Florida's Turnpike Enterprise Toll Model Development Program

Authors:
Adler, Thomas, Ph.D., President, Resource Systems Group
Dehghani, Youssef, Ph.D., P.E., Principal Professional Associate, Parsons Brinckerhoff, Inc.
Doherty, Michael, Project Transportation Planner, URS Corporation
Klodzinski, Jack, Ph.D., Senior Transportation Engineer, URS/Florida's Turnpike Enterprise
Olsen, William, Ph.D., P.E., Manager Travel Forecasting, URS/Florida's Turnpike Enterprise

Contact:
Jack Klodzinski, jack.klodzinski@dot.state.fl.us, 407-532-3999, extension 3819

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Abstract

Florida's Turnpike Enterprise is the equivalent of a Statewide District Office under the Florida Department of Transportation. The Turnpike Enterprise overlaps the jurisdictions of Florida's seven FDOT Districts for the purposes of planning, financing, constructing and managing the State's growing Turnpike System which currently consists of a 320 mile Mainline and six expansion projects built over the past ten years that have brought the total system up to 449 miles.

The Turnpike Enterprise's mission is "To help meet the State's growing transportation needs, ensuring value to customers, protecting investors and managing the Turnpike System in a business-like manner." An important part of this mission is to maintain a "best practice" standard for the Turnpike traffic and revenue forecasting procedures. These procedures are continually updated as new issues such as variable toll pricing and new project categories such as express lanes in freeways and other toll facilities become important to the Turnpike Enterprise's mission.

This paper highlights the Turnpike Enterprise's program for development of next generation of toll modeling procedure, its structure and advantages provided over the other toll facilities models used in the State. Perhaps the most significant difference is that the choice of toll versus toll-free route is included as part of a nested logit mode choice model rather than being represented only in the traffic assignment procedure. This approach allows the model to be responsive to the socioeconomic characteristics of trip makers and the attributes of different trip purposes. Other distinguishing features of the new procedure are its time-of day simulation capability featuring four time periods, its use of extensive revealed and stated preference travel surveys and the statistically-driven procedure used to estimate the model parameters.

The initial Toll Mode Choice Model development application was to the Orlando and Tampa Metropolitan Areas, which each encompass five-county regions. The next applications underway are in the southeast Florida region covering Miami-Dade, Broward and Palm Beach Counties. In each case, the model development process is linked to the feasibility assessment of major Turnpike Enterprise investment projects.

1.0 Overview

This paper highlights the salient aspects of the Florida's Turnpike Enterprise next generation toll model development program and its supporting data collection initiative. Florida's Turnpike Enterprise manages a system of 449 miles through 16 counties, covering 13 Metropolitan Planning Organizations and five of the seven FDOT District Offices. The Turnpike's system is highlighted in Figure 1. On a typical day, the mainline carries about 1,117,000 vehicles and the expansion projects carry 490,000 vehicles.

Florida's Turnpike Enterprise periodically updates its traffic and revenue forecasting procedures to maintain a "best practice" standard. Over the last 20 years, the best practice has conformed to the Florida Standard Urban Transportation Model Structure (FSUTMS). In the FSUTMS process, traffic forecasts on toll roads have typically been based on a simple network diversion approach within the highway assignment modeling step. This approach imposes a time penalty equivalent of toll cost at toll collection locations using an estimate for value of travel time or "willingness-to-pay" toll. The traditional procedures, however, have had limitations in addressing the new issues facing the Turnpike Enterprise, including variable toll pricing and new project categories such as tolled express lanes in freeways.

The Turnpike's next generation toll modeling procedures include development of toll forecasting tools that are suitable to different phases of a toll project evaluation. An initial version of a sketch planning model (for initial project screening) has been developed and tested and a statewide model for inter-city toll forecasting analysis is under development. In addition, a peak spreading methodology has been also developed for implementation within the regional toll models. The focus of this paper, however, is on the development of regional toll mode choice models and related data collection activities. Data collection and initial versions of the toll mode choice models have been completed for the Orlando and Tampa regions. In addition, survey data tasks have been completed to support similar toll mode choice model development efforts for the southeast Florida region.

2.0 Data Collection

Data collection efforts were undertaken concurrently with the development of the overall model design. The data collection tasks were structured to collect the data that were most relevant for the model development and in turn, the models were constructed to incorporate the data that were available. Recognizing the importance of data in the modeling process, an extensive effort was undertaken to collect the data required to support the toll modeling program.

