State-of-Practice Technologies on Accelerated Urban Highway Rehabilitation: I-15 California Experience

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Abstract: This case study paper presents an innovative fast-track approach applied to a heavily trafficked urban freeway reconstruction project in Southern California. Badly deteriorated truck lanes in both directions along a 4.5-km stretch of I-15 were rebuilt from the gravel base up. The operations, estimated to take 10 months using traditional nighttime closures, were completed in two 9-day continuous closures with round-the-clock (about 210 h for each direction) operations. This "Rapid Rehab" project adopted state-of-practice technologies to accelerate construction, mitigate traffic disruptions, and propagate project information. As a result, traffic demand through the construction work zone was reduced by 20% and the maximum peak-hour delay was reduced by 50%. The estimated benefits of accelerated reconstruction on this project included a 28% reduction in agency cost and 29% time value savings to road users, compared to the traditional approach of using repeated nighttime closures. Web surveys showed dramatic changes in public perception of the Rapid Rehab approach from initial reluctance and objection to positive support.

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Introduction

Challenges in Urban Highway Rehabilitation

Most of the American highway system became operational between 1950 and 1980 with pavements designed to last 20 years before requiring major rehabilitation or reconstruction. Higher traffic volumes and heavier vehicles have rapidly accelerated the deterioration of this aging highway infrastructure. Highway pavement deterioration adversely affects road user safety and ride quality and causes vehicle operation and highway maintenance costs (Leather 1987). As a response, federal and state transportation agencies have recently shifted their focus from building new transportation facilities to "4-R" projects involving restoration, resurfacing, rehabilitation, and reconstruction (Herbsman et al. 1995).

In 1998 the California Department of Transportation (Caltrans), which oversees a 78,000 lane km state highway system, launched the Long-Life Pavement Rehabilitation Strategies (LLPRS) program. The goal was to rebuild approximately 2,800 lane km of high volume urban freeway with pavements designed to last 30-plus years. LLPRS candidate projects were selected based upon criteria of poor pavement structural condition and ride quality, along with minimum 20-year projected volume demands of 150,000 average daily traffic (ADT) or 15,000 average daily truck traffic (ADTT). Most LLPRS candidate segments are concrete paved interstates in urban highway networks, especially in the Los Angeles Basin and the San Francisco Bay Area (Caltrans 1998).

Urban highway rehabilitation projects under high traffic volumes often create such undesirable effects as congestion, safety problems, and limited property access. Especially severe traffic disruption in a construction work zone (CWZ) creates difficulties for motorists and businesses, and conflicts between state highway agencies and abutting communities. To mitigate these problems, highway planners, designers, and traffic managers need to expedite rehabilitation processes and construction schedules through the use of comprehensive construction and traffic management plans utilizing innovations and technologies (de Solminihac and Harrison 1993).

For example, construction planning for urban highway rehabilitation must incorporate such concepts as contingency management, incentives/disincentives (I/D), and cost (A) plus time (B) bidding to balance the traffic needs of road users on one side of the lane closure barrier and construction access with equipment on the other (Arditi et al. 1997). Most state highway agencies are under increased pressure to complete their highway construction projects under tight schedules. In some states the public has demonstrated a willingness to pay to avoid severe traffic disruptions during highway construction, because they expect substantial benefits from accelerated project completion (FDOT 1997).

Research Approach and Benefits

This paper presents a detailed description of the innovative technologies and state-of-practice strategies used on the I-15 Devore reconstruction project. It was Caltrans' first large-scale implemen-

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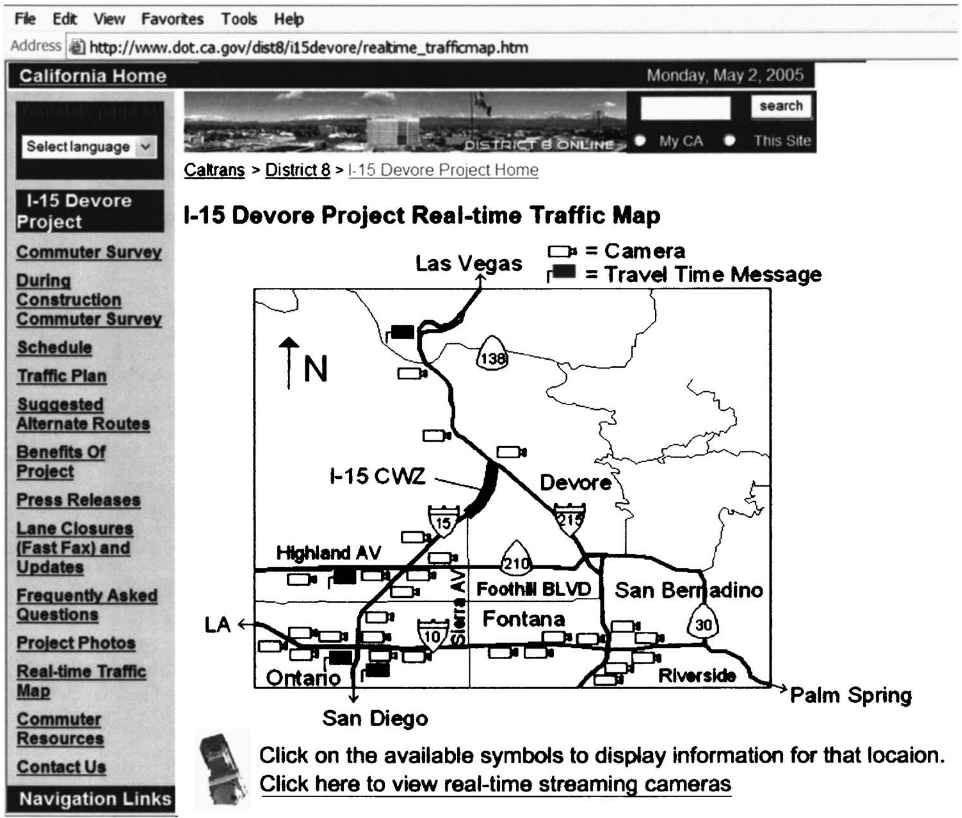

