Intelligent Transportation Systems in Work Zones

A Case Study

Work Zone Travel Time System

Reducing Congestion with the Use of a Traffic Management Contract Incentive During the Reconstruction of Arizona State Route 68

October 2004

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Foreword

Dear Reader,

We have scanned the country and brought together the collective wisdom and expertise of transportation experts implementing Intelligent Transportation Systems (ITS) projects across the United States. This information will prove helpful as you set out to plan, design, and deploy ITS in your communities.

This document is one in a series of products designed to help you provide ITS solutions that meet your local and regional transportation needs. The series contains a variety of formats to communicate with people at various levels within your organization and among your community stakeholders:

- **Benefits Brochures** let experienced community leaders explain in their own words how specific ITS technologies have benefited their areas.
- **Cross-Cutting Studies** examine various ITS approaches that can be taken to meet your community's goals.
- **Case Studies** provide in-depth coverage of specific approaches taken in real-life communities across the United States.
- **Implementation Guides** serve as "how to" manuals to assist your project staff in the technical details of implementing ITS.

ITS has matured to the point that you are not alone as you move toward deployment. We have gained experience and are committed to providing our state and local partners with the knowledge they need to lead their communities into the future.

The inside back cover contains details on the documents in this series, as well as sources to obtain additional information. We hope you find these documents useful tools for making important transportation infrastructure decisions.

Sincerely,

Jeffrey F. Paniati
Associate Administrator for Operations
Acting Program Manager, ITS Joint Program Office
Federal Highway Administration

Preface

This case study is one in a series of documents that examines the use of Intelligent Transportation Systems (ITS) in work zones. More information on applications of ITS in work zones is available in the companion document, *Intelligent Transportation Systems in Work Zones - A Cross–Cutting Study* (Report No. FHWA-OP-02-025, EDL# 13600).

This case study presents information gathered through interviews with key personnel on the Arizona State Route (SR) 68 project in Kingman, Arizona, as well as information and photographs obtained during a site visit. The authors greatly appreciate the cooperation of the Arizona Department of Transportation and its partners, who made the production of this document possible.

Contents

Project and System Background

The Arizona Department of Transportation (ADOT) used ITS to support work zone operations during the reconstruction and widening of State Route 68 (SR 68) in northern Arizona. The $42 million project involved widening approximately 13.5 miles of an existing two-lane rural highway into a four-lane divided highway. ADOT began the project in the summer of 2000 and completed it in April 2002. The project was unique in that ADOT procured it as a design-build project, the first rural project of its kind in Arizona. Faced with many challenging features on this project, ADOT determined that implementing ITS in the work zone would be beneficial to keep traffic moving on one of the region's most critical highways. ADOT decided to include an incentive/disincentive provision in the project contract to encourage the contractor to minimize work zone delays. ADOT needed a way to measure performance related to the provision and turned to ITS to help.

SR 68 is a critical highway for the northwestern region of the state, primarily serving commuter traffic traveling between Kingman, Arizona, and the nearby cities of Laughlin, Nevada, and Bullhead City, Arizona (shown in Figure 1). Several characteristics of SR 68 presented ADOT with a challenge in completing the construction while promoting mobility and safety. SR 68 is a major commuter route for those employed by casinos and other entertainment venues in Laughlin. Due to the nature of the employment in Laughlin, SR 68 does not have typical a.m. and p.m. peak traffic periods, and generally has a steady volume of traffic from early morning to late evening.

Figure 1 – Map of Project Location

Another characteristic of SR 68 is that the reconstructed section, which serves a significant amount of recreational vehicle and truck traffic, has a steep continuous grade of 6 percent. Due to the steep grade and significant amount of heavy vehicles using the route, ADOT determined that truck escape ramps would be needed. The project also included other challenging features, such as two structures to accommodate Big

Horn sheep crossings, a retaining wall, new drainage structures, and approximately 2.5 million cubic yards of excavation.

