Intelligent Transportation Systems in Work Zones

A Case Study

Real-Time Work Zone Traffic Control System

Using an Automated Traffic Information System to Reduce Congestion and Improve Safety During Reconstruction of the I-55 Lake Springfield Bridge in Illinois

October 2004

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.

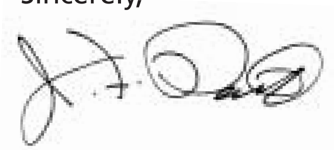
- **Case Studies** provide in-depth coverage of specific approaches taken in real-life communities across the United States.

- **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
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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 in interviews with key personnel on the Lake Springfield Bridge project on Interstate 55 south of Springfield, Illinois. Some of the information and photos were obtained during a site visit. The authors greatly appreciate the cooperation of the Illinois Department of Transportation and its partners, who made the production of this document possible.

Contents

Project and System Background

This case study focuses on the use of ITS to support Illinois Department of Transportation (IDOT) work zone operations for a major bridge and highway reconstruction effort on Interstate 55 (I-55) just south of Springfield. IDOT chose to deploy ITS for this project as a means to reduce congestion and improve safety based on its favorable experience with ITS on other projects. The ITS application, the Real Time Traffic Control System (RTTCS), covered the northbound and southbound approaches to the work zone, encompassing approximately 40 miles of I-55.

The RTTCS consisted of portable dynamic message signs (DMSs), portable traffic sensors, and portable closed-circuit television (CCTV) cameras linked via wireless communications to a central workstation. The system monitored traffic along I-55, automatically generated messages on the DMSs based on predefined thresholds, provided data for a real-time congestion map displayed on IDOT's website, and provided congestion/incident detection alerts for IDOT staff. The ITS application was deployed from February 2001 to May 2002.

The construction project entailed reconstructing the Lake Springfield Bridge on I-55, improving I-55 south of Springfield, and improving the Toronto Road and Southwind Road overpasses. Reconstruction of the Lake Springfield Bridge involved first closing the southbound span and diverting southbound traffic onto the northbound span, and then reversing the process once work on the southbound span was complete. IDOT required motorists traveling through the work zone to reduce their speed from 55 mph to 45 mph when construction activities were in progress. Figure 1, taken from the IDOT website, shows the location of the work zone and the DMSs (see DMS symbols) that were part of the ITS deployment.

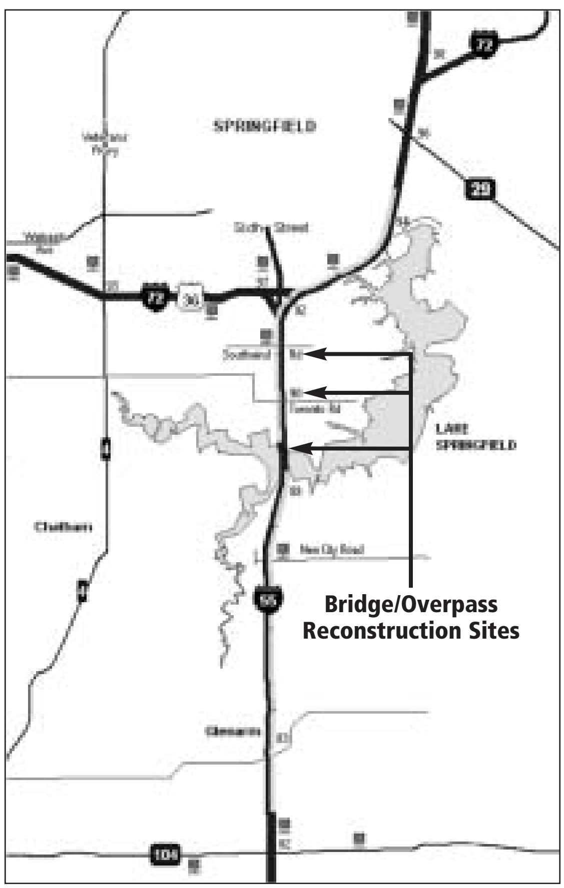

Figure 1 – Lake Springfield Bridge Reconstruction Project

System Design, Selection, and Implementation

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

In-House or Contractor Design

- The approach that IDOT staff took represented a hybrid solution to the question of developing a design for the system in house or relying solely on contractors for the design. IDOT staff developed detailed functional requirements for the system and then reviewed the approach proposed by the vendor against the functional requirements. IDOT then worked with the vendor to finalize the system design. The functional requirements that IDOT developed for the Lake Springfield Bridge work zone were largely inspired by other traveler information systems that had been implemented in the state.
- Key IDOT functional requirements for the system included:
  - Acquiring and processing traffic data, such as traffic speeds in all kinds of weather/visibility conditions, and automatically selecting motorist information messages for display on DMSs without human intervention, while allowing for manual adjustment of thresholds for advisory message selection or staff notification
  - Displaying independent advisory messages on each DMS based on conditions near specific DMSs
  - Operating continuously (24/7) for the duration of the project
  - Allowing IDOT staff to manually override motorist information messages for a user-specified time, after which the system returned to automated function
  - Protecting critical functions with a password system
  - Providing current traffic condition information via the Internet on a full-color map that utilized color-coding to depict traffic conditions
  - Archiving camera imagery
  - At a central location, displaying sensor data and imagery for locations equipped with sensors and CCTV.