During development on the new versions of the regional travel demand models, available traffic counts and vehicle occupancy data were supplemented with a new data collection effort. The district/MPO model databases provided a good foundation for model development. However, for toll facility traffic and revenue forecasting, these databases generally lack the detail required for accurate calibration and validation. Since toll facility use is very sensitive to congestion levels at different times of day and since time-of-day pricing is an important operating policy option to be evaluated with the models, a key element of these new models is explicit representation of conditions during different periods of the day. For these models, four time periods were specified: AM peak, mid-day, PM peak, and night. An extensive effort was undertaken to collect key data to describe these four time periods.

In addition to securing readily available traffic counts from various public agencies, the following related data were collected:

- Speed measurements
- Traffic counts by time-of-day

- Vehicle occupancy counts by time-of-day

The data were initially collected by technicians driving on selected routes while recording distance and travel time at specific stop points. Later, in order to improve data accuracy, a global positioning system (GPS) was used to collect speed data. Average speed values by area, facility type and time-of-day were calculated from the pool of speed data To further expand the inventory of traffic data, traffic counts recorded at the FDOT Telemetered Sites (TIMS) were used. This database was used to perform the analysis to produce average peak weekday, average weekday, and average off-peak weekday traffic counts from the pool of hourly traffic counts data for all locations.

Surveys are instrumental to assist in the overall Turnpike's model estimation and validation analysis. A number of surveys were conducted and analyzed for development of regional toll mode choice models. These included:

- External travel survey
- Toll facilities survey
- Household travel survey
- Revealed and stated preference mode choice survey

External travel surveys were administered to obtain origin-destination data. In addition to origin-destination information, this survey type collected information on the specifics of each trip, such as vehicle occupancy, trip length, frequency of trip, toll costs (if any) and SunPass transponder (used for electronic toll collection) information. The toll facilities survey collected trip length and specific origin-destination information by trip purpose and time of day (AM peak, PM peak, mid-day, and night). The household travel survey included a trip diary and the following information was collected:

- Trip lengths for toll-free roads by trip purpose, occupancy and time of day
- Toll/toll-free trip percentages
- Additional revealed preference observations for the toll mode choice modeling

The survey data helped develop detailed information about region-wide travel patterns including the proportion of all trips using toll facilities.

The "revealed preference" survey information (current choices being made by travelers) which is considered an origin-destination survey and "stated preference" survey information (choices that would be made under changed circumstances) were used to develop discrete choice models of mode and route choice behavior. Analysis of the survey results provided detailed information about travelers' values of time, their willingness and ability to shift travel time, and preferences about SunPass acquisition and ownership. In the field, the stated preference survey was administered on laptop computers using the *IVIS*™ (Interactive Video Interview Stations) survey technique developed by Resource Systems Group.

The data from these surveys were instrumental in a number of other areas, including:

- Developing time-of-day factors by trip purpose and traffic direction.
- Establishing target person trips by mode, trip purpose, and Time-of-Day (required for modal constants calibration).
- Calculating average auto occupancy.
- Calculating average trip length for both toll and toll-free facilities.

The survey data collected were also used for subsequent toll mode choice model refinements and validation analysis, including calibration of travel time friction factors.

3.0 Regional Toll Mode Choice Models

A central element of the Turnpike's next generation models is inclusion of likely use of a toll facility within the mode choice modeling process rather than as part of the overall highway assignment process. This distinction is highlighted in Figure 2. The new method has allowed inclusion of important socio-economic characteristics of trip makers as well as level-of-service attributes – such as income, trip purpose, trip length, and travel time variability across different periods - more explicitly in the modeling process. This has made the new models more sensitive to policy variables and thus enhanced accuracy and reliability of resulting toll traffic forecasts. The toll mode choice models are statistically estimated based on using recently collected survey data for each urban area. The toll mode choice models are developed in two phases. During the first phase, daily toll mode choice models are developed followed by development of four-period toll models. Key features of the toll mode choice modeling system include:

- A post-trip distribution time-of-day modeling capability that reflects travel time variation during four time periods (i.e., AM peak, mid-day, PM peak, and night).
- A multi-modal modeling system encompassing statistically estimated nested mode-choice models by time of day and trip purposes (i.e., home-based work, home-based non-work, non-home-based, and tourists/visitors if relevant).
- The toll modeling system includes specific decision-tree hierarchies for different auto occupancy classes (i.e., SOVs vs. HOVs) for toll and toll-free choices including choice-tree for transit submodes (i.e., primary transit vs. walk or auto access).
- A generalized assignment procedure that uses both travel time and costs by time of day (rather than travel time alone) in the highway equilibrium assignment process.
- Akcelik volume/delay curves were implemented in the Florida Turnpike's toll mode choice modeling system. A literature review showed that the Akcelik curves are more realistic models of actual delays under over-capacity conditions (Akçelik, 1991).
- A feed-back-loop process that uses a successive method of averaging highway travel times. This iterative process involves updating highway travel times via tolled and non-tolled (free) roads, and feeding them back into the mode choice modeling process.