The percentage of truck traffic on SR 68 increased after the 9/11/01 terrorist attacks, when ADOT closed the route over the Hoover Dam to trucks. The route had previously served as the main truck route between Arizona and Las Vegas. As a result, SR 68 has served as the primary alternate for these detoured trucks since then, which has led to a 25 percent increase in truck traffic.

In order to maintain traffic flow along SR 68 throughout the duration of the project, ADOT decided to include an incentive/disincentive provision in the contract. This provision, termed a "Traffic Management Incentive Specification," established a $400,000 bonus fund to encourage the design-build contractor to maintain a target travel time through the work zone. The provision required that the contractor select and pay for a system capable of collecting raw vehicle position data; calculate average travel times through the work zone; and report these average travel times to ADOT in 30-minute periods. The provision also stated that the average travel time could not exceed 27 minutes, and that the contractor would be charged a fee at a rate of $21.50 for each minute of delay when the average travel time exceeded 27 minutes. The requirement applied to both directions of travel, and the travel times and penalties were assessed separately for each direction. According to the clause, the contractor was to receive any bonus funds remaining at the conclusion of the project. Additionally, in the event that the bonus funds were depleted during the course of the project, the contractor would be responsible for any additional fees incurred for continuing to exceed the 27-minute target travel time. ADOT project managers analyzed the data submitted by the contractor to identify any violations and determine any resulting fees incurred.

ADOT arrived at the 27-minute figure by considering several factors. Prior to construction, the average time to travel the project limits at the posted 55 mph speed limit was 17 minutes. ADOT determined this baseline travel time by averaging actual travel time runs conducted at various times of the day on various days of the week. ADOT expected that the travel time during construction would increase to 21 minutes due to lower posted speed limits (35 to 45 mph) and other traffic control measures that would be in place. ADOT also anticipated that heavy trucks traveling up the steep grade would continue to impact traffic flow since there would be only one travel lane for each direction of traffic during construction, as shown in Figure 2.

