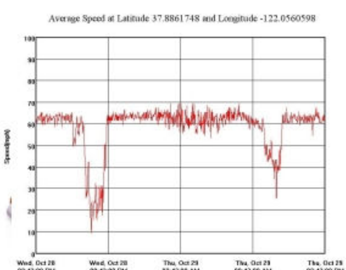
National Evaluation of the SafeTrip-21 Initiative: I-95 Corridor Coalition Test Bed Final Evaluation Report: North Carolina Deployment of Portable Traffic-Monitoring Devices

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-10-058

Submitted by:
Science Applications International Corporation
June 11, 2010

U.S. Department of Transportation
Federal Highway Administration

TECHNICAL REPORT DOCUMENTATION PAGE

1. Report No. FHWA-JPO-10-058	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: North Carolina Deployment of Portable Traffic-Monitoring Devices		5. Report Date June 11, 2010
		6. Performing Organization Code
7. Authors: Brian Chandler, Kari Beasley, Jennifer Rephlo		8. Performing Organization Report No.
9. Performing Organization Name and Address Science Applications International Corporation (SAIC) 8301 Greensboro Drive, Mailstop E-12-3 McLean, VA 22102		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 North Carolina conducted under the USDOT's SafeTrip-21 Initiative.

The North Carolina Department of Transportation (NCDOT) 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, NCDOT personnel reported that the PTMDs were easy to install and maintain. 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. Based on the findings from NCDOT users interviewed about PTMDs, the devices appear to be a cost-effective, safe, and flexible means for an agency to monitor traffic conditions on their roadways remotely.

17. Key Words Work Zone, WZ, Work Zone Monitoring, Portable Monitoring Devices, North Carolina, NC, 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 26	22. Price N/A

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Cover images courtesy of (clockwise from top): California Department of Transportation; Google; Calmar Telematics; Calmar Telematics; Calmar Telematics.

List of Abbreviations

CMS	Changeable Message Signs
DOT	Department of Transportation
FAP	Flashing Arrow Panel
I-95	Intestate 95
ITS	Intelligent Transportation Systems
NCDOT	North Carolina Department of Transportation
NCHRP	National Cooperative Highway Research Program
PTMD	Portable Traffic-Monitoring Devices
TOC	Traffic Operations Center
USDOT	U.S. Department of Transportation
US 64	U.S. Route 64

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, a major north-south route on the east coast, and in a number of locations in California. As part of this Federal initiative, the North Carolina Department of Transportation (NCDOT) 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 in-person interviews the Evaluation Team conducted with NCDOT staff in December 2009, and follow-up telephone discussions the team conducted with NCDOT in January and April 2010.

Background

Monitoring Traffic Conditions in Work Zones

Many roadways across the country are equipped with traffic-monitoring devices to provide State DOTs 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

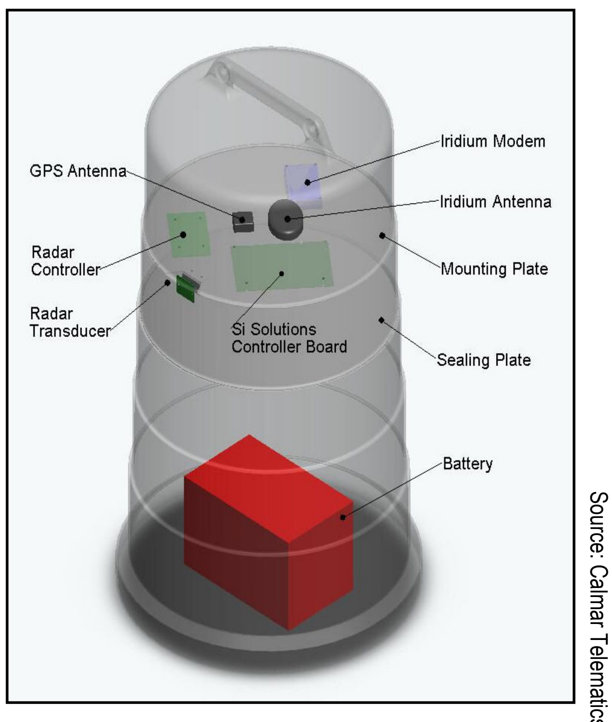


Figure 1. Diagram of PTMD

walks away. The device auto-locates using a built-in 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 a 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 North Carolina through interviews with NCDOT staff and the traffic control services provider. 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 NCDOT Test

NCDOT tested PTMDs in two work zones on I-95 and one work zone on U.S. Route 64 (US 64) during the 2009 construction season.

The Department has developed a set of mobility performance measures to apply to work zones on interstates and other access-controlled, high-speed freeways. The basic set of metrics is as follows:

1. Work zone queues less than three-quarter of a mile in length are acceptable for any length of time.
2. Work zone queues between three-quarters of a mile and 2 miles in length are acceptable for 2 hours in 1 day.
3. Work zone queues greater than 2 miles in length are not acceptable for any length of time.