Fig. 1. The I-15 site location and the AWIS traffic roadmap on the project Web site (adapted from Caltrans 2004, with permission)

tation of the LLPRS program based on the lessons learned from the I-10 Pomona (concrete) and I-710 Long Beach (asphalt) LLPRS demonstration projects.

Phase I research for preconstruction analysis of the I-15 Devore project was conducted to explore how the selection of pavement materials and roadway design might be integrated with decisions regarding construction logistics and traffic operations to determine the most cost-effective highway rehabilitation practices (Lee et al. 2005b). The practicality of the preconstruction analysis was validated with as-built construction and traffic performances monitored during construction (Lee et al. 2005a).

Phase II postconstruction evaluation, discussed in this paper, documented the technical "lessons learned" from this I-15 Devore project from the strategic perspectives of construction process, traffic control, and project management. As the main focus of the study, innovative technologies and state-of-practice strategies were exemplified showing how to: (1) accelerate the construction process and schedule; (2) mitigate traffic disruptions and measure its performance; (3) achieve more traffic diversions by providing road users with automated real-time travel information; (4) disseminate project information to the public through multifaceted outreach programs; and (5) capture change in public perception through the use of Web-based surveys. The backgrounds and processes of each innovation were briefly introduced and the benefits were assessed. State highway agencies and contractors can use the ideas and findings of this case study to frame comprehensive construction and traffic management plans for urban highway rehabilitation with the goals of accelerating construction schedules and minimizing public inconvenience.

I-15 Devore Reconstruction Project

Project Overview

The I-15 Devore project rebuilt a 4.5-km stretch of the two truck lanes from roughly 20 km north of the I-15/I-10 junction to just south of the I-15/I-215 junction near San Bernardino (Fig. 1). The I-15 freeway is one of California's heavily traveled routes, carrying an ADT of approximately 110,000 vehicles, with a peak hourly volume of 5,500 vehicles per direction during weekdays. About 10% of those vehicles are heavy trucks, since I-15 is an important route for transporting goods across the state. In contrast to typical urban freeways in California, which have higher traffic volumes during rush-hour weekday peak periods and lower traffic volumes on weekends, the I-15 Devore corridor has consistently high weekday commuter peaks and even higher leisure traffic volume on weekends. The two highest peak traffic volumes are northbound (NB) on Friday afternoon and southbound (SB) on Sunday afternoon, when leisure travelers in the Los Angeles area are going to and from Las Vegas and to resort locations along the Colorado River.

The existing pavement cross section has a 1970-era Caltrans design; i.e., 210–230 mm of (undoweled plain jointed) concrete slabs over 100–150 mm of cement-treated base. The reconstruction scope was to replace the damaged concrete pavements with a new cross section of 290-mm doweled slabs using rapid strength concrete and a 150-mm asphalt concrete (AC) base on the top of the remaining aggregate base or native subgrade. This reconstruction required the new outer truck lane pavement to be 600 mm wider than the existing configuration as part of a long-life pave-

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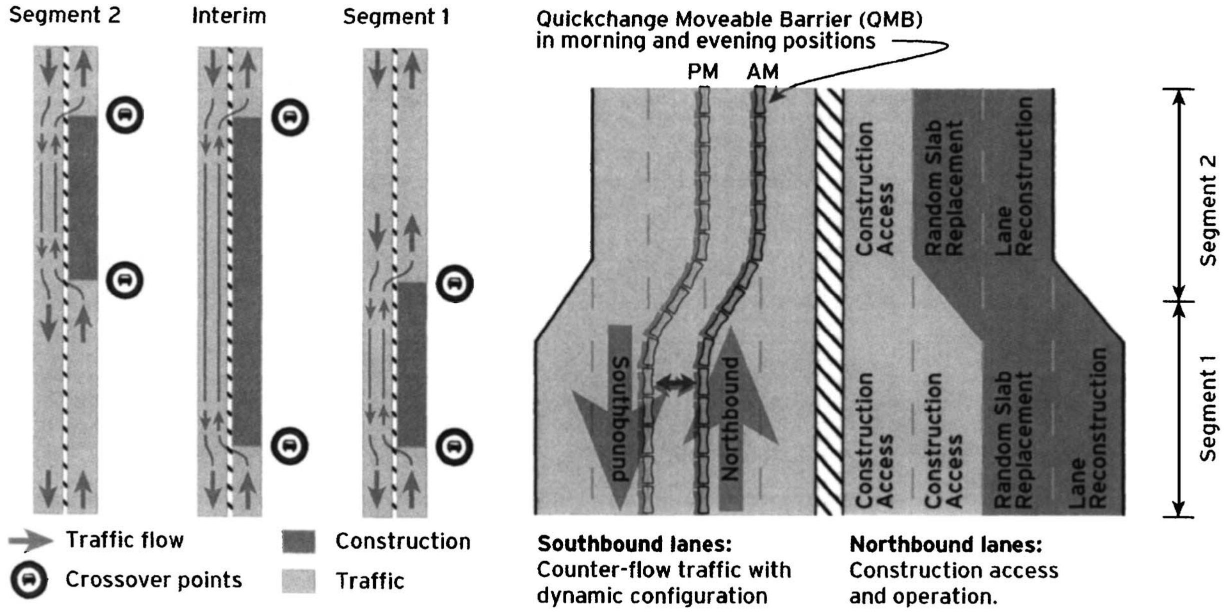

