TECHNICAL REPORT DOCUMENTATION PAGE

1. Report No. FHWA-JPO-10-059	2. Government Accession No.	3. Recipient's Catalog No. ....
4. Title and Subtitle: National Evaluation of the SafeTrip-21 Initiative: I-95 Corridor Coalition Test Bed, Final Evaluation Report: California Deployment of Portable Traffic-Monitoring Devices		5. Report Date June 11, 2010 6. Performing Organization Code
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9. Performing Organization Name and Address Science Applications International Corporation (SAIC) 8301 Greensboro Drive, Mailstop E-12-3 McLean, VA 221021		10. Work Unit No. (TRAIS) Contract or Grant No. DTFH61-06-D-00005, Task No. T-09-008
12. Sponsoring Agency Name and Address United States Department of Transportation ITS Joint Program Office Research and Innovative Technology Administration (RITA) 1200 New Jersey Avenue, SE Washington, DC 20590		13. Type of Report and Period Covered 14. Sponsoring Agency Code HOIT-1
15. Supplementary Notes Mr. James Pol, COTM		

16. Abstract

The purpose of this document is to present the findings of the national evaluation of the deployment of portable traffic-monitoring devices (PTMDs) at a variety of locations in California conducted under the USDOT's SafeTrip-21 Initiative.

The California Department of Transportation (Caltrans) tested the use of PTMDs in work zones. During this testing, the USDOT conducted an evaluation to gain an understanding of the technical and institutional issues associated with using these types of devices. The purpose of the evaluation is both to learn how highly portable, temporary traffic sensors with a small footprint can provide real-time traffic conditions in work zones and to determine how that information can be used effectively by State Departments of Transportation (DOT) to improve safety and mobility in work zones.

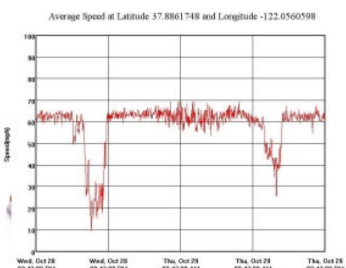
Based on their experience during this test, Caltrans personnel reported that the PTMDs enabled them to focus their activities on the areas that needed the most attention, while still monitoring areas that needed less active involvement. The data gathered during the test helped Caltrans personnel to better understand the queuing activity in and around work zones, and will help them plan work zone activities more efficiently and effectively in the future.

Overall, based on the findings from users interviewed about PTMDs, the devices appear to be a cost-effective and flexible means for an agency to remotely monitor traffic conditions.

17. Key Words Work Zone, WZ, Work Zone Monitoring, Portable Monitoring Devices, California, CA, SafeTrip-21, Evaluation, Final Report, Deployment, Traffic-Monitoring		18. Distribution Statement No restrictions.	
19. Security Classif. (of this report) Unclassified	20. Security Classif. (of this page) Unclassified	21.No of Pages 25	22. Price N/A

National Evaluation of the SafeTrip-21 Initiative: I-95 Corridor Coalition Test Bed Final Evaluation Report: California Deployment of Portable Traffic-Monitoring Devices

Contract Number: DTFH61-06-D-00005 Task Order T-09-008



Submitted to:
United States Department of Transportation
ITS Joint Program Office,
Research and Innovative Technology Administration
RITA Report Number FHWA-JPO-10-059

Submitted by:
Science Applications International Corporation
June 11, 2010

Notice

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List of Abbreviations

Caltrans	California Department of Transportation
CHP	California Highway Patrol
CMS	Changeable Message Signs
DOT	Department of Transportation
I-880	Interstate 880
ITS	Intelligent Transportation Systems
NCHRP	National Cooperative Highway Research Program
PTMD	Portable Traffic-Monitoring Devices
TMC	Transportation Management Center
USDOT	U.S. Department of Transportation

Introduction

Through its SafeTrip-21 initiative, the U.S. Department of Transportation (USDOT) is testing a variety of technologies along the Interstate 95 (I-95) corridor, and in a number of locations in California. As part of this Federal initiative, the California Department of Transportation (Caltrans) tested the use of portable traffic-monitoring devices (PTMDs) in work zones. During this testing, the USDOT conducted an evaluation to gain an understanding of the technical and institutional issues associated with using these types of devices. The purpose of the evaluation is both to learn how highly portable, temporary traffic sensors with a small footprint can provide real-time traffic conditions in work zones and to determine how that information can be used effectively by State Departments of Transportation (DOT) to improve safety and mobility in work zones.

This document presents the evaluation findings, resulting primarily from original in-person interviews the Evaluation Team conducted with Caltrans staff in October 2009, and follow-up telephone discussions the Team conducted with Caltrans, vendors, and engineering staff from the City of Pasadena in Los Angeles County in late 2009 and early 2010.

Background

Monitoring Traffic Conditions in Work Zones

Many roadways across the country are equipped with traffic-monitoring devices to provide State DOTs with information about real-time conditions on their roadways. In work zones, however, the investment required to install and maintain temporary Intelligent Transportation Systems (ITS) equipment can be cost-prohibitive due to the ever-changing nature of road conditions and the traffic situation. ITS devices are sometimes included in an initial temporary traffic control design, but they are often removed from the plan before or during construction due to the associated installation and maintenance costs, a lack of understanding of their capabilities, and/or an unclear plan for how they will be used. Additionally, installation of ITS assets typically includes a lead time of 2-3 months for ordering, shipping, testing, and final deployment.