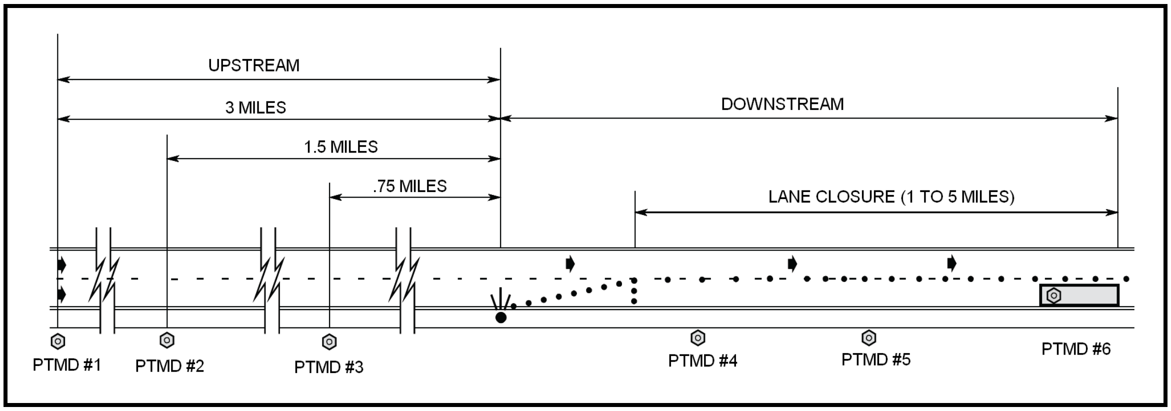
NCDOT chose to test the PTMDs on one type of construction project: an interstate asphalt overlay that involved closing one lane of traffic for a length of 1 to 5 miles depending on the day of week, as shown in Table 1 below. For the purpose of the test, each length of closure (number of miles) determines an individual test work zone. In a given week, the total length of the closure and the beginning length of the closure would be dependent upon the work performed. For a typical overlay project, the lane closure began as a 1-mile closure at the beginning of the week and progressed to 5 miles in length by the end of the week. Table 1 depicts a sample lane closure setup for a typical week of the North Carolina tests.

Table 1. Lane Closure Setup by Day of Week

Day	Lane Closure Setup	Length of Closure
Monday	The contractor sets up a 1-mile lane closure for personnel to begin their work.	1 mile
Tuesday	A second mile is added to the lane closure as the work continues down the road.	2 miles
Wednesday	A third mile of lane closure is added (and potentially a fourth, depending upon the week).	3-4 miles
Thursday	A fourth and fifth mile of lane closure is added by this time, if they have not already been added earlier in the week.	4-5 miles
Friday	The contractor completes the work for the week. The work zone is removed by noon on Friday to fully open the lanes for weekend traffic.	5 miles

Queuing in a work zone can be caused by a variety of factors, and it is often difficult to pinpoint the cause. Queues upstream of the merge area can be caused by merging or capacity issues at the merge point, or from unofficial rolling road blocks resulting from tractor trailers purposely slowing down side-by-side as they approach the work zone. Similarly, congestion issues downstream of the merge and adjacent to the work zone can be the result of capacity issues, motorists slowing to observe the work, or other factors such as the arrival and departure of construction delivery vehicles in and around the work zone. Work zones can be particularly challenging in situations where vehicular and work traffic share a lane. Going into this test, NCDOT personnel hoped that the PTMD system would help them to better understand where queuing most frequently occurred (i.e., either upstream of the merge point or downstream within the work area), how far the queues typically extended in either scenario, and the queue duration.

To begin the test, NCDOT developed a configuration for the PTMDs for each of the three test work zones. Each configuration required six PTMDs to collect the data needed to effectively determine where queuing was occurring. Three PTMDs were placed in the upstream portion of the work zone, and the remaining three were placed downstream in the active work zone itself (see Figure 2).



Source: North Carolina DOT

Figure 2. NCDOT Typical PTMD Layout

Upstream PTMD Placement

The PTMDs were placed upstream of the flashing arrow panel at increments of 3 miles, 1.5 miles, and .75 miles. To ensure that the upstream queuing was within NCDOT's 2-mile limit described in their performance measures, the second PTMD was placed 1.5 miles upstream of the FAP. By placing the device at this location, NCDOT staff would be able to monitor queuing and catch potential issues before they exceeded NCDOT's 2-mile queue length performance metric.

Downstream PTMD Placement

PTMD Number 4 was placed within 1,000 feet downstream of the FAP, after the lane drop, where traffic was merged into one lane. The fifth PTMD was placed at a point half the length of the total lane closure. This necessitated PTMD Number 5 to be moved each day as the lane closure length was extended or shortened. The sixth and final PTMD was to be placed within the work area to measure vehicles speeds adjacent to workers.

