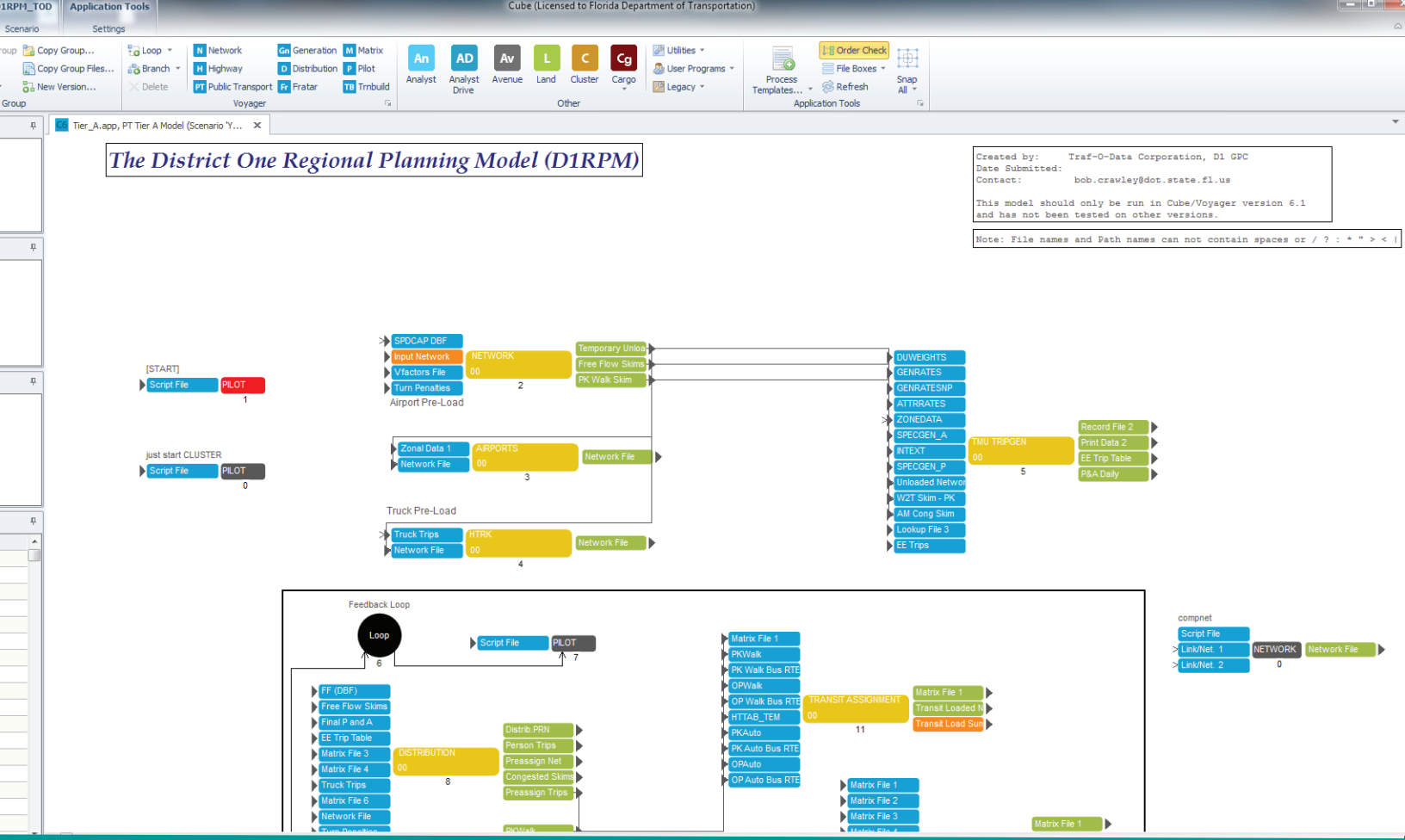


Transportation Modeling

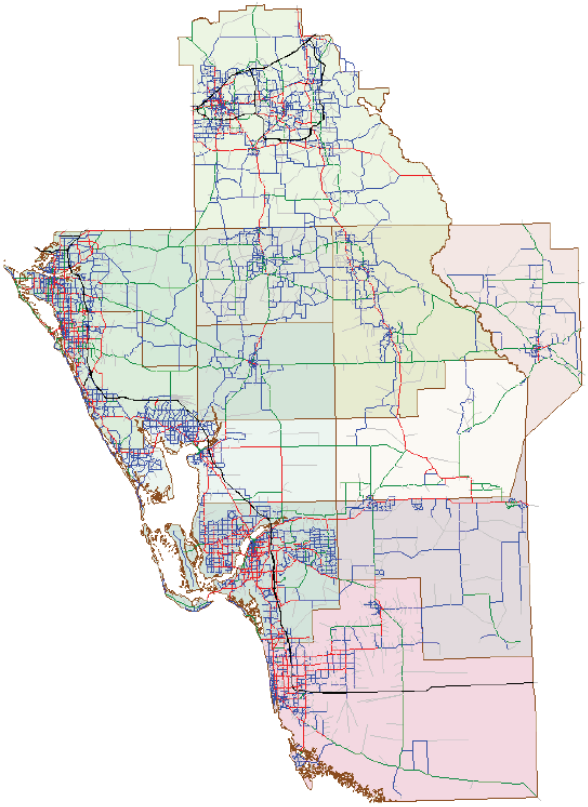
Transportation Modeling

Introduction

Prior to the formation of the HRTPO, transportation modeling in the 12 county region of southwest and central Florida in FDOT District One was accomplished utilizing individual county or MPO /TPO models. The previously existing MPO / TPO models were the single county Polk TPO model (which is also the "real" version of the rebranded statewide training model, "Olympus"), the Sarasota Manatee Charlotte (SMC) three county model, and the two county Lee Collier model. Transportation modeling on lengthy corridors (such as US 27, or SR 17) frequently required the development of multi county or and multi MPO / TPO models, these models sometimes being developed only for one specific purpose or task. Large developments such as Development of Regional Impact (DRI) or new massive Sector Plan developments required models that could track transportation impacts beyond the limits (size) of the traditional models.

Development of the District One Regional Planning Model

