Intelligent Transportation Systems
Field Operational Test
Cross-Cutting Study

Emergency Notification And Response

September 1998

Prepared for:
U.S. Department of Transportation
Federal Highway Administration
Washington, D.C.

By:
Booz·Allen & Hamilton
Highway & Vehicle Technology Group
McLean, Virginia

Technical Report Documentation Page

1. Report No. FHWA-JPO-99-033	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle INTELLIGENT TRANSPORTATION SYSTEMS FIELD OPERATIONAL TEST CROSS-CUTTING STUDY EMERGENCY NOTIFICATION AND RESPONSE		5. Report Date September 1998 6. Performing Organization Code Booz•Allen & Hamilton Inc.
7. Author(s) Samuel Boyd		8. Performing Organization Report No.
9. Performing Organization Name and Address Booz•Allen & Hamilton Inc. 8201 Greensboro Drive Suite 609 McLean, Virginia 22102		10. Work Unit No. (TRAIS) 11. Contract or Grant No. DTFH61-94-C-00207
12. Sponsoring Agency Name and Address U.S. Department of Transportation Federal Highways Administration Intelligent Transportation Systems Joint Program Office 400 Seventh Street, SW, Room 3422 Washington, DC 20590		13. Type of Report and Period Covered Cross-Cutting Study November 1997 – September 1998 14. Sponsoring Agency Code HVH-1
15. Supplementary Notes Contracting Officer's Technical Representative (COTR) - Joe Peters, Room 3416		

16. Abstract

Emergency Notification and Response report summarizes and interprets the results of two Field Operational Tests (FOTs) that included emergency notification and response system components. The tests included in this report are: Colorado Mayday and Puget Sound Help Me. These tests supplied technical lessons about the function of the emergency systems. The test evaluations solicited user responses regarding acceptance and ease of use of the systems through a series of focus groups. These tests encountered few institutional challenges. The report findings are organized in the categories of impact, user response, technical lessons learned, institutional challenges and resolutions, and cost to implement. This report highlights the successes and problems these tests encountered while attempting to develop the technologies appropriate to establishing and implementing emergency notification and response systems.

17. Key Words Emergency Notification and Response, FOTs, Field Operational Tests, ITS Lessons Learned, Cross-Cutting, ITS Impacts	18. Distribution Statement No restrictions. This document is available to the public through the National Technical Information Service, Springfield, Virginia 22161.

19. Security Classif. (of this report) Unclassified	20. Security Classif. (of this page) Unclassified	21. No. of Pages 15	22. Price

Form DOT F 1700.7 **(8-72)** Reproduction of completed page authorized

TABLE OF CONTENTS

EXECUTIVE SUMMARY

Emergency notification and response systems and associated services aid a specific individual or motorist to request help from, and provide information to, authorities about a distress situation. The existing 911 emergency phone system is often overloaded by multiple calls about the same emergency and by non-emergency calls. Emergency notification and response systems are intended to provide appropriate assistance to distressed vehicles in a more timely manner by providing accurate information to emergency response operators. This report summarizes and interprets the results of two Field Operational Tests (FOTs) that included emergency notification and response system components.

These tests supplied several technical lessons about the function of the emergency systems. The computer system and mapping database used by emergency call-takers must display and update the map quickly and display a wide range of geographic and political attributes in the area surrounding the location of the incident. The systems attained good positional accuracy (within 100 meters in 44% of the trials). Cellular communication coverage was strong and reliable in densely populated counties but unreliable in areas of marginal or poor cellular coverage. The tested Global Positioning Systems (GPS) experienced difficulties in accurately locating vehicles when they were in enclosed spaces or "urban canyons," but were accurate when vehicles were in forested or open terrain. Operators at the call taking service center were able to locate the calling vehicle accurately (within half a city block) in 82% of the trials.

The test evaluations solicited user responses regarding acceptance and ease of use of the systems through a series of focus groups. One focus group determined that a purchase cost of $150 and a monthly service charge of from $5 to $20 would be an acceptable price for the notification service. In another test, users found the system easy to use and felt more secure with the system available. These users also felt that the systems would help responding authorities deliver the appropriate assistance. Some users complained about the difficulty of physically connecting the components of the system to their vehicles. Opinions about one tested system indicated a negative response with regard to its reliability.