> *In North Carolina, upstream queues exceeding 2 miles for any length of time are unacceptable. Situational awareness is key for NCDOT to meet this performance measure.*

NCDOT Test Objectives

NCDOT developed very specific objectives for their PTMD test. They wanted to use the PTMDs to determine how well NCDOT lane closure restrictions met work zone mobility performance goals. The NCDOT test objectives are identified as follows:

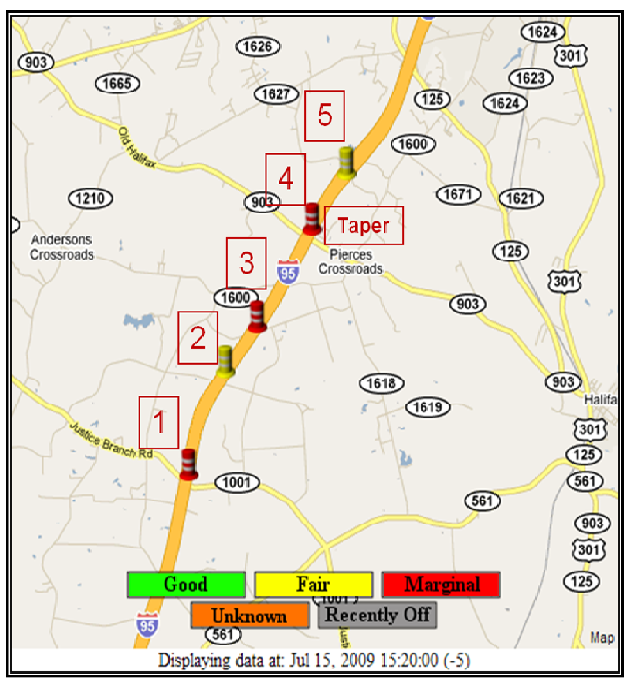
1. Determine where queues develop and determine the total lengths of the queues (upstream queue plus downstream queue).
2. Collect data to support establishing work zone performance measures for interstates and other high-speed, access-controlled facilities.
    - Verify that upstream queue lengths are maintained at 2 miles or less.
    - If upstream queue lengths exceed 2 miles, identify the days and times when the queues exceed 2 miles, the total duration of event, and the length of the lane closure when the long queues occur.
    - Identify whether queuing develops within the lane closure itself, and, if so, determine the length of the downstream queue (with the maximum downstream queue extending to the FAP).
    - Identify to what extent the physical length of the lane closure affects the total queue length and queue duration.
    - Identify travel speeds in close proximity to the work area (i.e., within 1,000 feet of the paving crew) versus speeds inside the lane closure but away from the work area.

Test Sites

NCDOT tested the PTMDs in three work zones during the 2009 construction season. The first two work zones involved setups along I-95 – one in Nash County and one near Roanoke Rapids. NCDOT tested the units in a third work zone on US 64 near Raleigh.

I-95

I-95 in this region is a popular route for vacation traffic traveling south during the summer months, so traffic can be heavy, particularly on weekends. Because of this, NCDOT only allows work zone lane closures during the work week and specified that they must be cleared by noon on Friday to accommodate the large weekend traffic demand. The two work zones on I-95 followed the Monday – Friday schedule previously described in Table 1 for most weeks that the work zones were active. Deviations from this schedule depended on construction site conditions.



Source: Calmar Telematics

Figure 3. Map Representation of a PTMD Application on I-95[2]

[2] Figure 3 shows only five PTMDs instead of the six discussed in the description of the setup due to one of the PTMDs having been struck by a vehicle and being rendered non-operational.

