ITS in Work Zones

An intelligent transportation system (ITS) moves large numbers of vehicles through an extensive construction zone.

The New Mexico State Highway and Transportation Department (NMSHTD) rebuilt the Big I interchange in Albuquerque to make it safer and more efficient and to provide better access. The Big I is where the Coronado Interstate (I-40) and the Pan American Freeway (I-25) intersect in Albuquerque. The original Big I was designed to support an average daily traffic (ADT) of only 40,000 vehicles and was severely over capacity, experiencing an average of 1.7 crashes per day that were estimated to cost about $12 million annually (data from 1999). ADT in the interchange was approximately 300,000 vehicles before its redesign; the redesigned Big I has a design capacity of 400,000 ADT. The two-year project began on June 30, 2000 and involved 111 lane-miles of construction and 45 new and 10 rehabilitated bridges.

For the Big I project, NMSHTD employed intelligent transportation systems (ITS) in the form of a mobile traffic monitoring and management system to help move the large number of vehicles through the extensive construction area. Mobile traffic monitoring and management systems use electronics and communications equipment to monitor traffic flow and provide delay and routing information to drivers and agency personnel. The ITS application deployed at the Big I in 2000 was used for the two-year duration of the work zone. The ITS components were deployed just before construction, with plans to incorporate portions of the system as part of a permanent ITS application for freeway management once construction was completed.

NMSHTD used ITS for this major construction project for several reasons, including:

- Changes in traffic patterns, nighttime closures, and pre-determined alternate routes required that travelers be provided with high-quality real-time information on travel route availability.
- The high volume of traffic moving through the Big I created great potential for congestion. NMSHTD estimated that normal traffic volume had to be reduced by at least 20 percent to keep traffic moving through the Big I area. Incidents would create further congestion and require rapid response to avoid additional delays. A system was needed to provide accurate information, support quick identification of incidents, and help manage traffic through the area.

Solar-powered sensors and communication equipment.

The main goals of the ITS were:

- To provide traffic management capabilities and traveler information on traffic routing, detours, and significant incidents.
- To minimize capacity restrictions due to incidents by more quickly identifying incidents and determining an appropriate and effective response to clear the roadway.
- To enhance traveler safety.

The Big I ITS included a series of cameras and sensors to monitor traffic conditions and detect incidents, and electronic signs, highway advisory radio (HAR), a website, and other media to transmit traveler information. The incident detection capability was a major component of the system. To effectively use the system information to expedite incident clearance, NMSHTD made use of its motorist assistance program.

Instituted before the Big I project, the Highway Emergency Lender Patrol (HELP) program consisted of two vehicles patrolling the Albuquerque Metropolitan area. NMSHTD recognized that the Big I project would require more HELP trucks. The Federal Highway Administration provided $250,000 toward the purchase of two additional HELP trucks. The additional vehicles were purchased through the construction contract to help patrol the Big I project area during construction. The original two HELP trucks were then able to patrol the rest of the Metro area.

The contractor was given (on a no-cost lease) two HELP vehicles to operate Monday through Friday from 5:00 a.m. to 8:00 p.m. to patrol the work zone during construction. The HELP trucks are equipped with an air compressor, arrow board, assorted tools, and a truck-mounted attenuator. The HELP vehicles provided assistance to more than 10,000 stranded motorists during the two years it took to rebuild the Big I. At the end of the Big I project, the HELP trucks were turned over to the NMSHTD for continued use.

System Design, Selection, and Implementation

NMSHTD used a design contractor for the Big I reconstruction project. The design contract had a task for construction oversight that included design and implementation of a work zone ITS. NMSHTD felt that it would be best to use a contractor with experience in designing an ITS system for complex projects such as the intersection of two large interstates.

The design and construction oversight contract called for the purchase and installation of all components of the ITS system as a lump sum purchase. The design contractor let a subcontract for the ITS system. The subcontractor provided all system components, software, and installation. Partial payments were made to the contractor as the system was deployed, and for cellular communication charges, but final acceptance and full payment did not occur until the end of construction. NMSHTD assumed ownership of all components of the system at the end of construction. The total cost of the ITS system was $1.5 million.