In work zones where permanently installed traffic-monitoring devices are already present, the devices are sometimes moved or disabled during construction, or temporary traffic lanes tend to shift vehicles outside the devices' detection area during construction activities.

Recent technological advances in traffic-monitoring technologies, battery power, and communications are removing this barrier and making it possible to manage work zones cost-effectively in real time with the use of PTMDs (see Figure 1). PTMDs have the potential to allow transportation personnel to monitor traffic conditions actively without a large investment of financial or staff resources.

How a PTMD Works

The PTMD under study in this evaluation uses a single K-band radar unit to obtain traffic condition information. The device can be set to collect either vehicle speeds or traffic volumes. The PTMD is housed inside a National Cooperative Highway Research Program (NCHRP) 350-compliant traffic channelizer (i.e., a construction drum), so it can be placed anywhere along the roadway where it would be appropriate to place a channelizer. The device's range is approximately 300 feet for speed detection (aimed parallel to the direction of travel) and 100 feet for traffic counts (aimed perpendicular to the direction of travel). Due to its location on the side of the road at ground level, in most cases the PTMD is limited to counting just one lane of traffic. To install, the user places the device on the roadside, aligns the arrow at the top of the PTMD to point *toward* traffic to collect speed data, or *perpendicular* to traffic to collect traffic counts, turns the switch on the device to the "on" position, and then walks away. The device auto-locates using a

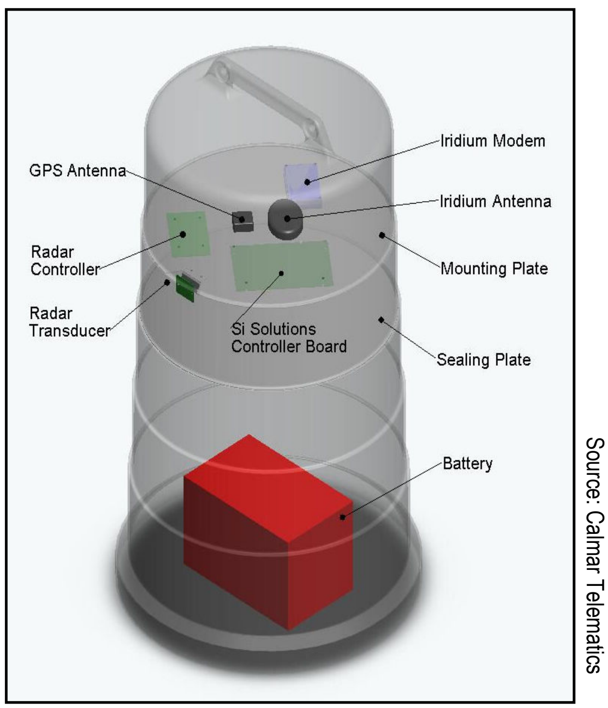


Figure 1. Diagram of PTMD

built-in Global Positioning System (GPS), which enables the device to report its location for use in tracking the device and in reporting its data on a map interface. The device is battery powered and does not require an external power source; it does, however, require regular battery charging.[1]

For the collection of speed data, the end user can define all attributes of collection and reporting. For example, one setting allows the PTMD to collect up to six speeds in every 30-second increment, turning off after these readings to conserve battery life. At the end of a 5-minute interval, the PTMD reports the number of readings collected and the average speed to the database.

For the collection of traffic volume data, the PTMD constantly counts the number of vehicles, reporting to the database at user-defined intervals.

In both cases, the most recent information reported is available to users on the web-based map, and the historical data can be downloaded in spreadsheet or chart format so that the data can be viewed or manipulated as desired.

Evaluation Team Objective

The objective of the evaluation was to gather lessons learned from the test deployment of PTMDs in California through interviews with highway agency staff, the traffic control services provider, and the product vendor. The goal of the Evaluation Team was to gain an understanding of:

- The institutional issues associated with collecting and making use of real-time information about traffic conditions in work zones.
- How real-time information about traffic conditions in work zones can be used effectively by a State DOT to actively manage work zones.

[1] According to State highway agency interviews, the PTMD batteries last approximately 2-3 weeks per charge for speed collection, and somewhat less for traffic counts.

The Caltrans Test

For this test, Caltrans had 12 PTMDs available for study purposes over a test period of 5 months beginning in September 2009. The devices were distributed to a number of Caltrans districts, including District 2 in Northeastern California, District 4 in the San Francisco Bay Area, District 5 along the coastline, District 7 in Los Angeles, and District 12 in Orange County. After a few of the districts conducted some traffic count testing, the devices were provided to District 4 for conducting the work zone-focused tests. As a result, the majority of the findings in this document represent findings from testing by District 4 staff in the San Francisco Bay Area. The report also presents findings from use of the devices during the District 12 traffic count tests.

> *In California, 26 percent of work zone fatalities occur at the back of a queue.*

Caltrans District 4 staff elected to deploy the units at a number of locations during the test period, choosing to use the devices on multiple short-term projects rather than on one large construction project. This approach provided them with the flexibility to move the PTMDs quickly without disrupting a large-scale operation, and enabled the staff to learn about the value of the PTMDs in a variety of situations.

