U.S. Department of Transportation

Roadway Operations & Maintenance: Work Zone Management

ITS Benefits, Costs, and Lessons Learned: 2017 Update Report

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Roadway Operations & Maintenance

Information Dissemination

Asset Management

Work Zone Management

- **Temporary Traffic Management**
- **Temporary Incident Management**
- **Lane Control**
- **Variable Speed Limits**
- **Speed Enforcement**
- **Intrusion Detection**
- **Road Closure Management**

Highlights

- Audible "slow traffic ahead" alerts can improve drivers' situational awareness and increase safety on freeways.
- Field data collected over the last two decades show variable speed limit (VSL) systems can reduce crash potential by 8 to 30 percent.
- Dynamic lane merge systems (DLMS) can improve freeway performance and reduce aggressive driving maneuvers.

Introduction

This factsheet is based on past evaluation data contained in the ITS Knowledge Resources database at: www.itskrs.its.dot.gov. The database is maintained by the U.S. DOT's ITS JPO Evaluation Program to support informed decision making regarding ITS investments by tracking the effectiveness of deployed ITS. The factsheet presents benefits, costs and lessons learned from past evaluations of ITS projects.

ITS applications for operations and maintenance can improve planning for roadway maintenance, enhance safety, and facilitate traffic movement through and around construction work zones. Smart work zones, automated enforcement, traveler information systems, and operations planning tools are a few of the most widely deployed solutions. Evaluation data clearly show these technologies can improve performance; however, with limited budgets and growing demand that exceeds capacity in most metropolitan areas, transportation agencies have adopted new more practical measures to increase benefits and justify costs. Mitigation strategies have shifted from a capacity-oriented approach that relies on increasing capacity to reduce travel times, to a reliability-oriented approach focused on maintaining existing capacity while minimizing disruptions to improve travel time reliability. Using work zone ITS, agencies can better plan and actively manage work zones, increase driver awareness, and improve quality of service.

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Both portable and permanent work zone ITS solutions are in use today. 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.

Benefits

Work zone ITS can have a wide range of benefits and costs. Benefit-cost ratios can exceed 2:1 depending on the work zone design and technologies used. Specific benefits include construction schedule compression; reductions in traffic volumes, vehicle speeds, queue lengths, and crashes; and fewer and shorter periods of congestion and unexpected delay. Tools such as the [Work Zone Impacts and Strategies Estimator (WISE)](#) software package, developed through the Second Strategic Highway Research Program (SHRP 2), provide impact evaluation and decision-making support for state and local engineers and planning professionals.

Figure 1 below highlights benefit ranges for several ITS work zone technologies based on entries in the ITS Knowledge Resource database at: http://www.itsknowledgeresources.its.dot.gov/. Benefits can be seen with many different measures across multiple goal areas including mobility, safety, and the environment. Dynamic Lane Merge Systems have demonstrated their ability to reduce the number of stops per vehicle, as well as the number of dangerous driving maneuvers at work zones. Variable speed limits and queue warning systems have shown promise in crash reduction. Automated enforcement systems have reduced speeding, and automated work zone information systems have reduced delays for trips that travel through work zones.