Some of the ITS work zone system components were designed to be part of a permanent freeway management system after construction. Therefore, the state decided to purchase the system components as opposed to leasing them. Purchasing the system required greater capital costs early on, but funding was available for this option. The design contractor purchased the system through its contract for NMSHTD using construction oversight funding.

The design contractor provided a draft implementation/configuration plan to NMSHTD that was based on its previous experience and tailored to the characteristics of the Big I reconstruction project. NMSHTD staff then reviewed and revised the implementation plan. The initial deployment phase lasted longer than anticipated due to larger than expected variations in traffic volume during the system calibration phase. The system took three and a half months to deploy from concept to full installation and operation. Setup time included three days per location to set up each VMS and camera, and half a day to set up each portable Smart Zone.

The system was designed to be portable and use wireless communication. Wireless communication links were tested before the installation of field elements to ensure adequate bandwidth availability. The complete system was brought online two weeks before the start of construction. This allowed for thorough pre-construction testing. The vendor trained NMSHTD employees on the use of the system and its capabilities so that they would be able to continue to operate it in the future. After the training, NMSHTD employees staffed the temporary Big I traffic management center (TMC), with periodic consultation with the vendor.


Example of ITS equipment deployed at the Big I.

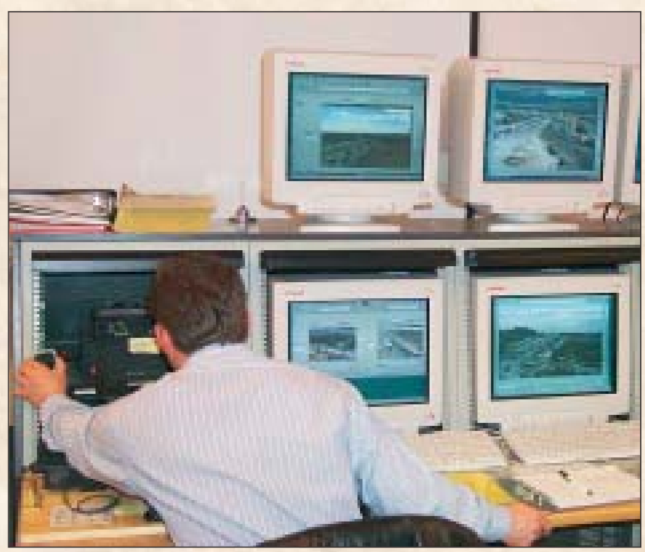
System Description and Operations

The system consisted of eight cameras; eight modular (expandable) dynamic message signs (DMSs); four arrow dynamic signs; four all-light emitting diode (LED) portable DMS trailers; four portable traffic management systems, which integrate cameras and DMS on one fully portable unit; and four HAR units, all linked electronically to the temporary Big I TMC. Components relied on solar re-chargeable systems for power.

Communications equipment for the system included spread spectrum radio, wireless Ethernet applications, and cellular digital packet data (CDPD) modems. (CDPD is being phased out as most cell networks are migrating to General Packet Radio Service/Global System for Mobile [GPRS/GSM] communications digital.) NMSHTD employees staffed the TMC monitored camera displays from 5 a.m. to 8 p.m., Monday through Friday to detect incidents

The staff was able to notify emergency personnel for dispatch, post messages on electronic roadway signs, and provide traveler information to the public via the Internet and a pager network. The information provided was based on the incident type and severity. NMSHTD also distributed information via a website, media outlets (radio, newspaper, television), pagers (provided by a commercial paging service), and fax and email distribution lists. Camera image data for the system were provided by electronic means, and system components were connected via wireless infrastructure to allow for data flow from the field to the TMC.

The system software held a set of message scenarios for the electronic roadway signs. Because the core of the Big I was entirely closed to traffic most nights to facilitate roadwork, a whole


The Big I Traffic Management Center (TMC).

Highway Emergency Lender Patrol Vehicle.

Faxes were sent out (at least weekly) to inform the media and other agencies about road closures, detours, schedule changes, and major incidents.

series of detour messages needed to be displayed each night. The ITS enabled TMC operators to activate a pre-defined message scenario for all the DMSs with "one click." These scenarios were not set to activate automatically, although they could be. During incidents, NMSHTD could also manually activate DMS messages indicating the accident location, lanes affected, and whether delays were occurring. The amount of delay and length of queue were not displayed.

