Automated Work Zone Information System (AWIS) on Urban Freeway Rehabilitation: California Implementation

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by

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ABSTRACT

In October 2004, about 9 lane-km of deteriorated truck lanes on Interstate-15 (I-15) at Devore in Southern California were rebuilt during 18 days using extended one roadbed full-closures with the counter-flow traffic system and 24/7 construction operations. The project implemented the Automated Work Zone Information System (AWIS) to reduce peak hour delay during construction by changing road user's travel patterns and diverting traffic to detour routes. This paper describes the design, performance, and validation of AWIS using monitored traffic data before and during construction. The AWIS was installed to provide road users with real-time travel information so that they could avoid traffic delays in the Construction Work Zone (CWZ) corridor. Travel times through the CWZ were estimated from speed data and enhanced in two ways: (a) portable and permanent changeable message signs on site, and (b) off-site (the project website) implementation with travel time messages, traffic snapshots, and video streaming. AWIS travel time estimated to be 90 percent of the actual travel times as measured by probe vehicles. The peak hour traffic demand through the CWZ was reduced by 17.5 percent with significant volume increases to detour freeways. The AWIS operation contributed to a decrease in the maximum delay for weekday peak hours (from 90 minutes to 45 minutes on average during construction). The outcome of this case study will help transportation agencies and practitioners efficiently design and operate AWIS for highway rehabilitation under high traffic volume.

ITS ON HIGHWAY CONSTRUCTION PROJECTS

Many U.S. highway pavements, built during the infrastructure construction boom between 1955 and 1970, have now exceeded their original 20-year design lives and have been subject to far greater traffic demands than were initially envisioned. The deterioration of these highway pavements hurts driving safety and ride quality. In recent years, state highway agencies have shifted their focus from building new transportation facilities to "4-R" type projects emphasizing restoration, resurfacing, rehabilitation, and reconstruction of existing roadways *(1)*.

Because construction activities decrease road capacity and interrupt traffic flow, construction work zone (CWZ) closures impeded traffic flow. Therefore, traffic management plans (TMP) for CWZ should be developed with a priority on minimizing road user costs (RUC). However, for most rehabilitation projects engineers depend upon their judgment from previous experience, rather than following a well-defined and reliable process using analytical tools to develop TMP and select rehabilitation strategies *(2)*. Traffic analysis methods and tools are needed to quantify the RUC associated with various types of highway rehabilitation and to help the agency develop TMP to effectively minimize costs.

Researchers and practitioners are developing TMP to mitigate traffic delays caused by such closures, especially in urban highway networks. To help mitigate traffic delay problems, intelligent transportation systems (ITS) are being utilized in a variety of transportation fields. As one of the more effective ITS technologies, an Automated Work zone Information System (AWIS) has been developed and employed in urban freeway construction activities. AWIS consists of traffic data collecting devices to monitor traffic conditions, changeable message signs to display traffic information, and a server computer to calculate estimated travel times in the designed algorithm. The main purpose of AWIS is to communicate real-time travel information to road users heading into the workzone corridor so that they may decide whether to take a detour route or continue through the CWZ. Several state agencies, including Arkansas, Nebraska, and California, have conducted research into AWIS performance.

Fontaine reviewed applications and results of Work Zone Intelligent Transportation Systems (WZITSs) in several states and provided an application guideline of WZITS *(3)*. However, the author concluded that testing result did not show conclusive benefits at all sites. He determined that more objective research was required to fully assess the potential of these systems.

In 2000, an AWIS was implemented for a highway reconstruction project along a rural work zone of Interstate-40 (I-40) in Arkansas. The major purpose of this AWIS was to increase work zone safety by reducing crash potential at the end of queues *(4)*. The system generated a message warning road users to reduce speed as they approached the CWZ. The AWIS was installed upstream of the CWZ and compared traffic backups indicated by the AWIS with backups observed in the field. Changeable Message Signs (CMS) were deployed to provide speed advisories along the CWZ corridor. The researchers found that backups formed at short term flow rates between 800 and 900 pce/h (passenger car equivalents per hour).

California Department of Transportation (Caltrans) evaluated an AWIS device called the Computerized Highway Information Processing System (CHIPS), which was deployed on the Interstate-5 (I-5) construction project in Southern California. The criteria used in judging its effectiveness included the system's impact on traffic diversion, its capacity to improve the safety for road users and construction personnel, and the responses it elicited from travelers *(5)*. Traffic diversion was observed on two evaluation dates and Caltrans concluded that the use of AWIS succeeded in providing a safer CWZ environment. Traffic volumes measured on exit ramps located upstream of the CWZ were compared with traffic volumes in non-construction conditions. The higher traffic volumes observed on the exit ramps duringAWIS operation indicated that the system had effectively diverted traffic away from the CWZ.

These recent studies were primarily focused on increasing safety in the CWZ by warning of traffic delays, rather than on implementing information systems designed to divert traffic to detour routes in the network. They deployed CMS along the upstream of CWZ corridors but not along other freeways within the network as would have been required for the purpose of checking traffic flow and encouraging diversion to other routes. These CMS did not display dynamic (real-time) travel information but instead displayed static delay messages. In these earlier implementations, travelers couldn't change their travel patterns, travel modes, or departure times in advance since no off-site (on-line) traffic information was provided during construction. This earlier research into the potential of AWIS was thus limited by its scope and did not provide concrete data with which to measure the benefits of AWIS operation.

