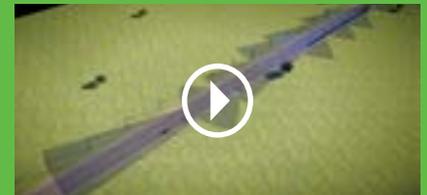


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PREVENTING WORK ZONE INTRUSIONS WITH ALERT SYSTEM



Video of Detection System Available

A manufacturer's [video](http://bit.ly/AWAREvideo) (available at bit.ly/AWAREvideo) shows the Advanced Warning and Risk Evasion system, which uses multiple radar detectors to detect speed, position and trajectory of up to 64 vehicles over 600 feet.

Nationwide from 2005 to 2010, 733 highway crew workers lost their lives — approximately half due to motorists intruding into work zones. This is why MnDOT has been systematically researching the cause of intrusions and how to prevent them.

More than 150 work zone intrusion crashes are thought to occur each year in Minnesota. This summer **MnDOT work crews began testing** a state-of-the-art intrusion alarm system developed by defense industry contractors. The system detects the speed and trajectory of approaching vehicles. If there's a threat, it alerts at-risk construction workers, who are tracked and notified via warning devices attached to hard hats or vests. The system also transmits audio and visual warnings to the oncoming vehicle.

Effectively notifying approaching motorists has been an ongoing concern for MnDOT, which has investigated different

signage and enforcement methods, as well as sounds and lights, to alert distracted drivers (Reports **2017-07** and **2016-06**).

Other research-backed initiatives to improve work zone safety include:

- A comprehensive, user-friendly reporting system for road crews to report work zone intrusions (Report **2018-09**).
- A prototype for sending in-vehicle warning messages to motorists via smartphones (Reports **2017-19** and **2016-38**).
- Development of a manual for temporary barriers, truck-mounted attenuators and other positive protection devices (**TRS 1703**).
- Improvements to automated flagger device (Report **2017-09**).
- Update to MnDOT's temporary traffic control guidance based on a study by local agencies (Report **2016RIC09**).

“Our analysis suggests that societal crash costs could be reduced by \$5 million to \$26 million per year, depending on the resulting effectiveness of the intrusion alarm technology.”

—Gerald Ullman, Senior Research Engineer, Texas Transportation Institute



In-Vehicle System Provides Dynamic Warnings for Rural Road Curves

TRAFFIC & SAFETY – A significant number of fatal crashes on rural Minnesota roads come from vehicles running off the road at a curve. Because it's not economical to install infrastructure like a sensor-triggered dynamic warning display on low-traffic roads, researchers have been investigating an alternative: warnings inside vehicles that are delivered from a smartphone (or ultimately through a system built into the car).

Using knowledge gained from the successful **Teen Driver Support System** app, researchers developed a prototype Android app to use a vehicle's current speed and location to warn drivers about upcoming curves. They tested various types of warnings, choosing icon-based communication rather than readable text, along with a simple audible warning like "Curve ahead, one-half mile. Reduce speed."

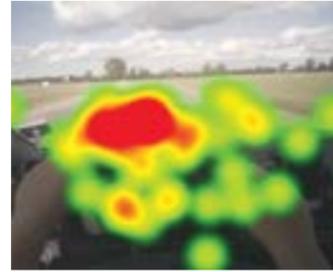
Further development and field operational testing of the system are planned.

A **project in progress** is collecting data about the speeds at which drivers travel through curves to better identify the thresholds at which a warning may need to be displayed. Drivers tend to ignore curve advisory speeds, which are commonly set at conservative levels. Research is needed to help determine how to effectively get drivers' attention and reduce their speed.

TECHNICAL SUMMARY 2018-12

"This in-vehicle warning system is potentially an inexpensive solution that could save lives on rural roads."

—Bradley Estochen, Traffic Safety Engineer, MnDOT Office of Traffic, Safety and Technology



To determine whether in-vehicle alerts would distract drivers, researchers recorded where drivers' visual attention fixated during a closed-course experimental trial. This heat-map display shows the duration of one driver's focus, from shortest (green) to longest (red).

New Software Models MnPASS HOT Lane Changes



RTMC engineers use new software to perform quarterly and annual analyses of corridor operations and recommend changes in HOT lane access.

TRAFFIC & SAFETY – Minnesota's high-occupancy toll (HOT) lanes have safely improved traffic capacity. But during heavy traffic, driving speeds can vary dramatically between HOT and general purpose lanes, and drivers moving into HOT lanes can force other drivers to brake suddenly. New software developed at the **Regional Transportation Management Center** (RTMC) enables traffic engineers to model the impact of changing lane access from open (allowing traffic to enter the HOT lane at any point along a given corridor) to closed (allowing traffic to enter only at certain points). Making this change in access only requires restriping and replacing signage, and can easily be done in response to changes in traffic patterns that affect mobility and safety.

