



## TECHNICAL SUMMARY

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### TOTAL PROJECT COST:

\$105,167

### LRRB COST:

\$52,584



A smartphone was replicated through installation of an LCD screen positioned inside the driving simulator.



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# Using Smartphones to Deliver Effective In-Vehicle Work Zone Messages

## What Was the Need?

Highway work zones require drivers to reduce speed and be aware of work crews, lane closures, traffic backups, construction equipment and other potential hazards on the roadway.

Transportation departments have long employed stationary warning signs, sometimes supplemented by portable changeable message signs (PCMSs), to alert drivers to upcoming construction projects. However, some previous studies have indicated that stationary warning signs are not always effective. In addition, PCMSs are costly and may be difficult to deploy in the field.

Smartphone technology offers an opportunity to deliver accurate and early in-vehicle warnings about road construction miles ahead. Digital messages could alert drivers about upcoming work zone conditions and improve safety for drivers and workers in the field.

But receiving in-vehicle messages about work zone conditions could distract drivers from safely operating their vehicles. MnDOT needed to study the advantages and disadvantages of using smartphones to deliver in-vehicle work zone messages.

## What Was Our Goal?

The primary goal of this project was to determine whether smartphones have the potential to safely deliver effective and accurate messages to drivers about upcoming road construction on Minnesota highways.

## What Did We Do?

The research team developed and conducted an online survey that focused on Minnesota drivers' perceptions of work zone safety and on their attitudes toward using smartphones and potentially receiving in-vehicle messages regarding work zone conditions.

Data from the surveys was used by the HumanFIRST Laboratory at the University of Minnesota to develop a driving simulation study designed to determine whether in-vehicle messages sent by smartphones could promote safe driving in work zones. The study analyzed 48 drivers operating a driving simulator within two work zones to test reactions to in-vehicle messages as compared to messages displayed on an external PCMS system. Researchers collected data about each participant's visual attention, driving performance, mental workload and opinions on smartphone technology.

Researchers also reviewed previous national studies and published works to identify environmental and driver behavior risk factors related to work zones.

## What Did We Learn?

An analysis of the simulation results showed drivers were very responsive to receiving in-vehicle messages regarding work zones and roadway hazards. Messages presented

*Under simulated conditions, drivers were not distracted by controlled work zone-related messages delivered through smartphones. In fact, driving performance improved. Researchers also learned that the location of the smartphone did not affect the driver if the message included an auditory component.*

*“The main goal was to determine whether in-vehicle warnings conveyed through smartphones would be distracting to the driver. We found that wasn’t the case.”*

—Ken Johnson,  
Work Zone, Pavement  
Marking and Traffic  
Devices Engineer,  
MnDOT Office of Traffic,  
Safety and Technology

*“We learned that drivers had a lower mental workload when they experienced the in-vehicle messages. It really didn’t matter what modality we used. Half the messages were auditory only, and half were auditory paired with visual.”*

—Nichole Morris,  
Director, University of  
Minnesota HumanFIRST  
Laboratory

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Drivers who participated in the study operated a 2002 Saturn SC2 complete chassis-driving simulator, which provided realistic control feedback through brake power assistance and resistance-based steering.

through smartphones did not cause driver distractions. In fact, some drivers' performance actually improved following delivery of audiovisual messages.

Drivers preferred to receive audio messages, and researchers learned that a synthesized female voice (like Apple's Siri) resulted in greater awareness and acceptance from the driver than a more natural or prerecorded voice.

Survey findings showed that only 5 percent of participants use a dashboard mount for their smartphones, while the vast majority keep their phone in the cup holder, on the console, in a backpack or purse, or on the passenger seat. A few participants said they hold their smartphone while driving. Investigating the safety impact of this behavior paired with an in-vehicle messaging system, researchers found that the location of the smartphone within the simulator (on the dash or passenger seat) did not negatively impact driver safety or performance, providing the work zone message contained the auditory component.

In-vehicle messages required less cognitive effort from drivers, and drivers had greater recall of the hazard warning message versus stationary PCMS signage.

A significant number of survey participants, nearly 20 percent, provided unprompted feedback that it was the state's responsibility to provide factual work zone messaging information and to ensure in-vehicle technology employed does not pose a distraction.

## What's Next?

MnDOT will need to continue research into the viability of smartphones as the way to deliver in-vehicle work zone messages. The simulation study provided the findings needed to advance the project to field testing, where drivers would respond to in-vehicle messages from smartphones on a test track or under real roadway conditions. Another potential topic to explore through further research is the viability of messages delivered through electronic interface or dashboard features offered on some newer vehicles.

MnDOT should identify the medium needed to deliver in-vehicle messages and use the prescribed syntax outlined by the study for communicating messages. Researchers noted the existing 511 service provided by MnDOT currently provides road, traffic, weather and other information. A study should be undertaken to determine whether the 511 or a third-party app would be most appropriate for a future statewide in-vehicle messaging program.

*This Technical Summary pertains to Report 2017-19, "In-Vehicle Work Zone Messages," published June 2017. The full report can be accessed at [mndot.gov/research/reports/2017/201719.pdf](http://mndot.gov/research/reports/2017/201719.pdf).*