The AWIS introduced in this case study on the I-15 Devore reconstruction project was designed as a far broader implementation, providing travel time estimates to road users in real time, both on site through the use of CMS, and off site (online) through the implementation of a project web site.

I-15 DEVORE RECONSTRUCTION PROJECT

The I-15 Devore pavement reconstruction project is located on I-15 between Interstate-10 (I-10) and Interstate-215 (I-215) in San Bernardino County, California (see FIGURE 1). The I-15 Devore corridor, with three or four lanes in each direction, carries a traffic volume of approximately 110,000 Average Daily Traffic (ADT), about 10 percent of which are heavy trucks. In contrast to typical urban freeways in California, this corridor has high leisure traffic volume on weekends. Since leisure travelers in the Los Angeles area are going to and from Las Vegas through this corridor, the highest traffic volumes northbound (NB) appear on Friday and the highest traffic volumes southbound (SB) appear on Sunday.

In October 2004, Caltrans rebuilt a 4.5-km section of the deteriorated concrete truck lanes within two 210-hour (about 9 days) extended closures using around-the-clock (24/7) operations. According to the pre-construction analysis, the project would have taken about 10 months using the traditional approach of nighttime closures *(6)*. For the full closure (called "extended closure" hereafter) of one roadbed for construction, the traffic was diverted to the other side on the traffic roadbed through median crossovers, using the counter-flow traffic system. The traffic roadbed had five lanes, including one temporary lane converted from the shoulder rehabilitated with asphalt concrete. The five lanes of the traffic roadbed were then converted to two-way traffic (two by three lane configuration) using Quickchange Moveable Barriers (QMB) as a "counter flow traffic" control system (FIGURE 2). The QMB provided three lanes to the commuting traffic direction during every peak period (three lanes SB in the morning and three lanes NB in the afternoon). The QMB was shifted twice a day in an operation that took less than 30 minutes in live traffic. This dynamic lane configuration (three by two lanes) was routinely accomplished without interruption of traffic.

FIGURE 1 Location of the Traffic Devices Employed in the Study Area.

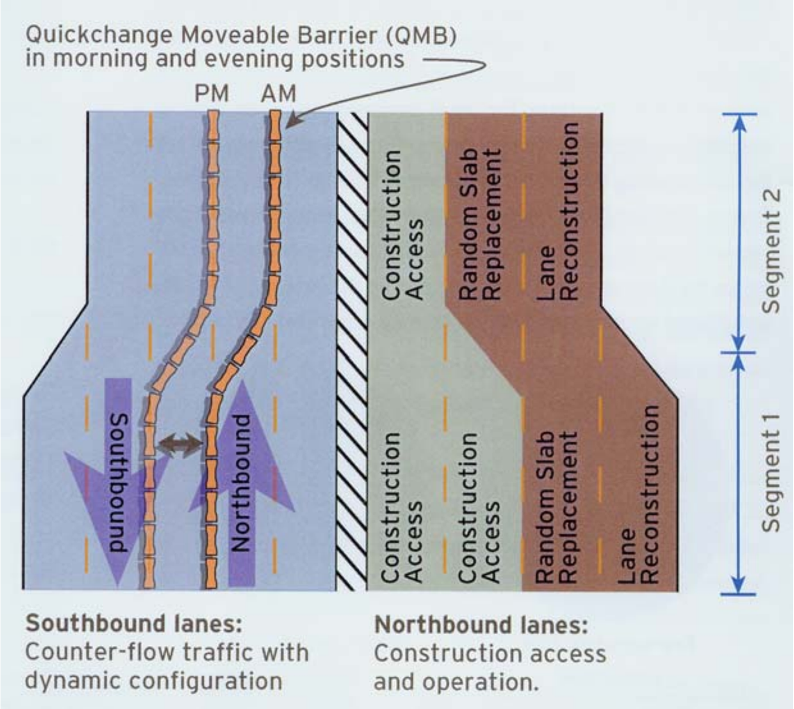

FIGURE 2 Dynamic Lane Configuration with the Operation of Quckchange Moveable Barrier.

Pre-construction traffic analysis, using a demand-capacity (D-C) model based on the Highway Capacity Manual (HCM 2000) with hourly traffic data collected in March 2002, was performed for the extended continuous closure scenario to estimate the maximum delay during peak hours. The estimated maximum delay within the CWZ was 95 minutes for NB traffic during the weekday afternoon peak when a 10 percent reduction of traffic was assumed, which was believed to be most realistic goal achievable in this network geometry. It was estimated that the maximum traffic delay could be reduced to only 50 minutes if traffic volumes could be reduced by 20 percent. A 20 percent reduction in peak hour traffic demand was necessary to ensure the success of extended closures and 24/7 operations *(6)*. Based on this pre-construction traffic analysis, Caltrans decided to implement AWIS coupled with multi-faceted proactive public outreach to achieve greater reduction in demand through the CWZ corridor during peak hours. Use of QMB was also implemented to enhance travel capacity within the CWZ.