These tests also encountered few institutional challenges. Project partners overcame several issues early in the projects. The most significant issues concerned the future deployment of such systems. Since the tests were conducted, the federal government has introduced regulations that require wireless phone systems to provide some of the capabilities that the tested systems developed and evaluated. (Specifically, the requirement that wireless phone calls be locatable within a certain distance.) These requirements and the progress of the technology have superceded some of the capabilities of the tested systems. Another issue concerned the use of private service centers to screen emergency calls before passing them on to Public Service Answering Points. The tests tended to support the concept of these private service centers to screen calls. However, the public partners of the tests did not consider the use of such centers essential while private partners considered these centers necessary.

This report highlights the successes and problems these tests encountered while attempting to develop the technologies appropriate to establishing and implementing emergency notification and response systems.

REPORT BACKGROUND

In 1991, the U.S. Department of Transportation (USDOT) initiated a new program to address the needs of the emerging Intelligent Transportation Systems (ITS) field. This program solicited and funded projects, called FOTs. The tests were sponsored and supported by several administrations of the Department, including the Federal Highway Administration (FHWA), the Federal Transit Administration (FTA), and the National Highway Traffic Safety Administration (NHTSA).

The FOTs demonstrated potentially beneficial transportation products, technologies, and approaches. The FOTs implemented these products, technologies, or approaches on a limited scale under real-world operational conditions. These tests were an interim step bridging the gap between conventional research and development (that formed the idea), and full-scale deployment (that would see wide-spread use of the idea). FOTs typically included a local or regional transportation agency, as well as the FHWA, as partners in the project. The partners often included private sector providers of the equipment, systems, and services interested in demonstrating their idea. The FOTs concentrated on user service areas needing a “proof of concept” in order to achieve deployment goals.

A fundamental element of each test was an independent, formal evaluation. The evaluation produced a final report that detailed the test’s purpose, methods, and findings. The evaluation aspect of the test intended to assess whether the product, technology or approach provided effective solutions at acceptable levels of cost, schedule, and technical risk.

As the sponsoring organization and a partner in many of the FOTs, the FHWA played a central role. FHWA supported the tests by providing a standardized set of evaluation guidelines and by helping coordinate and promote the relationships among test partners. The FHWA also acted as the communications clearing house collecting reviewing, and disseminating information about the tests.

Among the more than 80 FOTs, several tests encompassed the same or similar areas of interest. The FHWA is preparing several “cross-cutting” studies that compare or synthesize the findings of multiple tests within a particular area of interest. The purpose of this series of studies is to extract from the separate tests the common information and lessons learned that are of interest to ITS practitioners and that could improve the testing and deployment of future applications of the subject technology.

This study focuses on the topic of Emergency Notification and Response (EN&R) using ITS Technology.

INTRODUCTION

EN&R is a system and associated services for requesting help from, and providing information to, authorities about a specific individual or motor vehicle in distress. The idea of EN&R came into being in 1993 when FHWA published a request for proposals for systems that would improve emergency response to vehicular incidents.

These systems were to be deployed and evaluated on a limited scale in near real-world conditions in order to determine their feasibility and foster new economic markets. As a result, Colorado Mayday and Puget Sound Help Me (PuSHMe) began as federally funded operational tests.

The Colorado Mayday and PuSHMe FOTs have issued final evaluation reports. Consequently, the reported findings represent Booz•Allen & Hamilton current understanding of the lessons learned in EN&R based on these two FOTs.

The need for EN&R systems is demonstrated by today's emergency 911 phone system. Often saturated due to large call volumes and sometimes inappropriate use by the public, Public Service Answering Point (PSAP) operators estimate that for every incident on the roadway, twenty or more cellular calls are received from "good samaritan" drivers passing the incident scene. These redundant calls burden the PSAP operators and occupy the available phone lines, preventing other emergency calls from getting through. Additionally, non-emergency calls occupy the time of PSAP operators in lieu of true emergency calls.

EN&R systems offer a relief to emergency 911 phone systems by directing calls to the appropriate response agency or by introducing Mayday Processing Centers (MPCs) which receive emergency assistance request signals from in-vehicle units. A distressed vehicle containing an in-vehicle unit sends an emergency signal via GPS to an MPC. The emergency signal is received at the MPC as raw GPS data where it is analyzed and the distressed vehicle location is determined. EN&R systems also help define the type of service needed. Some systems offer in-vehicle devices configured with multiple service selection buttons to allow the user to request a particular type of service. Therefore, non-emergency calls may go directly to a private Customer Service Center (CSC). Both MPCs and CSCs are types of monitored response centers. The former typically being public and the latter privately run.