Regional travel demand models examine the mass movement of persons within a study area and are an integral part of transportation investment and management decisions. An obvious benefit to the use of larger regional transportation models is corridor planning, where the corridor may extend beyond the limits of a smaller (i.e. county or MPO / TPO) based model.

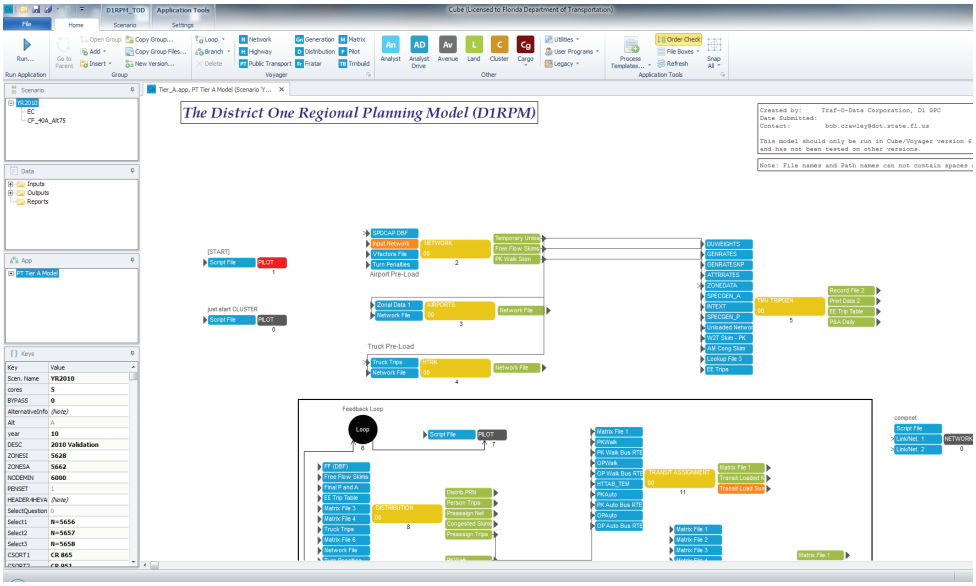


The D1RPM model network (under development)

The District One Regional Planning Model (D1RPM) model was developed by FDOT District One through their (GPC) Transportation Modeling Consultant Traf-O-Data, based upon pre-existing (rural county) models developed by the FDOT in the mid 2000's. FDOT District One produced "Long Range Transportation Needs Analysis Plans" (LRTNA) that included an updated Cube transportation models on behalf of the rural counties. It should be noted however, that Highlands County simultaneously conducted their own plan (Highlands County Long Range Transportation Plan, 2010), and produced an updated FSUTMS transportation model (subsequently updated to Cube by FDOT), separate from the FDOT LRTNP efforts.