RESEARCH APPROACH

The research team reviewed the literature detailing the experiences and practices of utilizing conventional AWIS. Based on this information, the hardware configuration and software algorithm of the AWIS were enhanced for the I-15 Devore reconstruction project, considering the unique topology of the study area. The primary objectives of this study were to practically implement the AWIS with real-time travel information in the urban freeway network containing the CWZ. The AWIS was implemented to maximize its performance during peak hours of the construction period to achieve its goal of more demand reduction through traffic diversion and an increased number of no-shows. Travelers were able to observe traffic conditions even before they entered the CWZ corridor and were guided by on-site AWIS messages to detour to either the neighboring freeways or the arterial roads. The off-site AWIS messages on the project website gave travelers the information required to make decisions about their travel plans and trip patterns, including departure times, modes, and alternate routes. A traffic measurement study was conducted in parallel to evaluate AWIS effectiveness. The traffic flows on major freeways and local arterials before and during construction were measured and the travel times through the CWZ corridor were manually collected for validation and evaluation of the AWIS performance. To achieve the primary objectives above, the traffic data collecting devices of the AWIS were first calibrated.

This research indicated that well-configured AWIS contributes to decrease in traffic demand within the CWZ corridor and to significant subsequent reductions in traffic delays during construction activities. The evaluation of the AWIS on the heavily traveled I-15 Devore corridor provides detailed guidelines for practitioners who will implement AWIS for future urban freeway reconstruction projects. This study also enables transportation agencies to use AWIS to more accurately estimate traffic delays and travel times within networks containing CWZ. This further enhances the abilities of agencies and planners to choose the most appropriate construction schedules considering RUC and construction costs.

The analysis results of before- and during-construction surveys on the project website, intended to evaluate feedback on commuters' experiences with delays and changes in their perceptions regarding the extended closures, will be presented in the project technical report.

AWIS CONFIGURATION

System Overview

The I-15 Devore AWIS consists of three major components: Remote Traffic Microwave Sensor (RTMS) traffic monitoring devices, portable CMS, and the server station where the Virtual Transportation Operation Center (VTOC) is run to estimate travel time in the programmed algorithm (FIGURE 3). The devices were connected to the server through a wireless communication service. The CWZ was located on I-15 between Sierra Avenue (south end) and the junction with I-215 (north end) in the triangle shaped highway network formed by I-15 (west), I-10 (south), and I-215 (east). According to the pre-construction traffic analysis, the length of the longest traffic queue during construction was expected to be about 4.8 km in NB traffic. Three traffic-monitoring stations for NB and two for SB were located at 1.6-km intervals upstream of the start of the CWZ (see FIGURE 1). A traffic-monitoring device was located on I-10 EB to check its traffic condition as a main detour freeway route. Three portable CMS were installed for NB traffic and one portable CMS was installed for SB traffic. Each was located at the downstream of the junction with I-15 to provide travelers with the alternative of using detour routes to avoid entering the I-15 CWZ corridor.

Traffic data collected by the RTMS were transmitted to the server station for the travel time estimation. When the estimated travel time from the algorithm corresponded with the measured lane occupancy the travel information generated was transmitted for display in real time on the on-site portable CMS and on line (off site) through the project website. The traffic information messages were classified into three levels depending on the severity of traffic delay through the CWZ.

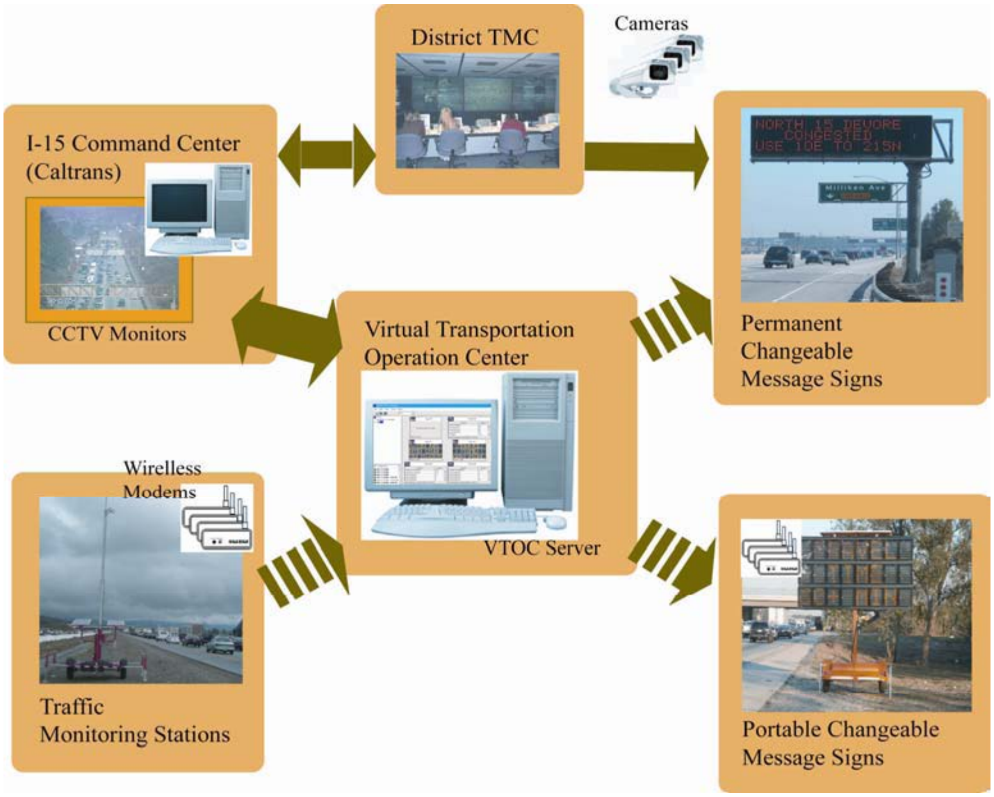

FIGURE 3 Schematic Diagram for the AWIS.

