



## TECHNICAL SUMMARY

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### TOTAL PROJECT COST:

\$102,000

### LRRB COST:

\$51,000



Flashing yellow arrows can increase intersection safety and efficiency.



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# Determining Relative Risk for Permitted Left-Turn Phasing Using Flashing Yellow Arrows

## What Was the Need?

Flashing yellow arrows are moving further into the main-stream as an alternative to a simple green light for left-turning motorists. They signal to the motorist that it is safe to turn left so long as they yield to oncoming vehicles, which have the right of way. These permitted left turns are unlike protected left turns, where the left-turning motorist does not need to consider opposing traffic because those vehicles have a red light.

According to Minnesota traffic engineers, flashing yellow arrows should simultaneously improve intersection safety and efficiency. So MnDOT has instituted a policy requiring signal heads with flashing yellow arrows to be installed any time new signals are put in place or existing ones are replaced.

However MnDOT's top priority is safety, and using a permitted left turn may not always make sense from a safety standpoint, such as when intersection traffic is heavy. Research was needed to determine when during any given 24-hour period it is optimal to use flashing yellow arrows.

## What Was Our Goal?

Researchers aimed to develop guidelines for time-of-day use of permitted left-turn phasing, which could then be implemented using flashing yellow arrows. These guidelines would be based on estimates of left-turn crash occurrence, intersection approach characteristics, turning movement counts, speed limits, turn protection and sight distances.

## What Did We Do?

To achieve this goal, the research team worked in collaboration with MnDOT to retrieve data from federal and state sources as well as a number of counties and cities in Minnesota. The team studied 436 crashes at 328 intersections with permissive left-turn treatments. Researchers also collected traffic data from each intersection under study at the time of the crash and for five additional one-hour periods throughout the day. The remaining traffic volumes were estimated using trends observed at similar intersections nearby.

With this data in hand, the research team developed a statistical model and embedded it within a spreadsheet tool. The output of the tool is a measurement of relative risk, which relates the risk of occurrence of a left-turn crash in a given hour of the day to the traffic and other conditions prevailing during that hour at a given intersection.

## What Did We Learn?

Guidelines for time-of-day use of flashing yellow arrows were created with the spreadsheet tool that generates a measure of relative risk. However, traffic operations personnel should use this tool as a supplement to their own professional judgment.

*This study provided traffic engineers with guidelines to determine what times of day are appropriate to use flashing yellow arrows. When applied, flashing yellow arrows can improve the safety and efficiency of intersections across Minnesota.*

*“MnDOT is way out in front in the use of flashing yellow arrows. No one else is doing research to determine the right time of day to use this kind of permitted signal phasing.”*

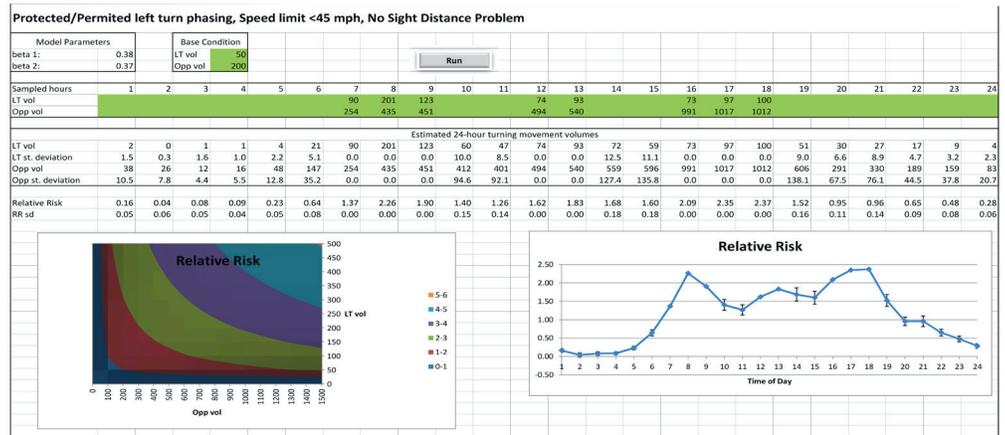
—Gary Davis,  
Professor, University of Minnesota Department of Civil, Environmental, and Geo-Engineering

*“This research will be of real help in the hands of traffic operations personnel at the state, county and municipal levels.”*

—Susan Zarling,  
Traffic Engineer, MnDOT Office of Traffic, Safety and Technology

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This project produced an Excel-based tool that allows users to enter information about an intersection and receive a prediction of how the risk of left-turn crash occurrence varied throughout the day relative to a specified reference condition.

The first step in using the tool is to determine if there is a sight distance issue at the intersection. The user must analyze aspects of the opposing left-turn lanes (if such lanes exist), such as number of lanes, opposing speed limit and other geometric considerations. Next, the user must refer to one of three spreadsheets, each containing different diagrams, to determine relative risk:

- Low speed (less than 45 mph), no sight distance problem.
- Low speed (less than 45 mph) with sight distance problem.
- High speed (greater than or equal to 45 mph) with sight distance problem.

Finally, the user will enter, for a candidate intersection approach, existing turning movement counts and opposing throughput traffic volume. The user then receives a prediction of how the risk of left-turn crash occurrence varied throughout the day relative to his or her own specified reference condition.

### What’s Next?

This research was considered a success by the research team and MnDOT, and is being submitted to the Local Road Research Board’s Research Implementation Committee for consideration for next steps.

The research report recommends that more traffic data be collected to increase the utility and accuracy of the spreadsheet tool. Analysis of more intersection types is also needed, especially high-speed intersections.

*This Technical Summary pertains to Report 2015-27, “Development of Guidelines for Permitted Left-Turn Phasing Using Flashing Yellow Arrows,” co-funded by LRRB and MnDOT, and published June 2015. The full report can be accessed at [mndot.gov/research/TS/2015/201527.pdf](http://mndot.gov/research/TS/2015/201527.pdf).*