



## RESEARCH SERVICES & LIBRARY

OFFICE OF TRANSPORTATION SYSTEM MANAGEMENT

## TECHNICAL SUMMARY

### Technical Liaison:

Ken Johnson, MnDOT  
Ken.Johnson@state.mn.us

### Project Coordinator:

Nelson Cruz, MnDOT  
Nelson.Cruz@state.mn.us

### Principal Investigator:

Chen-Fu Liao, University of Minnesota

### PROJECT COST:

\$89,500



Inexpensive, low-power Bluetooth beacons mount to work zone infrastructure to communicate with nearby smartphones.

# Smartphone App Gives Visually Impaired Pedestrians Audible Directions Through Work Zones

## What Was the Need?

Nationwide, pedestrians account for about 17 percent of all work zone fatalities. Visually impaired pedestrians face particular challenges in work zones because of physical barriers and lack of information to help them navigate.

The Federal Highway Administration requires audible navigation information for visually impaired pedestrians in pedestrian walkways through work zones. Currently, beeping devices typically alert pedestrians to the availability of this information and prompt them to press a button to hear audible directions. However, this information may be provided at the middle of a block, which forces users to backtrack to an access point where they can cross safely. Additionally, if the safe route is complicated, these messages may provide too much information for the user to easily remember.

## What Was Our Goal?

The objective of this project was to develop a system based on smartphones and Bluetooth devices to help visually impaired pedestrians safely navigate work zones.

## What Did We Do?

Researchers first performed a literature review of effective messaging for visually impaired pedestrians in work zones. They also drew on temporary pedestrian access route (TPAR) workshops organized by the [American Traffic Safety Services Association and MnDOT](#) in 2010, and by ATSSA, FHWA and California DOT in 2011. Ten new interviews were also conducted with visually impaired pedestrians to understand what information they find helpful in navigating work zones.

Using this information, researchers developed an Android smartphone app that automatically sends audible messages to visually impaired pedestrians as they approach a work zone to help them safely navigate through or around it. The app receives messages from low-power, inexpensive Bluetooth beacons that can be attached to barricades or traffic cones at decision points. When the pedestrian's app detects these beacons, it alerts the user with a brief vibration before providing navigation messages made audible by a text-to-speech interface. Users can repeat the message as needed with a single tap of the screen.

Researchers tested the basic functionality of the app at a University of Minnesota campus location by carrying a smartphone with the app and approaching traffic cones mounted with Bluetooth beacons. They also performed validation testing at two sidewalk construction sites at the Minnesota state Capitol. Graduate students rather than visually impaired pedestrians tested the app, which served as a proof of concept of the system's basic functionality.

*The navigation system developed in this project can help visually impaired pedestrians safely navigate work zones by automatically sending audible directions to a smartphone app as the pedestrian approaches inexpensive Bluetooth beacons mounted within the work zone.*

*“Some commercially available, infrastructure-based products beep and force users to press a button to receive audible navigation information. Our approach was to provide information to phones as users approach the work zone so they’ll be able to repeat it as needed.”*

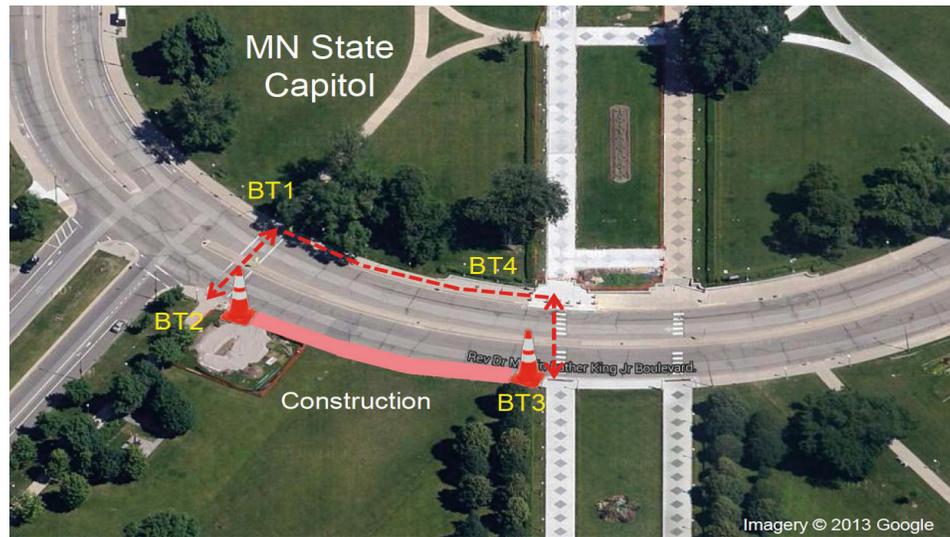
—Chen-Fu Liao,  
Senior Systems Engineer,  
Minnesota Traffic  
Observatory, University  
of Minnesota

*“The Bluetooth beacon is the critical component of this system. It’s small, inexpensive, easy to install and flexible, so it easily conveys the appropriate message to visually impaired pedestrians.”*

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

**Produced by CTC & Associates for:**

Minnesota Department  
of Transportation  
Research Services & Library  
MS 330, First Floor  
395 John Ireland Blvd.  
St. Paul, MN 55155-1899  
651-366-3780  
[www.mndot.gov/research](http://www.mndot.gov/research)



Four beacons at the state Capitol test site successfully alerted app users to a sidewalk that was inaccessible due to construction and provided directions to safely navigate around it.

### What Did We Learn?

The interviews revealed several details about useful navigation information. For example, visually impaired users generally preferred to receive detailed, turn-by-turn instructions as they progressed through the work zone rather than a long series of instructions provided just as they entered it. Recommended elements for audible work zone messages include an alert to attract the pedestrian’s attention, the pedestrian’s current location, a description of the inaccessible area and directions to an accessible path (including the length of the construction zone), and advisory information such as where the pedestrian can expect another message. While the sample size was small, researchers feel it provides a reasonable representation of visually impaired pedestrians who do want more work zone information.

Initial functionality testing confirmed that the smartphone app successfully detected Bluetooth beacons within 15 feet. Validation testing at two sidewalk closure sites demonstrated that the app functioned as designed, vibrating the phone for about one second as the tester approached a Bluetooth beacon and announcing the corresponding message to provide navigation information.

### What’s Next?

MnDOT has used the information generated by this research to update its [TPAR audible message content guidelines](#). Some future work will still be necessary before the system can be implemented, including developing a system to manage the audible messages and coordinating these with the appropriate beacon. Researchers have proposed architecture for this system that would allow a construction manager or project coordinator to update the messages via computer.

Details about access to transit and integration with a previously developed [Mobile Accessible Pedestrian Signals](#) system that provides information to visually impaired pedestrians at signalized intersections may also be incorporated.

MnDOT is hoping to turn implementation of this system over to private industry. Currently, responsibility for providing audible navigation information lies with contractors or their temporary traffic control agents. Due to the logistics of these contracts, MnDOT believes it makes sense for them to retain this responsibility.

---

*This Technical Summary pertains to Report 2014-12, “Development of a Navigation System Using Smartphone and Bluetooth Technologies to Help the Visually Impaired Navigate Work Zones Safely,” published February 2014. The full report can be accessed at <http://www.dot.state.mn.us/research/TS/2014/201412.pdf>. State TPAR guidelines, including audible message guidelines, are available at <http://www.mndot.gov/trafficeng/workzone/tpar.html>.*