Prior to the formation of the HRTPO, FDOT District One began the process of combining the 12 counties of the District into one single model, known as "stitching" the models together. In 2014, FDOT district one modeling staff developed this model joining the three large MPO / TPO models: the Polk TPO, the Sarasota-Manatee-Charlotte MPO, and the Lee-Collier MPO model, together with the 6 rural county models: Highlands (previously classified as rural), Hardee, DeSoto, Hendry, Glades, and Okeechobee. FDOT District One staff and District modeling GPC (General Planning Consultant) staff began this work in 2012 to develop what is now the over 6,000 Transportation Analysis Zone (TAZ) D1RPM, the largest FDOT districtwide model in the state of Florida (at the time).

The D1RPM is a "conventional" FSUTMS / Cube model, in that it follows the standard template issued by FDOT Central Office (CO) as a guide for Florida transportation modelers. The latest update to the standard model template is referred to as the Transit Model Update (TMU) released by FDOT CO in March 2010. The latest TMU update provides recommendations for modeling transit trips within the FSUTMS framework, though the name TMU could be potentially misleading, as it contains other items beyond those addressing only transit. This update was undertaken with the purpose of designing and implementing, within FSUTMS and associated support systems, the changes necessary to improve the preparation of transit demand forecasts to a point consistent with federal expectations, and simultaneously to incorporate other state of the practice techniques and tools.



Among the improvement procedures in the TMU, major new model features included:

- The incorporation of AutoCon functionality into CUBE 6.0 (FSUTMS previously initiated a call to a DOS program for this function),
- Transit market segmentation includes additional trip purposes HB (Home Based) School, HBCollege/ Univ, and splitting the single NHB (Non Home Based) into NHBW (Non Home Based Work) and NHBO (Non Home Based Other),
- Household segmentation - adding households by workers and households by income,
- Add auto sufficiency variable to distribution and mode choice,
- Marginal models to estimate households by income, workers, and size,
- Added an auto ownership model,
- HBW (Home Based Work) trip production model uses workers per household and auto ownership,
- New destination choice model with the size variable, replacing trip attraction model,
- Incorporation of special markets to include seasonal residents, visitors, external workers, and air passengers (previously modeled in District One in a custom DOS program called "Airtrips"),
- Incorporation of Time Of Day (TOD) stratification for distribution, mode choice and assignment. Peak and off-peak for distribution and mode choice, including 4 time periods for assignment,
- A feedback loop process involving distribution, mode choice and assignment,
- A walk market segmentation in mode choice, short and long,
- A more generalized and detailed nesting structure, includes local bus, express bus, urban rail and commuter rail modes.

There are also features not included in the TMU recommendations, but are included in the D1RPM model:

- A mode choice calibration feature is included.
- A special procedure for generating and distributing airport-oriented vehicle trips is included for Southwest Florida International Airport (RSW) and for Sarasota-Bradenton Airport (SRQ).
- Goods movement and freight truck trips are addressed by incorporating a matrix of 16 truck trip types taken from the Florida Statewide Model (v5124). It was noted that the statewide model contains many more procedures for estimating goods movement in the U.S and around the world, and also includes

seaports and airports.

- » A procedure for addressing changes in the unemployment rate has been included. This is because Florida's unemployment rate for 2010 of approximately 10.9 percent was much higher than Florida's historical long-term unemployment rate of about 5 percent, but there was no corresponding decrease in population or employment reflected in the model's socioeconomic data. The downturn in the economy did result in fewer vehicle trips in 2010, to which the model must be calibrated. However, if uncorrected, these trip rates would yield artificially low future year model volumes. A correction factor was needed. This downturn-upturn cycle may be confirmed by comparing traffic counts for the 2007-2010-2014 periods. It should be noted that the current unemployment rate has returned to nearly 2007 levels. Therefore, unemployment rates are included as KEY variables.
- » A procedure for addressing potential changes in roadway capacity and trip-making due to Autonomous Vehicles (AV) has been included in the D1RPM. Studies of AV operating characteristics and travel behavior conclude that: 1) roadway capacity will increase with closer vehicle spacing, and; 2) more trips will be made, with an increase in easy-access one-way trips in urban areas. These studies suggest traffic impacts beginning sometime during the 2030-2050 time-frame, depending on AV saturation levels. Therefore, an AV saturation rate-capacity lookup table has been included to a KEY variable.

