that has a goal of consistency with local/regional models. Local/regional models have developed trip generation methods to better reflect local socio-economic and travel conditions. The following is an illustrative list of large area models that have trip generation methods that are substantially different from those in the standard FSUTMS trip generation software:

- *Orlando Urban Area Model*: This model uses the standard FSUTMS trip generation methods; however it includes specialized calculations for Disney and Airport trip purposes.
- *Southeast Florida Lifestyle Trip Generation Model*: This model is a three-way cross-classification model to determine trip productions based on lifestyle factors. It also includes a special school trip purpose model. Truck trips have been put into their own categories separate from taxi trips (which are now part of the non home-based trip purpose). Traditional E-I trips are treated as part of the internal trip purposes. It should be noted that the trip attraction model is expected to be substantially revised in the near future.
- *District 1 FIHS Planning Model*: This model includes separate calculations for seasonal residents and Airport trips.
- *Tampa Bay Regional Planning Model*: This model uses a two-way cross-classification method to determine household trip productions based on lifestyle. Traditional E-I trips are disaggregated into occasional and routine E-I trips. This approach is somewhat of a hybrid between the traditional FSUTMS E-I method and the Southeast Florida method. It should be noted that the trip attraction model is expected to be substantially revised in the near future. New trip purposes are also expected to be introduced into the model in the next few months.

The solution to the different trip generation methodologies and their input data requirements was to run the trip generation model for each local/regional model and adopt the productions and attractions that are produced by each model. The productions and attractions generated by the local/regional models are then aggregated using special routines to the statewide model zone geography. This approach both simplified and expedited the software development process. Whenever the local/regional trip generation methodology or data is updated, minimal changes will be necessary to update the statewide model. This approach ensures that the statewide model is always consistent with the latest adopted trip generation models. Thus, for areas in the state that fall within the coverage of local/regional models, productions and attractions are obtained from the local/regional models.

Within the new statewide model, the standard FSUTMS model trip purpose classification scheme was adopted for local trips:

- Home-based-work (HBW)
- Home-based-shopping (HBSH)
- Home-based-social/recreational (HBSR)
- Home-based-other (HBO)
- Non-home-based (NHB)
- E-I
- E-E
- Truck
- Taxi

Wherever deviations from the standard FSUTMS trip purpose classification scheme occured, aggregation to the above set of standard trip purposes was accomplished using the same routines that aggregate productions and attractions to statewide model zones. For example, the home-based-school trips generated in the District 4 model were folded into the home-based-other trip purpose. The approach of combining trip purposes to a set of standard trip purposes satisfies the need of the statewide model to be consistent with the local models, yet maintain consistency with the total trips produced by the local models. As part of the model validation process, the definition of trip purposes was evaluated to ensure that the number of trip purposes used in the statewide model was consistent with the needs of the subsequent trip distribution and mode choice model steps.

There were several issues, however, in moving from urban/regional models to a statewide model that merit discussion within the context of the trip generation step. They are briefly summarized in the following paragraphs.

In addition to local trips, there are longer distance trips that are of importance to the statewide model. These types of trips can be classified into one of the following three groups:

- Intercity/intrastate business travel

- Intercity/intrastate personal travel by residents for recreational or personal purposes
- Intercity/intrastate travel by tourists for recreational purposes

Intercity/intrastate trips are often not explicitly calculated by local travel models as a distinct trip purpose. To estimate the number and characteristics of these trips, data from the American Travel Survey (ATS 1995) was reviewed. As the ATS data support the distinction of these trip purposes, separate trip generation, distribution, and mode choice for long-distance trips permitted a greater level of accuracy for these travel estimates.

The next issue involved the interface with the statewide intermodal highway freight model. This model produces truck trip tables by commodity group. It is necessary to make sure that these trips are not "double-counted." The truck trips from the freight model have to be removed from the truck and taxi productions and attractions produced by some urban/regional models, and the truck productions and attractions produced by others. This is somewhat complicated, as the statewide freight model does not estimate local service and delivery truck trips. Furthermore, the taxi portion from the models with the truck and taxi purpose have to be preserved. Several urban/regional models with truck (not truck and taxi) purposes have moved the taxi trips to the NHB purpose; for these models, taxi trips are not of any concern, but the local delivery trip portion of the model has to be preserved.