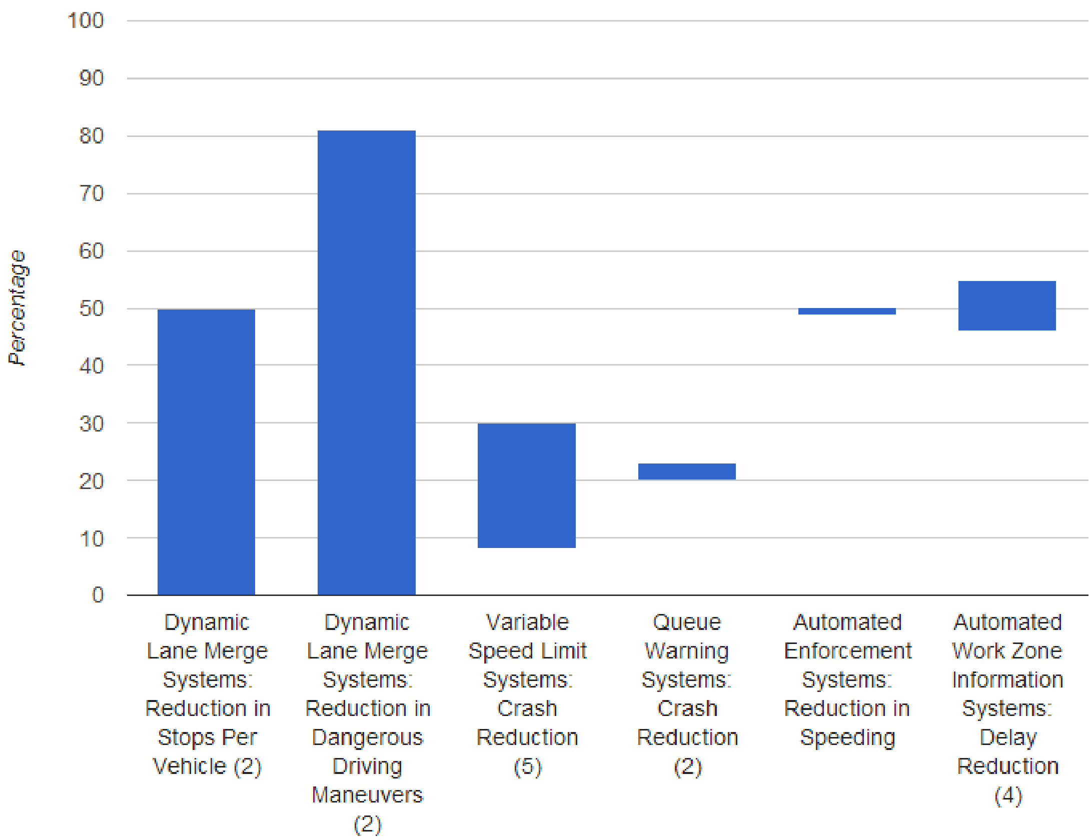

Figure 1: Work Zone ITS Benefits **(Source: ITS Knowledge Resources).**

The online versions of the factsheets feature interactive graphs that contain all the data points included in the ranges. Here, each metric has a number after the text, representing the number of data points used to create the range; no number means only there was only one data point.

Expanding permanent dynamic message sign (DMS) operations to include information on I-70 work zones in St. Louis has produced a benefit-to-cost ratio of 6.9:1. To accommodate closure of five westbound lanes at the Blanchette Bridge, five eastbound lanes were reduced to three lanes in each direction for period of one year beginning in November 2012. During construction, permanent DMS units on I-70 were programmed to notify drivers of lane closures, narrowed lanes, and reduced speed limits, provide travel times, and divert traffic to Rt. 364 and Rt. 370 during periods of congestion. To assess performance, an evaluation framework and simulation model were developed to estimate impacts on delay and queue lengths with and without ITS. Traffic data collected from traffic sensors and video cameras at ramps were used to capture the effects of messaging on diversion rates. In addition, a traveler survey was conducted to evaluate traveler behavior and driver compliance (2015-00982).

The Partners for Advanced Transportation Technology (PATH) developed, implemented, and field-tested an Augmented Speed Enforcement (aSE) system on SR 152 in Los Banos, California, with the goal to enforce reduced speed limits in construction zones and thereby protect personnel working in the roadway. The work was conducted under a project sponsored by the USDOT in collaboration with the California Department of Transportation (Caltrans), the California Highway Patrol (CHP), and the Western Transportation Institute (WTI) of Montana State University. The project was carried out with the goal of evaluating the effect of reducing traffic speed and minimizing hazards in a work zone in the rural environment. Analysis of project metrics found that the summation of percentage of vehicles moving faster than 65 mi/hr through the work zone decreased from 60.2 percent in the baseline scenario to 54.1 percent in the scenario when the PATH aSE system was in place (2015-01056).

