# ROADWAY OPERATIONS AND MAINTENANCE

WORK ZONE ITS DEPLOYMENT COSTS RANGED FROM $100,000 TO $2.5 MILLION WITH THE MAJORITY RANGING FROM $150,000 TO $500,000.

## ROADWAYS

Operating and maintaining transportation systems is costly. Many State DOTs are implementing ITS to better manage roadway maintenance efforts and to enhance safety and mobility on the transportation system. ITS applications in operations and maintenance focus on integrated management of maintenance fleets, specialized service vehicles, hazardous road conditions remediation, and work zone mobility and safety. Systems and processes are required to monitor, analyze, and disseminate roadway/infrastructure data for operational, maintenance, and managerial uses. ITS can help secure the safety of workers and travelers in a work zone while facilitating traffic flow through and around the construction area.

Information dissemination technologies can be deployed temporarily, or existing systems can be updated periodically, to provide information on work zones or other highway maintenance activities. Several ITS technologies can help State DOTs with asset management including fleet tracking and automated data collection for monitoring the condition of highway infrastructure. ITS applications in work zones include the temporary implementation of traffic management or incident management capabilities. These temporary systems can be stand-alone implementations or they may supplement existing systems in work areas during construction. Other applications for managing work zones include measures to control vehicle speeds and notify travelers of changes in lane configurations or travel times and delays through the work zones. In fact, work zone management systems are the most widely studied example of the information dissemination technologies mentioned above. ITS may also be used to manage traffic along detour routes during full road closures to facilitate rapid and safe reconstruction projects.

The roadway operations and maintenance technologies profiled in this chapter support the U.S. DOT's Congestion Initiative, as outlined in the May 2006 document *National Strategy to Reduce Congestion on America's Transportation Network*. One element of the national strategy is to reduce congestion by promoting operational and technical improvements that have the potential to enable existing roadways to operate more efficiently. One group of improvements identified in the national strategy is work zone safety and mobility.[234] For more information, visit the Congestion Initiative Web site: *www.fightgridlocknow.gov*.

### Findings

#### *Benefits*

ITS technologies deployed for roadway operations and maintenance activities can have system-wide impacts. Network simulation models estimate that smart work zones can reduce total delay by 41 to 75 percent.[235] During freeway reconstruction projects, evaluation data suggest these technologies can cut traffic queues in half.[236]

In addition to improving mobility, work zone ITS can improve safety. Evaluation data show that areas equipped with speed monitoring displays can decrease vehicle speeds by 4 to 6 mi/h[237] and reduce the number of speeding vehicles by 25 to 78 percent.[238] In addition to controlling traffic speed, smart work zones improve driver behavior. Evaluation data show that dynamic lane merge systems help reduce driver confusion at merge points and reduce aggressive driving.[239]

In rural areas, ITS technologies can improve the efficiency and effectiveness of operations and maintenance activities. With improved communication links between operation centers and field equipment, maintenance personnel can spend more time improving

## ROADWAY OPERATIONS AND MAINTENANCE CATEGORIES IN THE ITS KNOWLEDGE RESOURCES

**Information Dissemination**
- Portable Dynamic Message Signs
- Highway Advisory Radio
- Internet/Wireless/Phone

**Asset Management**
- Fleet Management
- Infrastructure Management

**Work Zone Management**
- Temporary Traffic Management
- Temporary Incident Management
- Lane Control
- Variable Speed Limit
- Speed Enforcement
- Intrusion Detection
- Road Closure Management

SIMULATION MODELS ESTIMATE THAT SMART WORK ZONES CAN REDUCE TOTAL DELAY BY 41 TO 75 PERCENT.

roadway conditions instead of traveling to remote sites to manually update or confirm the operation of field devices.[240]

As depicted in table 7, evaluations have documented the ability of work zone management systems to positively impact transportation operations in five of the six ITS goal areas: safety, mobility, efficiency, productivity, and customer satisfaction. Highlights of these research findings are presented later in this chapter. Several studies have shown that providing information to travelers regarding work zone and other maintenance activities can reduce related congestion. As further illustrated in figure 7, automated work zone information systems (AWIS) have reduced delay from 46 to 55 percent in three locations studied.[241]