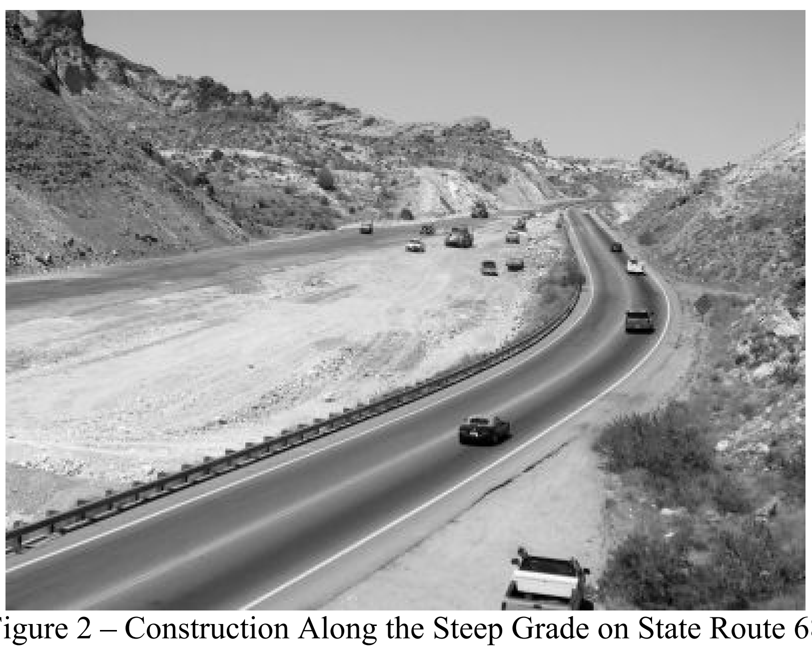


Figure 2 – Construction Along the Steep Grade on State Route 68

ADOT specified requirements for the use of a system to measure travel time through the work zone based in large part on technology demonstrations that key staff had viewed at the Rural Advanced Technology and Transportation Systems annual conference in Flagstaff, Arizona, in August 1999. ADOT had successfully used other incentive/disincentive programs in the past, such as lane rental and a quality workmanship incentive, and was interested in using similar techniques on this project. ADOT was concerned, however, that the contractor might plan for short frequent lane closures, thereby avoiding penalty under the lane rental incentive (which issued penalties for lane closures greater than five minutes in duration), but still imposing unnecessary delay on motorists. To address this concern, ADOT decided to supplement their planned incentive/disincentive programs with a travel time incentive strategy to encourage the contractor to keep traffic moving efficiently through the SR 68 work zone. The contractor selected a camera-based license plate matching system by Computer Recognition Systems to determine travel times through the work zone. The system included two monitoring stations, one at each end of the work zone, and a central processor. Cameras at the monitoring stations took pictures of vehicle license plates entering and leaving the work zone and the system used these images to determine vehicle travel times through the work zone.

> *The SR 68 project is not the first use of a travel time ITS license plate recognition system in a work zone in the United States. The state of Massachusetts currently deploys a similar type of technology at its Coolidge Bridge reconstruction project on Route 9 between Hadley and Northampton. The Massachusetts system is primarily focused on traffic management, rather than tracking contract incentives, and is expected to be in place until 2009. The system website (http://www.umass.edu/coolidgeinfo/) provides real-time travel times, speeds, and camera images.*

Back to Top

System Design, Selection, and Implementation

This section provides information on ADOT's experience in bringing the system from the concept stage to fully operational.

In-House or Contractor Design

- ADOT staff developed performance-based specifications for a travel time system so that the contractor would be free to choose a system suitable for the project. The system needed to be capable of measuring vehicle travel time within the project limits and providing data the contractor would need to report average travel times for 30-minute periods.

System Selection and Procurement

- Other technologies for measuring travel time were considered during the bidding process, including cellular phone tracking, vehicle probes, and radar systems. However, the selected contractor chose to use a license plate matching system.
- The main factors the contractor considered when selecting the system included overall cost, speed of installation, and reliability. In addition, the contractor found it important to choose a system that had been demonstrated and proven successful.

Lease Versus Purchase

- ADOT elected not to purchase the system because it was a temporary application specific to the SR 68 work zone. Therefore, ADOT required that the contractor obtain the system and maintain it.
- The contractor purchased the equipment for the system. After the project, the contractor sold the equipment back to the system vendor, as they did not see the potential for using the equipment again in the near future.

Testing

- The system vendor traveled to the project location to help the contractor install the system and to ensure that it was working properly prior to construction. The contractor also worked with the system vendor to determine the proper placement of the cameras within the work zone.
- Although measuring travel times in work zones with the use of license plate matching is a fairly new concept, license plate matching technology is well developed; therefore, the system required minimal testing.

Training

- The system was simple to use and required minimal training for the contractor's engineers, especially considering that the automated system functions minimized the need to interact with the system on a daily basis. The system vendor trained the engineers on how to operate the system and gather the data from the automated system. ADOT and the contractor found this training to be sufficient.

Back to Top

System Description and Operations

System Description

- The system consisted of two monitoring stations and a central processor. Each monitoring station included an inductive loop embedded in the roadway, a control cabinet with a communications system, and two digital cameras (one for each direction of traffic) linked to the cabinet via fiber-optic cable. In addition, each camera was equipped with a light source to assist in reading license plates with plastic covers.
- The system required access to public utilities for a power source since power requirements for the lighting system made the use of solar power prohibitively expensive. Figure 3 shows a light and camera at one of the monitoring stations.


Figure 3 – Light and Camera Used to Collect License Plate Data

- The system used point-to-point microwave communication technology that was already available at the project location. This communication system provided substantial data throughput (as much as 800 MB per second). The only drawback that ADOT noted in terms of using this method of communication was that line-of-sight was needed, which required the installation of repeaters to relay signals from the roadside sites to the main transmitter.
- The central processor consisted of an industrial computer with a processing speed of approximately 1 GHz, although the system could have been operated using a computer with a processing speed of 500 MHz. The operating system used was a standard commercial off-the-shelf product.
- The system used a common RS-232 interface, which allows access to system data via a wide range of communications and data storage devices.

