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DEPARTMENT OF TRANSPORTATION

RESEARCH SERVICES & LIBRARY

TECHNICAL SUMMARY

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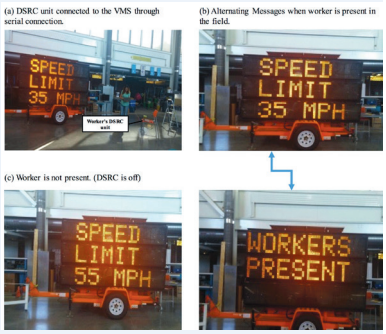
PROJECT COST:
$129,431



The system will be able to automatically change variable message signs as appropriate if workers are present.

Wearable GPS Receivers Tested to Improve Worker Safety in Construction Zones

To improve work zone safety, researchers developed and tested a prototype system that detects and locates workers in a work zone. The system uses dedicated short range communications-based equipment to communicate worker locations to monitors inside construction equipment, and to automatically change variable message signs that alert passing drivers.

What Was the Need?

Each year more than 20,000 workers are injured in work zones nationwide, with more than 100 fatalities. Nearly half of these injuries and almost all fatalities involve either construction vehicles or passing traffic.

Reducing speed limits is the traditional approach to improving safety in work zones. However, providing better information to drivers and construction vehicle operators about the presence and location of workers may also help improve work zone safety. MnDOT was interested in developing a system to provide this information.

As initially conceived, this system would use portable Global Positioning System (GPS) receivers embedded in safety vests or other wearable safety devices to locate workers. Android tablets or similar monitors within the construction equipment would show operators where workers are, and variable message signs would warn passing drivers that workers are present and set appropriate speed limits.

In addition to improved worker safety, this system could improve traffic mobility through work zones. If workers are not present, the system could display increased speed limits as appropriate.

What Was Our Goal?

The goal of this project was to develop and conduct proof-of-concept testing of a prototype system to improve safety in work zones based on readily available technology.

What Did We Do?

Researchers opted to use dedicated short range communication (DSRC)-based equipment to facilitate communication among the system's components. DSRC is a high-data transmission, short-range wireless bandwidth that the Federal Communications Commission has reserved for intelligent transportation systems applications, including connected vehicles. While other wireless technology might be suitable for this function, DSRC is expected to be readily available in work zone equipment in upcoming years. It is also highly secure and is not affected by severe weather.

Most of the system was developed as planned. However, the GPS receivers have not yet been made small enough to embed in wearable safety devices. In this stage of the system's development, the receivers were carried rather than embedded.

Field tests of the system were conducted in a parking lot to demonstrate the basic functionality of the technology.

Researchers developed but have not yet implemented concepts for two additional modes on the wearable safety device: Panic and Caution. Workers could activate the

continued

"There's a lot of potential for this kind of technology, but we want to make sure the wearable safety device is small enough that it won't interfere with maintenance tasks, is durable and is easy to maintain."

—Robert Vasek,
Engineer, MnDOT Office of Maintenance

"While there will be an initial cost to develop this system, we think it will ultimately be available for a relatively small investment—probably no more than a few thousand dollars per work zone."

—Imran Hayee,
Professor, University of Minnesota Duluth Department of Electrical Engineering

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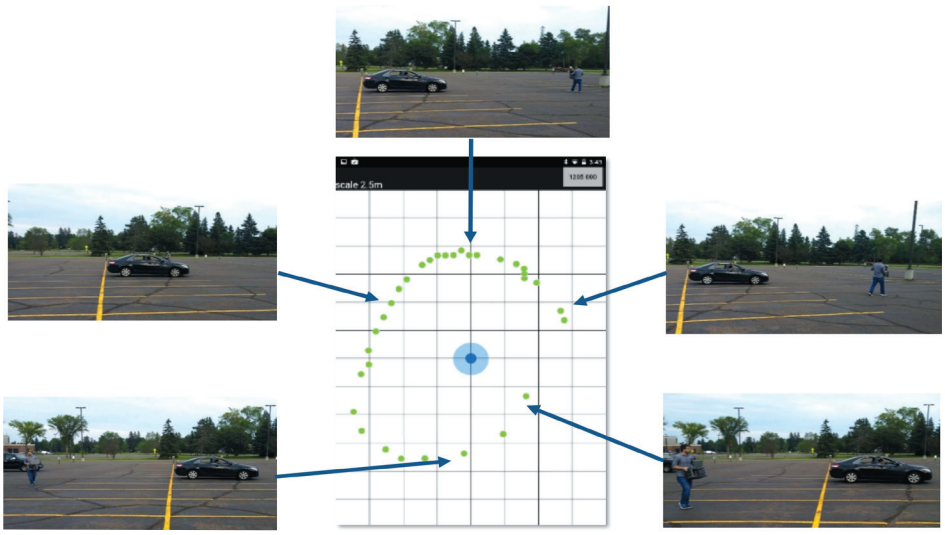

The tablet screen (center) shows the trajectory of a worker walking around the vehicle.

Panic mode to alert the construction vehicle if they are injured or need assistance, or the Caution mode to alert the operator of dangerous conditions.

What Did We Learn?

Accuracy in worker location was one notable challenge in developing this proof-of-concept system. When reporting a person's absolute position, current commercially available GPS receivers can be off by as much as 5 meters, which is not accurate enough to reliably locate a worker's position around a construction vehicle.

However, much of the error is due to atmospheric disturbances that remain constant throughout the work zone. Therefore, the system can use the GPS receiver in the tablet of the construction vehicle to locate workers relative to the vehicle's location (rather than on an absolute basis) and reduce the margin of error to about 2 meters.

In initial testing, the system also reported significant errors in directional orientation: The direction of the worker could only be calculated relative to a fixed reference direction. If a worker was standing in front of the construction vehicle but the vehicle rotated, the system still showed the worker in front of the rotated vehicle.

Researchers used two GPS receivers—one in the tablet and one in the DSRC device in the vehicle—to help resolve this error. If the tablet was placed at the front of the vehicle and the DSRC device at the back, the system software could compare GPS data and orient the display more accurately, reducing directional error to 15 to 20 degrees.

What's Next?

The GPS receivers used in the prototype were about an inch thick. Before GPS and DSRC equipment can be embedded in safety vests, the components need to be scaled down to about half an inch thick. Work is currently underway to create devices that are small enough to embed in a safety vest.

Researchers are also working on a technique to further improve the system's directional accuracy using the magnetometers already incorporated into most mobile devices. Preliminary tests suggest that this approach may reduce directional error to about 5 degrees.

Testing the system in an actual work zone is necessary before broader implementation. While this is not currently planned, MnDOT is interested in the system's continued development and plans to collect feedback from maintenance and other staff before deciding how to proceed.

This Technical Summary pertains to Report 2016-27, "Visual Warning System for Worker Safety on Roadside Work-zones," published August 2016. The full report can be accessed at mndot.gov/research/TS/2016/201627.pdf.