Travel Time Estimation Algorithm

Unlike with previous AWIS implementations in which CMS has been used to display static text messages with speed advisories or notices of delay times, the I-15 Devore AWIS provided the public with the estimated travel time between two designated points within the CWZ corridor. This use of the system was the result of earlier studies of urban freeway projects in California indicating that "travel time" information is more useful to the public than are estimates on "delay" time.

The AWIS estimated travel time from the I-210/I-15 junction to the I-215/I-15 junction (15.2 km) for I-15 NB, and from the I-15/SR-138 junction to the I-15/I-210 junction (26.1 km) for I-15 SB. Based on information derived from the use of probe vehicles, the average travel time under free flow conditions between the two points is about 11 minutes for NB traffic and 18 minutes for SB traffic. During the extended closures, RTMS continually measured travel speeds along the network and transmitted the data to a server located in St. Paul, Minnesota. The travel time algorithm in the server compared that real-time data against the data gathered under free flow conditions to provide minute-by-minute estimates of travel times for each direction of traffic given current conditions within the highway network. As total travel time information was computed, the corresponding level of message was activated and the display on the CMS was updated.

Each monitoring station represented a distance of 1.6 km to calculate the average travel time for that unit section at time *t*. The travel time (i.e., distance divided by the speed) for each unit section at time *t* was weighted by an adjustment factor that had been determined during the AWIS calibration process through experimentation with vehicles traveling at various speeds through various conditions of congestion. These experiments with various speeds were determined to be the most effective way to limit discrepancies in the AWIS calibrations. As summarized in FIGURE 4, four different adjustment factors were used in the travel time estimation algorithm. If the average travel speed was less than 24 kph, the factor was 1.4. If the average travel speed was greater than 24 kph but less than 48 kph, the factor was 1.25, and so on. The travel time within the coverage of traffic monitoring stations at time *t* was achieved by adding the sub-travel times of the unit sections.

The estimated travel time (ETT) was displayed on the portable and permanent CMS at 10-minute increments. Caltrans traffic engineers determined that, at a minimum, this level of incremental update was what was required to provide road users traveling within the network with sufficient information to make decisions regarding their travel patterns. Six display scenarios were categorized according to three levels of traffic congestion with the CWZ (Level 1: free flow to Level 3: severe congestion). When the ETT was over 50 minutes and became a Level 3 condition within the CWZ, the algorithm crosschecked the traffic condition on I-10 EB to decide whether the detour guidance message should be activated. If the traffic flow on I-10 EB was in a free-flow condition, with average speeds of 80 km/hr or higher, CMS sequentially displayed ETT and detour guidance messages (i.e., "TRAVEL TIME 50 MIN FROM I-15/I-210 TO SR-138" and "DETOUR TO I-10 EAST"). When I-10 EB was congested, ETT was displayed without the detour guidance message, which encouraged travelers to continue along I-15.

Monitoring Devices

RTMS were installed for traffic data collection at AWIS traffic monitoring stations. The RTMS detects traffic volume with vehicle classification, aggregate speed, and lane occupancy in multiple independent lanes. The RTMS radar technology collects traffic data with relative accuracy regardless of weather and road surface condition. It is a convenient side-scanning device, safe to install, and relatively easy to maintain without interrupting traffic in the freeway CWZ.