It should be noted here that use of the above AV procedure is optional, to be determined by the user if it should be used.

Because of tremendous advances in computer technology, the D1RPM was developed with the expectation that this model could be used (edited / modified and run) on a standard, unmodified Cube 6 platform; and executed (run) on any standard or typical configuration Windows 7 multi core desktop or workstation PC. The D1RPM was developed in a Windows 7 environment, and forward compatibility with subsequent versions of Microsoft Windows is assumed, but not guaranteed. In the past additional modification to the input files were necessary when upgrading to new versions of the Windows operating system. It should be noted, that significant efforts to increase performance were undertaken to reduce the runtime (approximately 10 hours on a "fast" machine) of the model using the multi core processing capability originally introduced in Cube version 5 called "Cube Cluster". This program is able to utilize multiple physical processor cores (and also additional PCs linked through a network) in a PC to process distinct functions simultaneously, and reassemble the results in the process of running the model. Due to the intense nature of calculations made in the FSUTMS process, it was assumed that only multi core processor PC machines would be utilized for modeling purposes, and the Cube scripts are written only for multi core processors. Cube Cluster is not technically necessary however, as the Cube scripts could be modified to use only a single processing core. However, such an approach would not be practical, and would dramatically increase run times to unacceptable levels. Further, due to the current market penetration of multi core processors, the model has never been tested (run) on what is now considered to be an "obsolete" single core processor machine.

The D1RPM was used to test model network alternatives for the previously mentioned MPO / TPOs in District One. Through a cooperative agreement initiated collectively by the MPO / TPOs (at the time), the five MPO / TPOs contributed state planning funds (PL) proportionally to be utilized for D1RPM model development and the testing of seven individual network alternatives. In 2014 and 2015, FDOT District One GPC modeling staff conducted all D1RPM development and network modeling efforts on behalf of the previously mentioned MPOs through this agreement.

The HRTPO LRTP is due to FHWA approximately three months after the other MPO / TPO s in District One. This being said, the "final" D1RPM model and network will not be fully complete until the HRTPO "adopts" the model in late March 2016.

The D1RPM was assembled, and was a working development model, being used to test the aforementioned

network alternatives as the HRTPO was formed in April 2015. This was advantageous, as the three component model networks (2010 Base, 2018 E+C, 2040 Future) were completed and ready for quality control checking, and subsequent HRTPO network development by HRTPO modeling staff. HRTPO modeling staff was able to test future (2040) network configurations working toward the development of the final 2040 HRTPO network.

History Transportation Modeling in Florida

Transportation plays a key role in the economy of industrialized nations. In the United States, about 15 percent of the Gross Domestic Product is accounted for by the transportation sector. To find solutions for complex problems, transportation experts have traditionally used models for transportation planning, engineering, and management.

Transportation planners use the term 'models' extensively. This term is used to refer to a series of mathematical equations that are used to represent or mimic how choices are made when people travel. A transportation model thus simulates human travel choices. Travel demand modeling was first developed in the late 1950's as a means to assist in conducting highway planning. The increasing need to look at problems such as transit, land use issues, and air quality analysis resulted in adding various techniques to deal with these problems, thus modifying the modeling process. Furthermore, models are used to evaluate the impacts of new developments and of proposed alternative transportation solutions.

Computer models are used to substantially increase the size or scope of the area to be examined, as well as the number of alternative solutions that may be considered as solutions to be considered, thus increasing productivity and reducing the costs associated with these analyses. Transportation systems are very complex and, typically, large scale, so use of computer models is necessary in their study, design, analysis and evaluation.