The premise of an EN&R system is to help provide appropriate assistance to distressed vehicles in a more timely manner by providing more accurate information to PSAP operators and ultimately to the response units they dispatch.

FOTs Considered In This Analysis

Colorado Mayday

The Colorado Mayday Emergency Response Request System utilizes the Tidget Mayday System (an In-Vehicle Emergency Response System (IVERS) developed by NAVSYS Corporation. The Colorado Mayday system test used GPS to determine vehicle location, and the cellular infrastructure to communicate between the vehicle and the MPC. To help reduce the production costs of the Tidget, a unique approach was taken by using GPS. The Tidget device captured a snapshot of the signals being received from the GPS satellite constellation. The Tidget forwarded only the raw "snapshot" data to the MPC instead of processing the GPS data in the vehicle and forwarding the calculated latitude/longitude to the MPC. A central processor at the MPC received the data through the cellular network and calculated the location of the vehicle. A map database provided support when fewer than four satellites were "visible". The entire system was triggered by the Tidget located inside the test vehicles. By removing the GPS processor from each Tidget and calculating vehicle locations centrally, the production costs of the Tidget was reduced.

PuSHMe

PuSHMe was an operational test project that implemented and tested a regional Mayday system. The project involved the deployment of two systems, Motorola and XYPOINT, that allowed test groups of users to signal a need for emergency assistance to a monitored response center. Both systems used Differential Global Positioning System (DGPS) technology to locate signaling vehicles. Both systems employed Private Response Centers (PRC) to facilitate interaction between distressed vehicles and public emergency service providers. The major differences between the two systems are that the Motorola system, based on the existing Motorola MotoTrack Emergency Response system provides two-way voice communication and relies on the standard communications infrastructure while the XYPOINT system is text based, and like a pager, employs an Liquid Crystal Display

(LCD). XYPOINT communicates via the newer Cellular Digital Packet Data system (CDPD). Motorola established its response center at the Washington Department of Transportation (WSDOT) Transportation System Management Center (TSMC) in northern Seattle, while XYPOINT established a separate response center at its offices near downtown Seattle.

A receiver in the Motorola device used GPS navigation messages being transmitted by the GPS satellite constellation to calculate the vehicle's position and velocity. For improved position accuracy, a DGPS reference station was located at WSDOT TSMC, where PuSHMe calls from subscriber vehicles were answered at a CSC. The Telephone Company (TELCO) and Analog Mobile Phone System (AMPS) cellular infrastructures provided the communications link between the CSC and subscriber vehicles.

The XYPOINT's emergency response system relied on a CDPD wireless network, DGPS location technology, and an emergency response center. The emergency response center integrated multiple databases with a rule based engine to facilitate interaction between distressed vehicles and emergency response providers to support three types of emergency calls: (1) police or highway patrol, (2) medical assistance, and (3) towing or roadside services.

Information Sources

This report was prepared using material gathered as part of Booz•Allen & Hamilton's work to provide evaluation oversight support of ITS FOTs. This material includes published and unpublished reports prepared by the test personnel and evaluators as well as information gathered in meetings and conversations with test personnel. Booz•Allen & Hamilton was not directly involved in the conduct of the tests. The reports prepared by the test personnel and evaluators present the findings, results, and conclusions of the tests themselves. This report interprets the results of a group of tests that have a common theme in an attempt to extract lessons that cut across the group of tests. Because it draws from the results of the tests as a group, this report may offer lessons and conclusions that are not found in the material from the individual tests.

FINDINGS

This section presents the comparison of the similarities and differences of these tests and an interpretation of the results. Findings are organized into five categories:

- **Impacts—**changes caused by the results of the test
- **Technical Lessons Learned—**conclusions about the ease of use, applicability, transferability, and safety of the tested technologies
- **User Response—**the reactions of the test participants
- **Institutional Challenges and Resolutions —**conclusions about the relationships among the test partners, institutional barriers, and legal issues
- **Cost to Implement**—descriptions of how costs may affect the potential development and deployment of the technologies.

IMPACTS

System impacts were not measured in either PuSHMe or Colorado Mayday. Both tests used focused groups to collect data and simulate emergency situations. Further, no actual emergency or official police vehicles were used in either test.

