Evaluation of Speed Reduction Techniques at Work Zones

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The goal of the Midwest States Smart Work Zone Deployment Initiative (MwSWZDI) is to develop better ways of controlling traffic through work zones, which improves traffic safety and traffic operating efficiency of work zones. To achieve this goal, the program is currently evaluating 20 different traffic control and traffic management strategies. This paper describes the evaluation of three traffic control and traffic management strategies that involve ITS technologies. In summary, the Wizard CB Alert System broadcasts a CB message warning motorists monitoring the CB of an approaching work zone. The Safety Warning System transmits a message to vehicles with Safety Warning receivers, informing those motorists of the approaching work zone. The Safety Warning System also acts like a drone radar system, alerting vehicles equipped with radar detectors, making drivers believe that radar-equipped enforcement officials may be present. The Speed Display Monitor uses radar to detect the speed of passing vehicles and displays their speed on a two-character variable message sign. Because the device uses radar, it acts like drone radar and alerts vehicles equipped with radar detectors. Each of these systems is evaluated in a freeway work zone environment.

INTRODUCTION

The Midwest States Smart Work Zone Deployment Initiative (MwSWZDI) is a pool-funded research program sponsored through the Federal Highway Administration by the state departments of transportation in Federal Region 7 (Iowa, Kansas, Missouri, and Nebraska). The goal of the program is to develop better ways of controlling traffic through work zones, which improves traffic safety and traffic operating efficiency of work zones. To achieve this goal, the program is currently evaluating 20 different traffic control and traffic management strategies. The Iowa Department of Transportation (Iowa DOT), working with the Center for Transportation Research and Education (CTRE), is evaluating several technologies. This paper describes the evaluation of three that involve ITS technologies. The others, evaluated for the Iowa DOT by CTRE, involve more conventional technology and are reported on elsewhere.

The devices evaluated were the Wizard CB Alert System, the Safety Warning System, and the Speed Display Monitor. In summary, the Wizard CB Alert System broadcasts a CB message warning motorists monitoring the CB of an approaching work zone. The Safety Warning System transmits a message to vehicles with Safety Warning receivers, informing those motorists of the approaching work zone. The Safety Warning System also acts like a drone radar system, alerting vehicles equipped with radar detectors, making drivers believe that radar-equipped enforcement officials may be present. The Speed Display Monitor uses radar to detect the speed of passing vehicles and displays their speed on a two-character variable message sign. Because the device uses radar, it also acts like drone radar and alerts vehicles equipped with radar detectors.

Each of these systems is evaluated in a freeway work zone environment. The Wizard CB Alert System is evaluated in a moving work zone on a rural interstate highway, while the other two systems are tested at a long-term lane closure at a rural interstate highway reconstruction location.

WIZARD CB ALERT SYSTEM

The Wizard Work Zone Alert and Information Radio was designed and patented by Highway Technologies Inc. and built and marketed by TRAFCON Industries Inc (see Figure 1). It is designed to give drivers of heavy trucks enough advanced warning of upcoming delays at construction sites or incidents to enable them to stop safely before encountering queues of halted vehicles. This system was developed at the request of the Pennsylvania Department of Transportation.

FIGURE 1 Wizard CB Alert System

In July 1999, the Wizard CB Alert System was used in conjunction with a work project performed by an Iowa DOT striping crew on Interstate Highway 35. The purpose of this field test was to examine whether the Wizard CB assists in advance warning of a lane closure for truck operators in particular.

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Evaluation Case Study

The painting crew consists of four to five vehicles spread out over approximately one mile and traveling at 25 miles per hour (mph). The lead vehicle is the stripping truck and the trailing vehicle is a pickup truck that carries a flashing sign which read "CENTERLINE / EDGELINE PAINTING AHEAD." The Wizard unit was placed in the trailing vehicle in order to give sufficient warning to the paint crew of approaching vehicles.

The Wizard was set to broadcast over CB channel 19, the most commonly used frequency by truck drivers. The 30-second interval between broadcasts was chosen to insure that approaching truckers heard the message at least once.

Evaluation Operations

Two people collected data for this project. One person stayed with the Wizard in the trailing vehicle of the interstate paint crew. This person monitored the CB and recorded truckers' responses to the warning message. The second person was stationed beyond the paint crew's work site at the next interstate rest area to interview truckers who stopped there.

A number of different broadcast messages were utilized and tested, however, the message that offered the most positive response was: "This is an Iowa DOT road work alert. Northbound drivers on interstate 35: you are approaching a slow-moving paint crew in the right lane. Please use caution."

This message presented all pertinent information clearly and concisely. Also, the message would only need to be changed when and if the roadwork changed direction or roadways.

Evaluation

We were unable to develop any quantitative evaluation criteria and we used only subjective measures to evaluate the effectiveness of the device. We monitored the CB broadcasts from vehicle operators in the area and their comments were overwhelmingly positive (a complete list of comments recorded is listed in the evaluation report). Typical comments from commercial operators via their CB radios are:

- " I think all states should get on the CB to warn you about this stuff."
- "This is the first time I've ever heard anything like this. I wish every state would do it. It'd make things a lot easier."