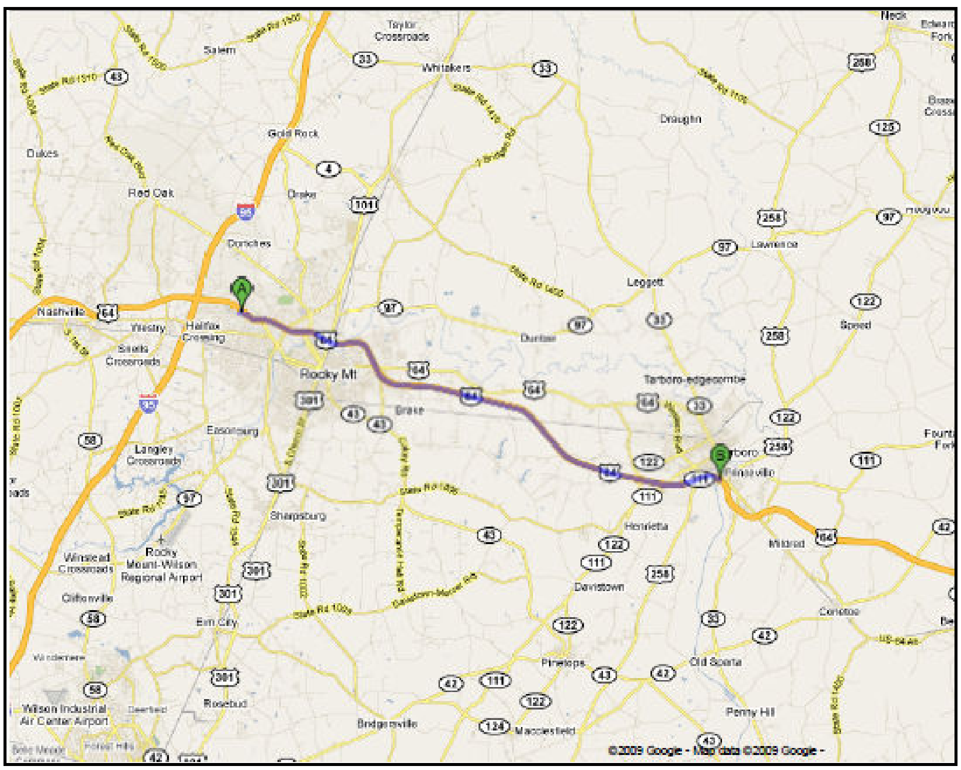
Figure 3 (above) depicts one of the test corridors along I-95, along with the deployment of the PTMDs. This I-95 application took place between mile markers 166 and 172. The work performed along I-95 consisted of a four-lane interstate resurfacing job (both lanes in both directions). Lane capacity was reduced from two lanes to one lane in the active work direction (see Figure 4).

Source: North Carolina DOT

Figure 4. NCDOT Lane Closure

US 64

This application occurred along US 64 between Rocky Mount and Tarboro, near mile markers 466 and 486. Figure 5 depicts the location of the work zone along US 64.



Source: Google

Figure 5. Map Representation of the US 64 test location

The initial purpose of this deployment was to install PTMD devices on US 64 as part of a low-cost dynamic merge system to handle the varying traffic demand throughout the day in this quick-moving work zone. The concept was as follows:

- When traffic was at free-flow speeds, the PTMD would communicate this information automatically to a nearby changeable message sign (CMS). The CMS would then direct motorists to merge into one lane at a distance upstream of the merge point, where vehicles would proceed single-file through that merge point and into the work zone.
- Conversely, if speed data gathered by the PTMD indicated congested conditions, the CMS would direct motorists to use both lanes until the merge point and to then alternate merging as they enter the work zone at the taper point (i.e., a "late merge"). This would shorten the overall queue length and hopefully prevent queues from spilling past advance warning signs or upstream interchanges.

Unfortunately, due to the age and legacy software of the NCDOT-owned CMS equipment, NCDOT was unable to interface the two devices in time to test the dynamic lane merge capabilities of the PTMDs on the US 64 project. When the agency determined that this application was not feasible with their current equipment, they used the PTMDs to collect data on US 64 similar to the aforementioned deployments on I-95.

One other innovation NCDOT tried on the US 64 project involved the sixth PTMD. On the I-95 projects, this device was located on the roadside near the work crew, but it was difficult to keep it in the optimum location for the duration of a work day. On the US 64 project, a special version of the PTMD was developed for mounting on the roller. Dubbed a "PTMD in a Box," this configuration enabled the last PTMD to move with the workers so that speed data could be collected at the exact point where motorists were adjacent to active work.

Evaluation Findings

The Evaluation Team conducted in-person interviews over a 2-day period in December 2009. The Evaluation Team interviewed a range of NCDOT staff, including the Statewide Project Engineer for Work Zone Traffic Control; the State Incident Management Engineer; and both a Resident Engineer and a Construction Inspector from the Division 4 (Nashville) Resident Engineer's office. Additionally, the Evaluation Team interviewed a traffic control services vendor who works with NCDOT on work zone-related devices.

The Evaluation Team conducted follow-up telephone interviews with these staff in January 2010 and April 2010, gaining further insight into their experiences.

Ease of Installation

NCDOT personnel reported that installation was quite straightforward. Since the PTMD is powered by battery, communicates via cellular or satellite communications, and looks like a traditional work zone drum, the device was able to be placed anywhere a work zone drum would be placed. Since North Carolina routinely uses drums as delineators in their work zones, the PTMDs blended into the work zone setups quite well. The operator positioned each drum at the desired location, aligned the arrow at the top of the PTMD to point *toward* traffic for collection of speed data, and turned on the device by flipping a switch. At this point, the PTMD began collecting data and sending it to the online database.

Ease of Maintenance

NCDOT found the devices to be relatively easy to maintain. The only significant maintenance activity found necessary during the test period was recharging the batteries, which is required for the device to be portable. Based on NCDOT's experience with the devices, the batteries lasted approximately 2 to 3 weeks before they needed to be recharged (assuming the PTMD was switched off each night at the end of the work day and over the weekend). Due to the construction phasing at the North Carolina test sites, the six PTMDs were typically transported to a charging location over the weekend.

