Research Report Summary

Didier Valdés, PhD; Benjamín Colucci, PhD, PE *9/28/2016*

Operational and Safety-Based Analyses of Varied Toll Lane Configurations

Problem Statement

The Puerto Rico reversible dynamic toll lane (DTL) is a multifaceted managed lane system located within the PR-22 median (Figure 1). This system integrates a reversible lane operation with congestion pricing and a bus rapid transit system. This new and unique concept introduced to local drivers has generated several safety issues, creating concern among transportation officials on the island. First, the posted speed limit inside the DTL for both travel directions is lower than the posted speed limit in the general-purpose lanes of PR-22. This issue could influence driving behavior (e.g., drivers' traveling speed), resulting in a trend of speeding inside the managed lane. Second, a considerable number of drivers have used the wrong express lane exit by exiting through the BRT exit lane (Figure 2). Therefore, the existing signage configuration may not comply with MUTCD

Figure 1. Reversible Dynamic Toll Lane System in PR-22

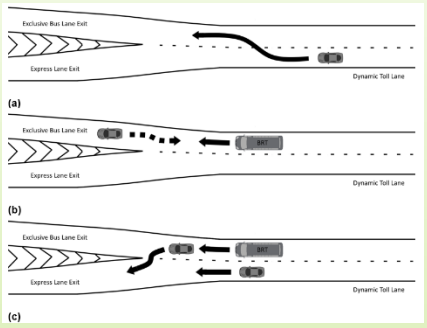

Figure 2. Driving Maneuvers when Exiting through the BRT Lane:
(a) Vehicle Exits through the Wrong Lane and Stops
(b) Vehicle Starts to Maneuver in Reverse
(c) Vehicle Changes into the Express Lane Exit

Figure 3. UPRM Cockpit Driving Simulator

requirements, creating driving confusion for some users of the DTL.

"This research study provides the first-ever freeway safety evaluation of a managed lane system that combines reversible lane operations with a congestion pricing system in a highway facility that is shared by private vehicles as well as a bus rapid transit (BRT) system."

Objectives

1. Generate virtual scenarios based on the existing conditions of the Puerto Rico DTL.
2. Evaluate how lane width influences subject driving behavior inside the DTL.
3. Evaluate if the posted speed limit in the DTL affects subjects' traveling speed.
4. Evaluate the variation in driver position at divergent segments throughout the DTL.

Experimental Design

- 3^3 full factorial design with 27 virtual scenarios and subject drivers.
- Research tool: UPRM cockpit driving simulator (Figure 3).
- Independent variables:
  1. *Time of day*
  2. *Lane width*
  3. *Posted speed limit*
- Dependent variables:
  1. *Average speed*
  2. *Acceleration noise*
  3. *Standard deviation of roadway position*
- Zones of interest:
  1. *DTL entrance*
  2. *Before the bridge mainline separation*
  3. *Bridge separation*
  4. *Bridge mainline connection*
  5. *DTL exit*

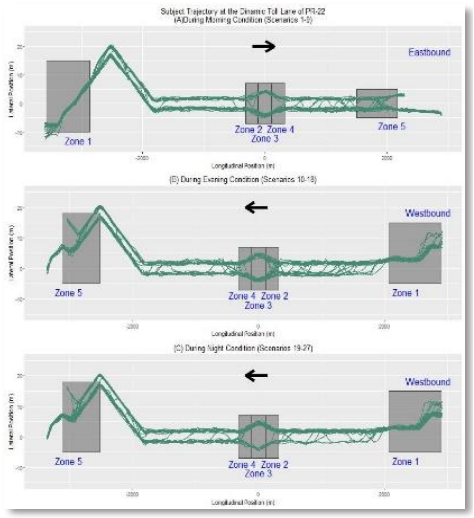

Figure 4. Lateral Position for the Time of Day and Direction Evaluated

Conclusions

1. Acceleration noise results confirmed conflict points in four of the zones of interest.
2. Subject drivers' traveling speeds were lower in scenarios with narrower lanes.
3. Participants presented speed profiles that were higher than the posted speed limit for scenarios with the existing speed limit (45 mph).
4. Drivers' lane position was only significant for the zones before and after the bridge separation (Figure 4).
5. Subject drivers used the DTL exit gate incorrectly by using the BRT exit lane in 26% of all scenarios (Table 1).

Future Work

1. Short-term: develop efficient solutions that can address the encountered safety issues.
2. Long-term: evaluate other possible countermeasures that are not feasible as a short-term solution.

Variable	Time of Day			Lane Width (ft)			Posted Speed Limit (mph)		
Level	**Morning**	**Evening**	**Night**	**10**	**11**	**12**	**45**	**55**	**65**
Total	12	4	5	7	9	3	6	5	10
%	44	15	19	26	33	11	22	19	37

Table 1. Subject Drivers Who Used the Incorrect DTL Exit by Independent Variable