Fig. 2. Progressive construction staging plan and lane closure scheme with construction access

ment design intended to reduce edge loading of trucks on the outer edge of the slab. AC shoulders were also cold-planed (milled) to approximately 60–75 mm of the existing AC shoulder and overlaid with the new AC pavement.

The staging plan split the reconstruction into two segments. Segment 1 consisted of a 2.5-km stretch with four lanes in each direction between the Sierra Avenue and Glen Helen Parkway interchanges. Segment 2 consisted of a 2.0-km stretch from the Glen Helen Parkway interchange to the I-215 system interchange with three lanes in each direction. A progressive staging plan was used to maintain the minimum length of CWZ closures. Segment 2 was closed for about three days at the outset of the project, allowing significant reconstruction progress to be made before Segment 1 was closed to traffic. Segment 2 was then reopened in the middle of the closure period while Segment 1 was still under construction (Fig. 2).

The NB roadbed was closed first, switching traffic to the SB roadbed through the median crossovers at the ends of Segments 1 and 2 for a counterflow traffic system. Construction occurred on the two truck lanes while the two inside lanes were used for access by construction trucks and other equipment. The two directions of traffic, shared the SB traffic roadbed as "counterflow traffic," was separated by a quickchange movable barrier (QMB) to provide a dynamic lane configuration catering to the heavier commuter direction. During construction the outside shoulder was used as a temporary traffic lane to provide more capacity within the CWZ. The same process was repeated for the reconstruction of the SB direction.

Preconstruction Evaluation

Evaluation of Rehabilitation Alternatives

An integrated approach was applied in the preconstruction analysis for the I-15 Devore project with the goal of selecting the most economical reconstruction closure scenario from the perspective of construction schedule, traffic inconvenience, and agency cost. Four construction closure scenarios (72-h weekday, 55-h weekend, one-roadbed 24-h/7-day continuous, and 10-h nighttime) were compared from those above-mentioned perspectives (Lee et al. 2005a).

The construction analysis for pavement rehabilitation strategies (CA4PRS) software (Lee and Ibbs 2005) was used as a scheduling tool in conjunction with different levels of traffic analysis tools such as the *Highway Capacity Manual* (TRB 2000) and macro- and microscopic traffic simulations. The integrated preconstruction analysis concluded that the one-roadbed continuous closure was the most economical scenario. Compared to traditional 10-h nighttime closures, the one-roadbed closure scenario would require 80% less closure time, 29% less road user cost due to traffic delay, and 28% less agency costs for construction and traffic control (Lee et al. 2005a).

Despite the schedule and cost advantages of this scenario though, Caltrans initially decided to pursue the 72-h weekday closure, which is the second most economical alternative from the evaluation perspectives. Without previous experience with this type of unique traffic pattern, they equally weighted the time value of weekday commuters and weekend leisure travelers through the I-15 Devore corridor. Caltrans was initially more concerned about the projected 120 min of maximum peak-hour delays on weekends, which would happen on 55-h weekend and one-roadbed continuous closures, than the projected 75 min delays on weekdays.

As a result of high project bids (80% higher than the engineer's estimate) in the first round of construction bidding, the initial rehabilitation scope to reconstruct both truck lanes was altered to include reconstruction of only the outer truck lane and targeted slab replacement on the inner truck lane. The consequence of 5% traffic volume increase as construction was delayed from Spring to Fall 2004 in the process of the rebid and the scope downsize was significant: the estimated road user cost (RUC) increased by 90% (from \$5 million to \$9.5 million) and the estimated maximum weekday peak-hour queue delay increased from 75 to 90 min (Lee et al. 2005b).

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Dynamic Responses to Challenges

About one month before the scheduled initial scheme of 72-h weekday closures, Caltrans held public meetings in which the local residents in the High Desert area voiced their concerns about increased congestion and additional commuting time during the construction. Commuters also expressed anger over a perceived Caltrans preference for weekend vacationers headed to Las Vegas in light of the scheduled construction breaks on weekends. The public consensus was that construction should be done either during weekday nighttime, or during 55-h weekend closures. As the electronic survey on the project Web site indicates, some respondents advocated cancellation of the project itself if Caltrans would not show a willingness to change the construction scheme from 72-h weekday to nighttime or weekend closures.

Caltrans' reaction was to implement a one-roadbed continuous closure scheme (called "extended closures" hereafter), with 24 h per day/7 days per week operations by combining weekday and weekend closures. Caltrans responded with a commitment to reduce the overall inconvenience (delay) of road users through the CWZ during the extended closures through the implementation of innovation and technologies. With the state-of-practice features to achieve the goal of minimizing the impact of this accelerated construction project on traffic delay, described in the following section, Caltrans' focus was on: (1) increasing roadway capacity through the CWZ utilizing dynamic lane configuration with the temporary conversion of the rehabilitated shoulder to the main lane; (2) diverting more traffic demand through the I-15 Devore corridor to neighboring freeways; and (3) deploying a proactive public outreach effort that included regular project updates.