System Operations

- The system captured, immediately encrypted, and then stored images of license plate numbers as vehicles entered and left the work zone. Vehicles passing over the inductive loops triggered the digital imaging process.
- The monitoring stations captured digital images of the vehicles' rear tag numbers and stored them locally. The system would then send the encrypted images to the central processing station every 10 minutes via point-to-point microwave technology.
- The central processor compared the encrypted images to match vehicles entering the work zone with vehicles leaving the work zone. The processor then compared the time a vehicle tag was detected entering the work zone with the time it was detected leaving the work zone to determine total travel time. The central processor stored the travel time information and periodically sent it to the contractor. The contractor then submitted an electronic copy of the data in 30-minute averages to ADOT project managers on the first day of each month.
- ADOT staff reviewed the data to identify any violations of the travel time provision. If the average travel time for any 30-minute interval was greater than 27 minutes, ADOT assessed the contractor a disincentive fee. ADOT computed the total disincentive fee by determining the delay, or the difference between the actual travel time averages and the goal of 27 minutes for each 30-minute interval. ADOT then charged the contractor a fee of $21.50 for each minute of delay incurred per travel lane.
- The concept of the operations diagram for the system is shown in Figure 4.

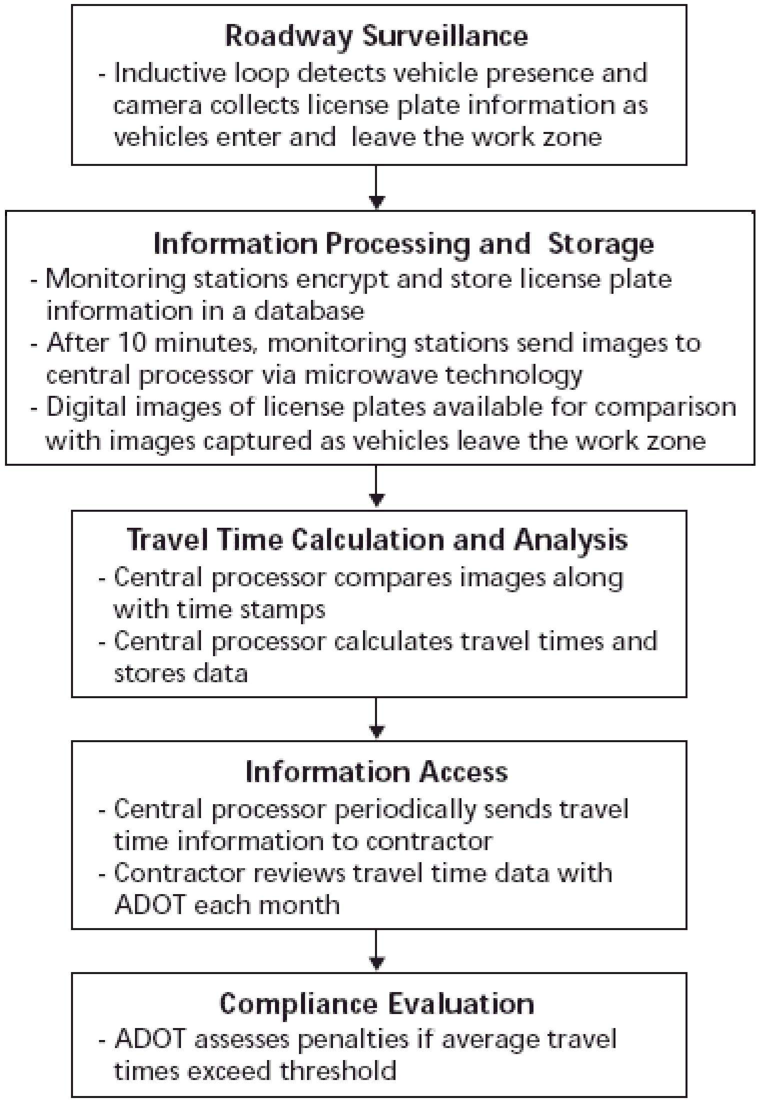


Figure 4 – Arizona ITS Concept of Operations

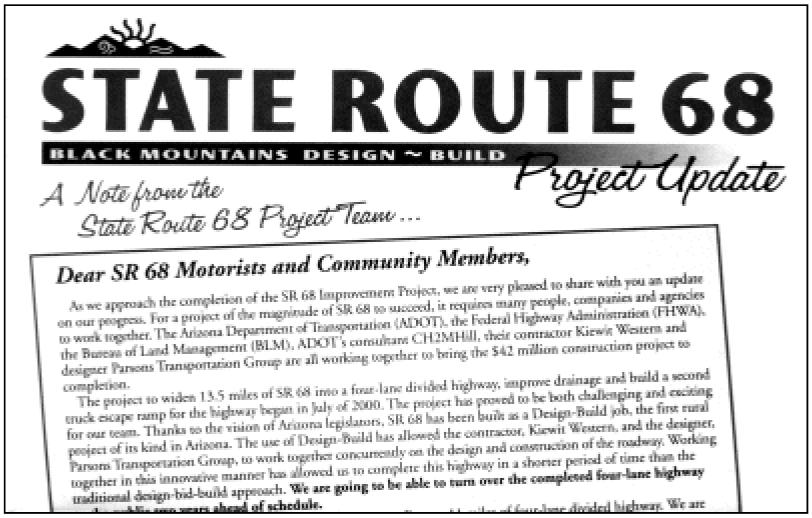
Contractor or Agency Staff

- The contractor monitored the system to assess whether its work operations were creating excess delays. If travel times from the system indicated delays, the contractor could adjust work operations to try to reduce congestion.
- ADOT personnel also monitored the system periodically, as well as reviewed the data submitted by the contractor to identify violations of the travel time provision and used the data to calculate the disincentive for any violations.
- The contractor was responsible for providing system maintenance support. Using an automated system eliminated the need for dedicated operations staff.