A recent project effort evaluated the effectiveness of a work zone queue warning system installed to improve safety during reconstruction on the I-70/I-57 interchange in Effingham, Illinois. The system used portable dynamic message signs (DMS) mounted on solar powered trailers equipped with traffic detectors and cameras to monitor traffic conditions and warn drivers of developing queues. Using cellular communications, DMS trailers located 10 to 12 miles upstream of the work zone were integrated into a wireless command and control system to provide drivers with real-time information on traffic queues and opportunities to select alternate routes if needed. Between 2010 (prior to system implementation) and 2011 (after system implementation), researchers saw nearly a 14 percent decrease in queuing crashes, and an 11 percent reduction in injury crashes, despite a 52 percent increase in the number of days when temporary lane closures were implemented during the evaluation (2014-00966).

A micro-simulation model (Paramics) was used to model a traffic network and simulate connected vehicle applications in a section of Toronto, Canada. The model included an additional application programming interface (API) to assess time to collision (TTC) data as a surrogate safety measure. The analysis compared safety "with" and "without" connected vehicle applications for a variety of market penetration rates ranging from 20 to 100 percent. In each of the scenarios modeled, connected vehicles became aware of work zone conditions when they were within 1,000 meters of a work zone, and then stored and shared this information with other connected vehicles for dynamic route guidance. Non-connected vehicles were unable to exchange information and always selected the shortest path (distance) to their destination as determined from the start. In networks with work zones, connected vehicle market penetration rates under 40 percent can contribute to a safer traffic network, while market penetrations above 40 percent can decrease network safety due to rerouting and longer average trip distances (2015-01042).

Agencies under pressure to improve operations and reduce lifecycle maintenance costs can use ITS tools in conjunction with sound planning and asset management strategies to improve the efficiency of maintenance operations. In areas where work zones are required, modeling and analysis tools can be used to coordinate multiple work zone schedules, and design and test alternate work zone plans and mitigation strategies, including ITS applications where appropriate, before and during construction. In Detroit, for example, a large transportation network micro-simulation model was used to estimate the impacts of changing traffic patterns, coordinate work zone activities, and implement efficient work zone management plans during major freeway closures on I-75 during the Ambassador Bridge Gateway Project. Improved traffic management saved freeway users more than $1.63 million per day during reconstruction of the I-75/I-96 interchange (2013-00862).

Cost

Costs for ITS at work zones represent one to six percent of total construction costs depending on the size and duration of the project, temporary and permanent functions required, and if ITS components such as DMS units, traffic sensors, and portable cameras are purchased or leased. Overall, estimates vary widely ranging from $100,000 to $2.5 million, with the majority of systems costing $150,000 to $500,000 over the first year (2006-00109).

Table 1: System Costs for Smart Work Zones.

Smart Work Zone Location	Project Duration	System Cost	Percentage of Total Project Costs
In Utah, Utah DOT installed 10 Bluetooth readers for $40,000 to monitor work zone traffic conditions. (2014-00334)	9 months (2011–2012)	$40,000 plus $33,000 O&M	-
In North Carolina, NCDOT leased a smart work zone system for a construction project on I-95 near Fayetteville. (2006-00106)	10 months (2002–2003)	$235,000	-
In Illinois, IDOT implemented work zone ITS on a 7.7 miles section of I-64. (2007-00126)	30 months (2005–2007)	$435,000	1%
In Illinois, IDOT leased a real-time work zone traffic control system for a major bridge and highway reconstruction project along a 40-mile section of I-55. (2006-00107)	16 months (2001–2002)	$785,000	2%
In Arkansas, contract bid estimates were provided for an automated work zone information system on a 6.3 mile section of I-40 in Lonoke County. (2004-00068)	12 months (2000–2001)	$322,500	-
In Arkansas, contract bid estimates were provided for an automated work zone information system on an 8.6 mile section of I-40 in Pulaski County. (2004-00068)	33 months (2001–2003)	$490,000	-
In Arkansas, the Arkansas State Highway and Transportation Department leased an automated work zone information system for a 3-mile section of I-40 in West Memphis. (2004-00072)	<18 months (2000-2002)	$495,000	<4%

Lessons Learned

Realize that ITS solutions are just one part of a successful work zone management plan.