Innovation and Technology

The $16 million Devore project combined conventional construction materials and operations with state-of-practice technologies to expedite construction and minimize adverse traffic impacts. These strategies and technologies, discussed in detail in the following pages, include:

- Project command center equipped with closed circuit television (CCTV) for team coordination and monitoring of construction progress and traffic impact;
- Contract incentives/disincentives designed to motivate the contractor to complete closures on time or ahead of schedule;
- Internet-based information systems on the project Web site for disseminating project updates and surveying public perception;
- Automated work zone information system (AWIS) to update travelers with real-time CWZ travel information;
- QMB system for dynamic lane configuration to maximize lane capacity and minimize traffic disruption;
- Safety and community support services, including freeway service patrol, an enhanced CWZ enforcement program, and commuter bus service, to help ensure efficient commuter passage through the project area;
- A multifaceted outreach program to gain public support and measure change in public perception; and
- Mix design of rapid strength concrete to enable the project to be opened to traffic 12 h after mixing/placement.

Command Center Coordination

One of the keys to the successful execution of the I-15 Devore project was the coordination and teamwork between District units during the planning, design, and construction phases. This involved the Caltrans design, traffic operations, construction, maintenance, and public affairs divisions. In addition to the internal teamwork, the department level of coordination with other agencies, such as California Highway Patrol (CHP) and local city governments, proved to be one of the biggest factors contributing to the success of the project. The establishment of a project command center, to organize and monitor daily construction progress and traffic impact, was an approach carried forward from the previous LLPRS demonstration projects. The I-15 Devore innovation was to locate the command center in the district office directly across from the traffic management center (TMC), rather than putting it on site, as was done on the previous projects. This helped centralize command operations.

Fig. 3. Monitoring of construction and traffic in the project command center

One of the key functions of the command center was the coordination of meetings that were held each morning during the extended closures, providing a single location where project information could be discussed and action items could be addressed immediately. The other advantage of locating the command center adjacent to the TMC was the access it provided to the TMC's traffic CCTV system. This networked into the command center so impacts on the traveling public, and construction activities could be monitored directly (Fig. 3). This made it possible, when calls from the public or the media were received through the public affairs office, for Caltrans to provide instantaneous, real-time updates on the status of construction operations and traffic conditions.

Incentive and Penalty Provisions

An increasing number of transportation agencies are utilizing I/D bidding for highway construction to shorten the total contract time by giving the contractor an incentive for early completion and a disincentive for late completion of a project. However, most agencies have used experience or a fixed percent of construction cost as the maximum incentive instead of using quantifying models (Shr and Chen 2004).

Because of high traffic volume during closures and the public's desire for early completion of the reconstruction, three levels of time value provisions were specified in the I-15 Devore contract to ensure the completion of closures on time: (1) I/D requirements for the extended closures; (2) late opening penalty for the segments with three-lane sections; and (3) cost plus time ($A+B$) contracting for the entire project.

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Two types of I/D provisions were specified for the extended closures: the primary incentives for the total extended closure numbers and the secondary incentives for the total closure days. The Devore project incorporated the unique approach of using the additional cost associated with road user traffic delay to develop the I/Ds requirement. Assessment of I/Ds was based on RUC utilizing the CA4PRS schedule analysis in conjunction with traffic delay analysis including macro- and microscopic simulations (Lee et al. 2005b). The incentives were limited by the realities of the budget limitations of the State of California, and a value of $600,000 was used as the incentive cap.

The contractor was eligible for a closure incentive bonus of $300,000 if one-roadbed continuous closure was completed in equal or less than two units of time segment (111 h per unit), and was subject to a closure disincentive penalty without a limit if the closure took longer than three units of time segment (one extra was given for realistic flexibility). In addition to this closure incentives requirement, the contractor was eligible to receive a daily incentive (secondary) bonus of $75,000 if the entire major reconstruction was completed in fewer than 19 days (a total of 456 h), and was subject to the daily ($75,000) disincentive penalty (without a limit) if the reconstruction took longer.

A late lane opening penalty of $5,900 per 15-min period without limitation was established in case Segment 2 (CWZ bottleneck) if the traffic roadbed was not completely opened by 5 a.m. Friday to accommodate the highest weekday commuter and weekend leisure traffic volumes. The progressive staging plan assumed that operations would be moved to Segment 1 by this time, where there was one temporary additional lane on the traffic roadbed.

The $A+B$ contract was applied for the overall project duration to ensure completion of the entire construction contract as soon as possible, including repeated nighttime closures before and after the extended closures for preparation and wrap up, respectively. For this case, liquidated damages for the overall contract were established at $17,400 if the total 100 (140 baseline) working days (including nighttime closures for miscellaneous activities) in the bid were exceeded.

