ITS DEPLOYMENT EVALUATION

Executive Briefing

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ITS for Work Zones

Highlights

- In 2019, work zone fatalities saw the largest percentage increase since 2006.
- Agencies are deploying various ITS technologies to manage work zones, including portable variable speed limit signs, work zone intrusion alarms and queue warning systems.
- FHWA is working to increase work zone safety for Connected and Automated Vehicles through the Work Zone Data Exchange (WZDx), an open data specification that facilitates the collection and sharing of live, accurate and actionable work zone data.

This brief is based on past evaluation data contained in the ITS Databases at: www.itskrs.its.dot.gov. The databases are maintained by the U.S. DOT's ITS JPO Evaluation Program to support informed decision making regarding ITS investments. The brief presents benefits, costs and best practices from past evaluations of ITS projects.

U.S. Department of Transportation
Intelligent Transportation Systems
Joint Program Office

Introduction

Work zones play a critical role in the preservation and enhancement of roadways. They separate construction and maintenance activities from traffic, providing a safe route for all road users (motorists, pedestrians, and bicyclists) and a safe area for workers. However, work zone-related changes in traffic patterns and rights of way, combined with the presence of workers and the frequent movement of work vehicles, can result in crashes, injuries, and fatalities [1].

In the United States in 2019, 842 people died in highway work zone crashes compared to 757 the year before. The 11.2 percent increase is the largest percentage increase of highway work zone fatalities since 2006 [2]. Crashes in highway work zones happen most frequently when drivers are not paying attention to changing road conditions. Distracted driving is a key element of many crashes, resulting in drivers crashing into other vehicles, highway equipment or safety barriers.

Though highway workers are often among the victims of work zone crashes, the dangers of reckless driving more often affect those behind the wheel and their passengers. Four out of five work zone fatalities were drivers or passengers, according to FHWA data [2].

Agencies use both portable and permanent work zone Intelligent Transportation Systems (ITS) solutions to combat such incidents. Portable Traffic Management Systems (PTMS) can be rapidly deployed to improve safety and mobility regardless of work zone location. Using queue sensors, Dynamic Message Signs (DMS), video cameras, communication equipment, and other hardware and software components, these systems can automatically monitor traffic conditions and communicate with vehicles and drivers to improve situational awareness, harmonize traffic flow, and lessen the impacts of reduced capacity at work zones. More permanent solutions can be implemented for longer term projects or where ITS can be integrated into initial construction.

Permanent work zone solutions are generally used as freeway or arterial management systems during time periods without construction activities. These systems often provide broader coverage and use traveler information networks such as 511 services, DMS systems, traffic detection networks, and agency websites to improve system operations, trip planning and traveler behavior.

Table 1 summarizes various strategies that transportation agencies use in work zones:

Table 1: Work Zone ITS Applications

System Type	System Description	Sample Depiction
Portable Variable Speed Limit System (PVSL)	System with traffic sensors and Portable Variable Speed Limit (PVSL) signs that collects traffic flow and speed data and provides dynamically changeable speed limit notifications to motorists.	 **Figure 1:** Sample PVSL
Automated Flagger Assistance Devices (AFAD)	AFADs are automatic traffic control devices that enable human flaggers to be positioned out of the lane of traffic. These devices are used to direct traffic at lane closures on two-lane, two-way roadways.	 **Figure 2:** Sample AFAD
Work Zone Intrusion Alarms	Equipment that uses vehicle-detection technology and audible, visual, or tactile alarms to provide roadway workers additional warning of unauthorized vehicles and errant motorists that enter a work zone.	 **Figure 3:** Sample Work Zone Intrusion Alarm

System Type	System Description	Sample Depiction
Queue Warning System	System that detects downstream stop-and-go traffic using roadway sensors and alerts motorists further upstream of the congestion ahead using changeable message signs.	 **Figure 4:** Sample Queue Warning System

Benefits

ITS for work zones can improve planning for roadway maintenance, enhance safety, and facilitate traffic movement through and around roadway construction projects. Using work zone ITS, agencies can better plan and actively manage work zones, increase driver awareness, and improve quality of service.

Table 2: Select Benefits of Work Zone ITS

Deployer Agency	Project Description	Benefit
Texas Department of Transportation (TxDOT)	An end-of-queue warning system implemented on a 96-mile section of Interstate 35 (I-35) used portable roadside radar detection devices mounted upstream of work zones and lane closures to monitor and measure the speeds of approaching vehicles and provided warning messages to drivers on portable roadside dynamic message signs installed further upstream.	Reduced crash potential by 18 to 45 percent (2020-01510).
Kansas DOT	A smart work zone system that included queue warning, automated variable speed limits, estimated travel time information, and alternative route detour information was installed along a on a 1.48 mile stretch of I-35 at the Homestead Lane interchange.	Achieved a benefit-to-cost ratio of 10:1 (2019-01398).
Utah DOT	A portable variable speed limit system was installed along I-15 and I-80 that used a dynamic Variable Speed Limit (VSL) algorithm to raise and lower the regulatory speed limits in work zones.	Average vehicle speed near work zones was reduced by 15 to 25 miles per hour (mph) (2018-01279).
Missouri DOT	An AFAD system was evaluated via combined field testing and driving simulator tests in Knob Noster, Missouri. The AFAD configuration, involving STOP/SLOW paddles, red/yellow lights, and a Changeable Message Sign (CMS), was incorporated onto a truck-mounted attenuator for operator protection.	Reduced vehicle approach speeds by four mph and improved stopping distance by 11 feet (2021-01584).