Closing lanes in California is a difficult task, as a true “off-peak” time period rarely exists, particularly in metropolitan areas such as those selected for the test. Caltrans policy restricts work zone managers to planning work zone activities that are expected to result in motorist delay of 15 minutes or less. As a result, all lane closures must be handled carefully to meet this performance objective. Figure 2 shows a typical work zone setup in California’s Bay Area, including PTMD deployment. Caltrans typically uses cones and channelizers as their typical delineators. Because of this, Caltrans chose to set the PTMD barrels off to the side (instead of in line with the other devices).

Source: Caltrans

Figure 2. PTMD Deployment in California[2]

[2] In this photo, two PTMDs are in use. One is collecting speeds, and the other is collecting traffic volumes.

Historically, work zone traffic in California has been monitored by a combination of field visits at the work site and through the use of existing traffic count stations and sensors, where available.[3] Staffing this operation is financially inefficient, and existing ITS devices—when operational—often provide insufficient coverage of the area of interest.

For example, the San Mateo Bridge in the San Francisco/Oakland area has Caltrans Performance Measuring System (PeMS) detectors at each end of the bridge, but there are no sensors across the 7 miles of the bridge itself. When work is being done on the structure, it is difficult for Caltrans staff to know the true traffic situation on the bridge. Knowing the length of queues in work zones is critical to Caltrans, as 26 percent of work zone fatalities in California occur at the back of the queue. [4]

Caltrans staff hoped the PTMDs could assist them in detecting and managing these queues more effectively. By setting up a series of PTMDs in a work zone, Caltrans personnel believed they could utilize the speed data at each location to determine the length and other characteristics of the queue.

As a result, Caltrans personnel were excited about the opportunity to test the PTMDs. Criteria used for selecting locations for PTMD deployment in District 4 work zones included:

- Expectations of large queues such as situations where closing even one travel lane was expected to significantly impact traffic.
- Potential to expand work windows, especially on sensitive jobs with high traffic volumes, such as work being completed on an uphill vertical grade. In this situation, queuing can be caused by even a small number of heavy vehicles decelerating. Managing these queues is especially critical on roadways with vertical grade, as sight distance is sometimes limited for approaching motorists.

Test Sites

Caltrans District 4 used the PTMDs in a variety of ways during the 5-month test period. The two most significant deployments had direct connection with the Bay Bridge between Oakland and San Francisco. Other deployments involved various interstates and U.S. highways in the Bay Area. The test sites are described in further detail below.

Interstate 680

The Interstate 680 project was a short, 1-day construction job on a 6-lane section of the freeway in the Walnut Creek area where there are numerous ramps and interchanges connecting the Interstate to other major routes in the region. One of the three-lane connector ramps was reduced to one lane during the mid-day, and Caltrans staff had concerns that the queues at this location might exceed Caltrans' thresholds for delay.

Caltrans staff set out PTMDs to monitor traffic on the ramp beginning approximately 30 minutes before work began. The PTMD units provided data to the Lane Closure Manager, who was able

[3] In California's District 4, these include the Caltrans Performance Measuring System (PeMS) and the 511 Traveler Information System.

[4] *California Strategic Highway Safety Implementation Plan: Challenge Area 14: Enhance Work Zone Safety*. Presented to SHSP Steering Committee – July 10, 2007, Revised August 1, 2007. Available at: www.ahmct.ucdavis.edu/images/SHSIP_CA14_SNAP.doc (last accessed December 2009).

Source: A. Karnstedt

Figure 3. Bay Area Bridges

to monitor the situation from the District 4 office. By providing speed data upstream of the work, the PTMDs could help Caltrans personnel determine if queues were manageable.

Bay Bridge Closure – Labor Day Weekend

For the past 3 years, Caltrans has closed the Bay Bridge between San Francisco and Oakland to complete major maintenance activities over Labor Day Weekend. During this work, a significant amount of traffic is diverted to the two major bridges to the south: the San Mateo Bridge and the Dumbarton Bridge (see Figure 3).

In the past, the only traffic monitoring information available for the San Mateo Bridge came from the California 511 Traveler Information system. The 511 detectors are spaced in such a way that Caltrans officials are not able to determine the location of the back of the queue when it is on or near the bridge.

The 511 website uses a color scheme (green, yellow, red) to provide basic congestion information to the public, but due to the lack of sensors in this area, the bridge is always shown as just one color from end to end. In reality, the level of congestion can vary significantly along the 7-mile bridge.

For the Labor Day 2009 bridge closure, Caltrans deployed PTMDs to collect additional data points along the San Mateo Bridge, at the 92 & 880 interchange, and at the 101 & 580 interchange.

While the Bay Bridge was closed, it was expected that queuing would be significant on the San Mateo Bridge, as it was the nearest detour to the south. Caltrans planned to monitor the queue on the San Mateo Bridge to provide motorists with information as they traveled the region. If the bridge experienced a certain level of delay, they planned to encourage motorists to use the Dumbarton Bridge to the south.

Source: Calmar Telematics

Figure 4. Golden Gate Bridge PTMD Deployment

Highway 101 - Golden Gate Bridge

During the Bay Bridge closure over Labor Day weekend, Caltrans wanted to determine how much additional delay would occur on Southbound Highway 101 in Marin north of the Golden

Gate Bridge and how far the queue would extend. The area had few permanent count stations or other ITS assets, so Caltrans decided this scenario was a good fit for PTMD deployment (see Figure 4).