System Selection and Procurement

- IDOT prepared functional requirements for a system to be used in the work zone. IDOT then secured use of the system by including the requirements as a bid item within the overall construction contract.
- The prime construction contractor for the project was responsible for procuring a system that met IDOT's requirements. The prime contractor used the IDOT requirements to select a vendor, United Rentals, Inc., to provide the system. Following selection, IDOT worked with the vendor to further refine and approve the proposed system prior to deployment.
- The decisive factor in IDOT's approval of the vendor and system proposed by the prime construction contractor was IDOT's familiarity with similar systems that the proposed vendor had implemented in other areas of the state (such as Chicago) that required significant traveler information efforts due to traffic congestion.

Lease Versus Purchase

- The prime construction contractor leased the system from a firm specializing in work zone systems. While IDOT did not technically lease the system, the result was essentially the same because they did not actually purchase the system to own (nor did the prime contractor, which leased it from a firm specializing in work zone systems).
- According to IDOT, procuring use of the system as a bid item rather than purchasing the system for this project resulted in significant cost savings. The cost of leasing the system was $785,000, representing approximately 2 percent of the total project cost of nearly $35 million.

System Implementation

- Implementation of the RTTCS was a collaborative effort involving IDOT and the vendor providing the system. The vendor initially provided a draft implementation/configuration plan to IDOT that was based on the vendor's previous experience as well as unique characteristics of the Lake Springfield Reconstruction project. IDOT staff then reviewed and revised the implementation plan. Revisions were required in part, due to differences in interpreting certain terms used by the vendor's software engineers and IDOT's traffic engineers.
- Implementation required system calibration that was complicated by the absence of significant traffic congestion. Consequently, the initial deployment phase lasted longer than anticipated.

Testing

- Vendor and IDOT staff tested components prior to the system coming fully online. In addition, traffic detectors were calibrated in the work zone prior to system acceptance.
- IDOT required that the system be deployed on I-55 and tested two weeks prior to initiation of reconstruction activities. The only "difficulty" encountered was that there was no significant congestion prior to the start of the reconstruction project, which prevented complete calibration of the traffic detection system. Consequently, recalibration of the system was required after the work zone was in place.
- Terms in the contract agreement specified fines that would be deducted from the fees IDOT would pay if system components did not function properly. This arrangement served as motivation for the contractor to keep the system up and running.

Training

- Use of an automated system and on-call vendor staff resulted in minimal training requirements for IDOT staff.

System Description and Operations

System Description

- The RTTCS provided the state with a highly portable system consisting of 17 remotely controlled portable DMSs, eight portable traffic sensors, and four portable CCTV cameras. All components were electronically linked to a central base station using wireless communications. A DMS and traffic sensor are shown in Figure 2.
- The roadside systems operated from batteries that could be recharged using small solar arrays. The RTTCS used a wireless modem system that enhanced deployment options of the system. These features make the RTTCS system a good candidate for rural or other applications where utilities are not available or in large work zones characterized by frequent changes in roadway alignments.
- The system's traffic sensors provided congestion information by detecting the speed and presence of vehicles as they passed the sensor stations. The central processor automatically generated predefined messages that were displayed on DMSs upstream from the sensor location and updated the traffic condition map on the project website.
- CCTV imagery was used to confirm data generated by the system, especially if the system detected an incident.

Figure 2 – Some of the I-55 System Components: DMS, and Traffic Sensor with Solar Array

System Operations

- The RTTCS consisted of data collection devices electronically linked via wireless communications to a central base station server. The base station server processed data collected by system sensors and calculated delay at each sensor station. The system then disseminated appropriate information to travelers and IDOT staff. A concept of operations diagram for the system is shown in Figure 3.

