Personal Warning Sensor for Road Construction Workers

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February 2019

Project Summary Report 2019-08
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This study demonstrated the capabilities of a work zone intrusion alarm system, called Advance Warning and Risk Evasion (AWARE), during a Minnesota paving project. The portable radar-based technology intelligently detects and tracks potential vehicle intrusion threats, as well as worker locations, to warn both workers and errant drivers. The research project’s Technical Advisory Panel observed the system in operation by a road crew in the Minneapolis area and gleaned insights about the technology and data it collects. Study authors also initially hoped to analyze raw individual vehicle trajectory data to assess intrusion behaviors in detail; however, the required data was unavailable due to system limitations.
PERSONAL WARNING SENSOR FOR ROAD CONSTRUCTION WORKERS

PROJECT SUMMARY REPORT

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February 2019

Published by:

Minnesota Department of Transportation
Research Services & Library
395 John Ireland Boulevard, MS 330
St. Paul, Minnesota 55155-1899

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EXECUTIVE SUMMARY

Oldcastle Materials, Inc., has teamed with a subcontractor from the US defense industry to develop a state-of-the-art work zone intrusion and worker alarm system named AWARE for Advance Warning And Risk Evasion. The system is a portable technology that can intelligently detect and track potential vehicle intrusion threats as well as worker locations in the work zone. The purpose of this study was to coordinate a deployment of the system on an Oldcastle road crew in Minnesota so that the technical advisory panel (TAP) could make a visit to the site. The site visit would allow the TAP to observe the system in operation, as well as glean any insights about the technology and the data it collects. Study authors also initially hoped to analyze raw individual vehicle trajectory data to assess intrusion behaviors in detail; however, the required data was unavailable due to system limitations.

Oldcastle worked with Hardrives, Inc., one of its asphalt paving partners, to outfit one of its crews with the AWARE system. This crew had a paving subcontract scheduled for the spring of 2018 in the Minneapolis area that would lend itself to the site visit by the TAP. The paving project was located on State Highway (TH) 65 north of the Minneapolis-Saint Paul metropolitan area, near the town of Cambridge. The TAP visited the site in May 2018 to observe the operation of the system. Overall, the demonstration site visit was successful in illustrating the potential of the AWARE system for detecting vehicle intrusions into workspaces and warning both intruding motorists and the work crew. The system developers have continued to work on refining the detection and warning algorithms as more field testing occurs and issues arise. Oldcastle was also working to identify a manufacturer/distributor to license this technology once it has been fully tested and deemed ready for commercialization. To date, however, no effort has yet been made to estimate the eventual cost of the system.
CHAPTER 1: INTRODUCTION

1.1 IMPETUS OF STUDY

In July 2016, the Minnesota Department of Transportation (MnDOT) issued a research needs statement to investigate the development of a wearable device that would alert workers of a vehicle that has intruded into the workspace and now approaching them. At that time, the Texas A&M Transportation Institute (TTI) proposed that, rather than develop new technology, MnDOT sponsor research to examine the feasibility and usefulness of an intrusion warning system that was already under development in the private sector.

1.2 DESCRIPTION OF THE SYSTEM

Oldcastle Materials, Inc., (herein referred to as “Oldcastle”) has teamed with a subcontractor from the US defense industry to develop a state-of-the-art work zone intrusion and worker alarm system to deploy within its work crews nationally, including those in Minnesota. The system, named AWARE for Advance Warning And Risk Evasion, is a portable technology that can intelligently detect and track potential vehicle intrusion threats as well as worker locations in the work zone.

Unlike previous intrusion alarm systems that rely on the detection of vehicles crossing a predetermined perimeter (typically identified with pneumatic tubes or infrared beams), this new system utilizes a target threat detection and tracking methodology to logically assess approaching vehicle speed, location, and possible trajectory. When the AWARE system is deployed in a roadway environment (i.e., a work zone), threats are detected in two flat, fan-shaped regions, as shown in Figure 1. The radar detection system mounts on a work vehicle or piece of equipment and moves along with the work crew as needed (see Figure 2).

Figure 1. AWARE Threat Detection Regions.

Source: TTI
If an intrusion has occurred or is imminent, workers downstream of the intruding vehicle are alerted via a small device worn in the hardhat, in the vest, or as an armband. The device, named "Worktrax," provides haptic and auditory alerts of an impending intrusion. Figure 3 illustrates the Worktrax device.

The system also includes flashing lights on the work vehicles/equipment where the radar system is attached and an audible alarm is directed towards approaching traffic. These lights and alarm activate if an intrusion is detected to alert the distracted or inattentive motorist intruding into the workspace.

Once activated in the field, the AWARE system “learns” the proper travel patterns of approaching vehicles and automatically defines the zones where vehicles are allowed to travel and where they are not (i.e., where they are intruding into the workspace). To account for work vehicles and equipment moving into and around within the workspace, the system does not activate if vehicles and equipment are moving in the workspace at speeds below 15 miles per hour (mph).