In North Carolina, a local traffic control services provider took responsibility for charging the PMTD batteries when necessary. The vendor took advantage of the product's automated alert system that sent an email notification directly to the vendor when the voltage for any of the PTMD batteries dropped below a certain user-determined threshold (typically 10.5 V). At that point, the vendor knew the PTMD would operate for approximately 48 hours before the battery needed to be recharged.

When a device needed to be recharged, the entire device was transported to a charging location (e.g., back to the nearest NCDOT office, or to any other location with a standard electrical outlet). The PTMDs were small enough to fit in the back of a pickup truck, and a single unit could even fit in the backseat of an SUV for transport, if necessary (see Figure 6).

The user manual for this particular device indicates that the battery can be fully charged in approximately 4 hours, but the traffic control services provider found that it was preferable to charge the devices over the weekend and to transport them back out to the field first thing Monday morning.

The vendor personnel did not find battery charging to be a problem for the six PTMDs being used in this test; however, depending upon the location of the work zones and the number of units in use, they felt that this could become a time-consuming process if their use was expanded throughout the state. In a rural state like North Carolina, work is often performed far away from any NCDOT offices; this could limit large scale, long-term deployment in North Carolina or in other states with a large number of rural work zones.[3]

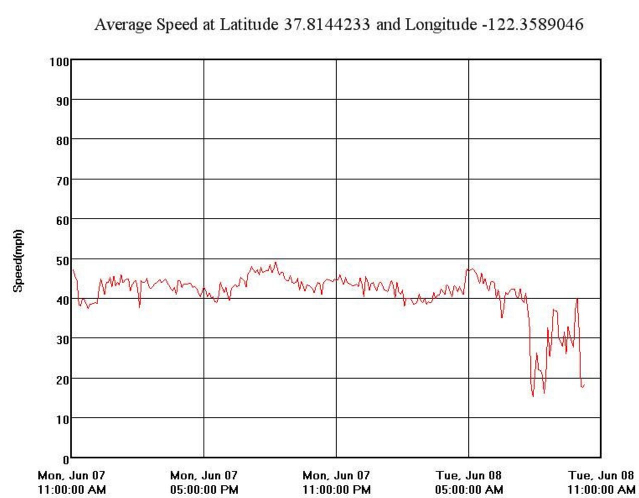
Source: Calmar Telematics

Figure 6. Transporting PTMD for Battery Recharge

Ease of Use of Data Interface

NCDOT staff reported that they were satisfied with the web-based user interface. They cited the website's ease of use and attractive interface as benefits. The interface provided them with a map of the area with icons showing the current location of the agency's deployed PTMDs on I-95 and US 64. The web site provided basic real-time speed data from the map view.

At the field level, the Resident Engineer expressed that the "access anywhere" feature of the web-based tool was beneficial. He was able to observe traffic flow data from his home computer via the PTMD web site, instead of having to travel to the office or the job site.



Source: Calmar Telematics

Figure 7. PTMD Graphical Report

NCDOT staff reported that the information available beyond the basic map was also useful. Real-time and historical data was available to the agency on a password-protected version of the web site. Authorized users accessed the data in a tabular format or in the form of graphical reports, similar to the example shown in Figure 7.

[3] 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.

Accuracy in Collecting Speed Data

Due to NCDOT's regular use of traffic drums in work zones, the PTMD was essentially invisible to the driver, mitigating data skewing that can occur when traffic-monitoring devices are conspicuously placed along a roadway. NCDOT's Resident Engineer for this project informally tested the validity of the data by using the web interface to monitor the speeds through the work zones and then calling the inspector at the job site to determine if the PTMD speeds seemed reasonable. In his experience, the speeds reported by the PTMDs were accurate when compared to the general speed reported by the inspectors from their visual observations. In the future, NCDOT staff plan to compare the speeds from their PTMD applications with permanently installed ITS assets to more rigorously evaluate the device's accuracy. Despite the fact that NCDOT staff did not conduct any formal studies to validate the accuracy of the speed data, they felt confident the data were sufficiently accurate for their purposes.

Benefits

NCDOT staff cited a number of benefits of the PTMDs, including cost-effective situational awareness, support of policy decisions, and data warehousing capabilities. These benefits are described below.

Situational Awareness

PTMDs provide situational awareness at a lower cost and with reduced highway agency staff exposure to traffic.

In many states, ITS equipment is typically located in urbanized areas that experience recurring congestion. This presents a challenge for effectively managing incidents and work zones in rural areas, as the cost to deploy ITS assets or place staff on-site is high. This is a particular challenge in North Carolina, where the vast majority of the more than 80,000 miles of State-maintained roadways are not near the urban centers and are therefore not often equipped with ITS devices. These locations are also often far from State highway agency offices, requiring a significant resource investment to provide first-hand support. In order to achieve situational awareness of work zones in these areas, NCDOT needed alternative means of collecting data to determine if their current traffic control methods are effective.