Outreach on Project Web Site

To achieve the goal of a 20% traffic demand reduction, Caltrans implemented a proactive Internet-based public outreach program to encourage more road user "no-shows," effect travel pattern changes (mode and trip time), and encourage diversions to detours. A project Web site was created to provide information to those in the target audience, especially daily commuters through the CWZ with Internet access (Caltrans 2004). The project Web site appeared as the first headline on the Caltrans District 8 home page and linked to neighboring local agencies and the surrounding three District offices (Los Angeles, Orange, and San Diego). It was launched in late July 2004, two months before the construction started, and updated regularly with the following features:

- Construction progress with project photos and innovative features;
- Traffic control plan and detour routes;
- AWIS real-time travel information (details are in the following section) on traffic road maps;
- Press releases and schedules for public meetings; and
- Before- and during-construction commuter surveys.

On the Internet, commuters could check for up-to-the-minute reports on traffic flow conditions within the CWZ and along the I-15 Devore corridor. The Web site instantaneously updated traffic snapshots every 30 s along the I-15 corridor and detour freeways. The Web site also provided a virtual tour through the CWZ using a video streaming feature. Eight high-resolution traffic cameras positioned along the I-15 corridor sequentially repeated 5 s video streaming of traffic flow televised from each camera in real time. Along with the Web cameras, real-time travel information between two known locations, displayed on the permanent and changeable message signs controlled by the AWIS, was posted on the traffic roadmap on the project site (Fig. 1). Motorists' ability to use the project Web site to access information on traffic conditions through the CWZ provided them with the flexibility to choose alternative travel routes or adjust their departure times.

The project Web site received nearly 100,000 page views (visits) during the 3 months before and during the extended closures and played an important role as an interactive tool to gain input from the public. The Web site visits increased significantly to about 40,000 in October 2004, when extended closures were in process, representing a nearly 300% increase in just two months after the Web site's opening. As discussed later, a survey of approximately 400 respondents indicated that the majority (72%) evaluated the project information provided on the Web site as useful in their trip planning.

Work-Zone Traffic Operations

Demand-Oriented Controls

Proactive Public Outreach

The key to the project's success was convincing motorists to use alternate routes or reschedule their commutes to avoid traffic delays during construction. The preconstruction traffic sensitivity analysis predicted a 90-min maximum peak delay during weekdays even if there were to be a 10% reduction in traffic demand through no shows (motorists avoiding the area) and diversions (motorists using alternative routes). Caltrans recommended that commuters avoid the CWZ during peak hours and use alternate routes. If 20% of commuters were to change their commuting times and also take these alternate weekday routes, delay times were expected to be cut in half to 45 min (Lee et al. 2005b).

To achieve the goal of 20% reduction in the peak-hour traffic demand, Caltrans implemented an extensive public outreach program. Outreach materials included warning signs on the freeway, a comprehensive project brochure, construction flyers, a construction advisory electronic bulletin, fast-fax through Email, a project information help hotline, and several public meetings for local communities. The media coverage publicized project progress, reached the target audiences, and provided an informational service to the public. It is estimated that there were 100 media articles and broadcasts covering of the I-15 Devore project on major TV stations and in newspapers throughout the four-week project. The project budget dedicated $160,000 for direct material costs for the public outreach program, an amount significantly greater than has typically been allocated for outreach programs on California highway construction projects.

Ridership Service and Truck Permits

To help alleviate CWZ delays, a free bus service between the High Desert (north) and Ontario (south) areas (about 100 km) was provided. Caltrans teamed up with the Victor Valley Transit Authority (VVTA) to temporarily provide more buses for those who commute south of Devore. Caltrans used state transportation

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Fig. 4. Operation of QMB to provide dynamic lane configuration

funds ($65,000) to provide additional commuter bus service, eight trips in the morning and six return trips in the afternoon, from the high desert to the south (San Bernardino and Los Angeles). This program provided an effective option for reducing congestion during the closures, which raised public opinion of the I-15 Devore project. The additional bus service led to a 40% increase in ridership over the course of the construction period.

Once the final construction plan was set for October 2004, new permits for oversize truckloads were put on hold and trucks that had permits were detoured to I-10 and I-215 during the period of construction. The restriction policy of oversize trucks was to avoid having heavy trucks getting stuck on the narrow single NB lane when the roadway was configured with three open SB lanes during morning peak hours. Overall, control of the oversize trucks improved the traffic flow through the CWZ, although this restriction could not completely block heavy trucks that had valid permits issued before the restriction was implemented.

Capacity-Oriented Control

Use of QMB helped to balance traffic impacts to commuters and weekend travelers with dynamic lane configuration. One additional lane was temporarily converted from the rehabilitated AC shoulder on the traffic roadbed to better accommodate peak directional traffic. Specialized equipment (transformer) traveled the traffic roadbed at 15 km per hour (kph) picking up the flexible QMB and shifting it to the next lane. Only 30 min were required to move the 5-km segment, which was done twice a day without major disruption to live traffic (Fig. 4). The project budget allocated $1.5 million for a three-month rental of the QMB system, a cost item not needed for traditional closures. Caltrans determined the expense was justified by road user time savings.

Segment 1, which had five lanes on the traffic roadbed during construction, temporarily maintained three SB by two NB (3 lanes $\times$ 2 lanes) in the morning (4 a.m.–9 a.m.), and reversed to the two SB by three NB (2×3) configuration in the afternoon according to the lane-closure charts in the project Special Provisions (Fig. 2). During the project's first phase of NB reconstruction, Caltrans kept three SB lanes and only one NB lane open on Segment 2 (four lanes total) during morning commute hours, but switched to two lanes in each direction all the time in the second phase of SB reconstruction. Safety considerations led to the switch to facilitate SB drivers traveling at 85 kph through the CWZ, special consideration was given to the median crossover with the downhill and a sharp double-curvature alignment (physically constrained with radii of only 450 m) compared to other crossovers with 600 m radii. Some vehicles were going as fast as 118 kph. The shift from three to two SB lanes helped to slow traffic.