The State of Florida has been a national leader in the development and application of transportation modeling since the 1970's, when transportation modeling was conducted on the mainframe computers of the era. As microcomputers were developed and desktop machines became available to users in the workplace, transportation model development in Florida shifted from the mainframe based Urban Transportation Planning System (UTPS) software, to a microcomputer version of the TRANPLAN based Florida Standard Urban Transportation Model Structure (FSUTMS). For more than 20 years, the TRANPLAN based program played a central role in engineering and planning activities in the state. In establishing a standard model and uniform modeling practices throughout the state, Florida has become a nationwide leader in the area of transportation modeling. Transportation models have evolved throughout the years and software packages have been developed to implement these models and address the needs of the transportation professionals, the tools and practices developed in this evolving process have become central for transportation planning in the state.

The Florida Model Task Force

The direction of modeling Statewide in Florida is set by a body of transportation experts known as the Florida Model Task Force (MTF). The MTF typically meets (in person) twice per calendar year, and holds numerous other meetings of the MTF leadership (Chairs), as well as various committees throughout the year in person, by phone, or video. The MTF establishes policy directions and procedural guidelines for transportation modeling in Florida for the FSUTMS. Voting members of the MTF consist of representatives from twenty-seven MPOs and TPOs, and the eight FDOT districts. In addition to these voting members, transportation professionals throughout the state of Florida participate in MTF discussions and technical committee activities as non-voting members.

The MTF ensures that the development of new modeling techniques follows a consistent and universal approach throughout the state of Florida. This universal approach entails encouragement of research and development

with periodic review of these new procedures to determine whether they should be incorporated into the FSUTMS. Maintaining a high level of production statewide during the model revision process is essential.

The MTF deliberates highly technical modeling issues and collectively adopts recommendations to be implemented in FSUTMS. The MTF is presided over by three Chairpersons ("Tri Chairs"), each chair being selected for their modeling expertise in the areas of MPO / TPO modeling, regional modeling, and (FDOT) district modeling. Each Tri Chair is elected by the voting members of the MTF by voice vote if there is only one candidate, or through suffrage of a secret ballot if there are more than one nominee for the open chair. The Tri Chairs are elected to serve a staggered five-year term, and there are no limits placed on consecutive terms of office.

As of the writing of this document, the current MTF Tri Chairs are:

- Wilson Fernandez (elected 2012), Transportation Systems Manager, Miami-Dade MPO
- Denise Bunnewith (elected 2014), Planning Director, North Florida Transportation Planning Organization
- Bob Crawley (elected 2015), Senior Transportation Planner, Heartland Regional Transportation Planning Organization

Evolution of The Florida Standard Urban Transportation Model Structure

The Florida Standard Urban Transportation Model Structure (FSUTMS) has evolved through this process from a MS DOS based TRANPLAN program, to the modern Windows Cube Voyager application developed by Citilabs, which is the current FSUTMS Model application.

FSUTMS was originally envisioned as an approach to standardize file structures, programs, trip purposes, and other model components to minimize the cost of mainframe model development and maintenance, as well as to provide a common modeling basis for interchange of models within the Florida modeling community. At that time, models were run on mainframe computers, and the primary function of transportation models was to support the Long Range Transportation Plan (LRTP) update process. The use of mainframe computers for modeling in Florida had virtually ended by the early 1990s, as the increasing computational power of PC based microcomputers had begun moving travel demand modeling to the desktop or workstation environment. With development funding support from the FDOT, FSUTMS (TRANPLAN) became a MS DOS PC based application, available to Florida's transportation planners statewide.

By the late 1980s, FSUTMS model development was rapidly shifting its focus from the mainframe Urban Transportation Planning System (UTPS) to the microcomputer version of TRANPLAN. Numerous enhancements to TRANPLAN (the software package developed by the Urban Analysis Group) were funded by FDOT in subsequent years to add important features to the software, and address a variety of transportation technology and policy issues.

It is interesting to note, that much of the code for TRANPLAN was ported to MS DOS for microcomputer use from the UNIX mainframe programming language FORTRAN (FORmula TRANslating System - today written as "Fortran"). Fortran is a general-purpose, imperative programming language that is especially suited to numeric computation and scientific computing. Originally developed by IBM in the 1950s for scientific and engineering applications, Fortran came to dominate this area of programming early on and has been in continuous use for over half a century in computationally intensive areas such as numerical weather prediction, finite element analysis, computational fluid dynamics, computational physics and computational chemistry. Today, it remains popular language in the area of high-performance computing, and is a language used for programs that benchmark and rank the world's fastest supercomputers. Modern Windows PC systems however, use contemporary programming languages, and FSUTMS evolved into the current Cube Voyager platform. In 2004 the MTF voted to migrate FSUTMS to the Cube Voyager platform.