The third issue is related to the treatment of the urban/regional E-I trips, most of which are I-I trips in the statewide model. Only the E-I trips from the urban/regional models with one and only one trip end outside of Florida are E-I trips in the statewide model. There are two general cases. The standard FSUTMS practice is to produce all E-I trips at the external stations and attract all of them to internal zones. For these models, the external productions have to be accounted for in the productions in statewide zones outside of the urban/regional model zones. Similarly, the E-I attractions must be accounted for in the other internal trip attractions in the statewide model.

Other urban/regional models include E-I productions and attractions in the internal trip generation, and the "pairs" for these productions and attractions are generated at the external stations. In these models, productions and attractions for each internal trip purpose are specified for each external station. For TAZs covered by these models, the E-I productions and attractions at the external stations have to be accounted for by the internal productions and attractions calculated for TAZs outside the area covered by each of these urban models. For the models using the standard FSUTMS method, internal productions and attractions have to be increased, perhaps surcharged, to account for the E-I trips that become statewide I-I trips. Furthermore, because the method for handling E-I trips varies by urban area, the surcharge method in the statewide model varies by urban area – for example, the surcharge is applied only for the areas using the standard

FSUTMS method. Some special treatment might be required for zones near the Alabama and Georgia state line.

The fourth issue is the treatment of E-E trips in the urban/regional models, most of which are I-I trips in the statewide model. The productions and attractions from all of the urban/regional models have to be surcharged to account for these trips. Again, special adjustments during the validation process was required for zones near the Alabama and Georgia state line.

Trip Generation for Rural and Non-Model Areas

While the procedures described previously adequately addressed trip generation for urban areas and areas covered by a local/regional model, they did not address trip generation modeling for rural areas and areas not covered within local/regional model boundaries. In the previous statewide model, the standard FSUTMS trip rates that were used for urban areas were also adopted for rural areas.

For the new statewide model, several options were considered for generating trip productions for rural and non-model areas. These options included:

- *Standard FSUTMS Trip Rates*: As was done in the previous version of the statewide model, standard FSUTMS trip rates (default trip production rates) could be used. Within this option, a dual structure could be adopted where separate trip rates are used for permanent and seasonal/temporary residents (similar to District 1 model).
- *Lifestyle Trip Generation Model*: District 4 and District 7 have adopted new lifestyle-based trip generation models that account for differences in socio-economic characteristics and activity patterns of different types of households. One of these models could be used for rural area trip production estimation.
- *Updated NCHRP Trip Rates*: Recently, the NCHRP report that provides standard trip rates (QRS trip rates) has been updated. The updated trip rates from that report could be adopted.

The lifestyle trip generation model was preferred because research conducted in conjunction with the development of the Tampa Bay Regional Planning Model showed that lifestyle variables are able to account for the explained variation in trip production rates between urban and rural areas. Then, the lifestyle based trip generation rates could also be applied in rural areas. This finding was explored further before a final determination was made with regard to the trip production methodology for rural and non-model areas in the state.

In order to obtain trip attractions for rural and non-model areas, there was a critical need to obtain good quality employment data. In line with the needs of the statewide intermodal highway freight model, it was considered ideal to obtain employment data for rural and non-model areas at the level of the 2-digit SIC code. Such employment data could then be rolled up (aggregated) into the three standard FSUTMS employment categories (industrial, commercial, and service) to apply FSUTMS trip attraction equations.