TECHNICAL SUMMARY 2018-11

Where Are the Truck Bottlenecks?

MULTIMODAL – The Twin Cities metropolitan area freight network is vital to keeping Minnesota companies in business. But many of the network's roadways are overcapacity at peak travel periods, and heavy truck traffic is only expected to increase. In a recent project, investigators built on the results of previous studies to analyze mobility, reliability and delay along key freight corridors. This analysis dovetails with federal guidelines (**NCHRP Research Report 854**) for identifying and addressing truck bottlenecks caused by weather, roadway geometry, weight limits and other factors.

TECHNICAL SUMMARY 2018-15

Upgrading MnPAVE-Rigid Design Software



In-house software helps MnDOT engineers design high-performing, cost-effective concrete pavements.

MATERIALS & CONSTRUCTION—MnDOT developed its own concrete pavement design software, MnPAVE-Rigid, in 2014,

which incorporates federal mechanistic-empirical design guidance adapted for Minnesota conditions. An upgrade was needed, however, to improve usability and expand the range of inputs for traffic, subgrade type, base type and thickness.

The new MnPAVE-Rigid 2.0 software is not only easier to use, it allows concrete pavement designers to select from more options for aggregate base types and pavement thicknesses, and use actual rather than estimated traffic values.

Researchers developed the software on Java 2.0, which allowed MnDOT to avoid expensive systems and enables the agency to upgrade the software internally as needed.

TECHNICAL SUMMARY 2018-17

Design Tool Offers Alternatives to Protect Pavements from Frost Damage

MATERIALS & CONSTRUCTION – Frost heave occurs when water seeps into the road base, freezes and expands. During spring thaw, the base weakens, which can lead to surface cracks and potholes. Since 1995, MnDOT has required frost-free materials—coarse gravel, sand and other materials—in asphalt pavement subgrades at depths of 30 to 36 inches, based on load requirements. Whether this practice was effective at all locations was unclear, however, and sometimes it was unnecessary. To determine necessary pavement structure requirements, researchers studied 72 Minnesota sites with different soil and pavement types to develop pavement profiles that looked for correlations between winter ride quality and construction characteristics. They developed spread-



Frost action causes significant damage to roadways by expanding and thawing beneath pavement. It is the principal culprit behind spring potholes.

sheets that included different frost depth predictions and soil type characterizations that engineers can use to optimize their use of frost-free materials. MnDOT is evaluating these results and plans to conduct a pilot implementation.

TECHNICAL SUMMARY 2018-06

Do Clear Bioseals Work?

MAINTENANCE & OPERATIONS – Maintenance crews often spray pavement surfaces with a "fog" of liquid sealant after the pavement has been in service for a year or more. These fog seals extend the water resistance of asphalt and protect pavements from oxidation. However, the seals are dark mixtures that interfere with pave-

ment striping visibility and can also reduce roadway friction. Researchers investigated bioseals, which are currently more expensive than petroleum industry products but do not obscure markings. Study results showed that bioseals temporarily reduced the retroreflectivity of pavement markings and still reduced friction to some extent,

Content Management Systems and Website Practices

A Transportation Research Synthesis (TRS) is a short-turnaround research project that summarizes research activity or practice among transportation agencies. If you need answers, request a TRS from MnDOT Research Services & Library today.



POLICY & PLANNING — MnDOT's website has 150 independently managed subsites that are inefficient and difficult to manage. As a first step in possibly replacing its outdated web development tool, the MnDOT Office of Communications gathered feedback about the web content management systems (CMS) used by other agencies, including a platform being piloted by MnDOT Research Services. A survey of 21 state DOTs and seven Minnesota public agencies identified the CMS used (SharePoint and Drupal were the most common), funding and management practices, and website integration with states' 511 systems.

TRS 1805

though not by as much as traditional seals. The traditional seals offered longer-lasting water resistance. The new sealant technology will be useful in some areas such as city streets and will provide some advantages over traditional fog seals.

TECHNICAL SUMMARY 2018-18



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Calendar

- 9/12** LRRB RIC fall meeting, St. Cloud
- 10/17** LRRB fall meeting, Stearns County
- 10/23-24** Toward Zero Deaths Conference, Mankato
- 10/31** MnDOT TRIG meeting, Arden Hills
- 11/1** CTS Transportation Research Conference, Minneapolis
- 11/1** National Cooperative Highway Research Program (NCHRP) problem statements due

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- › Design Tool Offers Alternatives to Protect Pavements from Frost Damage