PTMDs were placed near the bridge at a traffic camera location, north beyond the typical daily queue, and over a nearby hill. When the PTMD alerted Caltrans about queuing issues, DOT personnel planned to gather additional information by reviewing the input from the traffic camera located near the bridge. If conditions warranted, they could provide traveler information to approaching motorists as appropriate.

Bay Bridge Reverse Curve

In early November, a fatal crash occurred involving a large truck missing a 35-mph reverse curve and flipping off the Bay Bridge. Caltrans responded to safety concerns after this event by placing a PTMD near the curve location to monitor speeds (see Figure 5) to learn whether speeding at this location was a significant problem.

Source: Caltrans

Figure 5. PTMD Installation on the Bay Bridge

Interstate 880

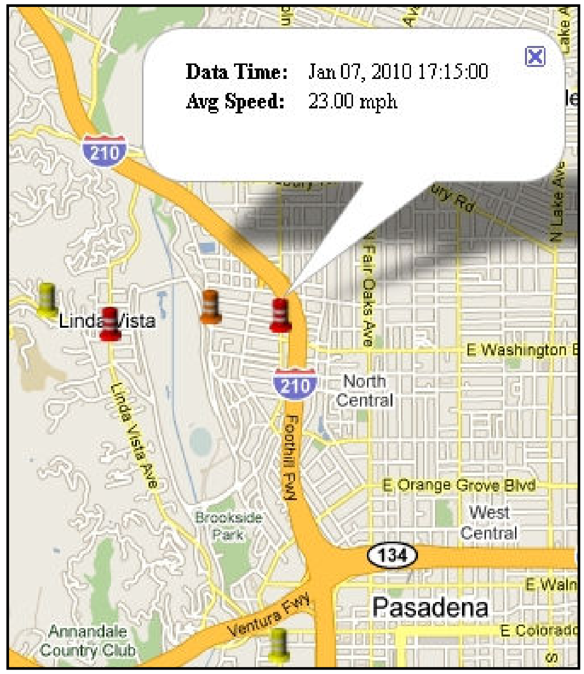
After the Bay Bridge closure over Labor Day weekend, District 4 moved six of the PTMDs to Interstate 880 (I-880) in Oakland in support of a bridge rehabilitation project. I-880 has a very high truck volume due to truck restrictions on other nearby Interstates, including I-580, the Foothill Freeway. I-880 has tight geometrics and operational challenges even without lane closures due to maintenance efforts. In this specific work zone, the length and duration of queue were greater than normal.

At this location there were severe constraints on PTMD placement. I-880 has no shoulders, so devices were placed in ramp gore areas or wherever Caltrans could find room. Placing the PTMDs approximately 1 mile from each other was intended to provide the District Lane Closure Manager with the information necessary to monitor traffic flow on this project and coordinate with the District 4 TMC.

Event Management in Pasadena

An additional application of the PTMDs in California occurred in early January 2010 in Pasadena to support the special event traffic surrounding the Tournament of Roses festivities on January 1 and the Bowl Championship Series (BCS) National Championship football game held on January 7.

The City of Pasadena deployed 10 devices at various locations around the city in preparation for the Rose Bowl events on January 1 (see Figure 6). There were four discrete traffic events that day: pre-parade, post-parade, pre-game, and post-game. Pasadena traffic authorities initially placed the devices along the primary routes into the city as visitors entered Pasadena to attend the Tournament of Roses Parade. At the end of the day, when the Rose Bowl game was over, the PTMDs were located along the routes out of the Rose Bowl stadium where city transportation officials expected the most severe traffic congestion.



Source: Calmar Telematics

Figure 6. PTMD Deployments in Pasadena

Evaluation Findings

The Evaluation Team traveled to the Bay Area to conduct in-person interviews over a 2-day period in October 2009. Interviews were held with the Lane Closure Manager for Caltrans District 4, the Bay Area; staff from the District 4 TMC in Oakland; and a traffic control service provider from northern California who supported Caltrans in the testing. Additionally, the Team visited active PTMD deployments in Oakland with Caltrans personnel to see the devices in action.

The Evaluation Team also conducted telephone interviews with additional members of the Oakland TMC and the Division of Research and Innovation in District 12, Orange County. In January 2010, the Evaluation Team conducted follow-up phone interviews with Caltrans personnel and vendors to learn about their experiences through the final months of the test period. The Team also conducted a telephone interview with personnel from the City of Pasadena to learn about their experience using PTMDs for event management.

Ease of Installation

Caltrans personnel reported that installation was straightforward. Since the PTMD is powered by battery and communicates via cell phone or satellite, Caltrans personnel were able to place the device anywhere motorists would expect to see other traffic control devices on California highways. The operator positioned the device at the desired location (generally upstream of the work zone in a place where queues were expected to be present), aligned the arrow at the top of the PTMD to point *toward* traffic for collection of speed data or *perpendicular* to traffic for collection of traffic counts, and turned on the device by flipping a switch (see Figure 7). At that point, the PTMD began collecting data as selected for speed or traffic counts and sending it to the online database.

Figure 7. PTMD On-Off Switch and Directional Arrow

One significant benefit the PTMD offered compared to traditional ITS assets was the ability for quick deployment. In the Bay Bridge fatal crash response discussed above, Caltrans was able to deploy a traffic-monitoring device immediately to address this potential safety problem. Both Caltrans and the California Highway Patrol (CHP) monitored speeds at the curve in real time, with no contract negotiations, lost start-up time, or testing period required. The PTMD quickly provided managers with a database of speeds near the reverse curve by time of day and day of the week.

