2015-26TS
Published October 2015

RESEARCH SERVICES & LIBRARY

OFFICE OF TRANSPORTATION SYSTEM MANAGEMENT

TECHNICAL SUMMARY

Technical Liaison:
Brian Kary, MnDOT
Brian.Kary@state.mn.us

Project Coordinator:
Dan Warzala, MnDOT
Dan.Warzala@state.mn.us

Principal Investigator:
Eil Kwon, University of Minnesota Duluth

PROJECT COST:
$98,700

Improvements to the VASL algorithm reduced sudden decelerations on I-35W.

Improved Active Traffic Management Strategies Make Travel Smoother on Twin Cities Freeways

What Was the Need?

MnDOT uses active traffic management strategies, including ramp metering and variable advisory speed limit control, to operate its freeways more efficiently at peak hours when they are at or near capacity.

Research project 2012-04, Development of Freeway Operational Strategies with IRIS-in-Loop Simulation, developed algorithms for a variable advisory speed limit system on Interstate 35W and for coordinated adaptive ramp metering throughout the Twin Cities freeway network.

The VASL system is intended to improve safety by encouraging drivers to slow down gradually as vehicles approach a congested area. The tail end of a queue on a congested highway has a high collision risk because drivers often need to quickly drop their speeds to avoid stopped vehicles ahead of them. The ramp metering system improves freeway capacity utilization by determining the appropriate metering rates for given traffic conditions.

Researchers enhanced the VASL algorithm on I-35W and the adaptive ramp metering algorithm used on freeways throughout the Twin Cities. Quicker response to real-time conditions results in improved travel time reliability and a reduction in vehicle delays and sudden traffic decelerations.

Both systems required refinements to improve their effectiveness. VASL systems are a relatively new technology, and the I-35W implementation needed to better assess traffic conditions to improve its responsiveness. While ramp metering is well-established, MnDOT wanted to address the issues with the current flow rate-based approach, such as variations in capacities, to better respond to traffic conditions in real time.

What Was Our Goal?

The goal of this project was to evaluate the VASL algorithm in place on I-35W and the algorithm for ramp metering, and to enhance them to improve performance.

What Did We Do?

Researchers developed three VASL algorithm enhancements to reduce the need for sudden braking:

- Replacing the algorithm's deceleration parameter, which was constant across all detector stations in the original algorithm, with one that varies at each station based on weather and traffic conditions at that station.
- Improving responsiveness to rapidly changing traffic conditions. The variable speed limit display activates only at detector stations where conditions warrant, and the original algorithm only permitted the speed limit to be displayed one station upstream of the originating station. The new algorithm permits the new speed limit to be displayed immediately at multiple upstream stations.
- Studying the potential benefit of 10- or 20-second traffic data detection intervals, which are feasible with Doppler radar-based sensors, in reducing the time needed to activate the VASL system. Currently, the system's loop detectors collect data only every 30 seconds.

continued

"With the variable advisory speed limit system, we hope to improve safety by easing people into the congested zone rather than having them slam on their brakes at the last minute."

—Brian Kary,
MnDOT Freeway Operations Engineer

"Field tests of the new metering system indicate substantial improvements in both mainline and ramp traffic performance."

—Eil Kwon,
Director, Northland Advanced Transportation Systems Research Laboratory, University of Minnesota Duluth

Produced by CTC & Associates for:
Minnesota Department
of Transportation
Research Services & Library
MS 330, First Floor
395 John Ireland Blvd.
St. Paul, MN 55155-1899
651-366-3780
www.mndot.gov/research

The improved ramp metering algorithm responds better to live road conditions by reacting to vehicle density rather than traffic flows, which reduces the number of meters operating on light traffic days.

MnDOT implemented the enhanced VASL algorithm on I-35W, and researchers measured its impact on traffic flow during morning peak hours. Using Vissim traffic simulation software, researchers also simulated the impact of the enhanced algorithm on the VASL system installed on I-94 in downtown Minneapolis.

The original ramp metering algorithm was based on traffic volume and capacity, which can vary significantly based on many factors. The new algorithm is based on traffic density, which has consistent variation patterns at each station. The new algorithm identifies bottlenecks in real time using acceleration and deceleration estimates at detector stations, and determines metering rates in such a way that the resulting density at bottleneck stations is close to the target level where the maximum flow rates are achieved. Further, the new algorithm includes a process to automatically activate or deactivate ramp meters depending on mainline traffic conditions.

What Did We Learn?

After implementation of the algorithm's deceleration parameter enhancement, travel time reliability (a measure of how consistent the travel time is for a given trip under different conditions) improved by 24 to 32 percent during morning peak periods in autumn 2010 compared to 2009. The overall deceleration between detector stations decreased by 28 percent, although the amount of extreme deceleration did not decrease by a statistically significant amount.

The simulation of the enhanced VASL algorithm resulted in significant and consistent reductions in sudden decelerations on the I-94 corridor. Field tests of the enhanced ramp metering strategy on Trunk Highway 100 northbound resulted in a 48 percent decrease in delayed vehicle hours, a 5.3 percent increase in vehicle miles traveled with a 9.5 percent decrease in vehicle hours traveled, and a substantial improvement in travel time reliability.

What's Next?

Parts of the VASL algorithm enhancements—improved determination of the starting VASL station and advance warning-message display before the first VASL sign—have not yet been implemented. MnDOT plans to begin testing the use of Doppler speed sensors in work zones in summer 2016. The algorithm enhancements should be applicable to the I-94 VASL system. I-94 is more challenging because it has several bottlenecks that regularly experience congestion, while congestion on I-35W typically radiates from a single point.

Both the VASL and ramp metering algorithms need to be continually monitored and enhanced based on field data. Potential future research includes collecting and analyzing long-term crash data to determine the safety benefit of the VASL system and evaluating the effectiveness of different speed control zone lengths on the driver compliance rate.

This Technical Summary pertains to Report 2015-26, "Development of Active Traffic Management Strategies for Minnesota Freeway Corridors," published June 2015. The full report can be accessed at mndot.gov/research/TS/2015/201526.pdf.