**Table 7—Roadway Operations and Maintenance Benefits Summary**

| | Safety | Mobility | Efficiency | Productivity | Energy and Environment | Customer Satisfaction |
|---|---|---|---|---|---|---|
| **Information Dissemination** | | ✚ | | | | |
| **Asset Management** | ● | | | | | |
| **Operations and Fleet Management** | ✚ | | | | | |
| **Work Zone Management** | ● | ● | ✚ | ✚ | | ✚ |

● Substantial positive impacts
❍ Negligible impacts
✖ Negative impacts
✚ Positive impacts
✱ Mixed results
**blank** Not enough data

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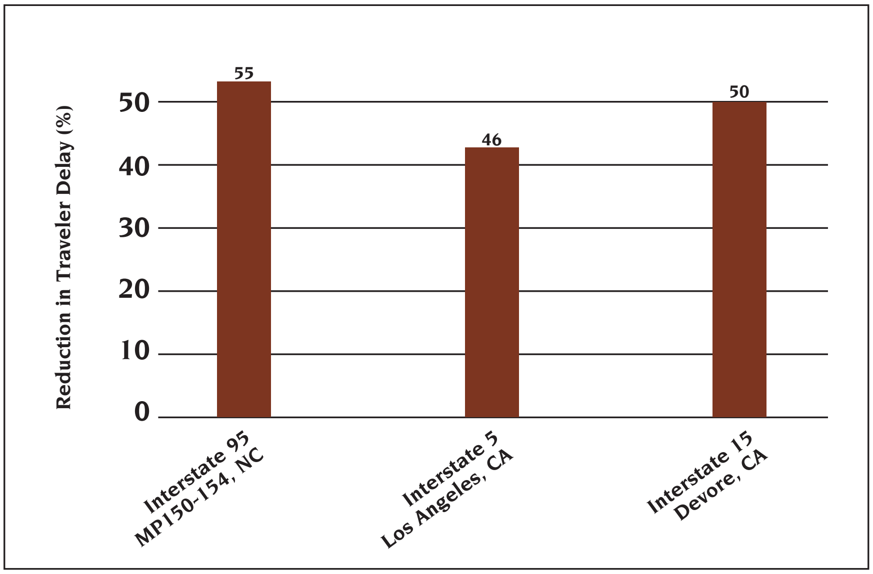


**Figure 7** – Delay Reduction with AWIS

## *Costs*

A review of work zone ITS deployments from 17 states showed that the costs vary greatly depending on several key factors: (1) purchasing vs. leasing system equipment, (2) temporary vs. permanent components of the project (e.g., equipment used in a work zone is later deployed as permanent equipment on the same or different project), and (3) size and function of the system. Costs ranged from $100,000 to $2.5 million with the majority of systems ranging from $150,000 to $500,000.[242]

## *Deployment*

The use of ITS applications in work zones is popular among state DOTs. A survey of each of the 50 states conducted in 2006 revealed that state DOTs use a variety of media to disseminate information about work zones; 44 states use portable dynamic message signs (DMS), 39 states use the Internet, and 29 states use highway advisory radio (HAR). This same survey revealed that more than two-thirds (38) use ITS technologies such as lane control signs, portable DMS, and dynamic lane merge systems to notify travelers of changes in lane configurations approaching work zones. More than half of the states (29) use ITS technologies, either as stand-alone implementations or to supplement existing systems, to support temporary traffic management in work zones.

Respondents to the 2006 survey exhibited variability in their willingness to use ITS for asset management. Nine states use automatic vehicle location (AVL), computer-aided dispatch, and handheld computers supporting data entry and dispatch-field communications help manage vehicles; 39 states use sensors and automated data collection systems to monitor the condition of the highway infrastructure.

The 2006 survey of each of the 50 states about deployment of ITS technologies in rural areas and on a statewide basis is the source of deployment statistics presented later in this chapter.