Ease of Maintenance

Overall, Caltrans found that the devices were easy to maintain. The only significant maintenance activity that Caltrans conducted during the test period was recharging the batteries, which was necessary for the devices' portability. Staff did note that, as with any battery, the battery life was dependent upon the ambient temperature. Based on Caltrans' experience with the devices, the batteries lasted approximately 2 to 3 weeks collecting speeds in moderate temperatures before they needed to be recharged. Caltrans experienced shorter battery life (approximately 12 days) when the devices were used to collect traffic counts due to device's constant data collection activities.

Since the PTMD web interface provided users with real-time information on the device's current voltage, Caltrans staff used this feature to monitor the battery life. They discovered that the devices typically stopped functioning within 24 to 48 hours after battery voltage reached approximately 10.5V, so they used that voltage value as an indication that it was time for a recharge.

When a device needed to be recharged, it was transported to a charging location (i.e., back to the nearest Caltrans office or to any other location with a standard electrical outlet). The user manual indicates that the battery can be fully charged in approximately 4 hours, but Caltrans staff found that it was preferable to charge the devices overnight and transport them back out to the field the next morning. While Caltrans staff did not consider this a problem for the 12 PTMDs being used during the test, they indicated that depending upon the location of the work zone and the number of units in use, this could become a time-consuming process.[5]

The only other minor maintenance activity reported was that, at times, a small and inexpensive (approximately $3) fuse blew and it had to be replaced.

Ease of Use of Data Interface

Both Caltrans and the City of Pasadena reported that they were satisfied with the web-based user interface. As shown in Figure 8, the interface provided Caltrans and City of Pasadena staff with an easy-to-use map of the area with icons showing the current location of the agency's deployed PTMDs. The web site provided basic real-time data to any user (including the general public) from the map view.

As an example, this real-time information was beneficial during the Labor Day Bay Bridge closure, as Caltrans staff were choosing the exact location of the devices. When initially placing the PTMDs on the San Mateo Bridge, Caltrans found that one of the units was not providing useful information because it had been located too close to the beginning/middle of the queue (it continuously reported a very low speed). By seeing that information immediately via the website, Caltrans quickly adjusted the unit's location to be closer to the bridge's toll plaza so that agency staff would receive more useful data.

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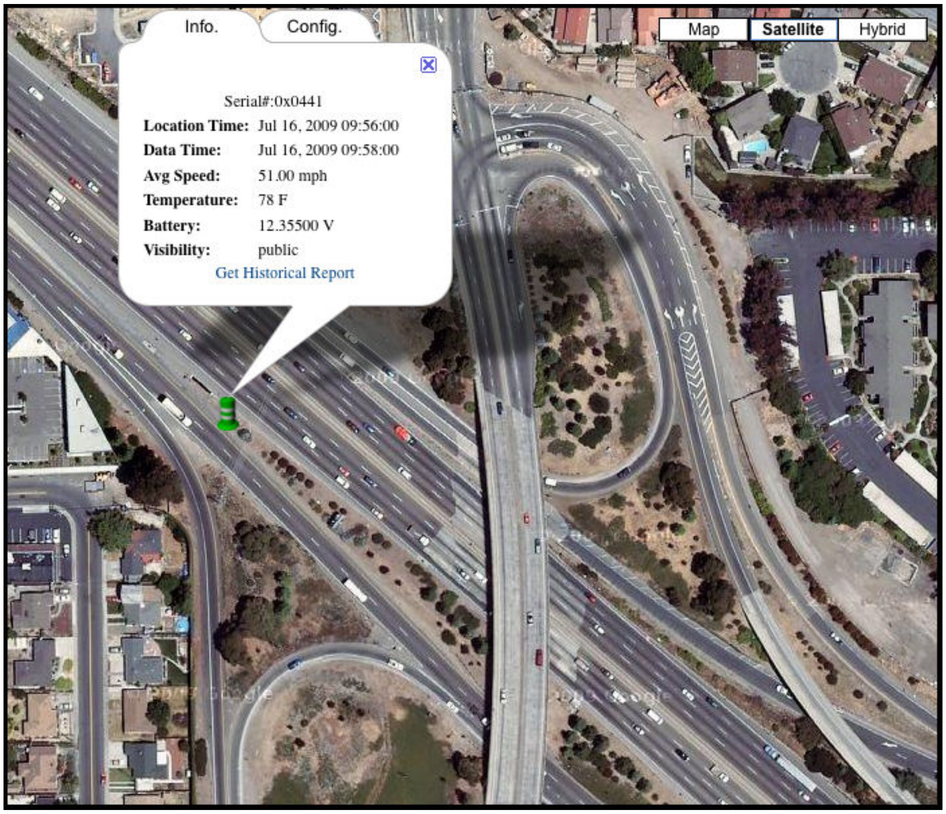
[5] Potential solutions include a swappable battery pack, solar powered PTMDs, and rental contracts that include standard maintenance (e.g., battery charging, preventive maintenance), communications, and data archiving services.



Source: Calmar Telematics

Figure 8. Screen Shot of the Web-Based User Interface

Caltrans staff reported that additional information beyond the basic map was also beneficial. Real-time and historical information data was available to the agency on a password-protected version of the web site. Authorized users could access the data in a tabular format or in the form of graphical reports. The District 4 Lane Control Manager used this option of the site extensively when analyzing the data it collected in California work zones.

