



TRANSPORTATION RESEARCH SYNTHESIS

Minnesota Department of Transportation
Office of Policy Analysis, Research & Innovation
Research Services
(651) 366-3780
www.dot.state.mn.us/research

TRS 1303
Published June 2013

Mobile Traffic Signals in Lieu of Flaggers for Moving Operations

The purpose of this TRS is to serve as a synthesis of pertinent completed research to be used for further study and evaluation by MnDOT. This TRS does not represent the conclusions of either CTC & Associates or MnDOT.

Introduction

Flagging in work zones is crucial to the safety of workers and drivers, but it is one of the most dangerous tasks, representing more than one-third of injuries to pedestrian workers (Odell 2013).

Automated Flagger Assistance Devices (AFADs) are portable traffic control systems that can help to improve safety because flaggers can operate them from outside the flow of traffic. Several states have evaluated AFADs, with generally positive assessments of their effectiveness. While compliance with the AFAD is not universal among drivers, violation rates were lower than red-light violation rates documented in other literature (Finley 2013).

MnDOT requested information about self-propelling AFADs for mobile work zones, with the specific idea of mounting an AFAD on a remote-controlled caravan mover.

Summary

We spoke to or emailed staff at the state departments of transportation in Iowa, Missouri, Montana, Oregon, South Dakota, Texas and Wisconsin as well as representatives of the Transportation Research Board Committee on Work Zone Traffic Control, the Smart Work Zone Deployment Initiative and the American Traffic Safety Services Association.

None of the state DOT representatives said that their states currently used or planned to implement any self-propelled AFADs. In fact, most of the states have not implemented any form of AFAD, although some are beginning to investigate the possibility.

None of the individuals interviewed were aware of any examples of self-propelled AFADs in use in other jurisdictions. However, some research has been conducted on robot-controlled traffic cones and road signs at the University of Nebraska–Lincoln Robotics and Mechatronics Lab. This project (Farritor 2005) developed a

working system of eight self-propelling safety barrels and one road sign, all controlled by a single lead robot. While the system was functional, it never became commercially available.

MnDOT's idea of a human-controlled, self-propelling AFAD operated by remote control represents a simpler system that is likely feasible from a technological standpoint.

A procedural issue was raised that would likely need to be addressed if MnDOT implemented a mobile AFAD. In a moving work zone, one of the devices would be traveling with traffic while the upstream device would be traveling against traffic. In moving work zones with human flaggers, that problem can be solved by using a third flagger. Two flaggers would be positioned on the upstream side, and they would leapfrog each other rather than attempting to move against traffic.

One respondent questioned the practicality of a self-propelling AFAD because temporary signs and devices would need to be moved as well.

Stationary AFADs are generally well understood by drivers. We found no information that suggests whether a moving device would be equally well understood.

AFADs: General Information

AFADs do not eliminate the need for qualified flaggers. Instead, they enhance safety by allowing flaggers to operate the device from an area away from traffic, which minimizes flaggers' exposure to traffic.

Two basic types of AFADs are included in the 2009 Manual on Uniform Traffic Control Devices (MUTCD): a remotely controlled stop/slow sign mounted on a trailer or movable cart, and a remotely controlled red/yellow lens with a mechanically gated arm. Although not required, a mechanically gated arm may be added to the stop/slow device (ATSSA 2012).

All AFADs must meet crash test standards as detailed in Section 6E.04 of the 2009 edition of the MUTCD (last revised May 2012).

The MUTCD does not place limits on where AFADs can be used, although many states do. Minnesota limits AFAD use to roads with fewer than 1,500 vehicles per day. Virginia allows AFADs on roads with up to 12,000 vehicles per day. AFAD placement is preferred within the shoulder, although the device may encroach on the travel lane if appropriate sight distance is available and the gate arm does not extend into the adjacent lane.

Currently, 11 states have standards for the use of AFADs. Most limit the distance between flagging stations to 800 feet, although some (including Minnesota) permit their use in 1,000-foot zones if each device has its own operator. Longer work zones may justify the use of AFADs as well, based on engineering judgment. A summary of state policies is available in the ATSSA guidance.

Some states have additional requirements such as supplemental warning signs, backup battery power, and flashing lights or gate arms on stop/slow signs.