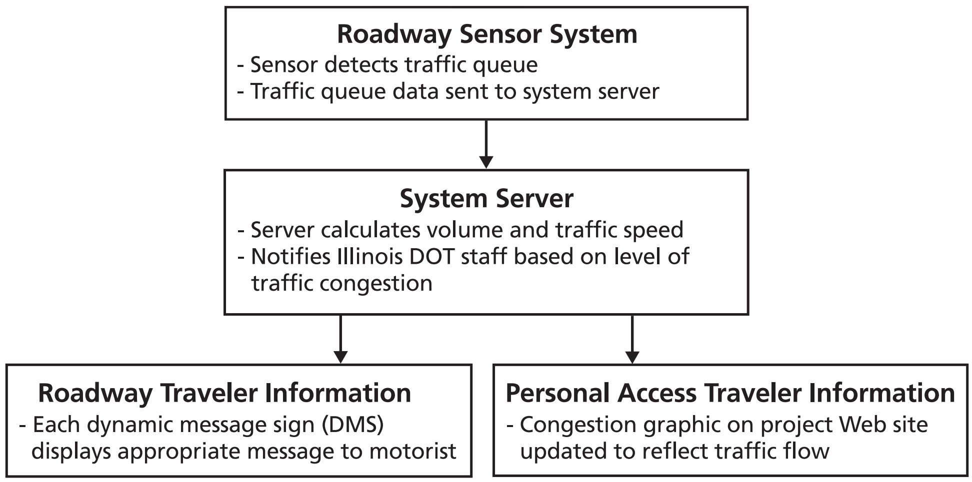

Figure 3 – Springfield Work Zone ITS Concept of Operations Diagram

- IDOT staff was automatically updated via email or pager based on predefined thresholds established by IDOT. Thresholds were based on length of delay and divided into 15-minute increments. The system would contact higher-level IDOT staff as longer delays were detected.
- Motorists received real-time traffic condition information, such as delay warnings, via the system's 17 DMSs that were updated automatically by the system. The system automatically displayed preprogrammed messages based on real-time traffic conditions. The DMSs displayed a variety of messages, including delay information and lane closure advisories. DMSs were typically placed upstream of highway junctions approaching the work zone as well as within the work zone itself.
- The system integrated information and imagery for display on IDOT's website to facilitate pre-trip planning. The system updated the website every five minutes based on congestion levels in the work zone.
- Visitors to the website could read the message displayed on a specific DMS by scrolling over it with their mouse.
- The vendor provided staffing for the system. This arrangement typically entailed one person for periodic system performance reviews and to be on call in the event of any problems occurring after normal business hours.

Contractor or Agency Staff

- The vendor was responsible for providing 24-hour maintenance support for the RTTCS seven days a week.
- The system's ability to function autonomously eliminated the need for dedicated IDOT staff.

Coordination with Key Personnel, Other Agencies, and the Public

- IDOT took a proactive traffic incident management approach. IDOT staff developed a Crisis Communication Plan that delineated coordination procedures to be followed for various types of incidents. The RTTCS was an integral part of the coordination process. The system paged or sent alerts to designated key personnel and displayed preprogrammed messages for travelers based on the extent of traffic delays.

Maintenance

- By acquiring use of the system as a bid-line item, IDOT procured the services it needed without purchasing the equipment and placed maintenance responsibilities on the vendor.
- Terms and conditions in the bid agreement specified fines for system deficiencies that the vendor did not correct within a specified time. This encouraged the vendor to maintain a high level of system readiness.
- IDOT's contract required the vendor to "dispatch sufficient resources within two hours of notification (of a deficiency) to make needed corrections of deficiencies." The contract also stipulated that all deficiencies had to be corrected within 12 hours.
- IDOT required the vendor to have staff available on a 24-hour-a-day basis to respond to IDOT regarding RTTCS performance.

Results

System Performance

- The system successfully monitored traffic along a busy interstate between Springfield (the state capital) and St. Louis, the location of a busy airport serving southern Illinois and eastern Missouri. IDOT reported that the system performed well, with little downtime.
- IDOT staff said that they would use the system again.

System Input and Output to the Public

- **Input** – The system's eight portable traffic detectors used X-Band radar to automatically collect vehicle speed and presence data. The system used four portable CCTV cameras to identify possible incidents detected by the traffic detectors (e.g., if the system detected traffic stopped for long periods of time) or to confirm traffic conditions "when system data was ambiguous."
- **Output** – Real-time traveler information was disseminated to motorists via portable DMSs. Information included delay information and lane closure advisories. IDOT also maintained a project website where those not yet enroute could access a map of the area showing real-time congestion levels in and approaching the work zone. An image from the website is shown in Figure 4. The lightly shaded area along I-55 in the figure shows that traffic is at free-flow speeds on both approaches to the work areas at the time the screenshot was captured. By scrolling over individual DMSs shown on the website map, users could access the message currently displayed on the DMS at that location. The website also provided real-time imagery from the system's CCTV cameras.