## Selected Highlights from the ITS Knowledge Resources on Roadway Operations and Maintenance

### Information Dissemination

Information dissemination technologies can be deployed temporarily or existing systems can be updated periodically to provide information on work zones or other highway maintenance activities. Examples of these systems include dynamic message signs, highway advisory radio, Internet Web sites, wireless devices, and telephone services.

| Information Dissemination | |
|---|---|
| **Deployment** | |
| Many states use a variety of media to disseminate information about work zones; 44 states use portable dynamic message signs, 39 use the Internet, and 29 use HAR. | |
| **Benefits** | |
| **ITS Goals** | **Selected Findings** |
| **Mobility** | ***Summary Finding:*** AWIS prevent severe congestion at work zones and reduce delay by 46 to 55 percent (see figure 7).[243] |
| **Mobility** | In Devore, California, a real-time work zone traveler information system on I-15 contributed to a 50 percent decrease in maximum peak period delay.[244] |
| **Customer Satisfaction** | In North Carolina, a survey of residents living near Smart Work Zone systems on I-95 found that over 95 percent of motorists surveyed would support use of these systems in the future.[245] |
| **Costs** | |
| **Unit Costs Data Examples (See Appendix A for more detail)** | |
| Roadside Information subsystem:<br>• Dynamic Message Sign: $48K-$119K<br>• Dynamic Message Sign—Portable: $18.6K-$24K<br>Roadside Detection subsystem:<br>• Portable Traffic Management System: $78K-$97K<br>Transportation Management Center subsystem:<br>• Software for Traffic Information Dissemination: $17K-$21K<br>• Labor for Traffic Information Dissemination: $107K-$131K (annually)<br>Roadside Telecommunications subsystem:<br>• Conduit Design and Installation—Corridor: $50K-$75K (per mile)<br>• Fiber Optic Cable Installation: $20K-$52K (per mile) | |

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| Information Dissemination |
|---|
| **Costs** |
| **Sample Costs of ITS Deployments** |
| **Minnesota:** The Minnesota DOT's Construction Office and Traffic Office developed a specification for a dynamic late merge system and worked closely with the vendor capable of providing the system. The deployed system provided guidance to motorists on proper lane usage via portable DMS. When a preset congestion level was reached, the signs were activated. When traffic returned to free-flow conditions, the signs returned to "dark mode." The costs provided were based on four study locations: three in urban settings and one in a rural location. The cost of vehicle detection was approximately **$300 per day** and three signs cost **$600 per day** for a total cost of **$900 per day per direction**.[246]<br>**Illinois:** The Illinois DOT used work zone ITS in the I-64 add-lane construction project to monitor traffic, reduce congestion, and promote safety. The work zone ITS—also referred to as the Traffic Monitoring System—included 12 DMS located within and in advance of the work zone, and a total of 10 vehicle detection stations within and at the exit and entrance of the work zone. The data collected by the detectors were processed by a commercial off-the-shelf software package. Real-time information about traffic conditions was posted to the signs and automatically posted to a project Web site. The system was deployed for 30 months at a cost of **$14,500 per calendar month** for a total cost of **$435,000**. The total cost of the system was less than one percent of the total construction cost. The system was leased as part of the overall construction contract.[247]<br>**Illinois:** The Illinois DOT (IDOT) decided to use ITS in a 40-mile work zone for a major bridge and highway reconstruction along I-55 south of Springfield. The ITS—referred to as the Real-Time Traffic Control System—consisted of 17 remotely-controlled portable DMS, eight portable vehicle detectors, and four portable cameras linked to a base station server via wireless communication. The system covered the work zone area as well as the northbound and southbound approaches to the work zone. IDOT indicated significant cost savings by leasing the system as a bid item. The cost of leasing the system was **$785,000**, which represented approximately two percent of the total reconstruction contract cost of **$35 million**. The system was deployed for a total of 16 months from February 2001 to May 2002.[248] |

## Asset Management

Several applications help State DOTs with asset management including fleet tracking applications, as well as automated data collection applications for monitoring the condition of highway infrastructure.

