EXHIBIT A
SCOPE OF SERVICES

INVESTIGATE THE EFFECTIVENESS OF USING BLUETOOTH LOW ENERGY TECHNOLOGY TO TRIGGER IN-VEHICLE MESSAGES IN WORK ZONES

BACKGROUND

According to work zone injury and fatality data, published by the Federal Highway Administration (FHWA) in 2010, there were more than 87,600 crashes in work zones, resulting in 576 deaths and 37,476 injuries. More than 20,000 workers are injured in work zones each year, with 12% of those due to traffic incidents. The situation got worse in 2012, with 609 out of 33,561 road fatalities in work zones. Challenges to work zone safety and mobility are also exacerbated by the growing issue of distracted driving.

This project is one of the three components of a work zone safety research proposal to investigate the effectiveness of using in-vehicle messages to calibrate drivers' understanding of the work zone in order to reduce risky behavior, associated with distraction. This project will examine an inexpensive new technology based on Bluetooth Low Energy (BLE) tags that can be deployed in or ahead of work zones. These can trigger spoken and contextual messages in existing smartphones located in vehicles passing by the tag. Such messages can be updated remotely in real time and as such, may provide significantly improved situational awareness about dynamic conditions at the work zones such as awareness of workers on site, changing traffic conditions, or hazards in the environment.

Key technical issues that will need to be addressed are: What is the maximum Bluetooth scanning rate on a smartphone? What is the Bluetooth and data communication latency? What is the power consumption on smartphone and Bluetooth tags? What is the repeatability of Bluetooth communication at high speed? What is the Bluetooth signal attenuation in different environments? How can such a smartphone app be activated requiring no intervention by the driver?

OBJECTIVE

The key focus of the proposed study is to investigate the feasibility of using inexpensive BLE technology to trigger in-vehicle messages for motorists in work zones. The proposed approach could establish an alternative to automatic speed enforcement to change behavior in work zones by providing dynamic work zone information. The research findings of this project will help to understand the BLE communication performance (latency, scanning rate, power consumption, etc.) in a work zone. The goal is to address potential technical issues of communication between a smartphone and BLE Tags at high speed. It is anticipated that this project will provide guidelines for engineers and operational staff to determine the placement of tagged landmarks at work zones for triggering in-vehicle messages.

SCOPE

The latest Bluetooth technology, BLE or Bluetooth Smart, has considerably reduced power consumption as compared to earlier versions. Low-cost BLE devices have enabled many applications using BLE tags and smartphone devices to locate or identify personal items, or alert owners when personal belongings are left behind. Newer generations of smartphones on the market are now equipped with BLE technology. For example, iBeacon from Apple uses BLE technology to identify locations which trigger an action on the iPhone. According to an article, "Mobile Telephony Market", the Bluetooth Special Interest Group (SIG) predicts that more than 90% of Bluetooth-enabled smartphones will support the low energy standard by 2018.

Commercially available BLE tags are usually configured as non-paired and discoverable Bluetooth devices. A BLE equipped smartphone app can continuously scan for BLE devices in the environment. The BLE tag can "broadcase" its service name or other information. When the smartphone app receives the wireless signal from a BLE tag, it will also receive a Received Signal Strength Indicator (RSSI) value with that broadcast message. The RSSI is used to evaluate distance from the tag. Commercially available tags are about the size of a United States dollar coin. Some BLE products are even smaller.

A smartphone app will be configured to run as a background service on the phone. This means that the app will be running as soon as the smartphone is turned on. The app can potentially be integrated with 511 or other navigation apps to receive work zone information.

The goal of this project is to address potential technical issues of communication between a smartphone and BLE tags at high speed. However, if the communication range and latency of BLE cannot meet the technical requirements of the proposed application, the University has proposed to explore a solution using Bluetooth beacons (e.g., Bluetooth class 1 devices) with higher power and a longer range of wireless communication.

In order to evaluate the BLE performance, a smartphone and various BLE tags from different manufacturers will be acquired. The research team will develop a data acquisition and testing program on the smartphone to collect BLE ID and signal strength. Multiple test scenarios will be designed to evaluate the communication range, latency, and power consumption under a variety of conditions and when the smartphone user is travelling at different speeds. An in-vehicle app will be developed to demonstrate the system capability and performance under a variety of conditions. BLE performance and experimental findings will be documented in a report.