Employment data for areas not covered by urban/regional/local models was obtained from several sources including InfoUSA and Florida Statistical Abstract, 2000. The project team explored the costs and implications of purchasing detailed employment data for the entire state. In addition, there were several recent surveys in the state that provided additional information for developing appropriate sets of trip attraction equations for rural areas in the new statewide model. The Northeast Florida Travel Characteristics Survey, for example, provided rural trip generation rates that could be used in the new statewide model. The project team also explored the availability of other data sets that could be used to model rural travel patterns. The project team also sought input from FDOT District staff (in particular, Districts 2 and 3) with regard to the rural trip generation methodology.

Within the context of trip generation, the project team worked with the statewide intermodal highway freight model team to designate special generator zones (intermodal freight facilities, for example). These are facilities (zones) of special statewide significance even though they may not have been designated as special generator zones in the local/regional models. Trip rates for such special facilities were developed in conjunction with the statewide intermodal highway freight model development effort.

At the end of the trip generation step, one obtains person trips. As the statewide model is exclusively a vehicle-based model, it was considered appealing to convert person trips to vehicle trips at this step rather than waiting until the mode step. In this way, vehicle trips would get distributed as opposed to person trips. When the statewide model is enhanced to become a multimodal model, then a minor program modification would make it possible to move the person trips-to-vehicle trips conversion process back to the modal split step. The new statewide model applies vehicle occupancy factors by purpose and by area to the person trips to convert person productions and attractions to vehicle productions and attractions.

TRIP DISTRIBUTION

The trip distribution modeling methodology is very closely related to the trip generation modeling approach proposed for the new statewide model. Most urban models use a gravity model to distribute internal-internal (I-I) trips and external-internal/internal-external (E-I) trips. The gravity model pairs the productions and attractions calculated in the trip generation model, and creates trips. The number of trips between two zones is proportional to the product of their productions and attractions, and inversely proportional to some measure of their spatial separation. A Fratar model is used to distribute external-external (E-E) trips. A Fratar model is a type of growth factor model. The previous statewide model used these same models for trip distribution. A similar set of procedures was adopted in the new statewide model. While alternative trip distribution methodologies were explored (e.g., destination choice model, intervening opportunities model, entropy maximization model), the exploration and potential implementation of such alternative methodologies was beyond the scope of this statewide model development effort. Moreover, the desire to maintain consistency between the statewide model and local/regional models and between the statewide model and statewide intermodal highway freight model called for the adoption of the gravity model approach.

In applying the gravity model approach to distribute statewide I-I trips, there were several issues that warranted further examination. They may be summarized as follows:

- The statewide model deals with possible trip times and distances that are much longer than those encountered in the urban/regional models. Indeed, trips with long trip lengths are those the statewide model is most interested in. The previous statewide model scaled trip lengths down by a factor of ten. It is believed that this is not necessary. This will be verified.

- In the previous statewide model, a computer program was used to develop the friction factors "on the fly" using a function. This was done in part because of the scaling of the travel times. Another advantage of using a function to develop friction factors was that it made it easy to change the shape and characteristics of the curve. Even though travel times are not scaled in the new statewide model, eliminating one reason for using a function, it may still be useful to use a function. TRANPLAN's gravity model now includes a deterrence function ($FF=e^{-ut}$, where t is travel time and u is a calibration constant) for generating friction factors. Using a deterrence function instead of friction factors would allow the use of a continuous function to represent the spatial separation of TAZs. The possible advantages of using a deterrence function were investigated.

- There is little information on the trip length frequency distribution for statewide (long distance) trips. The 1995 American Travel Survey data was used to develop friction factors and a deterrence function.

- The previous statewide model used K-factors to control, for each urban area, the number of trips that remained within an urbanized area versus those that crossed the urban area boundary. K-factors were estimated using a screenline comparison at each urban area cordon line. While this procedure worked, it was felt that there may be a better way of accomplishing this control. One way is to partition the productions and attractions into local and long-distance trips. Then, each could be distributed using different distribution functions (deterrence curves or friction factors). The challenge in this approach is to develop a method for partitioning the trip ends. Two methods were considered: the American Travel Survey data, and the number of E-I and E-E trips used in each urban/regional model. It was noted that for a large urban area, say the Southeast Regional Model region, a larger percentage of the trips might stay within the region, as compared to a smaller and more isolated area such as Gainesville. Also, K-factors might be needed to account for other distribution issues other than the urban area screenlines.