State evaluations have generally found the red/yellow lens version to be better understood by drivers than the stop/slow version. According to results from a Virginia study, drivers were confused when the stop/slow version was accompanied by signs reading "Wait on Stop" and "Go on Slow." Many drivers interpreted them to mean they should pause at the "stop" sign before proceeding slowly, rather than waiting until the sign changed to "slow" before moving (Cottrell 2006). In Texas, there were significantly more violations of the stop/slow version than the red/yellow lens version, although stop/slow violations dropped to similar levels as the red/yellow lens when a mechanical gate arm was added to the device (Finley 2013).

Intrusion alarms are available, but a study at a test facility found that workers were barely able to hear a 128-

decibel alarm when there was no traffic or equipment in operation, raising questions about the alarm's effectiveness in an active work zone (ATSSA 2012). States were encouraged to have an alternative plan in case of equipment malfunction.

Surveys of work zone crews in Maine, Missouri and Virginia have found enthusiastic approval of AFADs (ATSSA 2012).

Robotic Devices

Shane Farritor, a professor at the University of Nebraska–Lincoln Department of Mechanical Engineering, led the research into robotic highway safety markers. Specifically, the project developed a system of eight traffic safety barrels that are mounted on robotic bases. Each base has two 7.5-inch wheels, each driven by its own motor, and a passive caster that supports the rear of the robot. Each robot is powered by a 12-volt lead-acid battery.

The barrel robots were designed to be stable in 55 mph winds, climb slopes of less than 7 percent and negotiate small (8-centimeter) obstructions.

In an interview, Farritor described the platoon of barrels as “a sheep and shepherd.” A truck-mounted lead unit makes decisions about where to go and uses Light Detection and Ranging (LIDAR) technology to direct the eight robots. While the lead unit determines each robot's destination, the individual units identify and plan their own paths to reach it. A human operator can override the configuration at any time, and can also take manual control of any single barrel and maneuver it remotely.

The robotic road sign is “just another barrel” that is managed by the same system, Farritor said. Instead of a robotic base, the trailer uses a tricycle design. It is driven by a 16-inch front wheel with two electric motors, one to drive the robot and the other to steer. The trailer also has two trailing wheels to support the unit. It is designed to be able to maneuver a 4-inch drop-off, and it can travel at up to 2.5 mph.

This system was never made commercially available. The problems were not technical; investigators were unable to convince potential customers that the system was superior to manual operations. As the idea of putting an AFAD on a caravan mover and controlling it by remote control is a similar but simpler concept to this system, Farritor said, “I see no technological reason why it can't be implemented.” In our discussion, Farritor expressed his interest in returning to the project.

Caravan Movers

A caravan mover is a device for moving a trailer by remote control. Although generally marketed as devices to help maneuver camper trailers, caravan movers can be used to motorize other types of trailers as well. While we found no evidence that caravan movers had been implemented to move AFADs, we also found no evidence that would suggest a caravan mover could not be used in this way.

There are numerous manufacturers of caravan movers, primarily based in Europe, although many are available in the United States. Manufacturers include Elektrotechnik (Germany), Kronings (Denmark), Motor Mover (UK), Pamet (UK), Powrtouch (UK), Purple Line (UK), Reich (Germany), Rhyno (UK), Traveller Industries (Australia), Truma (UK) and Unipart Leisure (UK).

A comparison of different manufacturers and models is available at <http://www.caravanmoveronline.co.uk/pages/SINGLE-compare-movers.html>.

Organizational Contacts

DOT Contacts

Iowa

Mark Bortle, Traffic Safety Engineer, Iowa Department of Transportation, mark.bortle@dot.iowa.gov, (515) 239-1587.

Iowa DOT does not currently allow the use of AFADs, and Bortle does not expect the state to use them in the future. The state is concerned that an AFAD does not look enough like a signal, that one flagger may not be sufficient to control both ends, and that not having a human flagger would permit more cars to bypass the device and enter the traffic flow when they shouldn't.

The state does use flagger-operated temporary signals with good success on one or two projects per year, generally on high-volume roads where the work is done at night. The zones are a couple of miles long; each end has its own flagger who operates the signal from the shoulder.

Montana

Jim Wingerter, Construction Traffic Control Engineer, Montana Department of Transportation, jwingerter@mt.gov, (406) 454-5897.