| Asset Management | |
|---|---|
| **Deployment** | |
| Nine states use ITS technologies, such as automated vehicle location, computer-aided dispatch, and handheld computers supporting data entry and dispatch-field communications, to help manage maintenance vehicles; 39 states use sensors and automated data collection systems to monitor the condition of the highway infrastructure. | |
| **Benefits** | |
| **ITS Goals** | **Selected Findings** |
| **Productivity** | In Montana, weigh-in-motion (WIM) sensors were installed directly in freeway travel lanes to continuously collect truck weight and classification data at 28 sites. The study found that if freeway pavement designs were based on fatigue calculations derived from comprehensive WIM data instead of weigh station data, the State would save about $4.1 million each year in construction costs. The pavement fatigue calculations based on WIM data were 11 percent lower on Interstate roadways and 26 percent lower on non-Interstate, primary roadways.[249] |
| **Costs** | |
| **Sample Costs of ITS Deployments** | |
| **Southeast Michigan:** The Southeast Michigan Snow and Ice Management project is a multi-agency AVL system that will use 500 highway maintenance vehicles equipped with global positioning system receivers and sensors to monitor snow plow use, rate of application for deicing materials, and air and road temperatures. Each vehicle will use 900 MHz communications, and transmit data to a centralized system where the data will be uploaded onto an Internet server and made available to other agencies. Nearly **$8.2 million** has been spent to equip approximately 400 vehicles with sensors and communications infrastructure.[250] | |

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## Work Zone Management

ITS applications in work zones include the temporary implementation of traffic management or incident management capabilities. These temporary systems can be stand-alone implementations or they may supplement existing systems in the area during construction. Other applications for managing work zones include measures to control vehicle speeds and notify travelers of changes in lane configurations or travel times and delays through the work zones. Systems for work zone incident management can also be used to more quickly detect incidents and better determine the appropriate degree of response needed, thereby limiting the amount and duration of additional capacity restrictions. ITS may also be used to manage traffic along detour routes during full road closures to facilitate rapid and safe reconstruction projects.

| **Work Zone Management** | |
|---|---|
| **Deployment** | |
| The use of ITS applications in work zones is popular among state DOTs. More than two-thirds of states (38) use ITS technologies—such as lane control signs, portable DMS, and dynamic lane merge systems—to notify travelers of changes in lane configurations approaching work zones. More than half of the states (29) use ITS technologies, either as stand-alone implementations or to supplement existing systems, to support temporary traffic management in work zones. Seventeen (17) states deploy temporary incident management systems to facilitate safe clearance of incidents that occur near work zones; 16 states use ITS technologies to manage traffic along detour routes during full road closures. Only two states (California and Tennessee) use automated work zone intrusion detection and warning systems, and only one state (Illinois) uses automated speed enforcement in work zones. | |
| **Benefits** | |
| **ITS Goals** | **Selected Findings** |
| **Safety** | ***Summary Finding:*** In North Carolina and Arkansas, work zones equipped with AWIS had fewer crashes compared to similar sites without the technology.[251] |
| **Mobility** | A dynamic lane merge system deployed in a work zone outside Detroit increased PM peak period travel speeds by 15 percent. AM peak period speeds did not change.[252] |
| **Efficiency** | In Minneapolis-St. Paul, traffic speed data collected at two freeway work zones indicated that when portable traffic management systems were deployed, peak period work zone traffic throughput increased by four to seven percent.[253] |
| **Productivity** | The Illinois DOT reduced operating costs during the reconstruction of I-55 by deploying an automated traffic control system and eliminating the need for constant traffic monitoring.[254] |
| **Customer Satisfaction** | The Illinois DOT reported a high level of satisfaction with an automated traffic control system deployed during the I-55 reconstruction project.[255] |

### LESSONS LEARNED

**Consider deploying ITS in a work zone to improve traffic safety and mobility during construction.**

The Arkansas Highway and Transportation Department, upon undertaking a large and complex construction project, assessed the challenges associated with the extensive work zones and implemented an automated work zone information systems to cover the I-30 work zone corridor. The objectives of the AWIS were to improve safety and mobility during construction.

- Maintain flexibility when deploying ITS in highly variable environments.

Arkansas' effort to reconstruct and repair more than 350 miles of roadway was a large, complex undertaking with constantly changing configurations. As a result, the calibration of ITS became an important issue and required one full-time employee devoted exclusively to maintaining all sensors.

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

Intelligent transportation systems are only one part of a work zone management plan. ITS components can be instrumental in improving the safety of a work zone. However, they are not a cure all for eliminating the traveler's exposure to hazards that a work zone imposes. Based on Arkansas' experience, ITS helped reduce the number of crashes; but crashes, including fatal ones, were not fully avoided.