NCDOT staff cited the PTMD as an effective situational awareness tool for rural locations. Instead of visiting work sites, the Resident Engineer (RE) and other personnel were able to use the PTMDs to gain an awareness of the traffic situation in their work zones remotely. For lane closures that continued through the night and beyond a typical day shift, the RE found it helpful that traffic flow data from these locations could be accessed from his home computer via the PTMD web site.

NCDOT personnel cited an additional safety benefit associated with the PTMDs regarding the collection of traffic count data. Staff members currently place pneumatic tubes across the roadway, subjecting themselves to potential hazards while doing so. PTMDs allow personnel to collect traffic volume data without requiring them to work in the travel lane.

Data Warehousing

Beyond the ability to access traffic data in real-time, NCDOT staff indicated long-term data warehousing as a significant benefit of the web-based database the PTMDs generate. The web site for the PTMDs stores and archives the data for 5 years, giving NCDOT staff the flexibility to analyze historical data at their leisure.

Additionally, staff noted that in the future NCDOT will have the ability to hire a third-party firm to directly acquire, analyze, and report on the data without any direct intervention by NCDOT. The agency staff expressed that they do not have the resources available to analyze the data themselves, nor the time to act as a liaison between the data warehouse and the analysts. Further, hiring an independent contractor for analysis and reporting supports the unbiased nature of the final results.

> *"I will never have to touch the raw data. I can hire someone to analyze the data and report only the information I care about."*
> Steve Kite, NCDOT

Challenges and Limitations

NCDOT did experience a few challenges during the course of the test and discovered some limitations of the device. These challenges and limitations are described below.

Technical Difficulties

NCDOT experienced some technical issues early on with the PTMDs. When NCDOT originally received the PTMDs and placed them in the field, there was a problem with the chargers. Two of the three supplied chargers were wired incorrectly from the manufacturer, resulting in a blown fuse whenever the PTMDs were charged. It took NCDOT and the PTMD manufacturer about 2 weeks to troubleshoot and pinpoint the problem. Once the issue was resolved, the PTMDs were re-deployed in the field with the new chargers and experienced no further problems.

Another challenge NCDOT experienced was related to keeping the devices in the correct location throughout the week. NCDOT's PTMD setup included two devices inside the lane closure that were to be moved with the active work operation. For the RE and construction inspectors on the job, it was sometimes difficult to keep the PTMDs inside the lane closure at the desired location throughout the week during fast-paced paving operations. Because of this, PTMD 5 and 6 were not always collecting data at the ideal location.

This issue was mitigated on the US 64 project with the "PTMD in a Box" solution. When NCDOT attached the PTMD to the paver, it constantly collected speed data directly adjacent to the workers.

Devices Moved or Hit

The fact that the PTMDs look identical to a construction drum is a benefit in that they are invisible to motorists, but this attribute can also pose a challenge as contractors may not realize that they are a separate piece of equipment for which they are not responsible. On a few occasions, the PTMDs in North Carolina were mistaken as normal drums by the contractors and were hauled off to the contractor's storage locations at night or on the weekends. Typically, these units could be easily located with the built-in GPS functionality in the PTMD. On one occasion, however, the PTMD's battery died, rendering the GPS function inoperable and making it difficult for NCDOT and the vendor to locate the device.

Another challenge is that the devices, like regular construction drums, are susceptible to damage by motorists and construction equipment. NCDOT staff had initially placed the devices in line with the other drum delineators in the work zone, and as a result a few PTMDs were hit in the field either by contractor equipment or by the traveling public, with two PTMDs being damaged beyond repair during the test period. After these incidents, NCDOT elected to move the PTMDs further away from active traffic.

Limited Benefit for Field Staff on Large-Scale Projects

For work zone managers at the state level, the data provided by PTMDs was deemed beneficial, especially to aid in planning future temporary traffic control strategies, potential future performance measurement, and policy changes. However, NCDOT personnel on-site felt that the PTMDs may have limited benefit on large-scale projects, based on their experience during the test period. For a project the scale of the freeway resurfacing jobs in North Carolina, there is an inspector on-site at all times while work is in progress. The information provided by the PTMDs was sometimes redundant, as the inspector on the job was fully aware of any traffic situations that needed immediate attention.

NCDOT personnel indicated that PTMDs might provide an increased benefit during real-time application in short-duration work zones or during unscheduled incidents.

Potential Future Uses

During the 2010 construction season, NCDOT plans to use PTMDs on three to five projects across the State. NCDOT currently uses a third-party provider of travel times and traffic speeds using a combination of GPS-equipped vehicles and other means. NCDOT personnel would like to compare data collected by PTMDs with speed and travel time information gathered by the third-party provider to determine if one or the other is more helpful to the Department.

Additionally, NCDOT personnel see additional uses for the PTMDs across their State in the future, including construction work zone planning, measuring work zone performance measures and setting policy, setting work zone speed limits, work zone travel times, congestion management, integration with existing ITS assets for traveler information, emergency evacuation management, law enforcement support, and incident management. These potential future uses are described in further detail below.