TECHNICAL LESSONS LEARNED

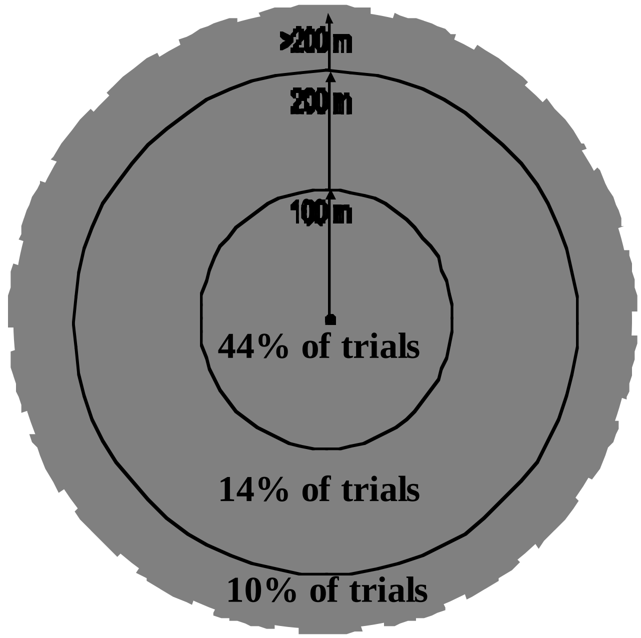
In Both Colorado Mayday and PuSHMe, the map display system and the map database used in the system were problematic. More specifically, in Colorado May, the speed of the computer used for the map display system was adequate for the test but likely to be too slow under real world conditions of multiple, simultaneous mayday calls. The display system needed to be enhanced to automatically display streets in the vicinity of the incident. The display system also needed the capability to display more than one incident at a time. The map databases and display should have included all roads, road labels, geographic landmarks, bodies of water, as well as city, county, state and dispatch region boundaries.

Both Colorado Mayday and PuSHMe produced results that provided critical information in determining if EN&R is practical for widespread deployment. The primary objectives of Colorado Mayday and PuSHMe were to assess the technical performance and feasibility of the system by:

- Determining the ability of the MPC to accurately locate test vehicles.
- Assessing the performance of the GPS component of the system under various topographic conditions
- Evaluating the ability of the system to track vehicles in motion
- Evaluating the ability of the system to handle dropped calls
- Evaluating the ability of a remote CSC to determine the location of a vehicle

Positioning Accuracy

In Colorado Mayday, the independent evaluator assessed the technical performance of the system and found the MPC was able to locate the test vehicle to within 100 meters of its actual position in 44 percent of the trials that produced a valid solution. The MPC was able to locate the vehicle to between 100 and 200 meters of its actual position in 14 percent of the valid trials. In 10 percent of the valid trials the positional difference was greater than 200 meters.



inconclusive due to non-connection and errors in the cellular links. In PuSHMe data collected during the Motorola trials indicated the mean distance error was about 37 meters and the median distance error was about 31 meters from the actual vehicle location.

Cellular and GPS Performance Under Various Topographic Conditions

In Colorado Mayday, the cellular communications coverage was strong and reliable in densely populated counties in the test area (where approximately 90 percent of the state's population resides). In areas of marginal to non-existent cellular coverage, the analog cellular system was unreliable in transmitting data. Test participants expressed a desire to have a better verification system of the progress of the communication during a call.

With PuSHMe, the GPS-based systems experienced difficulties in accurately determining locations in *enclosed spaces* like parking garages. XYPOINT experienced a 37 percent failure rate and Motorola 29 percent in updating locations in-between buildings (i.e., in "urban canyons"). Both systems also experienced difficulties determining accurate location as evidenced by the 71 percent "bad" rating assigned by the test evaluators for XYPOINT and 47 percent "bad" for Motorola.

However, for trials conducted in *forest terrain*, both systems had no trouble updating locations. Most of the calls were ranked "close" and none ranked as "good". This may be attributed to the fact that the maps used on the terminals include most, but not all roads. The lesser traveled roads were less likely to be on the maps and were the ones generally used by test vehicles during the trials.

In *open terrain*, the XYPOINT system updated locations with as little as 8 percent failure, while the Motorola had considerable difficulty with 44 percent failure.

Tracking Vehicles In Motion

With moving vehicles, both PuSHMe systems were able to track moving vehicles reasonably well. However, in the case of the XYPOINT system it was highly labor intensive for the CSC operator to continuously poll the vehicle in order to track it. With the Motorola system, the operator did not successfully make contact with the test vehicle in nearly one in every five trials.

