Effectiveness of Intelligent Lane Control Signals on Driver Behavior

What Was the Need?
A traffic crash on a busy highway can quickly create a backup that extends for miles. Frustrated drivers may shift from lane to lane as they try to determine the best way to avoid an incident that they can’t yet see, and these abrupt lane changes can cause secondary crashes.

On busy stretches of highway where incidents are common, intelligent lane control signal (ILCS) messages help alleviate congestion by giving drivers advance information about blocked lanes. These programmable displays are permanently mounted over the traffic lanes on key segments of Interstate 94 (I-94) and I-35W. Staff members at MnDOT’s Regional Transportation Management Center (RTMC) in Roseville, Minnesota, monitor the flow of traffic through closed-circuit video cameras and sensors embedded in the pavement. When an incident occurs, RTMC staff programs the ILCS units to display a series of messages directing drivers away from blocked lanes.

The standard message format allowed by the federal Manual on Uniform Traffic Control Devices for ILCS displays uses words to direct drivers to “merge left” or “merge right,” and the Federal Highway Administration requires that research be conducted to confirm that drivers understand any deviations from these standard messages. MnDOT staff suspected that drivers would respond more quickly if the word “left” or “right” were replaced with a series of chevrons pointing toward the desired lane, similar to the visual cue found on many roadside changeable message signs and patrol trucks.

What Was Our Goal?
The objective of this driving simulation study was to test the effectiveness of several types of messages presented on overhead ILCS displays—merge messages, speed limit signs and lane closure warnings—at directing driver behavior. MnDOT was particularly interested in identifying which merge messages drivers responded to most quickly and how much they slowed down after seeing the speed limit messages. Identifying the most effective messages improves MnDOT’s ability to manage traffic, alleviate congestion and improve safety on state highways.

What Did We Do?
Researchers used a PC-based driving simulator to evaluate drivers’ responses to a series of ILCS messages warning of a lane closure ahead. The simulator consisted of an automobile-styled seat facing a bank of three 17-inch monitors that displayed a virtual six-lane divided highway with a speed limit of 65 mph.

Drivers began in the center lane. After driving five miles, they encountered five sets of ILCS messages at half-mile intervals: a 45 mph speed limit display; a 35 mph speed limit display; a yellow lane closure warning; one of three merge messages that used a diagonal arrow, words or dynamic chevrons to indicate that drivers should move from the center lane; and a red lane closure warning.
The study participants were 160 licensed drivers consisting of 20 men and 20 women in each of four age groups: younger (18-24), middle (32-47), older (55-65) and senior (70+). Each participant performed the test three times, viewing a different format for the merge message each time. Researchers recorded when the drivers slowed down and when they changed lanes in response to the messages.

What Did We Learn?
The simulation showed that drivers understood all three merge message formats and that drivers responded more quickly to the diagonal arrow and dynamic chevrons than to the words-only messages. The diagonal arrow merge sign was the most effective; participants moved from the center lane 266 feet before reaching it compared with 123 feet before reaching the dynamic chevrons merge sign and 54 feet before the words-only merge sign. With all three formats, more than 90 percent of drivers moved from the center lane as instructed.

The speed limit signs were effective as well. Participants initially drove at an average of 63 mph but reduced their speed as they approached each speed limit display, ultimately driving an average of 38.7 mph shortly after passing the 35 mph speed limit display.

Researchers found that participants’ ages affected how quickly they changed lanes. Participants in the middle age group moved from the center lane most quickly, while participants in the older age group changed lanes much later, at 25 feet after they had passed the merge signs. Age had an effect on driving speed as well, with the younger age group initially driving the fastest. However, once drivers had responded to the 45 mph speed limit sign, the differences between age groups essentially disappeared.

What’s Next?
This research confirmed that drivers understand merge messages that use dynamic chevrons to indicate direction. MnDOT can continue to use this message format with confidence. This research paves the way for other states to use the diagonal arrow or dynamic chevrons as well.

“This study demonstrated that including an arrow or chevrons helped drivers understand the merge message earlier, at a distance when a words-only message may not be legible. This validates our use of these messages on our ILCS displays.”

—Brian Kary,
Freeway Operations Engineer, MnDOT

“MnDOT uses dynamic chevrons to communicate merge messages on our patrol trucks’ arrow boards, and the study results confirm our use of a consistent message format on both the trucks and the ILCS displays.”

—Jesse Larson,
Assistant Freeway Operations Engineer, MnDOT

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