Driver Interviews at Rest Areas

Over the course of six days, truck drivers at interstate rest areas completed a total of 94 surveys. Of the drivers surveyed, 88 (94 percent) had a CB radio in their truck. Of those, 70 (80 percent) had their radios tuned to channel 19 during the preceding hours.

Of the 70 truckers that were listening to channel 19, 59 of them (84 percent) saw the paint crew on the interstate. This made a total of 59 truckers out of 94 (63 percent) that had their CB tuned to channel 19 as they passed the paint crew on the interstate. Table 1 shows how these 59 drivers answered when asked what first alerted them to the presence of the paint crew.

Of the 59 truck drivers, 44 (75 percent) stated that they heard the Wizard CB Alert System announcement, although it may not have been their first indication that they were approaching the paint crew. Of the 44 drivers who heard the announcement, 39 (89 percent) thought the message was effective at warning them of the paint crew. When asked if the message was obtrusive or annoying, 43 of the 44 drivers (99 percent) answered no. Finally, when asked if they thought the system's continued use in the future would be helpful, all 44 drivers answered yes.

TABLE 1 Question: What First Alerted You to an Approaching Paint Crew

Method	Number of Responses	Percentage
CB Alert Message	24	(40%)
Lights on Trucks	14	(24%)
Signs	10	(17%)
Arrow Board	7	(12%)
Other Truck Drivers	4	(7%)
Total	59	(100%)

SAFETY WARNING SYSTEM

The Radio Association Defending Airwave Rights Inc. (RADAR) conceived and developed the concept of the Safety Warning System (SWS). This system consists of a transmitter and receiver (detector). MPH Industries Inc. manufactures SWS transmitters; and their device is shown in Figure 2. A number of other companies, including Bel-Tronics, Sanyo, Uniden, and Whistler also manufacture the SWS detectors.

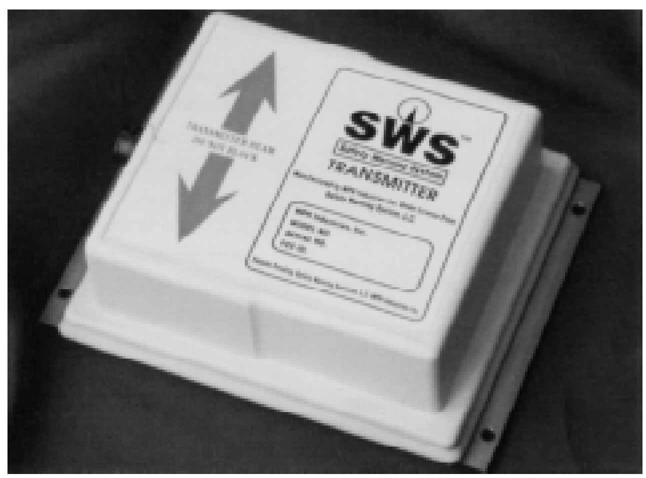

FIGURE 2 Safety Warning System Transmitter

The transmitter can be mounted on the outside of a vehicle (e.g., inside the emergency lightbar) or placed in a stationary outdoor location (e.g., on the flashing arrow board trailer at a work zone). The SWS transmitter sends warning messages concerning road hazards to drivers of vehicles equipped with SWS detectors. Any K-band radar detector will sound a basic alarm when the SWS transmitter is sending a warning message; however, the ones capable of reading transmitted SWS messages will specifically display (in some cases, state) applicable messages.

Evaluation Case Study

The case study work zone consisted of a left lane closure with a crossover leading into two-way traffic. The SWS transmitter was mounted atop a stationary pole located 2,250 feet upstream of the lane closure taper. Traffic flow performance data were collected at 1,500 feet and 500 feet upstream of the taper using two traffic data collection trailers. One of the trailers is shown in Figure 3. The trailer includes a pneumatic mast to hoist video cameras 30 feet above the pavement's surface where the cameras collect video of traffic operations. Videos are later reduced into traffic flow performance data through the use of image-processing technology.

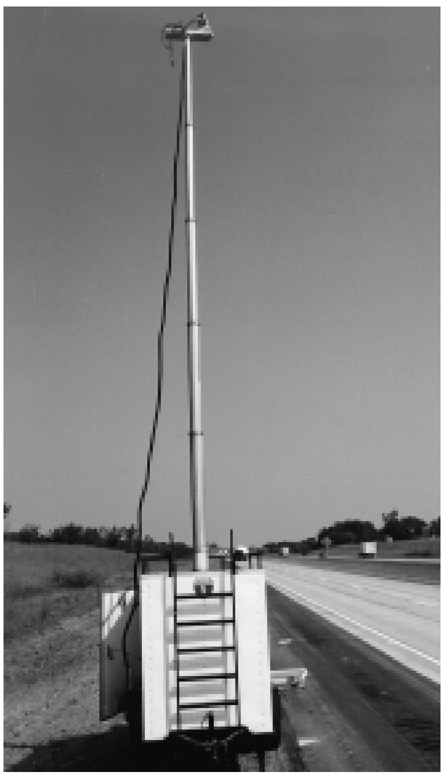

FIGURE 3 Traffic data collection trailer

Data were collected two days prior to the installation of the SWS transmitter and for two days following the installation. During each day more than 2,500 data points were recorded. A number of traffic flow performance parameters were calculated from the data collected for traffic 1,500 and 500 feet upstream of the merge taper. These parameters included:

- the time mean speed
- the speed that 85 percent of the vehicles travel (the 85th percentile speed)
- the 10-mph speed interval containing the most observations (the10-mph pace)
- the percentage of observations in the 10-mph pace
- the standard deviation of the time speed
- the percentage of observations complying with posted regulatory and advisory speed limits
- the time mean speed of the highest 15 percent of speeds

We had hoped to observe a reduction in speed, a reduction in the standard deviation of speed, an increase in the number of vehicles in the 10-mph pace speed, and a reduction in the highest 15 percent of speeds. Unfortunately, no change in any of the parameters was observed.

SPEED MONITOR DISPLAY

This device detects the speed of vehicles using radar and displays the speeds of approaching vehicles using a variable message sign. Speed monitoring displays are not generally used to enforce speed limits and issue citations; rather the assumption is that motorists will drive slower once they see their excessive speed on the display. Further, the speed measuring radar will set off the radar alarms in vehicles equipped with radar detectors, resulting in driver assumption that enforcement personnel are located within the work zone, causing speeding motorists to slow.

The speed monitor display is shown in Figure 4 and consists of a large white box housing a K-band radar and two 18-inch LED characters, which are visible in direct sunlight from up to 1,000 ft away. The radar detects the approaching vehicles and shows their speeds on the LED display. The display box also has an Overspeed Option, which flashes motorists' speeds when they exceed the speed limit. The speed threshold in this study was set to 55 mph, which was the posted regulatory speed limit of the work zone.

FIGURE 4 Speed Monitor Display

The speed monitor display used in this study included a solar power panel, which is mounted atop the box. This panel supplied power to the unit, and excess power was stored in a solar car-type battery housed in the box. The K-band radar used in the system broadcasts a directional radar beam over an approximate one-mile range.

In September 1999, the speed monitor display was deployed at a work zone on Interstate Highway 35. The purpose of this field test was to evaluate the impact of the speed display on reducing vehicles' speed and increasing speed uniformity at work zones.

Case Study Evaluation

The case study work zone consisted of a left lane closure with a crossover leading into head-to-head traffic. The speed display was mounted atop a stationary pole located 2,250 feet upstream of the lane closure taper. Similar to SWS testing, traffic flow performance data were collected at 1,500 feet and 500 feet upstream of the taper using two traffic data collection trailers. In this case, traffic data were recorded for two days prior to the deployment of the devices and four days after installation under two modes (active radar only and active radar and display) for five hours each day. The active radar mode (mode one) was used to test just the impact of the radar signal. The active radar and display mode (mode two) was used to test the impact of the radar signal combined with the reaction of drivers observing their speed shown on the display board.

The speed data initially were grouped into one-before and two-after data sets (i.e., modes one and two) for each data collection site (i.e., 1,500 feet and 500 feet upstream of the taper). The speed data parameters were determined for passenger cars, non-passenger cars, and all vehicles for all six data sets (i.e., before and after data [under two modes] at 1,500 feet and 500 feet).

Results

We experienced a modest mean speed decrease when the speed monitor display was deployed. We also found an increase in vehicle percentages complying with the posted speed limit (i.e., 55 mph), an increase in vehicles traveling at the 10-mph pace, and a reduction in the 10-mph speed interval.

In order to determine whether the difference between the mean speed before and after deployment of the speed monitor display was statistically significant, t-tests were conducted at the 0.05 level of significance. The average speed decrease was statistically significant in any case. However, the device did seem to reduce the number and percentage of very high-speed vehicles, it increased the number of vehicles in the pace, and it reduced the pace speed. In other words, the device seemed to improve the speed of traffic in terms of the variability of speeds and the number of very high-speed vehicles but it does not provide a statistically-significant reduction in average speed. We felt, however, that the size of the characters on the unit we tested were smaller than those needed for vehicles traveling at freeway speeds. The device may have been more successful if the variable message sign was larger or if the current sign were used on an arterial street system.

ACKNOWLEDGMENT

The authors thank the Iowa Department of Transportation for its support for this project. The opinions and views in this paper are those of the authors and not necessarily of the sponsoring agencies.

CONCLUSIONS

Of the three devices tested, the Wizard CB Alert System provided the most promising results, although our measurements of effectiveness were largely subjective. We have recommended that the Iowa DOT consider using this device at other moving or static work zones. Neither the Safety Warning System (SWS) nor the Speed Monitor Display (SMD) resulted in a statistically-significant reduction in the average speed of vehicles approaching the work zone. SWS did, however, provide subjective evidence that it was improving the speed performance of vehicles approaching the work zone. Others have found disappointing results using similar devices, although our findings may in part be due to lack of vehicles equipped with SWS devices and the size of the letters in the variable message signs used by the SMD.