Costs

The cost for deploying smart work zone ITS, such as Motorist Advisory Systems, depends on the project duration and the number of devices used (including dynamic message signs, traffic sensors, speed trailers, and cameras). Such equipment may either be leased or purchased through a variety of procurement mechanisms. In addition to the capital costs of the equipment, agencies must also budget for costs associated with equipment mobilization, training, and software configuration.

For short term projects, equipment can be rented on a per-day basis. With the assistance of an FHWA Accelerated Innovation Deployment demonstration grant, the Utah DOT (UDOT) initiated a Portable Variable Speed Limit (PVSL) program that used a dynamic VSL algorithm to raise and lower the regulatory speed limits at four work zones along I-15 and I-80. UDOT's equipment rental cost for the PVSL system varied between $173 and $329 per day, depending on the deployment scenario (2018-00404).

Minnesota Department of Transportation (MnDOT) prepared scoping guidance providing rental cost estimates for Intelligent Work Zone (IWZ) Motorist Advisory Systems. Based on the guidance document, for a Motorist Advisory System that includes detectors placed every half mile and portable CMS placed every 2 miles for an average queue length of 3 miles, agencies can expect to pay around $75,000 (2020-00475).

Best Practices

Agencies have published literature detailing their own experiences with deploying ITS in work zones. A partnership between Oregon DOT and Oregon State University (OSU) to study the effectiveness of currently available work zone intrusion alert technologies concluded that the following guidelines should be considered (2021-01006):

Figure 5: A worker alert system located 50 ft from equipment while activated by an intruding vehicle.

- **Sound Level and Type.** Sound alarms produced by the work zone intrusion alert technology should be at least 110 dB when the alarm is located 50 ft away from workers and above 95 dB when the alarm is 100 ft away. Workers preferred sounds such as a screeching noise or an emergency vehicle siren, which differ from the noises heard during work zone operations (e.g., diesel engine noise from equipment, truck backup alarms, passing automobiles). In addition, agencies should avoid short-burst alarms. Alarms that provide longer, continuous sound improve the possibility of capturing workers' attention.

- **Transmission Distance.** The minimum transmission distance should be 400 ft when the 85th percentile work zone speed is 35 mph. For work zones with historically higher vehicle travel speed, higher maximum work zone speed limits, and greater expected distances between workers, the transmission distance can be increased.
- **Haptic Alarms.** Any haptic or vibration feature included with the alarm technology should be mobile, portable, and wearable either on the worker's arm or on the hard hat. A patterned vibratory signal lasts for approximately 14 seconds and creates a vibration frequency of 150 Hz.
- **Visual Alarms.** Although no minimum "demand" luminance requirement for traffic control devices exists, it is recommended that the light produced by the intrusion alert should be visible 500 feet away.

National Work Zone Awareness Week (NWZAW), held every spring, has been successful in spreading awareness of ITS for work zone safety across the country.

Similarly, a National Cooperative Highway Research Program (NCHRP) report on the subject suggests that the following operational parameters should be considered when deploying Portable Variable Speed Limit Systems [3]:

- **Speed Limit Change Frequency.** Set minimum frequency for changing speeds at 5 to 10 minutes. Set 5 minutes as the minimum, but the project may consider collecting data using a 10-minute minimum to see if the 5- and 10-minute thresholds are notably different.
- **Maximum Speed Limit.** Ensure that the system has a maximum speed limit set for each project and that the maximum speed is the posted speed of the roadway before construction.
- **Merging Areas.** Avoid reducing speed limits in advance of taper as vehicles may need to accelerate to merge into a single lane of traffic.
- **Operating Periods.** Operate the system only when workers are present and return to posted speed limits when workers are not present.
- **End of Work Zone.** Use a static sign to advise drivers to return to posted speed limits at the end of the work area.

Case Study

Looking ahead to a future of automated vehicles, one of the most complex scenarios for Automated Driving Systems (ADS) and Automated Vehicles (AVs) is the ability to detect and maneuver through work zones. Up-to-date information about dynamic conditions occurring on roads, such as construction events, can help ADS and humans navigate safely and efficiently. While many Infrastructure Owners and Operators (IOOs) maintain data on work zone activity, a lack of common data standards and convening mechanisms makes it difficult and costly for third parties–including original equipment manufacturers (OEMs) and navigation applications–to access and use these data sets across various jurisdictions [4].