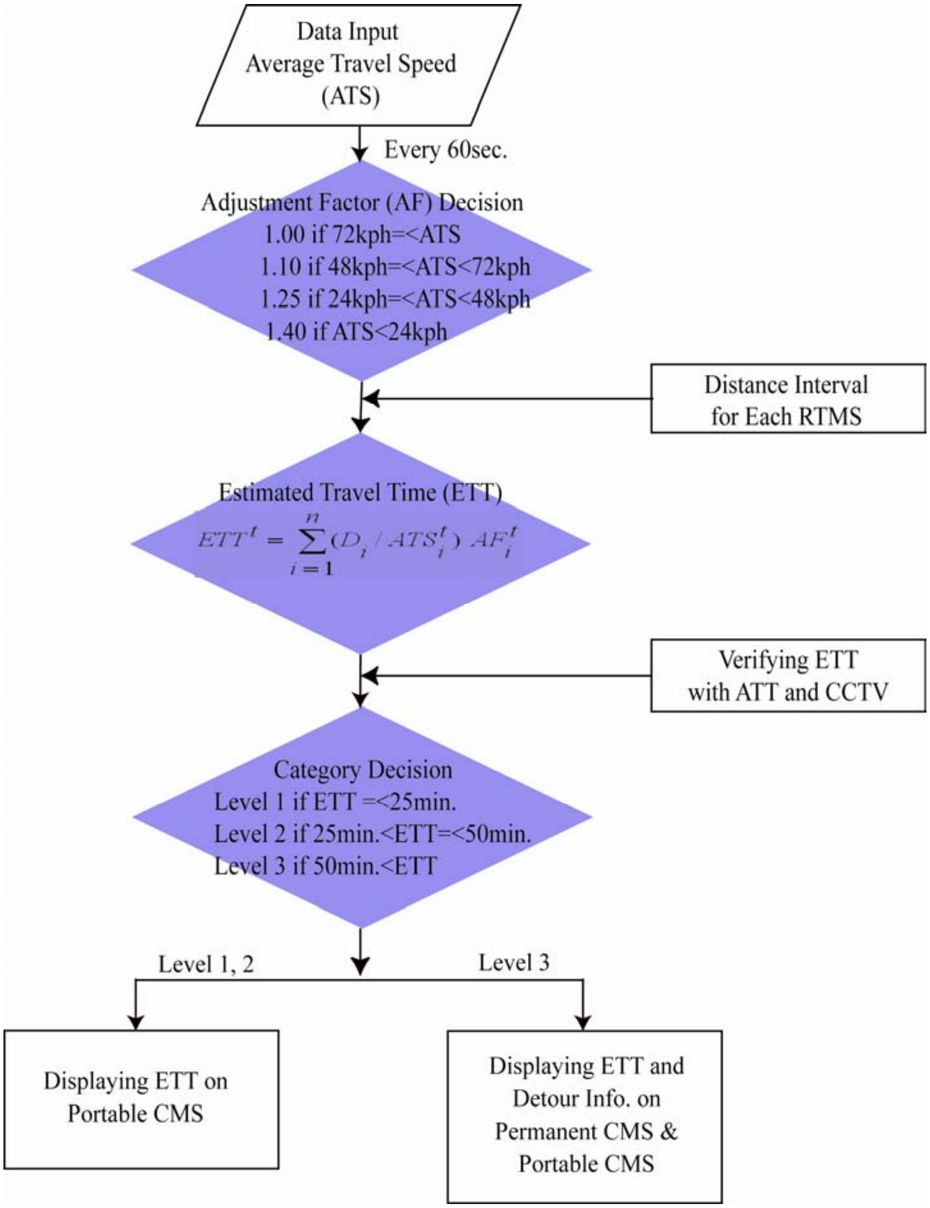

FIGURE 4 Flow Chart of a the Travel Time Estimation in the AWIS.

In addition to the six sets of RTMS for traffic data collection in the AWIS, two sets of RTMS were additionally operated for observing capacity and monitoring traffic flow in the I-15 CWZ. Traffic monitoring stations consist of a RTMS, a power kit, and a wireless modem for sending the data to the server in real-time. RTMS can be set up on either a portable platform or a light pole. In this study, each RTMS was installed on a portable platform to make it easy to relocate them depending on the construction staging plan. In the AWIS calibration process, intervals of RTMS location were adjusted for better performance. Detailed description is provided later in the calibration section.

Deploying Devices

On-site Displaying Devices

Four portable CMS were located at different locations. The first was located 1.6 km south of the I-15/SR-60 junction on I-15 NB, and the second was located 2.5 km west of the I-10/I-15 junction on I-10 EB. Those two portable CMS guided road users heading along I-15 north to detour to I-10 east and then to I-215 north or other detour roads. A third was located 2.5 km west of the I-15/I-210 junction on I-210 EB. It guided road users heading into the CWZ to stay on I-210 EB and take local detour roads. The last portable CMS was located 4.8 km north of the I-15/SR-138 on I-15. It guided SB road users on I-15 to continue to SB I-215. All the portable CMS remained blank in free-flowing traffic conditions to avoid encouraging road users to slow their traveling speeds to read messages.

Occasionally, the permanent CMS in the network were operated manually from the Caltrans District Traffic Management Center (TMC). This was sometimes done for displaying AWIS messages pertinent to drivers familiar with the permanent CMS locations who came to expect travel information as they passed by those locations. However, because the original purpose of the permanent CMS was to deliver emergency information, their use was limited to messages regarding Level 3 conditions.

Off-site Web Proactive Outreach

The project website was opened to the public and provided updated CWZ traffic condition information in real time during the construction period (*7*). The website also updated commuters with information on construction progress and the closure schedule. The website recorded 100,000 page views (visits) between August and October 2004.

The website provided ETT from the AWIS, information on current travel speeds within the CWZ, traffic snapshots at 30 second intervals, and video streaming features provided from 10 cameras positioned along the I-15 corridor. By clicking a CMS icon on the traffic roadmap on the website, real-time AWIS travel time estimates were displayed in text-format. The website also provided a virtual tour of the CWZ corridor using video streaming features by alternating camera positions from downstream to upstream at 5 second intervals. This view provided a context for traffic condition in the CWZ that helped road users recognize the queue starting point and estimate travel times based on their own travel experiences. Knowing the real-time traffic conditions through the CWZ corridor prior to their departures provided travelers with flexible alternatives around which to make their travel plans. They could choose to cancel their trips or change departure times, travel modes (public transit and car-pool), or travel routes.

Communication with the Virtual Transportation Operation Center (VTOC)

The VTOC software as a main control part of the AWIS enables operators to monitor, analyze, and integrate traffic data. The VTOC generates extensive logging and alarms to assist in diagnosing system problems and quickly alert operations and maintenance personnel to problems present in the system.

The software was mainly operated on the vendor's server at St. Paul, Minnesota. The VTOC was secondarily operated at the Caltrans TMC and monitored by Caltrans traffic engineers. They could override the message on the portable CMS when they found unacceptable discrepancies in the travel time estimate compared with traffic conditions witnessed on closed circuit TVs (CCTV) and actual travel times reported by probe vehicles.