Orlando area was the first area for which toll mode choice model development was undertaken. Key estimation analysis findings from the Orlando toll model development (shown in the TRB Record No. 1858) are highlighted below:

- Trip length was found to be a significant factor in the choice between tolled and non-tolled routes reflecting travelers' propensity to use toll roads for long-haul trips.
- Household income was a significant variable in explaining sensitivity to toll prices.
- Travel costs divided by the natural logarithm of average household income for home-based work (HBW), home-based non-work (HBNW), and non-home-based (NHB) model segments were used as generic variables for all modes.

Extensive testing revealed that vehicle occupancy has no significant effect on the disutility of travel costs, except for home-based work trips, where the relationship was best represented as costs divided by *ln (vehicle occupancy+1)*. This has an important implication for forecasting models, because dividing costs by vehicle occupancy for non-work trips would likely under represent the effects of cost changes on these trips.

Validation tests were used to check reasonableness during toll mode choice model development. For example, the overall model performance has been evaluated based on the level of accuracy in the results obtained for:

- Loading accuracy check against actual counts (on toll and non-toll facilities)
- Travel patterns (overall & toll users)
- Average trip rate
- Average trip length (overall & toll users)
- Sensitivity analysis for change in toll rates and comparison against historical toll demand elasticities with respect to change in toll rates.

Sample validation analysis results produced for the Orlando toll mode choice model are highlighted in Figures 3-5. Figures 3 and 4 highlight the overall goodness of fit for estimated versus actual daily vehicle volumes on toll and toll-free facilities at multiple count locations across the network. Figure 5 highlights sensitivity analysis results with respect to change in toll rates exhibiting toll demand elasticity historically experienced with respect to change in toll rate in the past.

4.0 Summary

With the new issues and toll facility types that are currently being considered, more data and more dynamic modeling structures are needed. Florida's Turnpike Enterprise next generation toll modeling procedures have successfully been developed and implemented in ways that respond to these new evaluation needs.

This new model program uses innovative ways to incorporate current toll road users' socio-economic characteristics and their travel patterns and reflect them accurately. In addition, the work has included development of a program that anticipates future enhancements. This program outlines how regional model development will continue as required by proposed projects and improvements. The program specifies the routine maintenance of the toll mode choice models that is needed to ensure that the models can be used for future applications. Regular updates and maintenance will eliminate delays to planning and production schedules and increase overall project performance. With this being said, future areas of improvement may incorporate such concepts as peak spreading and more detailed modeling of variable toll pricing.

The toll mode choice models developed for the Florida Turnpike Enterprise embody the "best practice" toll mode choice modeling procedures, using survey data and region-specific model estimation to increase the accuracy and reliability of toll project forecasts. Perhaps the greatest advantage of the new modeling approach is the treatment of toll travel as a mode choice. Using this approach, the next generation of Turnpike's travel demand forecasts will more appropriately reflect the socioeconomic characteristics of trip makers, their trip purpose, the time of day, and method of toll collection. Moving forward, the complement of Turnpike's multi-period toll-mode choice models will be expanded beyond the current regional models for Orlando, Tampa Bay, and Southeast Florida (Palm Beach, Broward, and Miami/Dade).

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Figure 1 Historical Perspective of Florida's Turnpike System