FHWA's Work Zone Data Exchange (WZDx) research program provides funding for public roadway operators to make unified work zone data feeds available for use by third parties and collaborate on WZDx specification development. The ultimate goal of the program is to get more work zone event data into vehicles via consumer and high-definition maps to increase worker safety while helping ADS and human drivers navigate safely and efficiently.

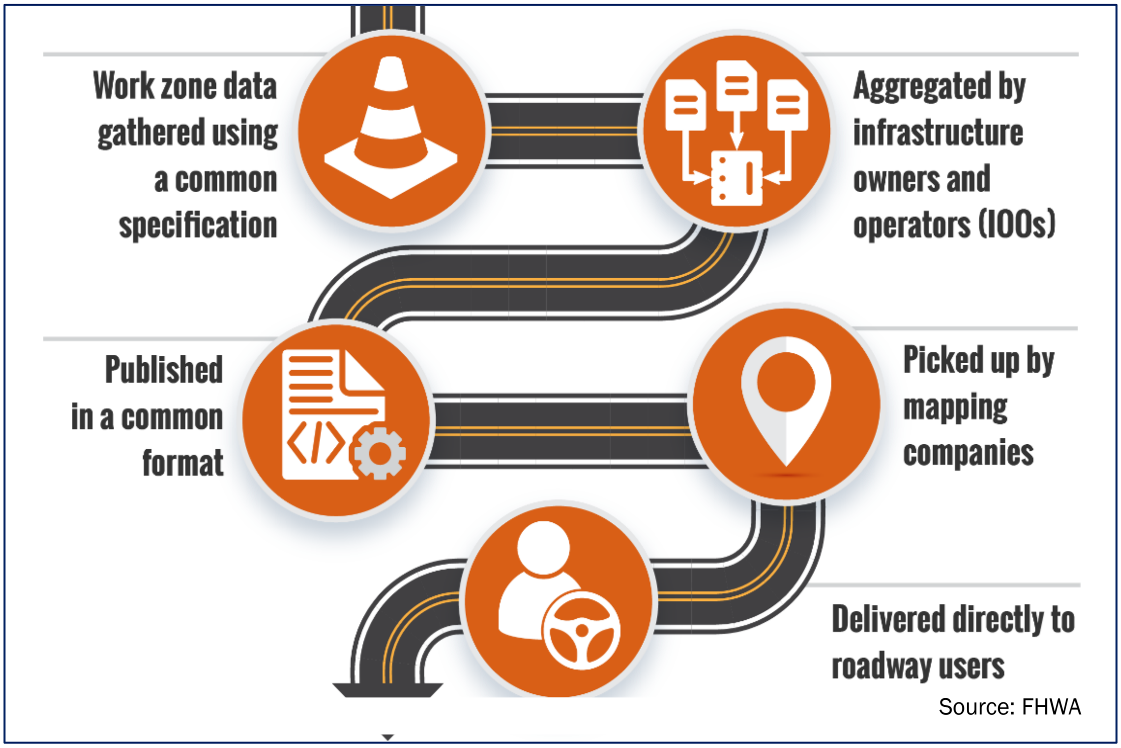

Figure 6: WZDx Roadmap

In 2017, foreseeing the need for smart work zones to support Connected and Automated Vehicles (CAVs) on the roadways, Arizona DOT (ADOT) and Maricopa County DOT (MCDOT) collaboratively deployed a Connected Vehicle (CV) Work Zone pilot focused on freight movements along MC-85 [5]. These efforts led to the initiation of a Work Zone Data Pilot in 2019, utilizing regional roadway construction and maintenance related closure and restriction data and focusing on expanding the WZDx common core specification to include Traffic Management Data Dictionary (TMDD) data. The smart work zone system included a series of detectors, four portable DMS, closed-circuit television (CCTV) cameras, excessive speed feedback signs and solar-powered roadside units (RSUs) [5]. MCDOT used the collected roadway construction and maintenance data to generate an open Application Programming Interface (API) feed for the work zone, based on the USDOT's WZDx specification. A primary user of MCDOT's WZDx API was a trucking company whose drivers were able to receive in-vehicle messages about lane closures, worker presence, as well as vehicle-specific alerts about hazardous conditions and excessive driver speeds (as shown in Figure 7).

Figure 7: In-vehicle messages provided about the work zone.

The MC-85 project allowed MCDOT to successfully demonstrate smart work zone technologies on an arterial, including an arterial travel time system to encourage the use of alternate routes based on current conditions, as well as innovative applications of vehicle connectivity technologies. In January 2021, the WZDx Program awarded $2.4 million in WZDx demonstration grants to fund projects in 13 states [4]. As one of the awardees, Maricopa County plans to use the WZDx demonstration funding to extend their pilot WZDx data feed to the entire county, including local, regional, and national highway system roadways.

References

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