Based on the extensive use of the web interface by Caltrans and City of Pasadena staff, they suggested the following enhancements to improve the user experience:

- **Directional Arrow Icons.** In some cases, Caltrans staff deployed multiple devices to monitor both directions of traffic in a work zone, and at times, it was difficult to determine from which direction each PTMD was collecting data. Adding directional arrows to the icons on the map would allow the user to easily distinguish the direction of traffic.
- **Save View.** The web site currently begins with a full United States map. Caltrans staff expressed interest in saving the view of their region as the default map when logging into the site.
- **Historical Data Retrievel.** Caltrans staff indicated that it can be difficult to find location and technical data for previously deployed PTMDs. They suggested that the site have more user-friendly tools to make this process easier.

Accuracy in Collecting Speed and Volume Data

Overall, Caltrans personnel indicated they were confident in the level of accuracy of the speed data collected by the PTMDs. Caltrans staff completed field checks to confirm the PTMD speed data was sufficiently accurate, including comparing and verifying the data collected with independent data collected from nearby permanent traffic-monitoring stations.

When collecting speed data with PTMDs, it was important for Caltrans personnel to place the device in a location where only the desired traffic was within range of the device (within about 300 feet) to screen unwanted vehicles from the data. Some type of barrier was necessary (e.g., concrete barrier, foliage, wide median) when the speed in only one direction of travel was desired.

There was, however, one specific location where Caltrans personnel were unable to obtain a proper speed reading from the device, presumably due to the K-band radar technology. The problem stemmed from the fact that the PTMD was situated on a ramp surrounded by concrete barriers and walls on all sides. Caltrans staff believed that the concrete may have acted as a reflector, causing radar waves to bounce back and forth on the concrete, causing distorted measurements.

Caltrans staff did not often use the devices for traffic counts since the devices are capable of accurately counting vehicles in only one travel lane, and most of the work zones were located on multilane roadways. Caltrans staff in Orange County did share that they used the PTMDs to count one-lane ramps and two-lane undivided highways (roadways with one lane of traffic traveling in each direction). When used in these situations, the results of the PTMD traffic counts were acceptable to field personnel; the data sufficiently matched nearby pneumatic tube counters.

Benefits

Caltrans and City of Pasadena staff cited a number of benefits of the PTMDs, including cost-effective situational awareness and cost-effective traffic counting. These benefits are described below.

Situational Awareness

The most often-cited benefit of the PTMD was its value as a cost-effective situational awareness tool. Instead of physically visiting work sites, the Caltrans Lane Closure Manager and other personnel were able to use the PTMDs to collect basic traffic data, allowing staff to focus their efforts only at locations needing further attention due to congestion or other traffic flow issues. In the Bay Area, Caltrans staff consistently referred to the devices as a "second set of eyes" to actively monitor lane closures in their district.

Additionally, using the PTMD devices enabled traffic monitoring without the need for a staff member to be present at the location, thereby reducing the cost of data collection, and also reducing risks associated with Caltrans staff exposure within the work zone. On the I-680 1-day maintenance project, Caltrans cited the PTMD was equivalent to having a staff person on-site for 3 hours collecting speed data and observing the queue for potential problems.

During the Labor Day Bay Bridge Closure, there was concern that the Golden Gate Bridge may experience significant back-ups. The PTMDs provided the staff with situational awareness during a time when many roadways in the region were pushed to their capacity due to the large-scale bridge closure.

In many situations Caltrans was able to achieve real-time situational awareness at a fraction of the cost and was able to determine the expected effects of similar lane closures in the future. In terms of equipment, power, and communication cost, the PTMD was considered by Caltrans to be a cost-effective alternative to traditional ITS devices for specific applications.

The technology's value was most apparent when multiple devices were deployed on California highways. When three or more PTMDs were set up in advance of a work zone, they worked together to provide the user with valuable information. Each PTMD had a specific role:

1. One PTMD, located closest to the work zone, showed the formation of a queue (if it exists) by displaying slower speeds than normal.
2. The second device, placed further upstream of the work zone, provided information about how far the queue extended.
3. The third PTMD was often placed at a location of concern upstream of the work zone. If a queue extended back to device #3, this indicated a potential problem in need of immediate response.

Another situational awareness benefit relates to the redundant communications technology of the PTMDs, especially for incident or event management. This benefit was illustrated during the January 2010 festivities in Pasadena. Even though Pasadena is a heavily populated area with typically adequate cellular coverage, there was an enormous strain placed on the cellular networks due to the large number of people using their mobile phones simultaneously in a concentrated area during the Rose Bowl and National Championship Game events in January 2010. The PTMDs automatically switched from cellular to satellite more than 100 times during the day due to heavy cell phone traffic. The device closest to Rose Bowl stadium used satellite the most, ensuring uninterrupted connectivity during peak travel times just before and after the major events of the week.

Enhanced Traveler Information

In a number of tests in Caltrans District 4, the PTMDs supported and enhanced the agency's ability to provide travelers information to reduce travel times through the area.