As computer hardware and software technology rapidly evolved, the MTF recognized that travel demand modeling needed to move beyond the limitations of the MS DOS (and briefly IBM OS/2) operating system platform used by TRANPLAN. In selecting the Cube Voyager application to replace TRANPLAN, it was recognized that a number of elements intrinsic to FSUTMS and TRANPLAN would also need to be reevaluated. Old default model parameters and coefficients were revised. At the same time, model research and travel behavior surveys had been conducted in different areas of Florida. The implementation of a new software platform presented a timely opportunity to make changes to the model structure to reflect newly available research data as well as advances in software development.

Transportation Model Networks

In working with representations of any transportation network in a computer model, three networks are absolutely necessary, as well as critically important:

1. Base Year
2. Existing Plus Committed
3. Future (or Forecast) Year

While a model may include other networks or time periods such as interim year, design year, opening year, or other projections between the Base year and Forecast Year, the above three networks are essential (and basic) to all transportation modeling efforts.

It should be noted that FSUTMS is more than just a "highway only" model, it is able to model transit, freight, toll facilities, airports, seaports, etc. However, this discussion will address mainly the highway component of the FSUTMS model.

Base Year Model Network

The Base Year is the first stage in the development of a transportation model, it is the "anchor point" where the model is developed utilizing data (population, employment, network, traffic counts, etc.) from a known point in the past. In development of the District One Regional Planning Model (D1RPM), 2010 was used as a base year, and this year also had the tremendous benefit of being the year a decennial census was conducted by the United States Census Bureau. Census Bureau information may be considered the essential basis for transportation modeling, in that the data is considered the best and most accurate available. With the Socio Economic (SE) information on population, housing, and employment, FDOT District One modeling staff assembled the base year zonal data, formerly known as "ZDATA", now known as "ZONEDATA".

As 2010 (2010 meaning the entire year, not a specific day or month) was a specific period in time that data was available for the existing network and traffic counts, this information was inserted into the model as appropriate. When the model was then executed ("run") using the Base Year ZONEDATA, and the model was "tuned" or "calibrated" and "validated" to match the historical conditions in 2010.

The process of model calibration and validation is vital to producing defensible travel demand forecasts. Florida standards for model calibration and validation were initially defined as part of a series of studies in the early 1980s.

Model validation addresses several needs in transportation modeling, notably:

- It provides a level of comfort to modelers, planners, policy and decision-makers, and, to some extent, the general public that the model is able to produce accurate results.
- It provides evidence that model results are accurate enough to be used for planning analyses
- It accounts for errors in observed data used for comparisons.

For example, validation guidelines produced by the Federal Highway Administration (FHWA) in 1990 for percentage volume differences reflect the expected level of error in traffic counts, which can be quite high when using a 24 or 48-hour count to represent Average Annual Daily Trips (AADT).

The terms "calibration" and "validation" are sometimes used interchangeably, however in Florida the two terms have distinctly different meanings to modelers and have typically been distinguished as follows:

- Model Calibration: A process where transportation models are adjusted to simulate or match observed household travel behavior in the study area; and
- Model Validation: The procedure used to adjust transportation models to simulate base year traffic counts and transit ridership figures.

Model calibration implies the availability of household travel survey data to adjust the model to match observed trip generation rates, trip length frequency distributions, aggregate trip movements, and mode of travel.

While validation may include elements of calibration if sufficient data is available, validation also consists of reasonableness checks beyond simply matching base year travel conditions, and meeting certain accepted accuracy standards. These standards represent "acceptable" (or preferable) ranges of percentage error in the model network as compared to observed data.

There are differing standards that specify the "acceptable" level of error for facilities in FSUTMS, and generally the lower the volume the higher the "acceptable" error rate. In general, the model is able to replicate the volumes on facilities with a higher traffic count.

There are great number of factors and validation statistics that are used in model validation that are far beyond the scope of this discussion. However, in model calibration and validation, a central concept is Volume Over Count ratios (V/C) and the percent error levels for differing facilities.