Construction Work Zone Planning

NCDOT personnel suggested that the PTMDs could be used to monitor pre-construction traffic conditions in work zones and could provide a control scenario to use when predicting the impacts that the work zone will have on travelers. Another use that NCDOT sees for these devices is in coordinating activities in multiple work zones. Each individual project's layout has an effect on other nearby work zones, but by using PTMDs to monitor these conditions, the impacts of multiple work zones on the traveling public could be better understood and minimized.

Measuring Work Zone Mobility Performance Measures and Setting Policy

NCDOT has developed a set of mobility performance measures as discussed in the *NCDOT Test* section above. Agency personnel expressed interest in using PTMDs to collect data and compare it to these measures.

As an example, if a large number of work zones on NCDOT interstates (e.g., 40 or more) were equipped with PTMDs for one construction season, enough data could be gathered to measure performance of North Carolina's overall work zone mobility program against their established metrics. Reports based on that data could tell NCDOT if problems exist, and if so, where they are most often occurring. Once this information is available, work zone personnel could more effectively deploy strategies to improve mobility.

Additional information regarding NCDOT's work zone performance measures is available in Appendix A: Draft Work Zone Performance Measures on the Statewide Tier 1 Network – Interstate and Control of Access Freeways.

Setting Work Zone Speed Limits

NCDOT personnel have been discussing potential changes to how they handle work zone speed limits during the overnight hours when there are no work activities. In some situations, the work zone speed limit signs are covered so that speeds can revert back to the non-work zone speed limit. In other cases, the work zone speed limit remains in place.

NCDOT could use the PTMDs to collect speed data in both overnight speed limit situations. Based on the information gathered, NCDOT staff would have the information necessary to make a substantiated data-driven policy decision about how to handle work zone speed limits during the overnight hours.

Work Zone Travel Times

North Carolina has been a national leader in efforts to include advanced technology in work zones in recent years. One goal of North Carolina's efforts has been to provide motorists with more information as they approach a work zone, and PMTDs could certainly be used in support of this effort.

As one example, data from the PTMDs could be used in combination with a changeable message sign to provide drivers with two important pieces of data:

1. Time to travel through the work zone.
2. Time to drive around the work zone on a prescribed detour.

Congestion Management

A non-work zone potential use NCDOT staff cited is that PTMDs could be incorporated into traffic incident management programs to help monitor recurring congestion at known hot spots, non-recurring congestion due to incidents, and congestion related to special events.

During the on-site interviews, NCDOT personnel discussed a situation involving an ongoing full closure on Interstate 40 (I-40) due to a rock slide. It was unknown how the closure and associated detour might affect traffic flow over major travel weekends. In future similar situations, PTMDs could be deployed near the road closure and on the detour routes. This information could provide situational awareness to NCDOT personnel and could be used to provide travelers more detailed information about detour travel times.

Integration with Existing ITS Assets for Traveler Information

NCDOT currently purchases data from a third-party vendor to populate its 511 Traveler Information system. The data is primarily derived from GPS-equipped fleet vehicles, so the number of data points is relatively small; NCDOT feels that the resulting data consequently lacks precision. NCDOT sees a potential opportunity for the PTMDs to be deployed at various locations around the State to increase the number of data points, thereby improving the precision of the data as a whole. Additionally, the spot-location speed data could be sent to a TMC to alert staff about potential incidents, or the PTMD could be linked directly to a nearby changeable message sign to alert drivers of potential congestion ahead.

NCDOT staff would like to see the PTMDs placed on more projects along the statewide interstate network to monitor traffic performance in urban areas, monitor traffic conditions in work zones and share pertinent information with the public.

Until this past fall, NCDOT did not have a map-based traffic management system, making it difficult to integrate the PTMD data with the purchased data described above. In the future, NCDOT sees the PTMDs as additional data points on the map, easily moved to the most appropriate locations based on real-time needs.

Emergency Evacuation Management

Natural disasters resulting in evacuation are another type of event where the use of PTMDs could help incident management professionals with situational awareness. In North Carolina, most evacuation routes are not instrumented with ITS assets. NCDOT personnel feel that PTMDs could be a cost-effective use of resources and technology for monitoring and improving traffic flow during these events. Additionally, the PTMD data could be used by NCDOT personnel to inform travelers of the most appropriate routes to use during emergency evacuations.

Law Enforcement and Incident Management

NCDOT personnel felt that law enforcement personnel could also potentially benefit from the data gathered with a PTMD. The PTMD could alert Highway Patrol units via email about speed-related issues, which could support targeted speed enforcement efforts. Highway Patrol personnel could monitor speeds within work zones in a low-cost manner, using valuable resources only at the locations with an identified need.