Coordination with Key Personnel, Other Agencies, and the Public

- The travel-time system required ADOT to coordinate extensively with the contractor to determine when fines should be assessed. There were times when average travel times were greater than 27 minutes for reasons other than construction activities. For example, a runaway truck jackknifed in the work zone early on in the project and caused a significant backup. Whenever a non-construction delay was suspected, ADOT would work with the contractor to review schedules to determine construction activities that occurred during these periods of time to determine if the contractor should be penalized for the delay experienced by motorists. If the contractor could prove that construction activities should not have impacted traffic flow, ADOT would not assess a penalty.

- Preparation for system deployment required communication and coordination between the system vendor, the contractor responsible for setting up wireless communications, the contractor, and ADOT.
- ADOT made extensive outreach efforts to communicate with the public on all issues regarding the project. ADOT hired a public relations firm to provide public outreach through a variety of means, including public service announcements, cable television announcements, radio media alerts, an informational telephone number, and a website.
- ADOT's public relations firm mailed out newsletters (example shown in Figure 5) three to four times per year to keep the public informed about the project status and to provide answers to frequently asked questions and concerns. In addition, the firm faxed weekly updates to the 144 businesses and individuals who signed up for this service.



STATE ROUTE 68

BLACK MOUNTAINS DESIGN ~ BUILD

Project Update

A Note from the State Route 68 Project Team ...

Dear SR 68 Motorists and Community Members,

As we approach the completion of the SR 68 Improvement Project, we are very pleased to share with you an update on our progress. For a project of the magnitude of SR 68 to succeed, it requires many people, companies and agencies to work together. The Arizona Department of Transportation (ADOT), the Federal Highway Administration (FHWA), the Bureau of Land Management (BLM), ADOT's consultant CH2MHill, their contractor Kiewit Western and designer Parsons Transportation Group are all working together to bring the $42 million construction project to completion.