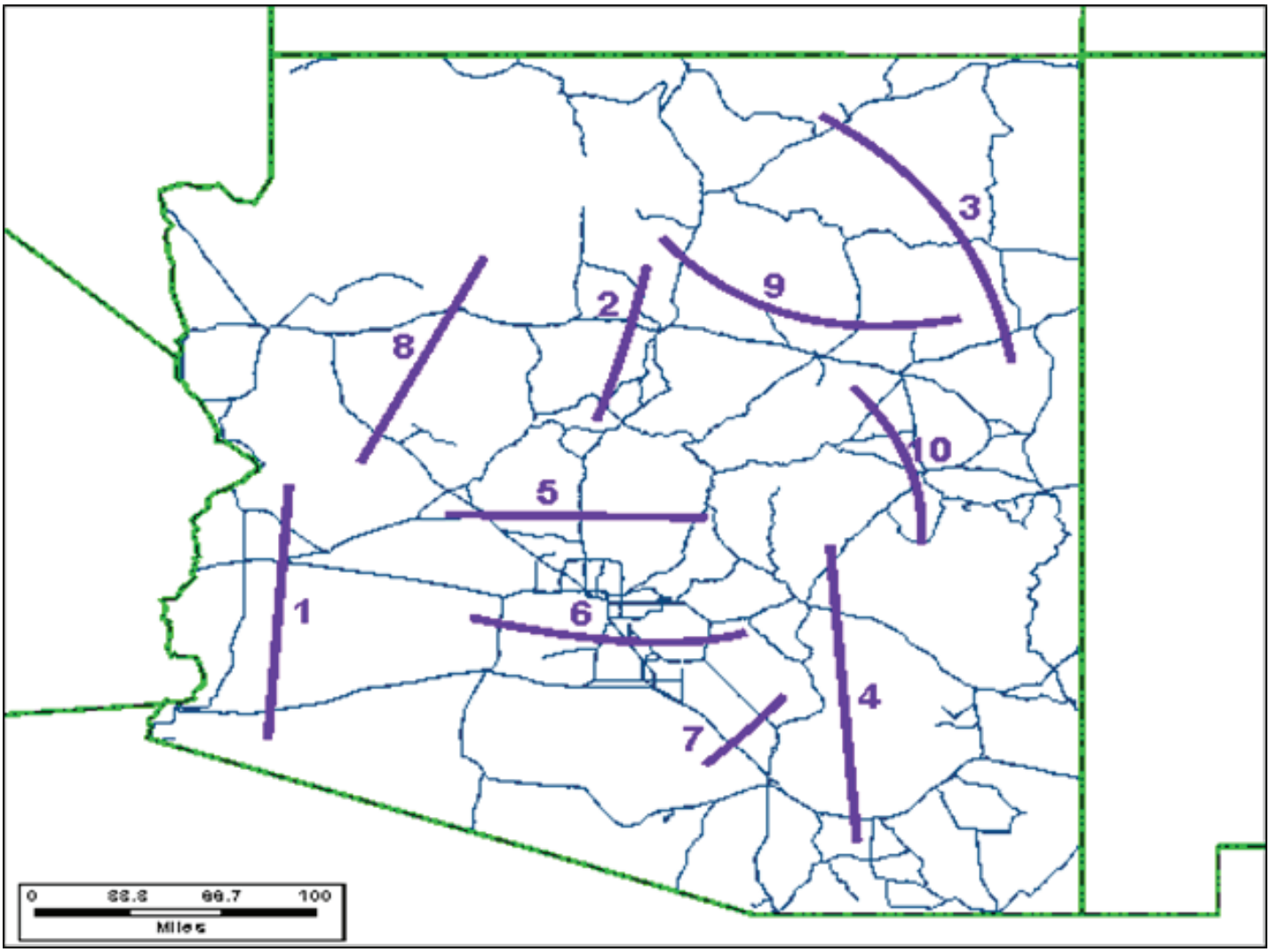
Volume Over Count Ratios

Percent error has historically reflected a "plus or minus one lane" criteria in Florida. This concept means that highway assignment accuracy should minimize incorrect future lane calls resulting from forecasted traffic. The following table depicts a desired percentage of links with counts in each volume group which is recommended by FDOT and accepted as a standard for link analysis.