Montana DOT does not use AFADs on construction projects. Instead the agency uses flaggers, temporary traffic signals or a combination of both.

Oregon

Scott McCanna, State Traffic Control Plans Engineer, Traffic-Roadway Section, Oregon Department of Transportation, scott.m.mccanna@odot.state.or.us, (503) 986-3788.

McCanna is unaware of remote-controlled AFADs, and he questions their practicality since a number of other temporary signs and devices would need to be moved in conjunction.

Oregon DOT permits AFADs. There are four qualified products, all of which are red/yellow lens devices: the Automated Flagger AF-100, IntelliStrobe W1-AG, IntelliStrobe W1-AG/TM and RC Flagman RCF 2.4.

Several models have been rejected:

- **Red/yellow lens:** IntelliStrobe W1-A (does not meet specifications) and Robo Flagger WFT-BS-1111-07A (does not have conflict monitor)
- **Stop/slow flagger:** AutoFlagger (does not meet specifications) and IntelliStrobe WS1-A (does not meet specifications)
- **Hybrid:** IntelliStrobe WS1-AG/TM (Oregon does not allow the red/yellow lens device with a stop/slow paddle.)

State regulations for the red/yellow lens device include the following:

- AFADs should be less than 800 feet apart.
- AFADs should be lit at night.
- The bottom of the lens must be at least 7 feet above the surface when mounted on the shoulder and 15 feet above any portion of the travel lane.
- The gate arm must cover at least half of the approaching travel lane.
- Signing and other traffic control devices shall move with the work area.

Regulations for the stop/slow device include the following:

- AFADs should be less than 800 feet apart.
- AFADs should be lit at night.
- The bottom of the sign must be at least 7 feet above the surface when mounted on the shoulder.
- The gate arm must cover at least half of the approaching travel lane.
- Signing and other traffic control devices shall move with the work area.
- The stop beacon flashes in stop phase; the warning beacon flashes in slow phase.

Regulatory details, including work zone drawings, are available at

http://www.oregon.gov/ODOT/HWY/ENGSERVICES/pages/details_traffic.aspx#Temporary_Traffic_Control.

South Dakota

Laurie Schultz, Operations Traffic Engineer, South Dakota Department of Transportation, laurie.schultz@state.sd.us, (605) 773-4759.

South Dakota DOT does not use AFADs.

Texas

Wade Odell, Research Engineer, Texas Department of Transportation, wade.odell@txdot.gov, (512) 416-4737.

Texas DOT used AFADs, but only for stationary applications during the day. AFADs are useful in operations where workers at one end of the roadway can't see the other end, but an operator positioned in the middle can see both ends. For moving operations, Texas uses standard flashing arrows and attenuators. Odell has not seen any examples of self-propelling AFADs.

Wisconsin

Peter Amakobe Atepe, State Work Zone Traffic Safety Engineer, Wisconsin Department of Transportation, peter.amakobeatepe@dot.wi.gov, (608) 261-0138.

Wisconsin DOT has not deployed any AFADs, and the state has no guidance or specifications beyond what is in the MUTCD. The state is likely to use AFADs in the future, however, and Amakobe Atepe is currently developing detailed drawings that will likely be available by June 2013.

Other Organizational Contacts

American Traffic Safety Services Association

Jim Baron, Director of Communications, American Traffic Safety Services Association, james.baron@atssa.com, (540) 368-1701, ext. 113.

AFADs were exhibited at the 2013 ATSSA Annual Convention and Traffic Expo, but none were mobile. One AFAD, the Remote Operated Safety Attendant (ROSA), won first prize in the 2013 Innovation Awards at the convention; ROSA is a stationary device, however.

Federal Highway Administration

Ken Wood, Traffic Operations Engineer, Federal Highway Administration, ken.wood@dot.gov, (708) 283-4340.

Wood has not heard of any self-propelling AFADs. There are units on dollies that can easily be moved by a single operator. The J4 Flagger Workstation was one such device that was used in Illinois. (It appears this device is no longer commercially available, and according to Trademarkia, its trademark has been abandoned.)

The only regulatory issue he sees with a self-propelling AFAD is that it might need to be crash-tested. Commercially available AFADs already are crash-tested; it is unclear whether an AFAD mounted on a caravan mover would need to be tested as a unit as well, with the determination made based on the specifics of the setup.