Automated Work Zone Information Systems

AWIS, one of the most cost-effective intelligent transportation systems (ITS) technologies, has been utilized on urban freeway construction projects to provide road users with real-time travel information as they move through the CWZ. The FHwA has been documenting case studies for the use of ITS in work zones to raise awareness of these technologies among transportation agencies, including those in Arizona, Illinois, and California, that have implemented and evaluated AWIS performance (FHwA 2002). However, previous AWIS case studies have focused on increasing safety within CWZ corridors while little focus has been placed on lowering the volume of traffic through the CWZ by encouraging diversion to alternate routes within the freeway network.

The I-15 Devore project was the first time the AWIS technology had been used on a California LLPRS project, and it played a useful role in informing motorists of real-time travel and detour route information. AWIS travel estimate information was posted for roadway users on the permanent and temporary changeable message signs (CMS), as well as on the traffic roadmap on the project Web site (Fig. 1). It monitored traffic data (count and speed) in several locations using remote traffic microwave sensor (RTMS) traffic surveillance units, roadside radar devices that were situated about 1.5 km apart. Wireless communication relayed the data back to a vendor's server in St. Paul, Minn., which processed the traffic data through an algorithm to estimate travel times through the CWZ. Real-time travel information was displayed on portable and permanent CMS that were strategically located at key decision making points for the traveling public. Fig. 5 shows a schematic diagram to illustrate the basic operation concept of the I-15 Devore AWIS.

A format of 10-min increments to display travel time information between two known points (the junction with SR-210 on the south and the junction with I-215 on the north) proved easier for the public to understand than overall delay time. For the calibration and validation of the AWIS, a travel time log was recorded comparing the manually measured traffic information reported from probe vehicles driving through the CWZ with the AWIS estimated travel time. The AWIS was operated in fully automated mode during construction and monitored by traffic engineers at the Caltrans traffic management center.

Safety Enhancement Services

Most current highway projects in urban areas in California utilize the construction zone enhanced enforcement program (COZEEP), implemented by the CHP and the Freeway Service Patrol (FSP). On the Devore project there were a maximum of 14 CHP officers paid by the construction contract (about $300,000) available for traffic control during the extended closures. Half of those were utilized on the freeway for enforcement and speed control; one officer wrote 21 tickets on the first day of enforcement, triple the usual total. The others were used during peak periods as traffic control officers at key intersections on local streets that lacked signals and signs. COZEEP data showed that a total of 1,034 traffic citations, including 12 for trucks, were issued during one month of construction in October. A total of 103 collisions, in-

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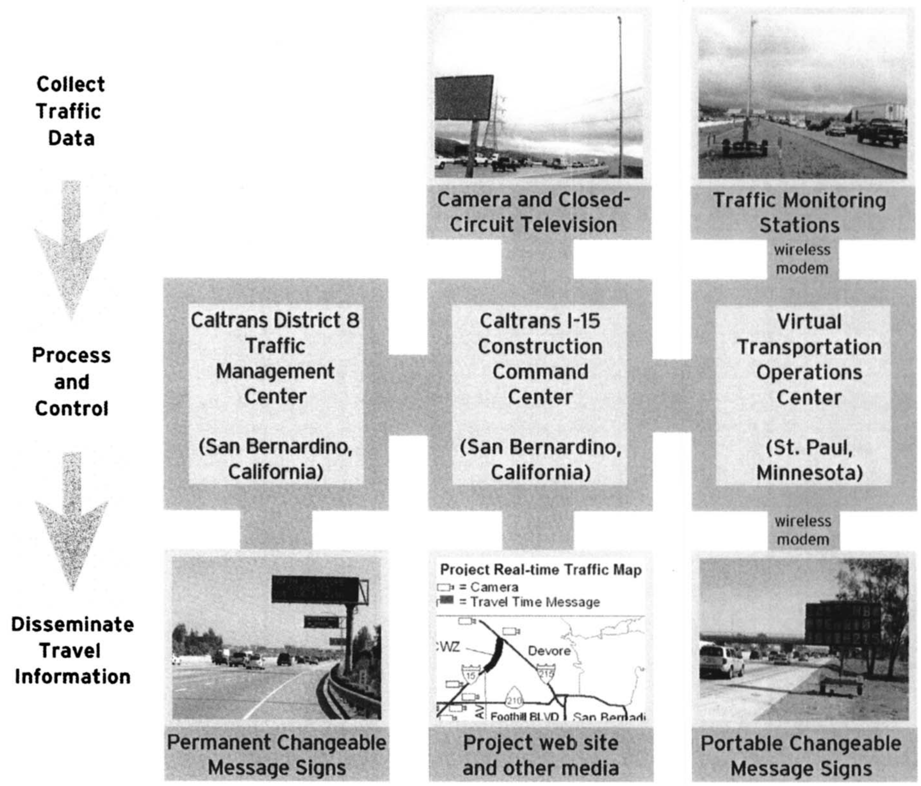

Fig. 5. A schematic diagram showing the I-15 Devore AWIS operation

cluding 43 injury (no fatality) collisions, were reported during the extended closures, which is still lower overall compared to statistics available for 10-month night-time closures.

