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DEPARTMENT OF TRANSPORTATION

RESEARCH SERVICES & LIBRARY

TECHNICAL SUMMARY

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PROJECT COST:
$300,000

To deploy the ATM system, MnDOT attached two sets of changeable message boards to gantries above the freeways.

ATM Queue Warning Systems Can Reduce Freeway Crashes

ATM queue warning systems were developed and deployed on two freeways to alert motorists to queuing conditions ahead that could lead to rear-end crashes. At one test site, the prototype system substantially reduced crashes and near-crashes. At the other site, it reduced speed variances.

What Was the Need?

To reduce congestion and improve safety, MnDOT has deployed active traffic management (ATM) technology on two highways in the Twin Cities freeway network. The ATM system incorporates intelligent lane control signals (ILCS) placed over selected lanes at half-mile increments to warn motorists of incidents or hazards ahead. With advance warning, drivers can slow down and possibly avoid crashes.

The deployed system, however, does not specifically target the prevention of rear-end collisions, which are the most frequent type of crashes on freeways. Research has shown that rear-end collisions tend to occur during extended lines of stop-and-go traffic and at end-of-queue locations. Overhead, real-time electronic messages that warn of queuing conditions ahead can prepare motorists to reduce speed and avoid potential rear-end collisions. Such messages have the added benefit of improving mobility since fewer crashes will improve traffic flow.

What Was Our Goal?

This project sought to develop and field-test two different prototypes for ATM queue warning systems. One prototype would address stop-and-go traffic and end-of-queue situations. The other would address shock waves, a crash-facilitating condition where there is a sudden change in traffic movement that causes a cascade of braking. The long-range goal of the project is to develop a unified ATM queue warning system that can be deployed at other locations within the freeway network.

What Did We Do?

Development of two prototype high-resolution ILCS warning systems began in 2014. The systems were then deployed on two high-traffic freeways in the Twin Cities: one on Interstate 35 West (I-35W) and the other on I-94. Both were still in operation in mid-2017.

The two locations have significantly different traffic conditions. On I-35W, congestion creates expanding queues that extend from the Trunk Highway 62 (TH 62) interchange to the 50th Street overpass. At the I-94 location, crashes are most likely to occur due to shock waves that can often quickly develop near the Portland Avenue overpass.

To capture traffic data, researchers used either live video from closed-circuit-camera detector stations or data from existing in-pavement loop detectors. The ILCS units displayed the message Slow Traffic Ahead, which would direct drivers to reduce speed due to the congested lanes ahead. Other messages, such as Prepare to Stop or Traffic Ahead 10 MPH, were considered but not tested during this initial study.

A server installed at the Minnesota Traffic Observatory at the University of Minnesota archived the time and location of each queue on I-94 and measured its duration and length. This provided the data needed to develop two algorithms that can be used to develop a rear-end-collision warning system that can be installed at freeway locations where similar queuing conditions exist.

continued

"The big lesson learned was that the detection method had to function quickly and display a message that was timely and accurate. This gains the trust and confidence of the motoring public."

—Brian Kary,
Freeway Operations Engineer, MnDOT Metro District

"Deploying the product of this research was not difficult. The challenge came in closing the gap to alert the drivers to slow down."

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

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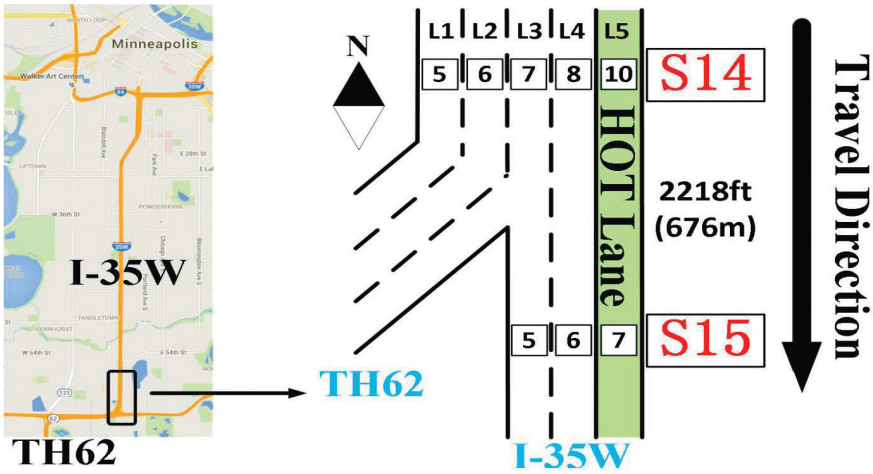

Data from upstream (S14) and downstream (S15) loop detectors in this segment of I-35W southbound were merged with live video from closed-circuit-camera detection stations.

What Did We Learn?

The data collected show that warning messages delivered by the ATM system can be effective in alerting drivers to queuing conditions. The ultimate benefit is a reduction in rear-end collisions in downstream locations on the freeway.

Data recorded at the I-35W location revealed that:

- Messages delivered by the ILCS system helped drivers maintain a steady speed and eliminate stop-and-go travel.
- The contents of warning messages should be crafted to have an impact on all motorists. Drivers responded differently to specific messages.
- Queue warning systems can be made more effective through deployment of a real-time, lane-specific ILCS system and collection of high-resolution data.
- Some drivers did not always heed the first queue warning message to decrease speed, but they did slow down further along the roadway.
- There was no significant difference in impact between warning messages issued during the morning peak travel period and those issued during the evening peak.

In the first three months of queue warning system operation, the crash frequency recorded at the I-94 test site was 9.34 crashes per vehicle miles traveled (VMT) and 51.8 near-crashes. This was a 22 percent decrease from the 11.9 crashes per VMT recorded at the site in 2013 monitoring data, and a 54 percent decrease from the 111.8 near-crashes recorded there in 2013.

The research showed that to prevent potential collisions, the ATM system had to deliver messages quickly and accurately to give drivers enough time to adjust their speeds. Also, the control algorithms developed in this project can provide the queue-estimation projections needed by MnDOT and other transportation departments to enhance the effectiveness of their ATM systems.

What's Next?

While the deployment of the two queue warning system prototypes was a relatively cost-effective option, a longer trial period of two to three years is needed to ensure that the ATM system delivers sustainable benefits.

This Technical Summary pertains to Report 2017-20, "Development of a Queue Warning System Utilizing ATM Infrastructure System Development and Field Testing," published June 2017. The full report can be accessed at mndot.gov/research/reports/2017/201720.pdf.