	Standards	
Statistic	**Acceptable**	**Preferable**
Percent Error: LT 10,000 volume (2L road)	50%	25%
Percent Error: 10,000-30,000 (4L road)	30%	20%
Percent Error: 30,000-50,000 (6L road)	25%	15%
Percent Error: 50,000-65,000 (4-6L freeway)	20%	10%
Percent Error: 65,000-75,000 (6L freeway)	15%	5%
Percent Error: GT 75,000 (8+L freeway)	10%	5%

Screenline Analysis

In measuring the accuracy of transportation models, screenlines or cutlines are used as a performance measure. Screenlines are imaginary lines drawn across roads in the model network which are used to compare the results of trip assignment (the model generated number) with the traffic counts on roads (the known or actual number). More precisely, it is a process of comparing the directional sum of ground count traffic volumes across a screenline or a cordon line with the directional sum of the assigned traffic volumes across the same screenline or cordon line. An example of screenlines, depicted by the blue lines in the example (the example is the state of Arizona) from the FHWA website follows below.



Florida accuracy standards along screenlines and cutlines have historically varied from +/- 5 percent to +/- 20 percent. Accepted volume ranges and standards for FSUTMS are:

- External model cordon lines should achieve +/- 1 percent,
- Screenlines with greater than 70,000 AADT should achieve +/-10 percent,
- Screenlines with 35,000 to 70,000 AADT should achieve +/-15 percent, and
- Screenlines with less than 35,000 AADT should achieve +/-20 percent.

Root Mean Square Error

Root Mean Square Error (RMSE) is among the most commonly reported statistics in model validation. RMSE, a measure of dispersion, tends to normalize model error better than volume-over-count ratios that allow for high ratios to offset low ratios. For overall RMSE, there is a wide variation in acceptability throughout the U.S. with most documents recommending values of 30 to 40, and several accepting as high as 50 percent areawide RMSE. For FSUTMS modeling, the following variable measures or ranges are accepted for RSME analysis:

Statistic	Standards	
	Acceptable	Preferable
RMSE: LT 5,000 VPD	100%	45%
RMSE: 5,000-9,999 VPD	45%	35%
RMSE: 10,000-14,999 VPD	35%	27%
RMSE: 15,000-19,999 VPD	30%	25%
RMSE: 20,000-29,999 VPD	27%	15%
RMSE: 30,000-49,999 VPD	25%	15%
RMSE: 50,000-59,999 VPD	20%	10%
RMSE: 60,000+ VPD	19%	10%
RMSE Areawide	45%	35%

Existing Plus Committed Model Network

Once the Base Year network is completed, including validation and calibration, the focus moves to developing an Existing Plus Committed (E+C) network. This network includes all new road or capacity projects that have come into existence after the Base Year of the model, and all projects that have construction funded within the FDOT 5 Year Work Program available at the time of model development. This model is run utilizing the same socioeconomic data as the Base Year model, and may only incorporate road network changes differing from the Base Year.

Future Year Model Network

The future Year (or forecast year) of a model utilizes the previously discussed E+C network and future year ZONEDATA developed using a wide variety of methods used by planning professionals.
The D1RPM utilizes extensive socio economic data developed by the Central Florida Regional Planning Council (CFRPC) in the Heartland 2060 Regional Vision Plan. The level of detail put into the Heartland 2060 projections by the CFRPC surpassed the abilities of FDOT staff to replicate such detailed projections in the time available for development of the D1RPM model. Rather than developing their own 2040 projections, FDOT modeling staff utilized the Heartland 2060 data. The Heartland 2060 population and employment projections were converted to a FSUTMS / Cube 2040 ZONEDATA (DBF) format by FDOT modeling staff. This data is utilized in the 2040 Future Year D1RPM network for the HRTPO region. No modifications or changes were made to the CFRPC Heartland 2060 data (other than format) by the FDOT modeling staff in development of the D1RPM.

Building on the E+C network, the HRTPO was able to model future road additions and capacity improvements from state and local sources, generally the FDOT 5 Year Work Program updated since the E+C network development year, and the FDOT Strategic Intermodal System Funding Strategy, Long Range Cost Feasible Plan 2024-2040, 2014 Edition August 2015 ("SIS Plan"). Any FDOT new road or capacity projects projected in the SIS Plan to have construction funding within the 2015-2040 timeframe were included in the HRTPO 2040 network.