The concept of operations diagram for the system is shown in Figure 1.

The Big I website was updated regularly with new information. The website displayed camera images in real-time and updated them automatically, providing the public with current, timely information. NMSHTD manually refreshed much of the other website content weekly. State agency staff operated the Big I ITS and its TMC. NMSHTD consulted subcontractor personnel on an "as-needed" basis for assistance with technical issues. This assistance was provided through the construction oversight task of the design contract.

NMSHTD used a proactive traffic incident management approach. NMSHTD staff developed a Crisis Communication Plan that delineated coordination procedures to be followed, for various types of incidents, by key personnel, the public, and other agencies as needed. Contact information posted on the project website allowed the public to voice opinions on the functionality of the system and also identify any problems.

A police substation was located in the general contractor's staging yard, allowing for quick access and response to the construction area. A police base station radio deployed at the TMC allowed for direct communication between the police and NMSHTD staff. A dispatcher was co-located in the TMC to dispatch the officers as needed. An emergency medical technician (EMT) unit and a tow truck were also located in the same compound as the police substation.

NMSHTD performed periodic, as-needed maintenance on system components with some initial help from the subcontractor. The subcontractor provided a warranty on all equipment for one year from the date of purchase. However, NMSHTD needed to cover the maintenance aspects of equipment problems and removal and installation of new parts. Therefore, NMSHTD decided to purchase spare parts and perform maintenance in-house.

System Performance and Evaluation

The ITS construction TMC participated in about 500 incident responses per month during construction.

Incidents in the construction zone ranged from stalled vehicles to multi-vehicle injury crashes. Visual coverage of the construction zone traffic resulted in average response times of less than seven minutes with average clearance times of less than 25 minutes. The system functioned properly approximately 95 percent of the time. Operational issues were typically resolved within 48 hours of detection.

NMSHTD evaluated the ITS system through surveys of public perception, through the measurement of impacts on crash frequency, and incident response and clearance times. Benefits were:

- Incident response and clearance time was reduced from 45 minutes (historically) to 25 minutes in the work zone with ITS.
- Approximate reduction in traffic as experienced from travel demand management techniques (outreach, public communication, etc.) was 15 percent.
- Information provided by the system allowed NMSHTD to determine the appropriate response for an incident, allowing the correct number of emergency services and motorist assistance vehicles to be sent. This both saved money and minimized the decrease in roadway capacity.
- A 32 percent reduction in crashes was observed during the first three months of the work zone (compared to the previous year).
- Over the entire first year of the work zone, crashes were seven percent higher than the previous year without the work zone. This increase was smaller than what NMSHTD expected with the complexity of the work zone.
- The reduced incident response and clearance time is believed to have resulted in a reduction in the frequency of secondary crashes. Other motorists were less distracted by incidents, and "rubbernecking" was reduced due to the shorter clearance time.
- Driver behavior observed using the system cameras allowed NMSHTD to identify areas where drivers were having difficulty navigating the work zone. This information was then used to make work zone configuration changes to improve traffic flow.

Most nights the core of the Big I was closed to traffic and detours were activated. Daytime traffic patterns through the work zone also changed frequently. The operator could activate pre-programmed message scenarios with a few keystrokes without leaving the TMC. This automation saved NMSHTD considerable effort in informing travelers of changes in the work zone and detours.

One person at the TMC could monitor work zone operations and disseminate information to the public and incident response personnel. System information allowed police, fire, and emergency personnel to assess incident severity and send the correct number of vehicles. Thus, costs were reduced, and other units were free to respond to other incidents.

NMSHTD administered over 1,000 surveys to assess the public's perception of the Big I ITS.

More than 60 percent of survey respondents were pleased with the accuracy and timeliness of the public information provided. NMSHTD found that the use of the system lead to improved communication and an improved relationship with the public.

Obstacles Encountered, Lessons Learned

System Communications. Systems need to have reliable communications. The communications network for an ITS application is vital to the operation of the system and must be reliable. Issues that may impact communications need to be addressed early in the system development and deployment process.

Start-Up Time. It is important to allow start-up time when deploying a system. Problems will arise—such as with sensor operation, communications (wireless or wireline), license applications, component calibration, hardware, or software—and will take time to address. NMSHTD found that a full service maintenance warranty would be too expensive to be practical (on the order of $100,000), so it invested the time to learn about maintenance of the system and performed maintenance in-house.