Wireless cellular communication technology was utilized to transmit traffic data and information between traffic monitoring stations, the Minnesota TMC, the Caltrans project command center, and deploying stations. Each device (RTMS or CMS) on the site contained a wireless cellular modem and the Minnesota and Caltrans TMCs were connected through the Internet. When relocation of a device was required, signal strength at the new location was first checked to select the best position for receiving a strong signal from the wireless network provider. Six RTMS and four CMS used the global system for mobile modems that allowed Internet accessibility. The traffic data were transmitted to the server every minute without storing in the local hard disk. Two RTMS, which were used for traffic measurement and not integrated in the AWIS, used code-division multiple access (CDMA) modems that allowed dial-up access to regularly download from their memory units to the local personal computer modem.

AWIS PERFORMANCE

According to the pre-construction traffic analysis, the longest queue for I-15 SB was expected to be over 7 km, assuming a 10 percent reduction in peak hour demand. However, the actual longest queue during construction was observed to be less than 4 km. Comparison to the actual traffic data collected proved that the AWIS and the other proactive TMP public outreach contributed to lessen the queue length and traffic delay with more traffic demand reduction than was initially expected.

In the first extended closure for NB construction, the bottleneck (from four lanes down to either three or two lanes) generated traffic delays and some queues reduced traffic speeds to less than 10 km/h during the peak period. It was observed that the RTMS over-measured the speeds and therefore underestimated travel time in congested conditions. This was particularly true in the early stages of the project when RTMS, calibrated using data from free flow conditions, failed to account for periods of low speeds and stop-and-go traffic through the CWZ. After the RTMS were recalibrated during the peak periods of slow traffic conditions they performed more accurately over a wide range of speeds, even under congested flow.

The AWIS were properly operated in full-automated mode. For the validation of the AWIS estimated travel time, probe vehicles were repeatedly driven through the I-15 CWZ corridor between two known points during peak and non-peak hours. The drivers reported traffic speeds and travel times to the TMC whenever they passed by the traffic monitoring stations after one complete trip cycle. The traffic engineers in the TMC compared the traffic speeds and travel times reported from the probe vehicles to the ones estimated from the AWIS and recorded them in a log file. The log file for the times measured by probe vehicles and the AWIS estimated travel time data consists of 3,921 lines of records 1.9 Megabytes in size.

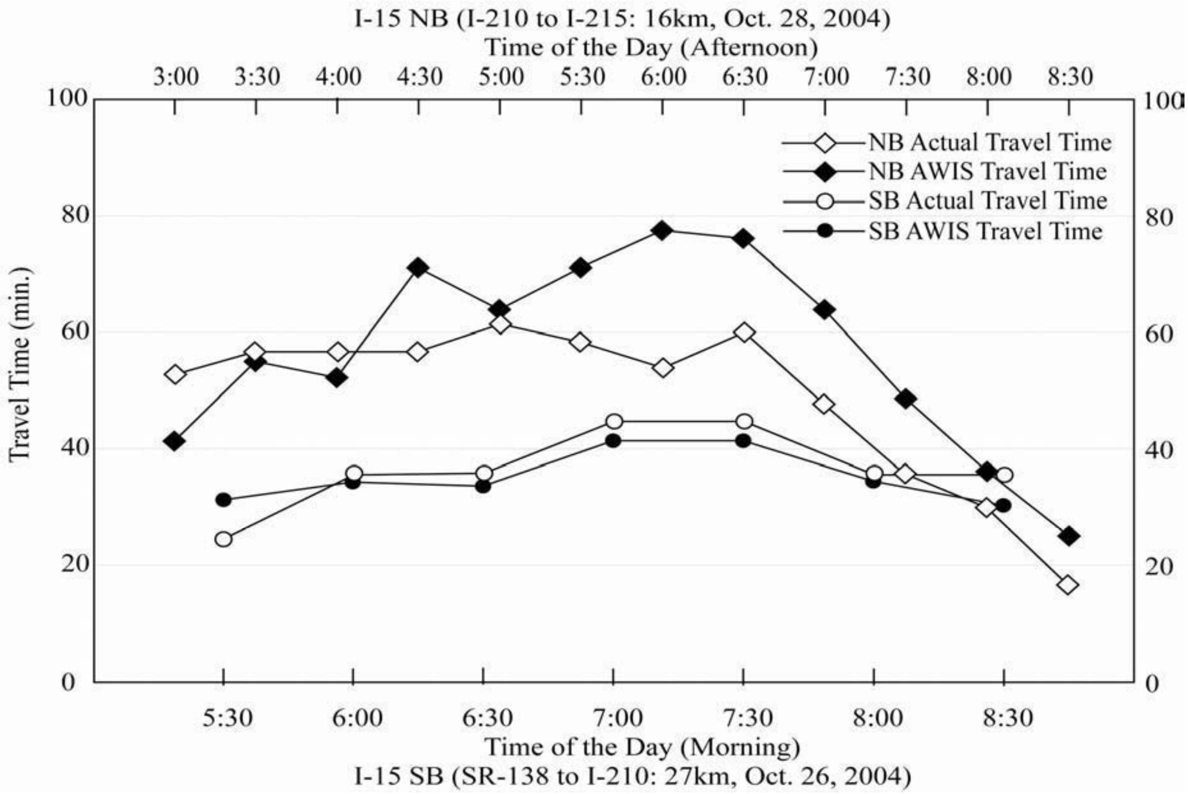

FIGURE 5 Comparison between the Actual and the AWIS Estimated Travel Times.