During bridge rehabilitation on I-880, deployed PTMDs offered an opportunity for the Lane Closure Manager to coordinate with the District 4 TMC. When the traffic queue on I-880 extended beyond Caltrans' limits, he contacted the TMC to divert traffic to the typically truck-restricted I-580 via changeable message signs (CMS) and California's 511 system. Once queues were manageable on I-880, the messages reverted to normal operation, providing travel times and other basic traveler information as appropriate.

On the Labor Day Bay Bridge closure project, Caltrans used the PTMDs to monitor the queue on the San Mateo Bridge. When the queue reached a point on the San Mateo where motorists would be better served to use the Dumbarton Bridge (an approximate 30-minute detour to the south), the Caltrans District 4 TMC used CMS boards to encourage drivers to use the Dumbarton detour.

The PTMD units provided Labor Day weekend travelers with more detailed and accurate information than they had received in the previous years' activities at this location. Additionally, the data collected from the 2009 closure's PTMDs will be used by Caltrans staff to better prepare for the planned 2010 Labor Day bridge maintenance activities.

Safe and Efficient Traffic Counting

The PTMDs provided significant benefits over traditional count tubes for collecting traffic volume data, including:

- Field personnel did not need to enter the roadway to place the devices, resulting in reduced exposure.
- Back at the District offices, the data were available immediately and without the need to physically connect the counting device to a computer.
- If problems were to occur (though none were reported by the Orange County Caltrans staff interviewed), they could be detected immediately in real time instead of waiting for a printed report after the count was completed.

Source: Calmar Telematics

Figure 9. PTMD

Challenges and Limitations

Because the device is not a fixed asset on or above the roadway, there are some disadvantages associated with its portability. Caltrans staff experienced some issues with the devices being moved, both intentionally and unintentionally.

Caltrans staff found that since the PTMD looks like a traditional traffic barrel (see Figure 9), contractors often assumed it was a normal barrel. As a result, sometimes they moved the devices either to get them out of their work area or to bring them closer to their work area for protection. When doing so, they often rotated the PTMD, improperly aiming the radar and rendering the device useless.

Source: SAIC

Figure 10. Vandalized PTMD

Another challenge was crime. One device was vandalized, as shown in Figure 10, and at least five were stolen from Bay Area work zones during the evaluation period. Due to the device's GPS feature, each was quickly recovered. The PTMD emits a signal to its "home base" when it uploads data to the web site. The device continues to emit a signal for up to 1 hour after the device is turned off. Law enforcement authorities were able to immediately determine the stolen property's location by looking at the same web site that Caltrans uses to download data from the system. Within hours of the equipment being stolen, it was recovered and the perpetrators were arrested for theft of government property. In District 12 (Orange County), Caltrans staff elected to secure the PTMDs with chains and locks to prevent theft from the collection locations.

As discussed previously in the maintenance section, battery recharging was sometimes a challenge. For a large-scale

PTMD deployment, regularly removing units from service for recharging could become a labor-intensive effort. However, options exist for the State DOTs to handle battery charging and other maintenance needs through service contracts with PTMD providers.

Since the PTMD is installed inside a work zone barrel, it lends itself most directly to work zone applications. However, Caltrans staff in Central and Southern California (specifically Districts 4 and 12) do not use barrels for their work zone delineation, so the PTMDs evaluated were not as inconspicuous as they might be in some other States. Also, due to its size, the PTMD is limited to locations where there are adequate shoulders or medians for placement.

Another challenge shared by Caltrans personnel was the limited physical space available in their work zones in which to deploy the PTMDs. Though the device has a very small footprint, it does take up some space on the roadside. Some California freeways have no shoulders and even have buildings positioned directly against the barrier wall. As discussed on the I-880 deployment, finding an appropriate place to deploy the PTMD was sometimes a challenge, and in some cases the final location was less than ideal.[6]

Also as previously discussed, traffic counting was available as an option, but with limitations. When attempting to count more than one lane of traffic in the same direction, occlusion could become a problem. The lane closest to the device would be counted with acceptable accuracy, but oncoming vehicles in that lane (especially large trucks) could block the PTMD from gathering accurate counts from the other travel lanes.

[6] Challenging locations like those in CA have caused the PTMD product developer is to consider considering additional housing options for the devices, including a portable box unit that could be strapped to a utility pole, sign posts, or other roadside device, since the footprint on the ground would not be a limiting factor.

Potential Future Uses

During the testing period, Caltrans staff identified a number of potential future uses for PTMDs. The PTMDs could be used in work zones to collect data in support of operational performance measures. The data could be shared with other agencies (e.g., law enforcement) to enhance their efforts to improve safety and mobility in work zones. Beyond work zones, the devices have potential utility in traffic operations studies and as a supplement to existing ITS assets during recurring congestion periods.

Identifying Work Windows for Construction and Maintenance

A number of decisions related to traffic flow at Caltrans (both work zone and non-work zone related) are based in part on a traffic capacity chart developed in the 1960s. Staff in Caltrans District 4 expressed interest in using PTMD devices to collect traffic volume data to calculate more realistic traffic capacity values for use in a number of applications, including the identification of work windows.

Due to high traffic volumes in California, especially in metropolitan areas, work windows for lane closures associated with construction and maintenance activity can be as short as 4 hours and be limited to the middle of the night. By reviewing recently collected PTMD data, Caltrans personnel hope they might be able to expand these work windows in certain situations. Adding available work hours during lower traffic volume periods can reduce the cost of contract work while still limiting the impact on motorists. The potential for "real-time window expansion" is also a possibility as Caltrans expands its use of PTMDs.