Building Public Awareness. It is important to use a proactive approach in building public awareness of the project and the information that the ITS application will provide. Successful techniques include holding press conferences, issuing news releases, and keeping local media (especially those the public turns to for traffic information) up to date. NMSHTD used public meetings and outreach to reduce travel demand during the work zone period.

Accuracy of Information. It is vital to deliver accurate information to the public. If inaccurate information is provided, the public can quickly lose confidence and negative public relations result. NMSHTD performed outreach to the public to help educate motorists and travelers and for travel demand management.

Interagency Coordination. Other stakeholder agencies, such as those responsible for incident management, need to be involved early. Coordination with other agencies is a primary issue that agencies should consider both in developing and implementing an ITS work zone system. NMSHTD coordinated extensively with the incident management community. FHWA assistance for incident management was obtained to help patrol the work zone area.

Information Delivery. It is important to carefully consider how to set up automated information delivery and sharing with other agencies. It is possible to deliver too much information for agencies to process effectively.

Relating with Other Agencies. State departments of transportation need to "sell" ITS to the incident management community and work with them to determine how to use the system to coordinate with incident response.

System Features/Capabilities. Portability of the ITS units is key in the core of the work zone because the work zone configuration changes frequently, which may require that the units be moved.

Communications Capacity. For CDPD communication, it is important to ensure that the cellular provider has sufficient unused capacity to eliminate communications failure during peak cell phone usage hours, due to service overload.

Start-Up. It is important to use a proactive approach to building public awareness of the project and the information that the ITS application will provide. Successful techniques include holding press conferences, issuing news releases, and keeping local media up to date.

Access/Security. It is necessary to allow for access to sensor stations for maintenance.

Use of System Information. When changes in work zone roadway geometry are made, it is important to allow time for drivers to learn the new traffic pattern before reporting problem spots to the contractor based on observations from the system's cameras.

Power Supply. Stations may need to be reset manually when there are power interruptions, such as lightning storms.

Maintenance. Maintenance needs can be met in-house, with help initially from the vendor. GE

The preceding article is based on Intelligent Transportation Systems in Work Zones *(FHWA-OP-04-072), January 2004, published by the U.S. Department of Transportation. For a current listing of available documents, please visit www.its.dot.gov.*

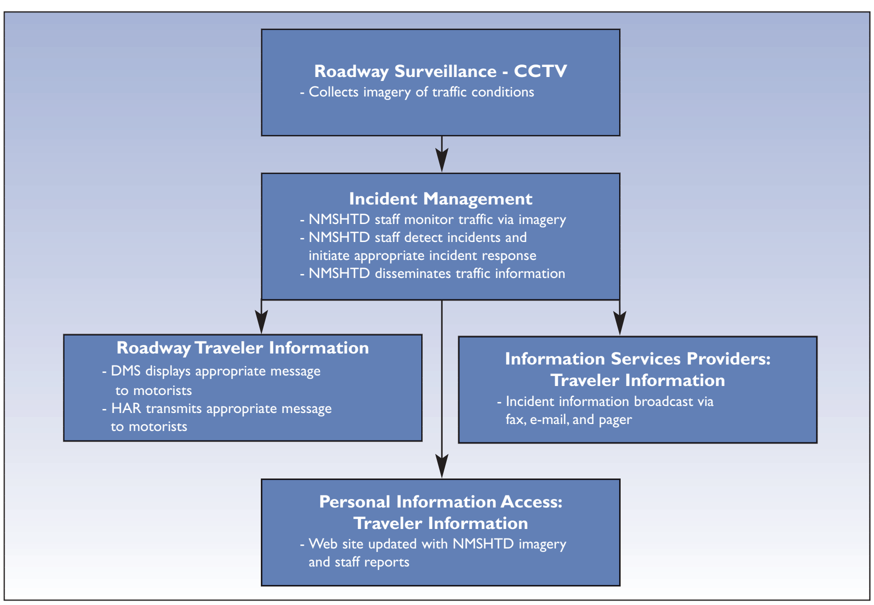


Figure 1. Albuquerque Work Zone ITS concept of operations diagram.