2015-37TS
Published October 2015

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OFFICE OF TRANSPORTATION SYSTEM MANAGEMENT

TECHNICAL SUMMARY

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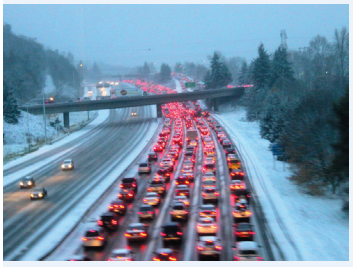
PROJECT COST:
$144,000



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Ramp metering is an important strategy for mitigating Twin Cities congestion, which leaves the average motorist stuck in traffic for 34 hours per year.

Optimizing Traffic Flow on Twin Cities Freeways

MnDOT's new density-based ramp metering algorithm reduces travel times and fuel consumption for drivers, leading to lower costs and reduced environmental effects.

What Was the Need?

To help reduce traffic congestion on its Twin Cities freeways, MnDOT uses ramp meters. These traffic lights at freeway on-ramps regulate the rate at which vehicles enter the freeway. Currently the Twin Cities area has 433 ramp meters—some operating during morning peak traffic (5:30 to 9 a.m.), some during the afternoon peak (2 to 6:30 p.m.) and others during both peaks.

Minnesota's ramp meters are operated by a computer algorithm that uses current traffic patterns to determine when to allow more vehicles onto the freeway. These algorithms have evolved over the years. Before 2000, MnDOT employed a ZONE Metering strategy that maximized freeway throughput, regardless of wait times or length of the queue for vehicles on the ramp. By 2003, the agency had developed a Stratified Zone Metering strategy that aimed to strike a balance between freeway efficiency and ramp delays. More recently, investigators have developed ramp metering algorithms that further enhance this balance by focusing on traffic density—the number of vehicles per lane mile—instead of traffic volume. Computer simulations conducted during previous MnDOT studies suggested that two algorithms developed in Minnesota were more effective than the SZM algorithm. Research was needed to validate this result in the field.

What Was Our Goal?

The goal of this project was to use field tests to compare the effectiveness of MnDOT's SZM ramp metering algorithm with that of a density-based strategy developed at the University of Minnesota Duluth, the UMD KAdaptive algorithm.

What Did We Implement?

This project implements two previous studies that developed and used computer simulations to test the effectiveness of density-based algorithms:

- The UMN Density algorithm, developed by the University of Minnesota Twin Cities in "Development of the Next Generation Stratified Ramp Metering Algorithm Based on Freeway Density."
- The UMD KAdaptive algorithm, developed by the University of Minnesota Duluth in "Development of Freeway Operational Strategies with IRIS-in-Loop Simulation."

Because of issues that arose during this project, investigators decided to compare the SZM algorithm only to the UMD algorithm, rather than both the UMD and UMN algorithms.

How Did We Do It?

Collaborating with the Minnesota Traffic Observatory, investigators compared the field performance of the SZM and UMD ramp metering strategies on Trunk Highway 100 northbound between 50th Street and Interstate 394. They also conducted a before-and-after study of a refined version of the UMD algorithm on a previously unmetered section of TH 212.

They analyzed the performance of algorithms by using roadside video cameras to record vehicle travel time data (the length of time it takes for a vehicle to get from one location

continued

"Because it looked only at traffic volume, our previous algorithm couldn't distinguish between free-flowing and stop-and-go traffic. The new algorithm's focus on density allows it to be far more responsive to traffic conditions."

—Brian Kary,
Freeway Operations Director, MnDOT Regional Transportation Management Center

"The UMD algorithm is much better than SZM at stabilizing ramp queue sizes, instead of allowing cycles in which they become full and then dump traffic into the mainline."

—John Hourdos,
Research Associate Professor, University of Minnesota Twin Cities Department of Civil Engineering

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Minnesota Department of Transportation
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The UMD ramp metering algorithm tested in this project helps avoid lengthy lines at ramp metering queues while smoothing freeway traffic flow, ultimately lowering travel delays for drivers.

to another) and data from loop detectors (in-pavement sensors that can be used to determine traffic speed and volume). Both methods compared traffic measurements between pairs of days with similar traffic and environmental conditions.

What Was the Impact?

Results showed the UMD algorithm to be superior to the SZM algorithm for managing traffic flow and ramp meter queues. Travel time data showed that despite the greater traffic demand when the UMD algorithm was used, UMD handled this traffic better than SZM. During these periods, congestion under SZM persisted, while congestion recovered under the UMD algorithm. Traffic flow under UMD was more stable while it fluctuated greatly under SZM. The UMD algorithm also handled ramp demand better, leading to more fluid conditions upstream of bottlenecks. While UMD did have some sharp spikes of very long travel times, this may be evidence that it was successfully recovering from heavy congestion conditions.

An analysis of TH 100 loop detector data showed that UMD performed better than SZM when conditions were not extremely congested. The UMD algorithm allowed more vehicles on average to flow into the mainline and kept the number of vehicles waiting at on-ramps relatively low. In the mainline, the flows were also higher with the UMD algorithm, and in most cases speeds were higher as well.

The TH 212 before-and-after analysis of the UMD algorithm found benefits in total travel time, with a 12 percent reduction in delays and a 3 percent increase in vehicle miles traveled on the metered portion of the highway.

What's Next?

MnDOT began implementing the UMD algorithm on Twin Cities ramp meters in the summer of 2014. The agency will continue to monitor the effectiveness of this algorithm and adjust it as needed to further improve highway traffic conditions.

This Technical Summary pertains to Report 2015-37, "Field Implementation, Testing, and Refinement of Density Based Coordinated Ramp Control Strategy," published June 2015. The full report can be accessed at mndot.gov/research/TS/2015/201537.pdf.

The research implemented through this project can be found mainly in Report CTS 11-05, "Development of the Next Generation Stratified Ramp Metering Algorithm Based on Freeway Density" (www.cts.umn.edu/Publications/ResearchReports/reportdetail.html?id=2012) *and Report 2012-04, "Development of Freeway Operational Strategies with IRIS-in-Loop Simulation"* (www.lrrb.org/media/reports/201204.pdf).