Another issue is the procedure of balancing trip attractions. While the gravity model balances attractions to productions, most urban trip generation models balance attractions to productions before trip distribution. However, there are additional considerations in a statewide model. For some trip purposes, for example home-based work (HBW), a given urban area might produce more trips than it attracts. This was found to be the case within the Southeast Regional Planning Model, where more HBW trips produced in Broward County go to Miami-Dade County than Miami-Dade County HBW productions go to Broward County. If the attractions are balanced within each county, there is a deficiency of HBW trips at the Dade/Broward line. In other words, Miami-Dade County has more jobs than workers, while Broward County has more workers than jobs. Thus, the regional model does not balance trips within the counties. The other side of this issue is the market balancing process used in the Tampa Bay Regional Model. This process attempts to keep certain trips within market areas. The development of the statewide model considered whether to use balanced or unbalanced attractions from the urban/regional models and whether market balancing is appropriate. In the new statewide model, the calibration process has been programmed to implement the appropriate market balancing methodology.

Trucks

Statewide truck trip tables are provided by the statewide intermodal highway freight model and included in the overall statewide model. As noted earlier, trip purposes are reconciled in the new statewide model to ensure that truck trips are not double-counted.

MODAL SPLIT

The statewide model deals exclusively with the simulation of vehicle trips on a statewide basis. As such, it is not a multimodal model at this time and does not include a formal modal split model. As HOV facilities are all within the boundaries of local/regional models and are restricted only during certain times of the day, HOV modeling is abrogated to the local/regional models that have far greater detail than the statewide model.

Within the context of this effort, it is planned to keep auto occupancy factors by purpose and by area available at this step in the model so that the conversion from person trips to vehicle trips can be undertaken at this stage of the modeling process, if the analyst so desires. This will also facilitate enhancing the model in the future to accommodate multimodal systems. The project team explored recent travel survey data sets to obtain auto occupancy factors applicable to rural areas (not covered by existing local/regional models).

TRAFFIC ASSIGNMENT

Currently, all Florida local/regional models use TRANPLAN's iterative equilibrium assignment method and this procedure has been adopted for the new statewide model as well.

Preloading Trucks Versus Multi-Class Assignments

Some urban and regional models preload truck trips. Similarly, it was considered advantageous in the statewide model to preload truck and other long-distance trips. The rationale is that trucks and other long-distance trips plan their trips and are not likely to be sensitive to congested conditions on portions of their long trip. Furthermore, alternative routes may be less familiar to long-distance travelers than for short-distance travelers who may be making trips on a more frequent basis. Therefore, it is expected that long-distance trips would be more likely to adhere to the shortest route. To model this travel behavior, trucks and other long-distance trips would be loaded on the free-flow shortest time paths. These loads would become a preload for the iterative equilibrium assignment of all other trips. Given the earlier discussion of partitioning the trip tables into local and long-distance trips, long-distance trips may be the trips from the long-distance part of the trip table. Alternatively, if it is decided not to partition the trip tables, trips could be designated local or long distance in the assignment process by examining the travel time or distance for each trip interchange. The point of demarcation between local/short and long-distance trips is a calibration variable.

While many modelers preload truck trips, there is another option available in the new statewide model, i.e., the multi-class assignment. Multi-class assignments are most often used to allow simultaneous loading of carpools and single-occupant vehicles, while restricting the use of carpool lanes to carpools. This same technique could be used to perform a simultaneous loading of cars and trucks, while prohibiting trucks from certain facilities. A major disadvantage of the multi-class assignment is that it does not necessarily load trucks on the shortest free-flow time path. However, it would allow for the development of selected link assignments, which cannot be done accurately with the preload procedures.

Other issues related to trip assignment include the use of passenger car equivalents (PCEs), the specification of the speed/capacity table, VFACTORS, treatment of high-occupancy vehicles, and toll assignment procedures. They are briefly discussed below.