Towing service with a total of three tow trucks was utilized, at a cost of about $100,000, to remove disabled vehicles from the CWZ as quickly as possible during the extended closures. They quickly cleared accidents and breakdowns within the work zone; a few accidents were cleared within 5 min after they happened. Without any shoulder room within the project limits, it was critical that stalled or stopped vehicles were moved out as soon as possible under high traffic volume. With this feature, Caltrans had a system that could function at better than normal conditions as the increased monitoring systems helped tow trucks quickly get to stalled vehicles. The FSP log indicated that 1,243 service calls were provided, including 1,060 for disabled vehicles.

Innovations Produce Significant Benefits

The innovative Rapid Rehab highway reconstruction process used on the I-15 Devore project is the latest effort by Caltrans to devise accelerated construction techniques that compress construction schedules while limiting the maximum peak-hour delays. Rapid Rehab benefits include: (1) faster construction and project delivery (3 weeks versus estimated 10 months for the traditional nighttime method); (2) shorter period of disruption to commuters and the traveling public; (3) doubled pavement lifespan, expected to last 30 years instead of the average 15 years; (4) improved safety for workers and motorists through the use of QMB to separate traffic from the work zone; and (5) reduced construction costs. According to the preconstruction analysis, the estimated benefits of using accelerated (fast-track) reconstruction on this project, compared to the traditional approach of using repeated 10-h nighttime closures included a 28% ($6 million) reduction in agency cost and 29% ($2 million) in time value savings to road users.

Caltrans concluded that the direct cost increase for the implementation of the additional features, usually related to contract change orders, was eventually paid off by the value of time saved to road users and improvements in the public perception of the accelerated construction approach. Caltrans' responsiveness to the public's concerns received much praise from the public and politicians alike and proved instrumental in saving the project and setting high standards for what can be accomplished using the Rapid Rehab approach.

Mitigated Traffic Disruption

A traffic monitoring study was also conducted in parallel with the AWIS implementation to quantitatively evaluate impact of the extended closures on highway network traffic. The research team measured traffic volumes and speeds before and during construction using several types of traffic surveillance devices, including RTMS. The overall impact of reconstruction closures on traffic was "acceptable" according to a traffic measurement study, and this was confirmed by Web-based surveys conducted before and after the construction. The maximum peak hour delay, although infrequent, reached about 75 min on weekends for NB travelers and 45 min on weekdays for SB travelers. The traffic monitoring study comparing before- and during-construction traffic volume observed about a 20% reduction in actual traffic demand through the CWZ during the extended closures, 10% greater than the reduction initially expected in the traffic management plan. More specifically, the daily traffic demand (volume) reduction measured in volume on I-15 NB was 16% and SB reduction was 19% with a similar trend of reduction even during peak hours.

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Table 1. Measured Traffic Volume Change during Extended Closures Compared with before Construction

Traffic	Route	Average daily traffic (%)	Peak-hour Traffic (%)	Remarks
CWZ corridor	I-15 Northbound	−16	−17	With RTMS
CWZ corridor	I-15 Southbound	−19	−18	With RTMS
Detours	I-215 Southbound	+15	+16	I-15 Southbound detour
Freeways	I-10 Eastbound	+10	+36	I-15 Northbound detour
Detour arterials	Major intersections	−5	+6	With rubber tubes

The majority of the reduced traffic demand was diverted to the major freeway detour routes as confirmed by traffic measurement statistics, i.e., I-10 eastbound as the I-15 NB detour showed 10% daily (with 36% in the morning peak hours) traffic volume increase, and I-215 SB as the I-15 SB main detour showed about a 15% daily volume increase (Table 1). This reduction resulted in less inconvenience to motorists than had been anticipated. It was attributed to Caltrans' proactive public outreach and traffic control efforts, as discussed in the public outreach section below. This helped avoid potentially grievous public relations and resulted in positive feedback for Caltrans for keeping traffic moving well during the extended closures.

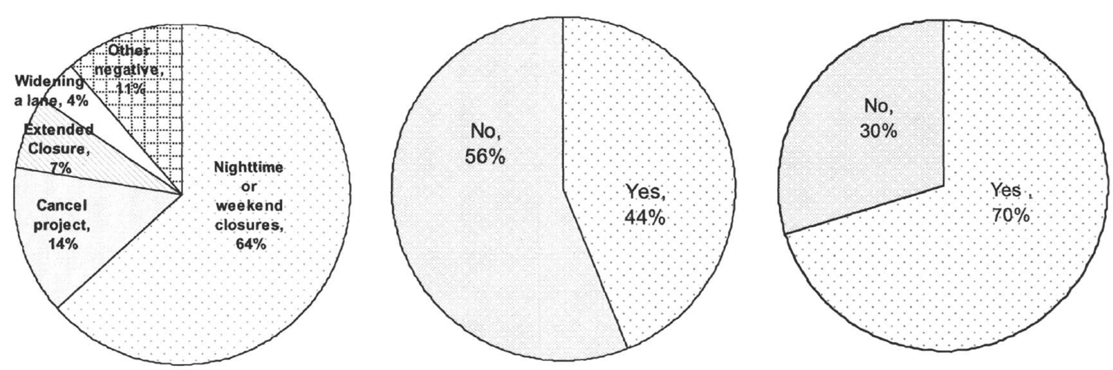
Public Perception Changes

The project Web site proved to be a great tool for getting feedback from the public. Surveys were especially valuable in capturing changes in perception supporting the concept of Rapid Rehab on this project. Two different sets of survey questionnaires were uploaded to the Web site with about 400 respondents, one for before-construction and the other for during and after construction. Most of the survey respondents (94%) were identified as weekday commuters, which confirmed that weekday commuters needed to be given higher priority as the main target audience for the urban highway rehabilitation project.