Figure 4 – Screen Capture from Project Website

System Evaluation

- Overall, IDOT officials were satisfied with the performance of the RTTCS, though no official evaluation of the system was performed. IDOT was using similar systems at two other work zone sites at the time this case study was prepared.
- The system appeared to be effective given the absence of severe congestion in the work zone. IDOT attributed this lack of congestion to the absence of major incidents and to a reduction in ticket-writing activities that frequently cause traffic delays due to rubbernecking by drivers passing the scene.

Benefits/Impacts

IDOT staff identified several major benefit areas for the RTTCS, which are listed below.

Mobility

- IDOT staff reported no significant traffic backups while the RTTCS was in place, despite the work zone's location on a busy interstate between the Illinois state capital and the nearest airport, Lambert - St. Louis International Airport, in St. Louis. Daily traffic on the I-55 approaches to the bridge averaged approximately 41,000 vehicles per day.

Safety

- IDOT staff responsible for operations in the Lake Springfield work zone reported only two crashes in the construction area during the implementation of the RTTCS. One of the crashes was attributed to driver fatigue and the other to driving while impaired. IDOT staff attributed the small number of crashes to the absence of backups and to the ample warning drivers received via DMSs (as shown in Figure 5), some of which were located 40 miles upstream of the work zone.
- RTTCS DMSs notified drivers as they approached the work zone area of the number of citations that had been issued in the work zone. IDOT staff reported a significant downward trend in the number of violations after the system began displaying these messages.

Cost Savings

- The RTTCS automatically alerted the appropriate personnel only when human intervention was required, eliminating the need to have staff constantly monitor CCTV displays or patrol the work zone. The system sent automatic alerts based on thresholds defined by IDOT and preprogrammed into the RTTCS.
- IDOT avoided large capital costs by securing use of the system only for the duration of the project, thereby avoiding the purchase of major hardware components of the RTTCS. Operating costs were minimized by a system design that focused on automation.

Figure 5 – DMSs Alerted Drivers to Traffic Conditions in the I-55 Work Zone (Figure Shows an Example 3-Phase Message)

Public Reception/ Reaction to the System

- IDOT did not receive significant public reaction to the system (positive or negative). The project website recorded 2,400 hits during the course of the project, which is greater than the amount of traffic typically received by IDOT construction project websites.

Obstacles Encountered and Lessons Learned

Planning and System Development

- *Relating with Other Agencies:* It is important to involve agencies responsible for 911 and other emergency response operations during system planning and design. This effort can help facilitate a coordinated response to incidents during the roadwork.
- *Relating with the Public:* It is important to use a proactive approach to building public awareness of the project. Successful techniques include holding press conferences, issuing news releases, and keeping local media up to date.
- *System Selection:* It is important to assess when it is appropriate to use a work zone ITS application and what type of system best meets the site-specific needs.
- *System Features/Capabilities:* During the requirements definition process, it is important to ensure that software/systems engineers and transportation engineers use common terminology.
- *System Features/Capabilities:* Including the vendor's engineering staff, in addition to vendor marketing staff, in early discussions of vendor capabilities is important.

System Deployment

- *Start-Up:* It is necessary to allow significant time for system calibration during initial implementation of queue-length detection systems. The calibration process will likely take longer than the best estimate of the time required.
- *Deployment Constraints:* The primary constraint on the system as configured for the Lake Springfield Bridge Reconstruction project was the requirement for cellular digital packet data (CDPD) coverage in the work zone area and between the work zone area and the central communications center. Given current plans by the wireless industry to phase out CDPD service in the summer of 2004, it should be noted that there are an increasing number of inexpensive communications products becoming available that can operate in the 2.4 GHz frequency range and support systems such as the RTTCS.

System Operations

- *Calibration:* Agencies should expect to need to recalibrate detection systems during the course of the project.

Conclusion

"The Illinois Department of Transportation will continue to implement cutting-edge technologies and approaches such as those in use in the Lake Springfield construction area to ensure that the traveling public has the most up-to-date information possible when making travel decisions."

– James Slifer
Illinois Director of Highways during the Lake Springfield Bridge reconstruction project

IDOT staff reported a high level of satisfaction with the RTTCS deployed in the I-55 work zone. The system provided important traveler information for those traveling or planning trips through the area with minimal human intervention or downtime. Any downtime experienced by the system was typically attributed to the need to recalibrate the system following movement of traffic sensors. In addition, IDOT staff believes that the system also provided safety benefits based on the decreased number of moving violations after deployment and the small number of crashes that occurred in the work zone. The system also enhanced IDOT incident detection in the work zone, though this was not the main goal or function of the system. IDOT was using similar systems at two other work zones at the time this case study was prepared.

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Notes

Federal Highway Administration Resource Center Locations

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FHWA-HOP-04-018 EDL# 13984