Iowa State University

Tom McDonald, Smart Work Zone Deployment Initiative Manager, Iowa State University Institute for Transportation, tmcdonal@iastate.edu, (515) 294-6384.

Iowa uses a lot of temporary signals powered by solar panels, but no AFADs. While there is some interest in AFADs, there is not much information in the state. McDonald often hears that there are not enough people for proper flagging in work zones, and AFADs could help to reduce the number of workers needed. However, the cost of the devices has thus far been too high for purchase. He has never heard of anyone using a mobile AFAD.

Texas A&M Transportation Institute

Gerald Ullman, Chair, Transportation Research Board Committee on Work Zone Traffic Control, and Senior Research Engineer and Program Manager/Work Zones and Dynamic Message Signs Regents Fellow, Texas A&M Transportation Institute, g-ullman@tamu.edu, (979) 845-9908.

Ullman is not aware of any self-propelling units, although he has seen trailer-mounted ones.

At the 2013 ATSSA Annual Convention and Traffic Expo in March, he saw one unusual-looking AFAD that resembled a robot, but he didn't know if it was mobile. (It was not.)

Moving AFADs does raise one concern with him: "The problem I see is how to move both sides at the same time. The upstream side would have to move against traffic, and I don't see how that would work." In typical operations, a third flagger would be placed upstream and they would leapfrog.

References

ATSSA (American Traffic Safety Service Association). 2012. "Guidance on the Use of Automated Flagger Assistance Devices." Available at http://www.workzonesafety.org/files/documents/training/fhwa_wz_grant/atssa_afad.pdf.

Cottrell Jr., B.H. 2006. *Evaluation of the AutoFlagger in Virginia*. Report Number VTRC 07-R12. Charlottesville, Virginia: Virginia Transportation Research Council. Available at http://www.virginiadot.org/vtrc/main/online_reports/pdf/07-r12.pdf.

Farritor, S. 2005. *Robotic Safety Markers*. Final Report for NCHRP IDEA Project 90. Washington, D.C.: National Cooperative Highway Research Program. Available at http://onlinepubs.trb.org/onlinepubs/archive/studies/idea/finalreports/highway/NCHRP90_Final_Report.pdf.

Finley, M. 2013. "Field Evaluation of Automated Flagger Assistance Devices in Work Zones on Two-Lane Roads." Paper Number 13-1209. Presented at the 92nd Annual Meeting of the Transportation Research Board, January 13-17, 2013.

Odell, W. 2013. "Automated Flagger Assistance Devices (AFADs): Saving Lives." Paper Number P13-5653. Presented at the 92nd Annual Meeting of the Transportation Research Board, January 13-17, 2013.

Additional Resources

Federal Highway Administration. 2003. "Experimenting Agency Comments on AFADs." *Manual on Uniform Traffic Control Devices*. Available at http://mutcd.fhwa.dot.gov/hfm/2003r1/afad/afad_comments.htm. Includes comments from Alaska, Illinois, Minnesota, Missouri, Ohio and Wisconsin.

Finley, M., B. Ullman, N. Trout, and E. Park. 2012. *Studies to Determine the Effectiveness of Automated Flagger Assistance Devices and School Crossing Devices*. Report No. FHWA/TX-12/0-6407-1. Austin: Texas Department of Transportation. Available at <http://tti.tamu.edu/documents/0-6407-1.pdf>.

Jessberger, R. 1999. *RC Flagman Evaluation*. Ohio Department of Transportation. Available at http://www.workzonesafety.org/files/documents/database_documents/Flaggerman.pdf. Includes work zone drawings.

Missouri Department of Transportation. 2012. Lane Closure on Two-Lane Highways Using Automated Flagger Assistance Devices (AFAD) with Red and Amber Signal System. Available at http://epg.modot.org/files/0/0c/616.8.10a_2012.pdf. Includes work zone drawings.

Missouri Department of Transportation Organizational Results Division. 2008. "Evaluation of Automatic Flagger Assistance Devices." Available at <http://library.modot.mo.gov/RDT/reports/Ri05037/ss08005.pdf>. Evaluated AFADs from IntelliStrobe, AutoFlagger and RC Flagman.