Connection of this project to the other two components of the work zone safety research proposal:

1. The driver behavior and distraction component will be led by Nichole Morris. This project will identify the problems and assess driver distraction in work zones using crash data analyses as well as through studying objective driver behavior data. This project will design and test dynamic in-vehicle messages that influence the drivers' understanding of the work zone in order to reduce risky behavior, such as distraction and speeding.
2. The Traffic Control device tagging and geolocation methodology and application effort will be led by John Hourdos. In this effort, a quick and simple means for BLE Tag/asset deployment and automatic detection will be developed and tested. BLE tags will be located on work zone assets such as signs and barrels. In order to report the deployment of a tagged asset to the central database, the worker that deploys the asset will carry a Global Positioning System (GLS)-enabled smartphone (or tablet) running an app. As soon as s/he walks away from the asset, the app reports it, with its location "dropped" into a cloud-based work zone database. The database capturing the location and tagged asset type can be used to assign a warning message linked to it, which can be dynamically changed, as needed, from any location.

WORK PLAN

<u>Task Descriptions</u>

Task 1: Acquire BLE Tags and a Smartphone
The University will purchase a PC, smartphone, data service plan and BLE tags from various manufacturers.

Task 2: Develop a Smartphone App for BLE Experiments and to "Play" Work Zone Messages
The University will develop a smartphone app on a PC to communicate with BLE tags and collect communication parameters. The app, when deployed on a smartphone, will trigger audio work zone messages (and other modalities, as needed) when a tag is detected. The University will make sure that the app will run and preempt all other apps that may be running simultaneously, especially 511 and navigation apps. The app will also disable other phone functions while driving through work zones; all incoming calls arriving while in the work zone will be routed to voicemail and outgoing texts and calls will be restricted (except 911 emergency calls). The content of the messages to the "played" will be determined from the human factors and driver behavior study.

Task 3: Experimental Design and Data Collection
This task will consist of experimental design and testing of the app with BLE tags. Research staff will conduct experiments (at different speed at locations such as MnROAD, the Minnesota State Fairgrounds, or the University's transit way) and collect performance data from BLE tags. A Technical Advisory Panel (TAP) meeting will occur to review Task 2 and 3 upon completion of this task.

Task 4: Data Analysis
Under this task, the University will analyze data obtained from the experiments. A TAP meeting will be scheduled before the end of this task to discuss the results.

Task 5: Compile Report, TAP Review and Revisions
The University will prepare a draft report, following MnDOT's publication guidelines, to document project activities, findings and recommendations. If the outcome if this project is satisfactory, the report will document steps needed for a pilot implementation and a plan to develop an iOS version of the app. Potential barriers and opportunities for implementation will also be included in the final report. This report will need to be reviewed by the TAP, updated by the University's Principal Investigator to incorporate technical comments, and then approved by the Technical Liaison before this task is considered complete. Holding a TAP meeting to discuss the draft report and review comments is strongly encouraged. TAP members may be consulted for clarification or discussion of comments.

Task 6: Editorial Review and Publication of Final Report
During this task, the Approved Report will be processed by MnDOT's Contract Editors. The editors will review the document to ensure the document meets the publication standard. The University's Principal Investigator will then prepare the Final Report and submit it for publication through MnDOT's publishing process. This task must be completed within the contract timeframe because the editors will provide editorial comments and request information from the University's Principal Investigator.

Task Deliverables

Task:	Deliverable(s):
1:	Brief Summary Report
2:	A Summary Report, describing the developed smartphone app
3:	A Summary Report, describing the experimental results; Meeting Minutes, from the TAP meeting
4:	Completed Data Analysis; Summary Report of Results
5:	Draft Report; Final Report, approved for publication
6:	Final Published Report

PROJECT SCHEDULE

Task Completion Dates

Task:	Draft Deliverable Due Date:	Final Task Approval Date:
1:	July 31, 2015	September 30, 2015
2:	November 30, 2015	January 31, 2016
3:	March 31, 2016	May 31, 2016
4:	April 30, 2016	June 30, 2016
5:	August 31, 2016	October 31, 2016
6:		December 31, 2016

Task Durations

	2015						2016											
Months:	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Task 1	X	X	X															
Task 2		X	X	X	X	X	X											
Task 3						X	X	X	X	X	X							
Task 4									X	X	X	X						
Task 5												X	X	X	X	X		
Task 6																	X	X

Key Milestones

Key Milestones	Target Date	Description
TAP Meeting	April 2016	Discuss and Review Experiment Results