Passenger Car Equivalents

In the traffic stream, large trucks are equivalent to more than one car. This is especially true in hilly terrain and on roads with interrupted flow. PCE factors are listed in the *Highway Capacity Manual*. While it was considered potentially useful to use PCE factors for trucks in the statewide model, the reason not to use them is that traffic counts are usually stated in vehicles, not PCEs. Nevertheless, assignment scripts with and without PCEs have been developed and incorporated into the new statewide model.

Speed/Capacity Table

A single statewide speed/capacity table is used in the model. This table is compatible with the designation of area types and facility types for the statewide model. As an initial point of departure, the default FSUTMS speed-capacity table (that is consistent with the 2000 LOS Handbook) was used. Adjustments were made to the table during model validation.

The definitions of area and facility type variables in the highway network is an important issue in this context. A single statewide convention had to be adopted for the statewide model. This is because, in practice, there is little consistency in the coding of area and facility types among the urban areas. The Roadway Characteristics Inventory (RCI) provided a consistent method for classifying the area types and facility types of each roadway in the network. Furthermore, it was considered desirable to determine the area type from zonal data or another similar data source, so that the area type variable would change automatically in the network when the character of an area changes over time. Procedures have been developed for implementation in GIS programs such as Viper and ArcView that provide tools for transferring area type codes, which are usually a polygon attribute, to links. Similarly, GIS programs have been included to transfer area type from an urban or regional network to polygons (zones) and then to the links of the new statewide model highway network.

VFACTOR Parameters

In FSUTMS, the VFACTORS file defines, by facility type, the UROAD factor, CONFAC, and the volume/delay function. The UROAD factor converts the input LOS E capacities used by the model to the "practical capacity" values used in the BPR volume/delay function. CONFAC is used to convert between hourly capacities and daily model volumes. The volume/delay function determines the increase in travel time that occurs with increasing congestion. All of these values are calibration variables. A good starting point for the statewide model was FSUTMS default values, adjusted as necessary to fit the statewide area and facility type definitions.

The possibility of applying different values of CONFAC for each urban area was considered, as the existing level of congestion is not the same in all urban areas. The need for this is illustrated by comparing congestion levels in South Florida to those in the panhandle. Spreading of the peak is much more likely in South Florida, and this travel behavior is accounted for in CONFAC. The current equilibrium model program specifies values of CONFAC by area type or geographic location using a relatively simple change within the program.

Special Use Lanes

Intermodal uses of the highway system (buses, carpool, vanpool, special truck facilities, etc.) form the fundamental driving force for providing "special use lanes". From a theoretical standpoint, the statewide model should be able to accommodate the planning and modeling needs associated with such facilities and uses. However, it was recommended that high-occupancy vehicle (HOV) facilities not be modeled in the statewide model. The primary reason for this is that the urban and regional models provide much better tools for analyzing HOV lanes because they are more detailed. Furthermore, all HOV lanes are within urbanized areas. Finally, a daily model, such as the statewide model, has great difficulty assessing the behavior of HOV lanes that are restricted only during certain hours of the day.

Toll Roads

Tolls collected from toll roads provide an alternative revenue stream for expanding highway capacity in the State of Florida. Modeling methods for toll roads are guided by the economic principles underlying toll operations and travelers willingness to pay. While most planning for toll roads is done using special models developed by the Turnpike District, the statewide model must also be able to handle toll roads in a reasonable fashion. Therefore, the toll facilities model used in many urban and regional models is also used in the statewide model. The ability to code separate toll links for autos and trucks was incorporated so that it would be possible to directly account for the differences in the value of time, and differences in tolls, for auto and trucks.

New models under development by the Turnpike District treat toll roads as a mode. In these models the choice of using a toll road or non-toll road is made at the mode choice step. At this time, the new statewide model models toll path choice within the traffic assignment stepl. However, future updates of the statewide model may explore the adoption of the Turnpike District approach for modeling toll path choice (i.e., within the mode choice step).