The project to widen 13.5 miles of SR 68 into a four-lane divided highway, improve drainage and build a second truck escape ramp for the highway began in July of 2000. The project has proved to be both challenging and exciting for our team. Thanks to the vision of Arizona legislators, SR 68 has been built as a Design-Build job, the first rural project of its kind in Arizona. The use of Design-Build has allowed the contractor, Kiewit Western, and the designer, Parsons Transportation Group, to work together concurrently on the design and construction of the roadway. Working together in this innovative manner has allowed us to complete this highway in a shorter period of time than the traditional design-bid-build approach. **We are going to be able to turn over the completed four-lane highway ... ahead of schedule.**

Figure 5 – Example of a Public Outreach Newsletter Distributed by ADOT

- ADOT's public relations firm provided a toll-free phone number so that the public could reach a live person on weekdays between 8:00 a.m. and 5:00 p.m., and leave messages with questions or concerns at night or on the weekends. The firm estimated that it received an average of approximately 25 calls per week related to the overall project schedule, specific delays, closures, and/or business access. The most frequently asked questions related to specific traffic delays. The firm received a few questions about the travel-time system soon after it was installed, particularly regarding privacy issues. Calls about privacy concerns dropped off after ADOT addressed these issues in its public outreach newsletters.
- As a result of the increase in truck traffic on SR 68, the public relations firm developed outreach documents especially for truckers, and worked with the Arizona Motor Transportation Association to distribute these to truckers at truck stops.

Maintenance

- The system supplier/vendor was able to perform system status checks remotely, and the system required little maintenance. According to the contractor, operating and maintaining the system required approximately one hour per week. The system vendor performed daily system status checks at the start of the project and then weekly status checks throughout the rest of the project.
- The contractor had to periodically adjust and recalibrate the cameras, as strong gusts of wind occasionally moved them out of position. This problem would either be detected by the contractor when reviewing the data or by the vendor when performing the weekly status check of the data and the camera views. If contractor staff noticed a problem with the data, they would contact the vendor to determine if the camera views had changed, which would indicate that they needed to be adjusted.

Back to Top

Results

System Performance

- The system functioned as intended. It was able to read approximately 60 percent and match approximately 11 percent of the license plates photographed during the operation. ADOT considered this level of performance to be adequate, both for this application and compared to other license plate detection systems.
- The system went down near the beginning of the project due to a power surge that damaged the 12-volt power supply. As a result of this problem, the system was down for approximately 30 days and ADOT was not able to assess the contractor's compliance with the travel time incentive/disincentive clause for this time period. After learning that the area was prone to power surges, the vendor elected to install surge protection equipment when replacing the damaged power supply.

System Evaluation

- Overall, both ADOT project managers and the contractor were satisfied with the performance of the system and with the concept of the travel time incentive/disincentive clause, though no formal system evaluation was performed.
- For the most part, the contractor was able to maintain traffic flow through the project according to the ADOT time-specified requirements. The contractor was charged only $14,857 against the $400,000 travel time bonus incentive at the end of the project, thereby earning 96 percent of the bonus fund.

Benefits/Impacts

Mobility

- The contractor responded to the travel time incentive/disincentive clause by limiting the number of flagging stations in the work zone and by limiting the duration of directional closings to two to three minutes at most. Both of these actions were taken to minimize the impact of the construction on motorists.
- The contractor worked with ADOT and ADOT's public relations firm to schedule work periods to reduce adverse impact on motorists. For example, they worked together to determine the blasting schedule by studying traffic volumes and surveying the casinos in Laughlin about the times of their shift changes. After plotting the casinos' shift changes along with the traffic volumes on SR 68, they determined that the best time for blasting would be between 8:00 and 9:00 pm.

Safety

- A secondary benefit was reduced exposure of workers to traffic. The contractor scheduled work to be performed in close proximity to travel lanes during periods of low traffic volume to minimize their disincentive fee.