The before-construction survey indicated that 94% of the respondents felt that less than a 30-min delay through the CWZ would be acceptable. In the during- and after-construction survey, travelers reported the following delay experiences: 27% reported 60-min delays, 20% reported 45-min delays, 22% reported 30-min delays, and so on. Overall, the additional travel time that they reported to have experienced matches the estimated travel time information from the AWIS. Through the during- and after-construction surveys, it is observed that 67% of the traveling public felt the changeable message signs from the AWIS were only partly accurate, but a majority of them (91%) felt they provided a useful service.

The surveys showed the significant change in the travelers' reactions to the CWZ. The before-construction survey showed that 43% of respondents would not change their travel pattern even if the I-15 CWZ corridor was congested. In actuality, only 24% of respondents on the during- and after-construction survey indicated that they did not change their travel plans, 34% of the respondents adjusted their departure time, and 38% took alternative detours during the extended closures.

Most survey respondents showed initially strong reluctance to the extended closures, with 64% expressing an initial preference for the traditional nighttime or weekend closures, and 14% requesting that the project be canceled. However, 70% of the respondents to the postconstruction survey expressed support for Rapid Rehab projects in the future (Fig. 6). This result indicates that, with the expectation of the benefits from accelerated project completion, the public is willing to bear increased traffic impacts in exchange for reduced construction schedules, thus mitigating the overall inconvenience of traffic disruption. Caltrans believed that the main contributor to the trend change in public perception from negative to positive was the comprehensive public outreach, the use of innovative technology, and Caltrans responsiveness to the public's concern. This conclusion is supported by the numbers in the survey: 88% respondents were aware of the extended closure prior to construction, and 75% of respondents felt that the public awareness campaign for the Devore project was sufficient.



(a) **With the initial closure scheme:** *Do you support the 72-hour weekday closures on I-15?*

(b) **Before-construction:** *Do you support the one-roadbed continuous closures on I-15?*

(c) **After-construction:** *Do you support future "Rapid Rehab" projects?*

Fig. 6. Public perception changes captured on the Web surveys

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Summary and Conclusions

This paper introduces the innovation and technologies used in the fast-track concrete pavement reconstruction of two deteriorated truck-lanes (4.5 centerline km) on I-15 at Devore. One-roadbed continuous closures and around-the-clock operations (24/7) were used to complete the reconstruction in about 210 h (about 9 days) for each direction of the roadbed. This project is the first large-scale implementation of Caltrans' LLPRS program using state-of-practice features to implement innovation and technology based on experience and lessons-learned from the recently completed I-10 Pomona and I-710 Long Beach LLPRS demonstration projects.

Use of QMB helped to balance traffic impacts to commuters and weekend travelers by activating a dynamic lane configuration with one additional lane converted temporarily from the rehabilitated AC shoulder. AWIS played a useful role in informing motorists traveling through the CWZ of real-time travel and detour route information, as indicated by the results of before- and during-construction surveys conducted on the project Web site. AWIS information was posted on the permanent and changeable message signs, as well as on the traffic roadmap on the project Web site and was used in mounting an effective public outreach campaign.

The Web site was created with the cooperation of transportation partners and the surrounding three Caltrans district offices to provide up-to-date comprehensive project information. Two Web-based surveys were undertaken to compare commuters' expectations of potential traffic delays prior to construction with their actual experience during the extended closures, as well as to study their overall perceptions of the Rapid Rehab approach of the extended closures. The before-construction Web survey indicated the public's strong reluctance to the 72-h weekday scenario, their initial preference to the traditional nighttime operation, and the desire of some to cancel the project altogether. However, the results of during- and after-construction Web surveys revealed a change in public attitude in support of Rapid Rehab projects in the foreseeable future.

The overall impact of reconstruction closures on traffic was "acceptable" according to a traffic monitoring (measurement) study and the Web surveys. The maximum peak hour delay was measured at about 45 min on weekdays during the extended closures, compared to the projected 90-min delay during weekdays with the initial assumption of 10% reduction estimated in the preconstruction traffic analysis. A total 20% of actual traffic demand (volume) reduction through the CWZ was attributed to Caltrans' proactive public outreach and traffic control efforts.

The advantages of using this method of fast-track (accelerated) reconstruction, known in California as Rapid Rehab, included the shorter period of disruption for the traveling public, longer (30-plus years) life expectancy for the new pavement, improved safety for motorists and workers, reduced (by 28%) agency costs, and saved (29 percent) road users' time, compared to those of traditional repeated nighttime closures.

Based on experience from this case study, the writers suggest that further future research on Rapid Rehab projects for decision makers (i.e., contractors, designers, and agencies) should focus on: (1) refining technologies and techniques and synthesizing them into best practices and easy-to-use guidelines; (2) developing planning tools to identify potential problems and the most efficient processes; and (3) defining methodology to calculate costs and to quantify economic benefits of innovation and technologies to be implemented.

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