NCDOT is currently working on developing a plan for integrating law enforcement into incident management using ITS technologies. Under this plan, some NCDOT personnel would have direct access to the Highway Patrol radio system, and the patrol would be co-located in NCDOT's new Traffic Operations Center (TOC). NCDOT envisions GPS-equipped DOT and Highway Patrol vehicles integrated with the TOC, enabling the dispatchers at the TOC to accurately choose the closest and most available unit to respond to a traffic incident or other emergency. Once an incident is identified and first responders activated, NCDOT could deploy PTMDs immediately to provide on-scene traffic flow data to the TOC.

Conclusion

Based on their experience during this test, NCDOT personnel reported that the PTMDs were easy to install and maintain. 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. They are hopeful that the data gathered during the test will help them better understand queuing activity in and around their work zones and help them to better plan work zone activities in the future.

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

The devices appear to have many other potential uses and applications in non-work zone-related areas, including incident and evacuation management, law enforcement, and travel time data collection 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.

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

Acknowledgements

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

- Steve Kite, North Carolina DOT
- Brian Purvis, North Carolina DOT
- Steve Joyner, North Carolina DOT
- John Arms, North Carolina DOT
- Dean Fowler, Stay Alert Safety
- Lee Maynus, Calmar Telematics
- Ross Sheckler, Calmar Telematics

Appendix A: Draft Work Zone Performance Measures on the Statewide Tier 1 Network – Interstate and Control of Access Freeways

North Carolina DOT
Draft Version: November 23, 2009

POLICY STATEMENT

The North Carolina Department of Transportation is committed to the continuous movement of traffic through all work zones by the reduction or elimination or delays on the statewide tier network of interstate and control of access freeways. It is our goal to minimize the impacts on the traveling public resulting from the implementation of work zones. Therefore, all projects and activities which impact the travelling public shall be analyzed to ensure the necessary steps to prevent unreasonable traffic delays to the extent possible.

Compliance with the policy will benefit the traveling public, the construction industry and the business community by reducing the travel time and potential work zone crashes. Because of its impact on project development, the determination and analysis of options for maintenance of traffic must occur at the beginning of the planning process as described herein.

This policy outlines the procedures to be followed and the personnel responsible for its full implementation on the statewide tier network. The North Carolina Department of Transportation can waive mandatory conditions contained in the policy upon approval by the State Traffic Engineer and the State Traffic Management Engineer.

PERFORMANCE CRITERIA

North Carolina's performance criteria will be a combination of acceptable queue lengths and queue duration. A queue is present and defined as the point at which traffic is either stopped or slowed more than 25 mph below the posted speed limit to the point where traffic has resumed an average speed of 45mph or greater. The following thresholds shall be used to establish the Work Zone Mobility Performance Index on the Statewide tier for interstates and freeways.

Criteria 1. All queues less than .75 miles are acceptable for any duration of time.

Criteria 2. Once queues reach .75 miles and extend to maximum length of 2 miles, they are considered acceptable for a duration of up to 2 hours for any given day's work operation. If conditions exist longer than 2 hours, then the work zone impacts are unacceptable. Alternative strategies shall be considered per the provision of this policy.

Criteria 3. Queues that exceeds 2 miles in length for any period of time are unacceptable.

SAMPLING PERCENTAGES

Since it's impractical to sample every project on our State's interstate and freeway network, some reasonable amount of sampling has to be established in order to manage measurement efforts. It's our goal to **measure 20% of the statewide projects let annually** through the Transportation Improvement Program. These projects will include the pavement preservation/

resurfacing program as well as traditional interstate/freeway reconstruction projects. Project selection will be made through a coordinated effort between the FHWA, State Traffic Engineer, State Traffic Management Engineer, the Division and the Construction Unit. **These measurements will be taken annually during peak construction season between the months of April and October until each candidate project is completed.**

Data is to be collected using portable intelligent transportation collection devices that will be either included in the prime contract or let as a separate contract through the State Traffic Management Engineer. These devices will be provided and maintained by an unbiased, non-stakeholder in order to ensure the integrity of the data collection process.

REPORTING THE RESULTS

Once the data is collected, the North Carolina Department of Transportation will either use the Traffic Safety Unit, or private consulting services to analyze and the report the results. In either case, the measured data is to be compared to the above mention criteria to establish the Work Zone Mobility Performance Index. This index is defined as the percentage of time the project meets, exceeds or falls below the performance criteria.

Work Zone Mobility Performance Index

Exceptional Performance = Compliance with Performance Criteria 1 and 2 above 90% of the measurable days between the months of April and October and cannot violate Criteria 3 on more than 2 occurrences during the measureable days.

Acceptable Performance = Compliance with Performance Criteria 1 and 2 between 70% and 90% of the measurable days between the months of April and October and cannot violate Criteria 3 on more than 7 occurrences during the measureable days.

Unacceptable Performance = Less than 70% of compliance with Performance Criteria 1 and 2 during the measurable days between the months of April and October or more than 7 violations of Criteria 3 during the measureable days.