ITS components can be instrumental in improving the safety of a work zone; however, it is not a cure-all for eliminating travelers' exposure to hazards at work zones.

- Use variable advisory speed limit systems to lower speeds and achieve better compliance with posted speed limits in areas without congestion in urban work zones (2014-00678).
- Verify that proposed innovations and technologies will operate as advertised (2014-00685).
- Plan to recalibrate traffic sensors near work zones to accommodate lane shifts and other changes during construction (2014-00682).
- Allow for sufficient start-up time when deploying an ITS application. Unanticipated issues may arise that will take time to address (2005-00061).
- Follow accepted guidelines to create concise, effective DMS messages to notify motorists of slow traffic and queuing ahead (2007-00336).
- Conduct outreach and permit drivers to become comfortable with new work zones by allowing an adjustment period (2005-00041).

Case Studies - SafeTrip 21 Initiative

Through the SafeTrip-21 initiative, federal and state agencies collaborated to test and evaluate a variety of technologies designed to reduce congestion, improve efficiency, and enhance safety on the nation's roadways. Findings from two case studies that evaluated work zone applications are highlighted below.

I-95 Corridor Coalition Test Bed, Final Evaluation Report: North Carolina Deployment of Portable Traffic-Monitoring Devices

The North Carolina DOT tested the use of portable traffic-monitoring devices (PTMDs) and the U.S. DOT conducted interviews with agency staff to evaluate their experience (2013-00860). The following benefits were cited:

- **Accurate speed counts.** PTMDs resembled traditional work zone drums to mitigate data skewing that can occur when traffic-monitoring devices are more visible to drivers. The data reported were confirmed on-site.
- **Ease of installation and operation.** Devices were battery powered, equipped with wireless communications, and designed to easily replace traditional work zone drums. Data were accessible using a web-based interface.
- **Data warehousing capability.** In addition to providing real-time data, the web-based system was designed to archive data for up to five years, giving NCDOT staff the flexibility to analyze historical data.
- **Safety benefits.** PTMDs allowed personnel to collect traffic volume data without requiring them to work in the travel lane, reducing the potential for injuries.
- **Staff Productivity.** Staff could monitor sites remotely and limit site visits, saving staff time.

Experience with Prototype Testing on San Francisco Freeways

In San Francisco, recent studies suggest that vehicle-infrastructure (V2I) applications can further improve benefits achieved through work zone ITS. A field study of 24 vehicles equipped with in-vehicle traveler information systems designed to provide auditory alerts of "slow traffic ahead" effectively smoothed the driving profiles of drivers approaching end-of-queue traffic on a congested freeway (2013-00823). These data agree with previous research in Minneapolis where portable traffic management systems were found to reduce speed variability by 70 percent and slow speeds of approaching vehicles by 9 mph (2007-00411). Considering evidence that suggests an 8.4 percent increase in crash risk for each 1 mph increase in the standard deviation in speed, variable speed limit (VSL) systems that produce smoother driving profiles may have significant safety benefits [1]. The information provided to drivers, however, must be accurate, reliable, and delivered at the right time. Studies show that when drivers are directed to change speeds at 2-minute intervals, crash potential increases; however, when recommendations are made at 5- or 10-minute intervals, crash potential is reduced [2].

References

[1] Zheng, Ahn, Monsere. "Impact of traffic oscillations on freeway crash occurrences," Accident Analysis and Prevention, Vol. 42(2), 2010, pp. 626-636. http://eprints.qut.edu.au/41883/2/41883.pdf

[2] Lee, Chris. "Assessing Safety Benefits of Variable Speed Limits," *Transportation Research Record 1894*, Report No. 04-4835. 2004.
http://www.civil.uwaterloo.ca/bhellinga/publications/Publications/TRR%202004%20Assessing%20VSL%20(04-4835).pdf

All other data referenced is available through the ITS Knowledge Resources Database, which can be found at http://www.itsknowledgeresources.its.dot.gov/.