Overall, the travel times estimated by the AWIS were well matched with the travel times reported from the probe vehicles on each day during construction. The longest queue on I-15 SB was recorded at 7 a.m., during the morning commute, and reached 2 km upstream from the south cross. The maximum travel time measured with a probe vehicle was 44 minutes, which occurred at 7 am on October 26th, 2004. The difference between the average measured travel time (34.7 minutes) and the AWIS estimates (36.4 minutes) was less than 2 minutes. FIGURE 5 shows the comparison of the manually measured travel times and the AWIS estimated travel times at the identical time periods. Although the travel times were displayed at 10-minute increments, the values for both the estimated and measured travel times were recorded at 1-minute increments.

To compare the relative performance of the AWIS, the traffic reduction proportions during the non-peak periods, when the portable CMS of the AWIS are blank (i.e., on free flow), were compared with the traffic reduction proportion during the peak periods while the AWIS displayed high travel time, such as during Level 3 conditions (when the CMS message displayed "travel time 60+ min"). The average NB traffic reduction during non-peak periods was less than 7 percent, while the reduction during peak hours was 21 percent. While the analysis does not attribute 100 percent of the reduction to the performance of AWIS, the result does indicate that as higher travel times were displayed on the portable CMS, travelers detoured around the CWZ in greater numbers.

TRAFFIC IMPACT ASSESSMENT

Traffic measurements were performed with various types of surveillance devices to capture traffic pattern changes as they related to various construction activities along the CWZ corridor, the neighboring freeways, and alternative local roads (see TABLE 1). Traffic data along the CWZ corridor and the neighboring freeways were collected for 14 days before construction and 18 days during construction. Traffic data on alternate local roads were collected for four days before and four days during construction.

I-15 CWZ Corridor

Traffic flow changes within the CWZ, especially due to changes in lane alignments, were continuously monitored with two supplementary RTMS during construction periods. The research team observed the following traffic flow reductions through the CWZ corridor during construction: 16 percent during peak hours (18 percent in ADT) for NB traffic, and 17 percent during peak hours (19 percent in ADT) for SB. With volume reductions exceeding the 10 percent level initially anticipated by Caltrans, the maximum delays on average decreased by about 50 percent. The maximum peak hour delay was 95 minutes on weekdays in the pre-construction traffic analysis. According to interviews with Caltrans traffic engineers after construction, they believed that the AWIS operation and proactive outreach efforts were the main contributors to the higher reductions in traffic flow.

TABLE 1 Traffic Flow Reductions on the Network

Category		Change		Before- construction		During-construction	
		ADT	Hourly Peak	ADT	Hourly Peak	ADT	Hourly Peak
CWZ	I-15 SB	-19%	-18%	52,900	4,083	42,700	3,350
	I-15 NB	-16%	-17%	52,500	3,877	43,900	3,237
Detour Freeways	I-15 to I-215 SB (I-15 SB Detour)	15%	16%	20,800	1,730	24,000	2,001
	I-10 EB (I-15 NB Detour)	10%	36%	77,934	3,248	85,812	4,408
Arterials	Others	2%	5%	49,177	5,641	49,972	5,944

Neighboring Freeways and Arterial Roads

The major purpose of capturing traffic measurement on the detour freeways was to assess the volume of traffic that avoided the I-15 CWZ corridor during the extended continuous closures. The California Freeway Performance Measurement System (PeMS) was used for traffic surveillance along the I-15 corridor (outside of CWZ) and the neighboring freeways (I-10 and I-215). PeMS, a real-time database accessible on the Internet, provides aggregated traffic data such as total flow, average flow, and speed from loop detectors (*8*).

The ADT volume on I-215 SB, which is the main detour route for I-15 SB, increased by 15 percent during the extended closures. No doubt some of the 19 percent decrease in traffic volume along I-15 SB was due to diversion to the I-215 SB detour. I-10 EB, the main detour of I-15 NB, showed about a 10 percent ATD increase during the period of construction.

Portable rubber tube type traffic detectors were installed at four intersections on the alternate arterials south of the CWZ to capture traffic pattern changes during the extended continuous closures. Directional hourly traffic volume was collected for four days each (two for weekdays and two for weekends) before and during the extended closures. Because most road users on I-15 are either long-distance commuters, with one to two hour drive times, or leisure travelers between Los Angeles and Las Vegas, they were not expected to take the alternate arterials around the CWZ during the extended closures. Therefore, the project TMP did not call for the placement of detour signs on local arterials. It was, however, expected that the traffic heading to local areas, such as San Bernardino and Fontana, would take alternate roads instead of passing through the I-15 CWZ.

During construction, the average peak traffic at the nearest intersection from the I-15 CWZ increased by 6 percent, and the average peak traffic at the other major intersections increased by 5 percent. This increase, without major arterial detours, was noticeably less than the traffic increase (14 percent) in a grid type network on the I-710 Long Beach Project (*9*). This difference of spatial interaction in traffic flow mainly resulted from drivers re-routing to get around the CWZ. The drivers in Southern California were observed to prefer the freeway rather than the arterials, although they knew they would experience traffic delays through the CWZ.

