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RESEARCH
SERVICES SECTION

TECHNICAL SUMMARY

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PROJECT COST:
$65,000

Researchers analyzed the safety effects of adding left-protected signaling and other countermeasures to high-speed intersections.

Measuring the Safety Effects of Signal Installation and Left-Turn Phasing Schemes

What Was the Need?

There are several ways that a traffic signal system copes with left turns at an intersection: The "permitted phase" allows drivers to choose a safe gap in oncoming traffic; the "protected phase" provides turning vehicles with an exclusive turn phase and the "permitted/protected phase" combines the two to accommodate different left-turn and through patterns. The Mn/DOT Signal Design Manual provides guidance for implementing safe and efficient left-turn phasing.

Mn/DOT traffic engineers are currently developing new guidelines for this manual to address protected and permitted/protected phasing schemes at high-volume and low-volume (rural) high-speed intersections. A review of traffic research studies suggests the safety effects of these phasing schemes have not been quantified, presenting Mn/DOT with a knowledge gap in preparing the new guidelines.

What Was Our Goal?

The primary objective of this research was to determine crash modification factors, or CMFs—estimates of the change in crash risk—associated with the introduction of countermeasures including signals and various left-turn phasing schemes at intersections where the major approach speed limit exceeds 40 mph.

A secondary objective was to investigate the plausibility of using a computer simulation model to assess the effect of left-turn phasing changes on crash frequency.

What Did We Do?

Crash Modification Factors. Investigators estimated CMFs by analyzing before-and-after data from a set of intersections in Mn/DOT's Metro District where countermeasures had been implemented. They used as a reference group a larger number of intersections where the "before" condition still applied; analysis of these data yielded a statistical model to predict crash frequency in the absence of phasing or traffic control changes. This analysis involved an enhanced empirical Bayes approach. Researchers computed Bayes estimates of the CMFs associated with the following types of changes:

- Thru/stop control (no traffic controls on the major through road, and stop signs on the minor secondary roads) to signals with left-turn protection on the major approaches
- Permitted to permitted/protected phasing
- Permitted to protected phasing
- Permitted/protected to protected phasing
- Protected to permitted/protected phasing

Simulation Model. Researchers then developed a simple simulation model for left-turn cross-path crashes of the sort that occur during permitted left-turn phases on major intersection approaches. There were two components to this model: a probabilistic model of acceptance/rejection of traffic gaps for the turning vehicle and a standard braking model to represent the opposing driver. The simulation model was coupled with an estimate of the minimum gap in opposing traffic (measured in seconds) that left-turning vehicles would accept, and produced reasonable estimates of left-turn collision rates similar to those reported in other studies.

continued

"This study attempted to clarify the safety effectiveness of signal installation and left-turn phasing at high-speed intersections."

–Ben Osemenam,
Mn/DOT Traffic Signal ITS Engineer

"For those situations where we had sufficient data, our findings were basically consistent with Mn/DOT's current guidelines for the use of protected left-turn phasing on higher-speed highways."

–Gary Davis,
Professor, University of Minnesota Department of Civil Engineering

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This image was taken from a video feed that researchers used to generate data on driver acceptance/rejection of traffic gaps. They used this data to develop a simulation model to assess the safety effects of left-turn signal phasing.

What Did We Learn?

Crash Modification Factors. When signals were installed at previously thru/stop-controlled intersections, rear-end crashes increased while right-angle crashes decreased. Installation of the signal had no detectable effect on left-turn crashes from either the major or the minor roadway approaches, as long as the protected-only left-turn phasing was used on the major approach. For at least one location, installing a signal with permitted/protected left-turn phasing on the major approach was followed by a marked increase in major approach left-turn crashes. When protected-only major approach left-turn phasing was implemented at this intersection, no major approach left-turn crashes were recorded over a period of five years. These findings are on the whole consistent with, and support, current Mn/DOT guidelines for signalizing highway intersections.

Simulation Model. Researchers showed how a statistical model could be developed that provided a reasonable description of drivers' acceptance/rejection of gaps for left turns and reasonable estimates of left-turn collision rates.

What's Next?

For several of the phasing changes (permitted to permitted/protected on the minor approaches, permitted to protected on the minor approaches, permitted/protected to protected, and protected to permitted/protected on the major approaches), it was not possible for the researchers to construct an after-treatment data set of sufficient size to permit reliable estimation of an effect. The researchers recommended that these analyses be repeated when at least five years of after-treatment data are available for the treated sites. Because the results of these analyses were inconclusive, Mn/DOT has no immediate plans to use the results of the study as guidance.

Researchers do not believe that the simulation model could be readily implemented by Mn/DOT traffic engineers as an operational decision-making tool. However, the model is being used as a component in a Strategic Highway Research Program 2 safety project, "Development of Analysis Methods Using Recent Data." Researchers for that project are evaluating models similar to the simulation model as a tool for investigating the use of surrogate measures such as traffic conflicts and near-collisions to predict intersection crashes.

This Technical Summary pertains to Report 2007-03, "Safety Effects of Left-Turn Phasing Schemes at High-Speed Intersections," published January 2007. The full report can be accessed at http://www.lrrb.org/PDF/200703.pdf.