2015-22TS
Published June 2015

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OFFICE OF TRANSPORTATION SYSTEM MANAGEMENT

TECHNICAL SUMMARY

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PROJECT COST:
$150,000

Future research may work to better model which vehicles have the transponders necessary to use the MnPASS lane.

Optimizing the MnPASS Pricing Algorithm Using Traffic Simulations

Optimizing the pricing algorithm for MnPASS high occupancy lanes is aimed at increasing usage, smoothing out pricing spikes and raising transportation revenue. This research using traffic simulations provides the confidence to support further expansion of the MnPASS system.

What Was the Need?

High occupancy toll lanes—special freeway lanes that are open to vehicles carrying more than one person as well as other vehicles that pay a toll—are a relatively new strategy for addressing highway congestion. MnDOT currently has HOT lanes, branded as MnPASS lanes, on I-394 and I-35W, and more are planned for future implementation.

A vehicle entering a MnPASS lane is charged an electronic fee that increases as the lane gets more congested; current fees range from 25 cents to $8. MnPASS is one of the few fully dynamically priced HOT lanes that exist, so there is little information available on best practices for their operation. MnDOT wanted to optimize the algorithm that dynamically sets MnPASS prices and develop a tool to test future changes or new corridors before implementation in the field.

What Was Our Goal?

MnDOT's primary goal for the pricing algorithm is to maximize utilization of MnPASS lanes, although maximizing revenue is a secondary goal. This project pursued those goals by creating a simulation-based tool to optimize the MnPASS pricing algorithm and also by conducting real-world tests of the impact of price changes on MnPASS usage.

What Did We Do?

Researchers first conducted a field experiment on the two MnPASS installations that raised or lowered by 20 percent the vehicle density thresholds that trigger a new price for MnPASS access. They analyzed the impact of the resulting price changes using price and demand data from critical plazas on both corridors: the toll plazas that typically have the highest vehicle density.

Next, researchers developed a simulation model of the MnPASS corridors in the Aimsun traffic modeling software. The simulation incorporates a lane choice model, effectively modeling how drivers who use the MnPASS corridors regularly make decisions based on their prior experiences as well as the prevailing price. They used this model to test the impact of several pricing algorithms on HOT lane usage, revenue, travel time and travel time variability. The modeled algorithms included:

- The current pricing algorithm, which is based on traffic density and level of service in the MnPASS lane.
- Continuous pricing, a simplified algorithm based only on traffic density in the MnPASS lane.
- Unweighted value pricing, which bases price on the difference in density between general-purpose and HOT lanes.
- HOT-weighted value pricing, which is similar to unweighted value pricing but provides more weight to the HOT lane vehicle density.
- General-purpose-weighted value pricing, which provides more weight to the general-purpose lane traffic density.

continued

"The old algorithm had a lot of spikes in price that weren't justified, probably because of its complexity. The continuous pricing algorithm should smooth price transitions and make it easier to look back and see what causes pricing changes."

—Brian Kary,
MnDOT Freeway Operations Engineer

"We have a limited ability to experiment on people in the real world, so if we want to make radical changes to invent new pricing algorithms, we need to simulate that in a virtual world."

—John Hourdos,
Director, Minnesota Traffic Observatory, University of Minnesota

Produced by CTC & Associates for:
Minnesota Department
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This research improved understanding of the algorithm that determines MnPASS pricing and developed a simplified pricing algorithm that should smooth out spikes in prices and be easier for MnDOT to debug.

What Did We Learn?

The field experiment found that up to about $4.50, increasing the price of MnPASS access increases use of the lane. This may be the result of drivers viewing the price as an indication of time savings the MnPASS lane can provide rather than an indication of the current conditions on the MnPASS lane. Above $5, further price increases decreased the likelihood of a driver choosing to enter the lane.

In the simulations, general-purpose-weighted value pricing maximized use of the MnPASS lane, while continuous pricing maximized revenue. However, in some of the corridors tested, the simulation of the existing pricing algorithm produced results with sizable variations from real-world observations. This indicates that each corridor, given the present lane choice model, needs to be individually calibrated. Regardless, the project was still valuable as a first attempt to create a model of the MnPASS network that can be refined, and at giving MnDOT a tool to predict how a change in MnPASS price will affect revenue, which it could not do before.

Additionally, the project provided significant insight into the pricing algorithm that MnDOT can use in managing the system. For example, the existing algorithm often produces rapid spikes in price. The continuous pricing algorithm smooths those price fluctuations, is easier to debug and makes it easier to determine which traffic conditions cause changes in pricing.

What's Next?

A vendor currently operates the MnPASS customer service center, its transaction center and the pricing algorithm. MnDOT is looking to take over the pricing algorithm and incorporate the continuous pricing algorithm into its software, which will allow MnDOT to keep the algorithm consistent even if it changes vendors.

A potential avenue for future research is refining the simulation to improve its accuracy in reflecting real-world conditions. Refinements may include a better estimation of which vehicles are likely to have the transponders that are required to pay the MnPASS tolls, and connection of the MnPASS model to a model of the Twin Cities as a whole to better simulate how the presence of a MnPASS lane affects a driver's route choice. A Twin Cities-wide model would also allow the simulation to be used for future MnPASS installations.

This Technical Summary pertains to Report 2015-22, "MnPASS Modeling and Pricing Algorithm Enhancement," published May 2015. The full report can be accessed at mndot.gov/research/TS/2015/201522.pdf.