Public Reception/Reaction to the System

- Motorists initially voiced concern about privacy issues due to the use of cameras to photograph license plates. This issue was addressed by informing the public, through the use of newsletters and

other public outreach methods, that the system immediately encrypts all license plate numbers before archiving them so that no actual license plate information is retrievable. This action ultimately eased any privacy concerns of the public.
- Although the contractor mounted the light and camera system behind construction signs to avoid causing distraction to motorists, some motorists complained that the light was distracting at night. These complaints diminished after the contractor adjusted the angle of the lights and ADOT educated the public about the purpose of the lights.
- ADOT received a great deal of positive feedback from the public through e-mails and letters of appreciation. The public seemed genuinely pleased that the delays were not as bad as might be expected along such a highly traveled corridor. Many also expressed satisfaction with the level of outreach related to construction activities and schedules that ADOT provided throughout the duration of the project.

Obstacles Encountered and Lessons Learned

General

- The contractor felt that having the incentive/disincentive clause in the contract forced the crew to pay closer attention to the impacts that their construction would have on the traveling public.
- ADOT felt that agencies considering a travel-time incentive program should consider requiring a shorter reporting time frame to provide a more realistic calculation of average travel times through the work zone. They felt that 10-minute intervals would have been more realistic.
- ADOT also felt that the maximum travel time used to calculate the disincentive fee should have been closer to the average time it took to travel the project limits before construction.
- ADOT and the contractor both felt that this system worked well in a rural setting, but were unsure how well it would perform in a more urban setting with a greater number of access points. However, the same type of system is being used successfully in an urban setting on the Coolidge Bridge Reconstruction Project in Massachusetts. In this setting, a license plate match rate of 10 to 20 percent has been sufficient for determining average travel times. The system can identify vehicles that exit the road and return a short time later as outliers by setting a threshold and automatically removing any travel times from the data set that are greater than a specified percentage over the average travel time. Therefore, access points within the work zone do not pose an insurmountable problem for this type of system.

System Deployment and Operations

- The main challenge ADOT encountered with the surveillance system was that it was difficult for the system to read license plates when the camera was facing directly into the sun. Fortunately, this was only a problem for approximately one hour each day, so it was a minor concern.
- A traffic camera was stolen during the course of the project, and it took approximately two weeks to replace the camera. The contractor responded by purchasing an extra camera in case it would be needed in the future, and by welding the cameras to the sign structures and installing chains and padlocks to secure them. ADOT project managers felt that it would have been beneficial to specify a requirement in the contract for the contractor to keep an additional camera on-hand to be able to respond more promptly to unexpected situations.
- ADOT project managers found it to be somewhat time consuming to process the travel times received from the contractor. ADOT felt that this procedure could be more automated in the future.

Communications

- A major obstacle ADOT encountered in using this system was the remote project location and limited infrastructure, which made system communications challenging. ADOT had initially hoped to use solar power for the cameras and lights, but found this option to be prohibitively expensive.

Therefore, camera locations were limited by the availability of public utilities for power in this remote location. Because the project was located in a mountainous region, additional equipment was needed to provide the communications required by the point-to-point microwave technology. The terrain of the region required installation of repeaters to relay signals from the roadside sites to the main transmitter for the line-of-sight technology.

- Some electrical problems occurred at one point during the project, and the system was down for approximately 30 days while technicians repaired the problem. During this period, ADOT could not assess compliance with the travel time incentive/disincentive clause due to lack of data. As a result, ADOT felt that future contracts should include a penalty stating that the contractor will incur a fee if the system is down for more than 48 hours.

> ***"The travel time incentive program truly minimized the construction impacts to the traveling public and commuters."***
> *— Jennifer Livingston, Sr. Project Manager ADOT*
> *(Former Resident Engineer - Kingman District)*

Back to Top

Conclusion

The use of an ITS application on State Route 68 in rural Arizona was a success for all involved. Both the contractor and the ADOT project managers were pleased with how the system worked, and ADOT received a great deal of positive feedback from the public. With the use of the travel-time system and the incentive/disincentive clause, the contractor was forced to be innovative in managing construction efforts to minimize impacts on the traveling public. This case study is one example of how ITS is being implemented across the nation to help agencies better manage traffic while performing necessary infrastructure improvements.

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Back to Top

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