Dropped Calls

In the PuSHMe operational test, the ability of the system to handle dropped calls was of chief concern. Motorola built into the system an automatic re-dial feature that enabled a dropped call to be automatically reconnected. This feature was designed to counterbalance calls disconnected by the user, unit malfunction, bad cellular connection, or phone line problems. Of the 150 trials conducted, 95 percent of the calls connected with the first button push. Of those that connected with the first button push and were then disconnected, 93 percent of calls reconnected. Of calls that reconnected, 98 percent were reconnected validly (recognized as dropped calls and re-established under the same identification number).

CSC Vehicle Location

The ability of a remote operator to locate a distressed vehicle was key in the evaluation of how an emergency response system would handle peak loads. The general concern was that a large-scale traffic accident or a natural disaster could overload a local processing center. In these situations, service centers in other areas of the country could be used to process calls when local service center operators are overloaded or unable to answer calls. In 60 percent of the 50 Motorola trials, the remote CSC operator was able to identify the exact location of the vehicle. For 22 percent of the trials, the remote CSC operator was *very close*, either being within a half block, naming one of the cross streets slightly incorrectly, or showing a stopped vehicle as moving. Therefore, for 82 percent of the trials, the remote CSC was able to identify the location of the vehicle within half a block. In 2 percent of the trials, the operator identified location was off by more than a block, and in 16 percent of the trials, the operator either did not or could not correctly identify the name of one of the cross streets.

USER RESPONSE

Both Colorado Mayday and PuSHMe evaluated the user's acceptance and ease of use of the systems. Focus groups were used as the qualitative source of information. Specific objectives included:

- Assessment of the system reliability and consistency
- Assessment of system ease of use

- Evaluating the perception of security and safety
- Assessment of user perception of market issues, such as price sensitivity

The demographic characteristics of the respondents for both tests were varied. However, focus groups for both represented a cross section of users for the given areas of the tests. For both tests, the majority of the focus groups were men (82 percent for PuSHMe and 60 percent for Colorado Mayday). The income range for both groups was between $25,000 and $75,000.
The general conclusions drawn from the Colorado Mayday focus group centered around the similarities and differences in men and women's perceptions and acceptance of the Mayday system. The men tended to focus on technical factors, and believed they knew both the questions and the answer. Women were wary consumers and were hard-nosed bargainers seeking a good deal. The women had a lot of questions and wanted the answers. A market price in the $150 range with a monthly service fee of $5 to $20 was the expectation of the focus group.

For the Motorola portion of PuSHMe, 100 percent of the users found the device easy to use. The auto re-dial feature was also unanimously viewed as user friendly. With respect to security and safety, 95.7 percent felt more secure in their vehicle if the system was permanently available to them and other members of the family. When the users were in situations requiring police, medical, or roadside assistance, 95.6 percent of them thought that the system would be likely to help authorities deliver assistance. In the area of reliability and consistency, 91 percent of the respondents reported that only rarely or occasionally were they disconnected when speaking with the response center operator, and 100 percent reported that they were almost always or frequently automatically reconnected.

For the XYPOINT test in PuSHMe, the majority of the respondents found the system easy to use but not as overwhelmingly so as in the Motorola tests. Only 61 percent found the device easy to handle. A number of respondents commented that the cords of the in-vehicle unit were too long and easily tangled; there was no convenient location to place the in-vehicle unit; and it was inconvenient to plug it in and attach the antenna on the roof. Regarding security and safety, 70 percent of participants felt the system afforded them a sense of security in their vehicle, compared to 96 percent of Motorola respondents." In the areas of reliability and consistency, 71 percent of the respondents disagreed or strongly disagreed when asked if they felt the XYPOINT system consistently and reliably interacted with their test vehicles.

In general, the user acceptance in both tests in the areas of system reliability, security/safety and ease of use indicate in nearly every respect there is widespread satisfaction with the respective systems. The least favorable responses were reported on the system reliability and consistency of the XYPOINT portion of the PuSHMe test. The inconsistent performance of the XYPOINT system was in part due to the infancy of the CDPD network which was undergoing upgrades and improvements at the time of testing.

