Florida Department of Transportation
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SIMULATION AND EVALUATION OF THE ORLANDO-ORANGE COUNTY EXPRESSWAY AUTHORITY (OOCEA) ELECTRONIC TOLL COLLECTION PLAZAS USING TPSIM©

PROBLEM STATEMENT

Computer simulation provides an excellent means for evaluating a wide spectrum of traffic management schemes within the framework of controlled experiments. Greater understanding is needed of the effects of toll plazas on toll roads, including the impact and potential of electronic toll collection (ETC), in order to determine plaza configurations that would maximize traffic flow efficiency.

OBJECTIVES

The main goal of this research was to evaluate current and future traffic conditions at a toll plaza with different configurations and traffic characteristics in order to recommend the most appropriate (and near optimal) plaza configuration. The specific objectives of this research included:

- Testing and assuring the reliability of the Toll Plaza Simulation (TPSIM©) model in predicting performance of toll plazas.
- Quantifying the traffic operational benefits with various levels of E-PASS.
- Setting criteria for the optimization of traffic operations at toll plazas as applied to OOCEA plazas and then extending them to FDOT Turnpike plazas in the near future.

FINDINGS AND CONCLUSIONS

TPSIM© was validated through two processes, *Conceptual Validation* and *Operational Validation*. The first observed the animation of the simulated real-life case with the model output. Animation was displayed side-by-side with the real-life videotapes collected at the Holland-East Plaza. The comparison of the TPSIM© animation and the videotapes indicated that the simulated traffic condition resulting from TPSIM© was close to the actual real-life traffic condition at Holland-East Plaza. The second input real-life data collected at the Holland-East Plaza into the model and compared the simulated results with the observed measures of effectiveness macroscopically and microscopically. These measures of effectiveness included plaza throughput, average queuing delay, maximum queuing delay, and total queuing delay. Both *Conceptual* and *Operational Validation* confirmed the effectiveness of TPSIM©.

Using TPSIM©, a simulation experiment was designed to study the impact of ETC market penetration on the benefits of this technology. This experiment focused on the Holland-East Plaza condition during the morning peak hour. Several conclusions were drawn from the results of this experiment:

- Plaza delay sensitivity to the traffic demand increases more rapidly with higher traffic volumes. This increase in the estimated peak hour delay is not linear, but more exponential in nature.
- Delay sensitivity to the ETC market penetration indicated a decrease in the estimated peak hour delay when

the percentage of ETC usage increases. This decrease is not linear, but more exponential in nature. Clearly, the benefits of ETC depend on the plaza configuration. For all plaza configurations simulated with the manual lanes operating over capacity, the average queuing delay per vehicle can be reduced by *more than 90 seconds* if as few as 10% of the users switch from manual to ETC lanes.

- An increase of 20%-30% of the plaza throughput can be achieved by switching only 10% of the manual users to ETC during the morning peak hour when the manual lanes operate above their capacities.
- Adding more dedicated ETC lanes without increasing the level of ETC subscription could increase the plaza queuing delay and decrease total plaza throughput. By converting one of the manual lanes to a dedicated ETC lane when the ETC lanes are operating under capacity, the demand for manual lanes that already exceeds manual capacity would suffer with one less lane to manage throughput.
- Since ETC vehicles do not experience delays when the dedicated ETC lanes operate under capacity, total plaza delay does not have any impact on the decision of converting one of the manual lanes to a dedicated ETC lane. Sensitivity analysis of the ETC market penetration supported this conclusion and showed that when ETC usage during the rush hour is high (> 60%), delays achieve a considerably reduced level for all plaza configurations, and any additional dedicated ETC lane does not have any impact on the plaza operational performance.

Several simulation scenarios were conducted to investigate the impact of various dedicated ETC lane locations on traffic operations of the Holland-East Plaza. This experiment investigated three levels of plaza configuration, including *one dedicated ETC lane, two dedicated ETC lanes,* and *three dedicated ETC lanes.* Sensitivity analysis of the dedicated ETC lanes indicated the following:

- A plaza configuration with one dedicated ETC lane results in no significant differences in plaza delay when the dedicated ETC lane is in the middle or at the far left of the plaza.
- A plaza configuration with two dedicated ETC lanes resulted in a significant decrease (30%) in the estimated peak hour delay when these lanes were located in the middle of the plaza rather than to the far left, which resulted perhaps because these dedicated lanes were accessible from all approach lanes.
- A plaza configuration with three dedicated ETC lanes resulted in a slight decrease (5%) in the estimated peak hour delay when these lanes were located to the far left of the plaza, perhaps due to the increase in ETC vehicle accessibility to three dedicated lanes from the approach lanes. Another reason for this decrease is the well organized traffic pattern within the approach zone resulting from grouping conventional payment types (manual and automatic) associated with queued vehicles to the right of the plaza and the payment type (ETC) associated with high speed vehicles to the left of the plaza.

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