Overall, average traffic volumes along the CWZ corridor decreased and the traffic volumes on the neighboring freeways and the local roads increased during the construction period. However, serious differences in traffic speeds on of the neighboring freeways were not observed in comparisons of before- and during-construction data. It indicates that the traffic diverted from the CWZ corridor did not substantially cause additional travel time delay on the neighboring freeways during construction, and total travel times on the road network were decreased as a result of the AWIS implementation.

LESSONS LEARNED

The AWIS implementation on I-15 Devore reconstruction incidentally encountered some practical difficulties during the initial operation period in the field. The difficulties and lessons learned described in this study will help practitioners implement AWIS on future highway rehabilitation projects.

There was a shadowing effect experienced in the use of RTMS mounted at 6 m heights along the roadside. They occasionally failed to detect vehicles in left lanes when high profile vehicles in right lanes blocked the RTMS radar beam. Parameter calibration of RTMS proved to be a key point in avoiding this situation. Adjusting the “sensitivity” and “fine-tune” parameters improved the vehicle detection rate up to 97 percent.

The RTMS were installed on portable plat trailers in this study, as they are easier to be relocated their positions during calibration or staging construction. However, they are more exposed to vandalism and danger of a crash because they were positioned on roadsides. During this study, two plat trailers were involved in collision accidents by reckless drivers, resulting in temporary interruption of AWIS operation.

While portable CMS proved convenient to operate and to relocate as needed, their LED message panels were occasionally blocked from drivers' views by other vehicles. On the I-15 Devore project, CMS were located in medians or along outside lanes. Their displays were situated between 2 m (bottom) and 4 m (top) from the road surfaces, which depending upon the profiles of vehicles within the lanes at any one time made them difficult for some drivers to see. It is recommended that in the future the portable CMS be located at both median and outside lane positions at over 5 m in height to provide the highest possible visibility.

The wireless modems were initially programmed at the server's location with 651 area codes as account identifiers for the vendor's convenience. Although the accounts were active with nationwide roaming, the local wireless provider happened to drop connectivity of a modem to conserve its network bandwidth when the modem did not send out a signal for a certain amount of time. Due to this issue, there were times that the data failed to reach the server at the two traffic-monitoring stations. This caused gaps in the collection of traffic data and affected the accuracy of travel time estimation. When the data breakdown happened, manual commands were needed to reconnect the modems to the network. The local area code should be programmed as the account identifier to solve this issue if continuous data collection for 24/7 operation is a key requirement in future installations.

It will be essential to include automatic incident detection and a sufficient number of traffic data collecting devices over the CWZ network for future AWIS implementations. The ideal number and location of AWIS monitoring stations are recommended as: one at the end, one in the middle, and three or more at the upstream of the CWZ. Less than 1 km interval between the monitoring devices might provide better accuracy of real time AWIS travel time estimates.

CONCLUSIONS

In October 2004 the pavement reconstruction of a 5-km stretch on high traffic volume I-15 in San Bernardino in Southern California was successfully completed in just 18 days (9 days for each direction) of one-roadbed full closures with counter-flow traffic in accelerated construction with 24/7 operations. This project was the first large-scale implementation of Caltrans' Long-life Pavement Rehabilitation Strategy (LLPRS) program based on previous demonstration projects (concrete on I-10 Pomona and asphalt on I-710 Long Beach). The AWIS was implemented to provide real-time travel information to road users through the CWZ, both on- and off-site, to encourage diversion to detour routes and reduce potential traffic delay.

During the construction, the AWIS successfully performed its automated travel time estimation function, producing estimates within only a 10 percent error range compared to actual travel times measured with probe vehicles. Traffic data monitored along the CWZ corridor, detour freeways, and the adjacent arterials before-, during- and after-construction was utilized for the quantitative evaluation of the AWIS performance.

Road users heading into the CWZ corridor were provided with information displayed on portable and permanent CMS so that they could know what traffic conditions they might expect, and could make decisions on alternate detour routes to avoid traffic delays.

The AWIS performed with satisfactory accuracy after calibration of the devices with travel time adjustment factors and trial positioning of the monitoring device locations. During the SB construction (the second closure), the difference of average travel times between the AWIS estimate of 49 minutes and the actual measured travel time of 55 minutes (measured during the afternoon peak hours for I-15 NB) was only 6 minutes. The ADT volumes decreased by 19 percent on I-15 SB and 16 percent on I-15 NB during the construction period. The ADT volumes increased by 10 percent on I-10 EB and 15 percent on I-215 SB, and the ADT volumes on the adjacent major arterials were increased by only 2 percent. The AWIS operation led to reductions in traffic flow through the CWZ corridor.

Commuter survey questionnaires posted on the project website before and during construction, which received the inputs of about 400 respondents, indicated that about 90 percent of travelers perceived the AWIS travel estimates to be accurate and useful. About 76 percent of the respondents answered that the AWIS information influenced them to change their travel patterns, including trip schedules, trip routes, and modes.

The evaluation of the AWIS on the high volume I-15 Devore corridor provides detailed guidelines to help practitioners to implement AWIS in future urban freeway reconstruction projects. Transportation agencies can gain the benefits of a well-configured AWIS by following the design and operational process presented in this study. This study also enables transportation agencies to use AWIS to more accurately estimate traffic delays and travel times on networks containing CWZ. With this information, agencies and planners can choose the most appropriate construction schedules, considering RUC as well as construction costs.

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