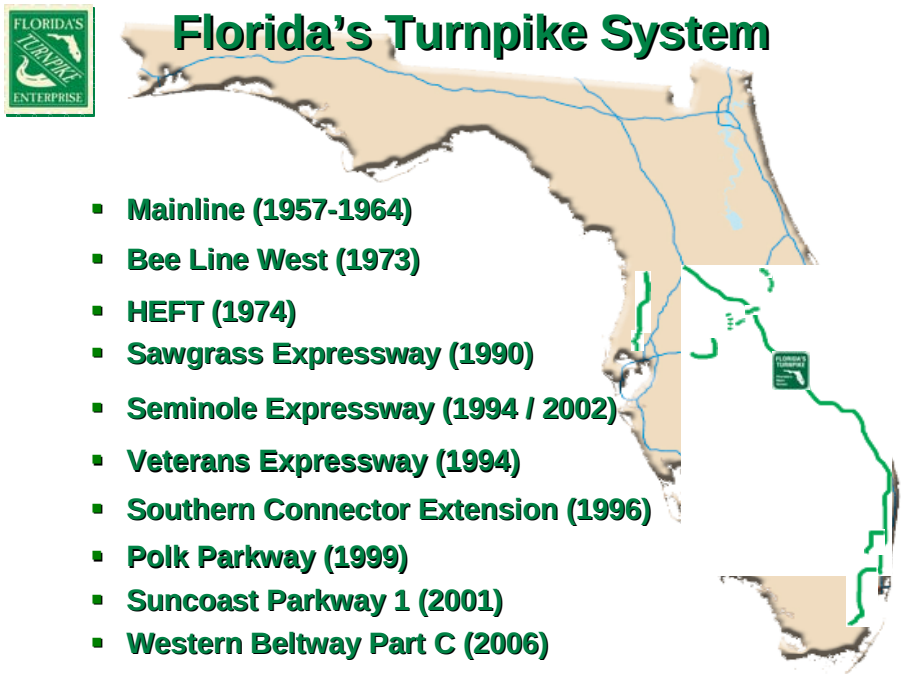
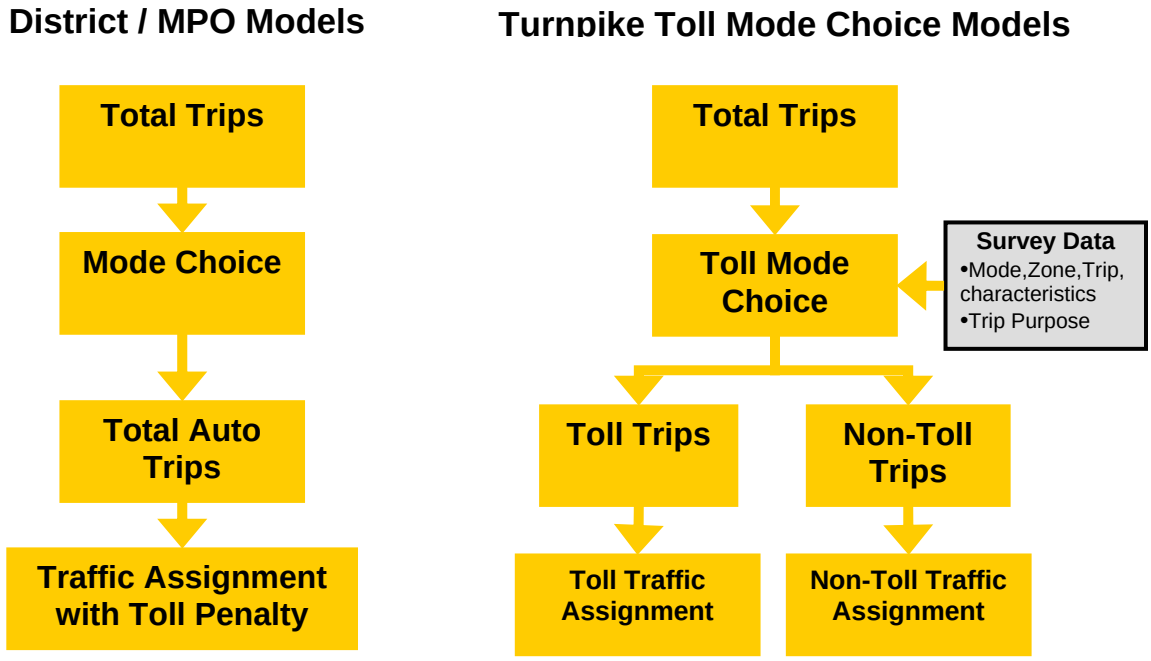
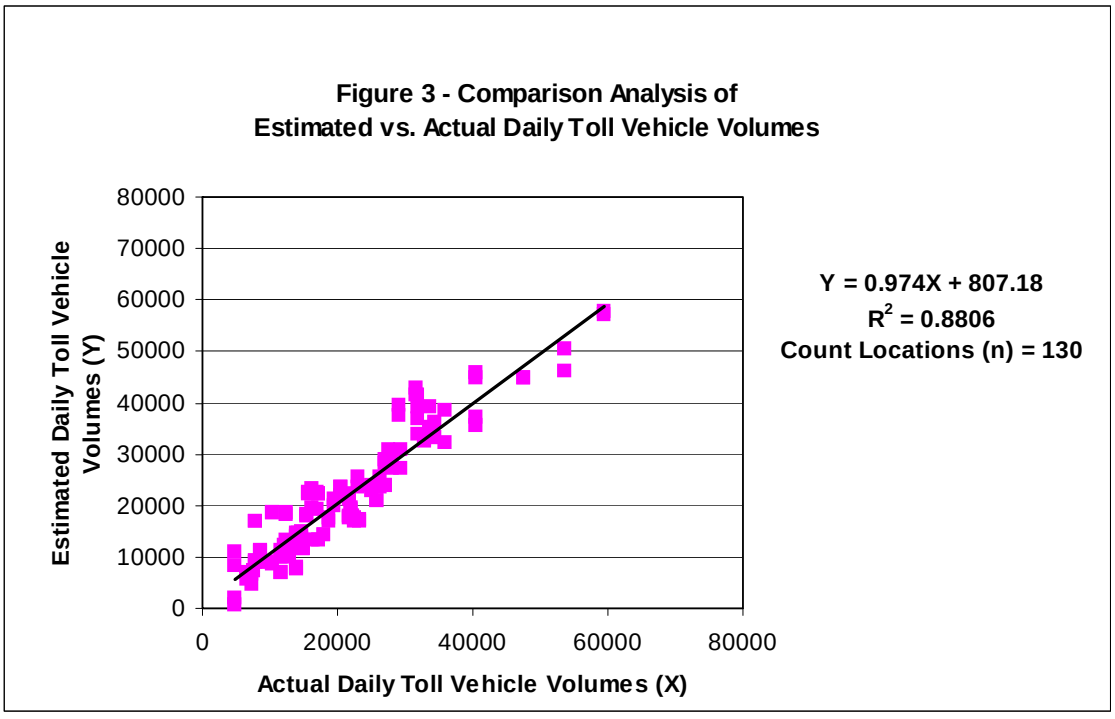