**1.3 AWARE SYSTEM TESTING RESULTS**

Oldcastle has been testing the system on a sample of its work crews across the country over the past few years. A number of changes and improvements have reportedly been made to the system software as a result of these various test deployments. In addition, Oldcastle also contracted with the Texas A&M Transportation Institute (TTI) in 2015 to conduct third-party testing of the system. TTI conducted human factors testing to evaluate the response of approaching motorists to the audible alarm and flashing lights, as well as system performance testing of intrusion detection and alarm activation. The human...
factors testing focused on determining if motorists near the audible alarm and flashing lights would be excessively startled and result in undesirable driving reactions (hard braking, swerving, etc.). The system performance testing focused on timeliness of intrusion detection, potential for intrusion false positives, and operation of the Worktrax when an intrusion occurs.

Overall, the results of those tests were positive. The human factors testing did not suggest an increased probability of adverse driving behaviors by motorists when the system activated the alarm and lights, although some motorists did state afterwards that it did “surprise” them somewhat. The study did suggest that the audible alarm could confuse some motorists into thinking that an emergency vehicle was nearby and that they may need to pull over and stop to let it by. To counter that tendency, TTI did recommend that Oldcastle modify the alarm to operate in short bursts similar to how back-up alarms work on construction equipment (1). Meanwhile, the system performance testing yielded a nearly 100 percent accuracy response with essentially no false alarms for the conditions and test parameters evaluated (2).

1.4 PURPOSE OF MNDOT STUDY

Given that Oldcastle was continuing to deploy and test the system, the purpose of this study was to coordinate deployment of the system on an Oldcastle road crew in Minnesota so that the technical advisory panel (TAP) could make a visit to the site. The site visit would allow the TAP to observe the system in operation, as well glean any insights about the technology and the data it collects.
CHAPTER 2: FIELD DEMONSTRATION OF THE AWARE SYSTEM

2.1 DESCRIPTION OF THE FIELD DEMONSTRATION LOCATION

Oldcastle worked with Hardrives, Inc., one of its asphalt paving partners, to outfit one of its crews with the AWARE system. This crew had a paving subcontract scheduled for the spring of 2018 in the Minneapolis area that would lend itself to the site visit by the TAP. The paving project was located on State Highway (TH) 65 north of the Minneapolis-Saint Paul metropolitan area, near the town of Cambridge (see Figure 4). TH 65 is primarily a four-lane divided roadway with at-grade driveway and cross-street access. The roadway also has occasional crossover points with left-turn lanes to facilitate turnarounds and access crossroads and driveways.

Figure 4. Location of the TH 65 paving project.

Oldcastle and the paving crew mounted the AWARE system on the back of the steel roller operating at the rear of the paving train (see Figure 5). Workers wore the Worktrax devices on their arms or in their safety vests.
2.2 MNDOT TAP SITE VISIT

The TAP site visit to observe the AWARE system in operation occurred on Tuesday, May 22, 2018. A total of 6 TAP members, 4 additional MnDOT personnel, 1 consultant, 2 Oldcastle representatives, and 2 TTI researchers participated in the site visit. Participants met at a parking lot near the project site and received an initial briefing about the AWARE system from the Oldcastle representatives. Participants then donned appropriate personal protection equipment, consolidated into three vehicles, and traveled...
to the project. Vehicles were parked beyond the left shoulder upstream of the paving roller with the AWARE system, and participants got out of the vehicle to observe the operation of the system (see Figure 6). The briefing continued at the site, and the Oldcastle representative brought out additional Worktrax units for the participants to see close up. At the time of the site visit, the paving crew was located just downstream of a crossover point. An occasional motorist would enter into the closed travel lane to access the left-turn lane for that crossover, which would trigger an alarm by the AWARE system. Consequently, participants were able to see firsthand that the detection system worked as did the audible and flashing light alarms and the Worktrax devices.

![Figure 6. Participants at the project site observing the operation of the AWARE system.](image)

2.3 LESSONS LEARNED AND FUTURE WORK

Overall, the demonstration site visit was successful in illustrating the potential of the AWARE system for detecting vehicle intrusions into workspaces and warning both intruding motorists and the work crew. It was hoped that it would be possible to obtain the raw individual vehicle trajectory data generated by the system for further processing and analysis to assess intrusion behaviors in detail. Unfortunately, the Oldcastle representatives determined that the system still has some data storage and synthesis issues, which precluded performing such an analysis at this time. The developers continue to work on refining the detection and warning algorithms as more field testing occurs and issues arise, as well on resolving the data storage and synthesis challenges.

Oldcastle anticipates the continued use of AWARE systems by its work crews across the country as beta-testers over the next few construction seasons. In addition, the company is working to identify a manufacturer/distributor to license this technology once it has been fully tested and is deemed ready for commercialization. As a result, no effort has yet been made to estimate the eventual cost of the system.
REFERENCES