> *"The more we use the PTMDs and get used to them, we'll think of additional applications to improve our operation."*
> Kane Wong, Caltrans

For maintenance activities, Caltrans personnel typically call the Lane Closure Manager on the day of the closure. A maintenance supervisor will drive the route twice, confirm with the TMC, and then receive permission to perform their work. The devices could be collecting this data while the maintenance crew is having their pre-work "tailgate" meeting. TMC personnel could check the PTMD data on the web site and then call maintenance to authorize the lane closure based on that real-time data.

Innovative Contracting with Performance Measures

Caltrans has discussed a number of potential performance measures for contractors, including traffic flow. Caltrans could require a contractor to keep traffic moving at a minimum speed through the work zone. The PTMDs could measure that speed and report directly to the web site, which could be monitored by Caltrans staff. Based on some speed-related measurements (coupled with crash history data), the contractor could receive financial incentives or disincentives based on traffic flow and safety targets.

Enforcing Work Windows

Because of California's short work windows for lane closures, contractors sometimes attempt to "lengthen" these windows for their own financial gain, often to the detriment of the traveling public. Caltrans cannot have staff onsite at the beginning and end of every work window for every job; however, they could deploy PTMDs to collect pertinent information if there is a legitimate concern. Significantly reduced speeds outside the permissible work window could indicate a problem. Using this information, Caltrans personnel can follow up with a site visit to determine if the contractor is, in fact, working outside the allotted time.

Augmenting Speed Enforcement

In California, automated photo speed enforcement is not allowed, so Caltrans and the CHP have discussed the possibility of using PTMDs for "augmented speed enforcement" applications. The PTMD data could signal CHP officers of approaching motorists who are violating the speed limit within work zones.

Another potential application relates to law enforcement and speeding in work zones. Contractors sometimes insist they need law enforcement presence due to motorists exceeding the posted work zone speed limit. In Caltrans' experience, perceptions sometimes do not match reality, and engaging law enforcement staff can be costly. Instead of immediately dispatching an officer, Caltrans staff could assess and confirm the contractor's concerns by first placing a PTMD in the work zone. When the speeds consistently register significantly higher than the speed limit, Caltrans staff could then justify contacting law enforcement to request their presence.

Capacity Studies

Caltrans expressed interest in using the traffic volume counting feature of PTMDs to study capacity in unique situations. For example, when a one-lane ramp is temporarily striped for two lanes to increase capacity (due to a nearby work zone or some other issue), the ramp's capacity does not double, even though the number of lanes does. Caltrans would like to use PTMDs to measure the actual capacity in these situations to better predict the effect of future traffic control modifications on traffic flow.

Determining Travel Times

With a designated number of PTMDs deployed, an estimate of travel times can be calculated using speed data and the devices' GPS coordinates. With enough PTMDs in the study area, this information could be useful.

Beyond work zone applications, Caltrans personnel have discussed the idea of using the PTMDs to collect travel time data to analyze recurring congestion. Significant staff time is spent conducting travel time runs during congested peak hours throughout the individual districts, and the amount of data gathered is small—usually only two to three travel time runs each peak period. Deploying a number of PTMDs through a recurring bottleneck area would allow for a more cost-effective means of collecting speed data (that could be used to estimate travel times), potentially resulting in more effective traffic management.

Ramp Metering

Caltrans is considering using PTMDs to supplement permanent ITS devices along ramp metered freeways in the State. Caltrans staff indicated that they would benefit from more accurate data on certain routes at specific times, and the PTMDs could easily be moved to the locations with the greatest need.

Conclusion

Based on their experience during this test, Caltrans personnel reported that the PTMDs were easy to install and maintain. They felt that the devices enabled them to focus their activities on the areas that needed the most attention, while still monitoring areas that needed less active involvement. The data gathered during the test helped Caltrans personnel to better understand the queuing activity in and around work zones, and will help them plan work zone activities more efficiently and effectively in the future.

The device appears to have other potential uses and applications for the future to support the development of expanded work windows, the efforts of law enforcement, capacity studies, and collection of travel time data for both recurring and non-recurring bottlenecks. In addition, data from PTMDs can be used to supplement data gathered through permanent ITS devices in the field to improve the accuracy of the information available to traffic management center staff.

A few challenges were noted with using the device related to portability. One challenge is that, depending on usage, the batteries typically last only a few weeks, and recharging the batteries can be a somewhat cumbersome process as the devices have to be transported to a power source and then back to the field. Another challenge is that because the devices are so highly portable, they can easily be moved, intentionally or unintentionally, by contractors, maintenance workers, or the public.

Overall, based on the findings from users interviewed about PTMDs, the devices appear to be a cost-effective and flexible means for an agency to remotely monitor traffic conditions in their work zones and on their roadways in general.

Acknowledgements

Special thanks are offered to the following public agency and vendor personnel for their assistance in interviews and document review in support of this project:

- Dale McCrossen, Caltrans District 4 Division of Operations
- Kane Wong, Caltrans District 4 Traffic Management Center
- John Slonaker, Caltrans District 12 Division of Research & Innovation
- Amanda Ta-Chavez, City of Pasadena
- Joe Jeffrey, Road-Tech Safety Services, Inc.
- Lee Maynus, Calmar Telematics
- Ross Sheckler, Calmar Telematics