Figure 2 Model Comparison (District/MPO vs. Turnpike Toll Mode Choice Models)





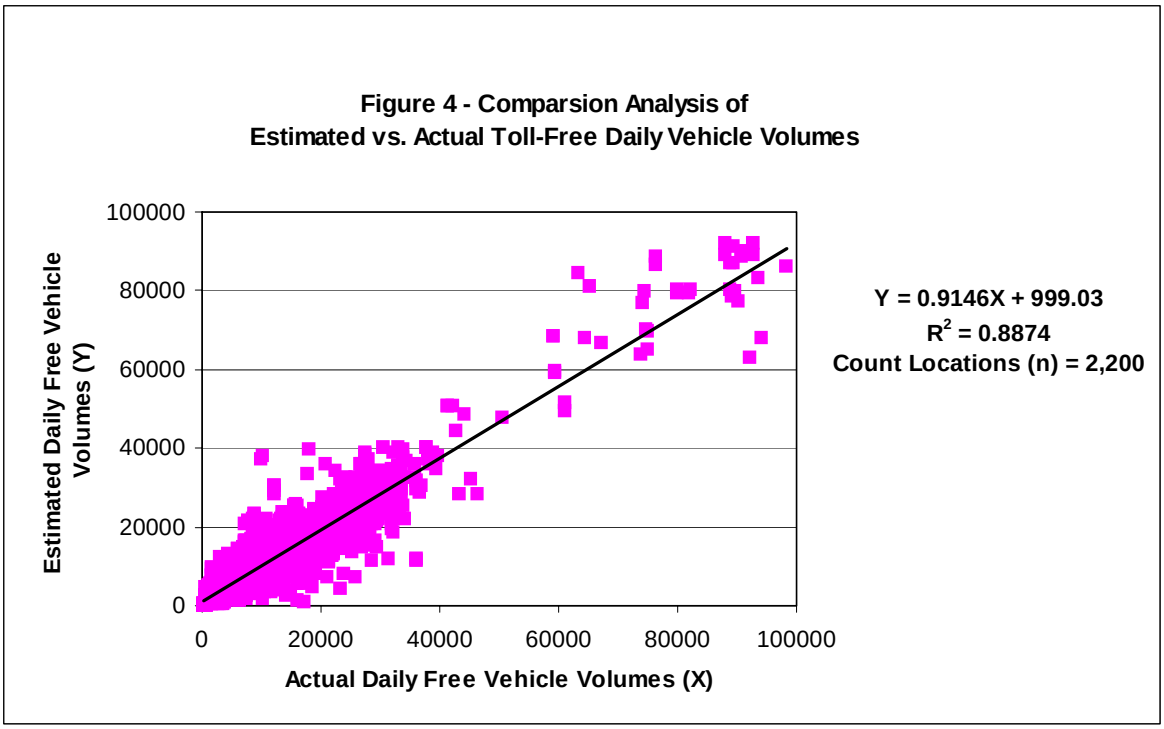


Figure 5: Comparative Analysis of All Orlando-Area Toll Road Revenues and Vehicle Volumes