## LESSONS LEARNED

**Conduct necessary pre-implementation tests in order to secure smooth system operations.**

In deploying ITS during rebuilding of the "Big I" interchange in Albuquerque, the New Mexico State Highway and Transportation Department found a number of ways to help ensure operational efficiency of ITS resources.

- Grant ample start up time when implementing new ITS technologies.

Problems will arise, such as with sensor operation, communications, license applications, component calibration, hardware, or software. These issues will take time to address and need to be identified as soon as possible before going "live".

For instance, the mobile traffic monitoring and management system used by the department for the "Big I" interchange ITS deployment in Albuquerque was designed to be portable and use wireless communication. Wireless communication links were tested prior to the installation of field elements to ensure adequate bandwidth availability. The complete mobile traffic monitoring and management system was brought online two weeks prior to the start of construction allowing time for thorough pre-construction testing.

(*Continued on next page.*)

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| Work Zone Management |
|---|
| **Costs** |
| **Unit Costs Data Examples (See Appendix A for more detail)** |
| Roadside Detection subsystem:<br>• Remote Traffic Microwave Sensor on Corridor: $9K-$13K per sensor<br>• Closed Circuit Television (CCTV) Video Camera: $9K-$19K<br>Roadside Information subsystem:<br>• Dynamic Message Sign—Portable: $18.6K-$24K<br>• Highway Advisory Radio: $15K-$35K<br>• Highway Advisory Radio Sign: $5K-$9K<br>Roadside Detection subsystem:<br>• Portable Traffic Management System: $78K-$97K<br>• Transportation Management Center subsystem:<br>Software for Traffic Information Dissemination: $17K-$21K<br>• Labor for Traffic Information Dissemination: $107K-$131K (annually)<br>Roadside Telecommunications subsystem:<br>• Conduit Design and Installation—Corridor: $50K-$75K (per mile)<br>• Fiber Optic Cable Installation: $20K-$52K (per mile) |

| Work Zone Management |
|---|
| **Costs** |
| **Sample Costs of ITS Deployments** |
| **Michigan:** Michigan DOT leased a dynamic lane merge system for an I-94 reconstruction project at a cost of **$120,000**. The subcontract period of performance was for six months during each of two years. Each of the two six-month periods included installation, testing, and operation time. The system included five dynamic lane merge trailers spaced 1,500 feet apart and in advance of the work zone.[256]<br>**Michigan:** In Lansing, a planning study was conducted to evaluate the feasibility of implementing real-time work zone traffic information during a major freeway reconstruction and rehabilitation project on I-496. The total project investment was over $40 million. The real-time traffic information component of the work zone management system was estimated to cost **$1,900,000**. In addition, the costs for project design, contract administration, and construction engineering were estimated at **$600,000**. Overall, the cost to design the system, furnish and install hardware and software components, and operate and maintain the system for the duration of one year was estimated at **$2,500,000**.[257]<br>**North Carolina:** The North Carolina DOT leased its first smart work zone system along I-95 near Fayetteville at a cost of **$235,000**. The lease consisted of three contract pay items: mobilization, monthly rental, and remobilization. The successful bid was guaranteed for 4 months usage not to exceed 10 months. The total bid breakout was: **$75,000** for mobilization, **$15,000 per month** for equipment rental, and **$10,000** for remobilization.[258] |
| **Benefit-Cost Studies** |
| **United States:** Based on a review of work zone ITS deployments from 17 states, the estimated benefit-to-cost ratio ranged from 2:1 to 42:1 depending upon conditions and assumptions.[259]<br>**Michigan:** The use of ITS for temporary construction zone management in Lansing yielded a benefit-to-cost ratio of 1.97:1 and a net benefit of $4,874,000. The benefit-to-cost ratio was calculated by dividing the benefits of the system ($9,874,000) by the overall cost of the deployment ($5,000,000 which included $2,500,000 for opportunity costs).[260] |

## LESSONS LEARNED

(*Continued from previous page.*)

- Keep the future in perspective when planning and deploying a traveler information system.

Because New Mexico's State Highway and Transportation Department planned for future use, the agency used a combination of equipment purchases and rentals for its project to rebuild the "Big I" interchange in Albuquerque. Once the project ended, the department was able to reuse the purchased equipment as part of a permanent freeway management system.

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