INSTITUTIONAL CHALLENGES AND RESOLUTIONS

Overall, the impact of institutional issues was minimal for EN&R. Project partners acknowledged that there were a number of challenges to be overcome, particularly early in the project, but they were all handled successfully. The chief concern with both tests was with respect to institutional issues affecting future deployment. Since 1993, when the PuSHMe Operational Test was first conceived, administrators of PSAPs, the cellular industry, the Federal Communication Commission (FCC), and others have been working toward introducing new cellular 911 call requirements to better enable PSAPs to handle cellular 911 calls. To that end, in 1997, the FCC ruled that by the year 2001, the sites of 66 percent of all wireless 911 calls must be locatable within 128 meters (420 feet). In fact, addressing the difficulties associated with cellular E-911 calls was an important motivation in the original conception of the PuSHMe operational test. PuSHMe addressed these difficulties through the use of (1) in-vehicle emergency response systems that utilize GPS technology to automatically locate vehicles and (2) private CSC operators who route the call to the appropriate PSAP. As a result, location information can be relayed from cellular calls to the appropriate PSAP.

Another institutional issue encountered in the PuSHMe test was the relationship between existing PSAPs and the proposed private CSCs. Currently, most 911 calls are answered and handled by PSAPs. PSAPs, sometimes known as E-911 centers, are publicly run services that respond to all calls within a given coverage area.

CSCs are privately operated. As private response centers, they provide services only to subscribers or paying customers. Examples of CSCs in the Puget Sound region include the American Automobile Association (AAA), home and office security system services, and a variety of ambulance services.

Essentially, PuSHMe was established to support the concept of CSCs screening calls from subscribers and then, where appropriate, calling PSAPs (or another CSC) that would dispatch aid or communicate medical advice.

The PuSHMe operational test helped partners better understand the role of a PRC in the deployment of an in-vehicle emergency response system (IVERS). Private partners felt that a PRC would be a necessary component of any early deployment scenario and pointed to existing PRCs such as those serving the Ford Lincoln RESCU system. Public partners were less concerned, seeing the PRC as a viable and likely scenario but not the only one.
Most of the partners regarded additional in-vehicle services that went beyond emergency response as being key to the relationship between PRCs and public PSAPs. They regarded the successful integration of PRCs and PSAPs as being based on the PRC handing emergency calls directly over to the PSAP while PRCs provide direct service for lower priority calls such as motorist assistance and directions.

As the PuSHMe operational test came to a close, the partners began to find their niches in the overall operation on which they wanted to focus. For example, both Motorola and XYPOINT decided during the test that they didn't want to operate CSCs. Another benefit to the commercial partners was the fact that PuSHMe was useful in their efforts to attract venture capital.

COST TO IMPLEMENT

No cost data on either Colorado Mayday or PuSHMe was collected or evaluated.

SUMMARY

Colorado Mayday and PuSHMe operational tests illustrated the many facets of EN&R systems. In so doing, they brought to the forefront varied technology essential in the development of EN&R systems. The use of GPS, DGPS technology, AMPS, CDPD, and in conjunction with two way voice communication and text based LCD as demonstrated in these tests, present a realistic potential for future practical application.

Of the three emergency systems evaluated, the Motorola system was regarded by the users as the most reliable, most user friendly, and most practical. The CDPD network of the XY POINT system underwent several upgrades during the PuSHMe operational test. The periodic upgrades often times rendered the system inoperable or unreliable during the test. The unfavorable responses from the users reflected their "lack of confidence" and "lack of sense of security" in the system. Because of the incompleteness of the operational test, the Mayday system's results were inconclusive. However, when asked if they would participate in a full scale deployment of the Mayday operational test in which they would only use the Mayday unit for assistance during actual emergencies (planned Phase III), the user focus group participants responded six to one in favor.

- The institutional challenges clearly show an involved partnership. As a result, issues involving working relations between PSAPs, and private CSCs were thoroughly worked with innovative solutions derived. As EN&R systems continue to respond to both the practical as well as FCC issued challenges, the findings and lessons learned from these tests demonstrate the benefits of using a GPS based emergency notification system which can be achieved with the proper application of available technology.

BIBLIOGRAPHY

Castle Rock Consultants, *Mayday Operational Test Project Phase I Evaluation Summary Report-Draft,* October 1997

Haselkorn, Mark, *Evaluation of the PuSHMe Regional Mayday System Operational Test*, June 1997

Castle Rock Consultants, *Mayday Operational Test Project Phase II Evaluation Summary Report-Draft,* November 1995

To access an electronic version of this publication and other ITS related publications visit the

ITS Electronic Document Library (EDL):
http://www.its.fhwa.dot.gov/cyberdocs/welcome.htm
EDL Document Number 6326

Visit Our ITS WEB Site
ITS Joint Program Office: http://www.its.dot.gov

Publication No. FHWA-JPO-99-033
HVH-1/9-98