Intelligent Transportation Systems
Field Operational Test
Cross-Cutting Study

Advanced Traveler Information Systems

September 1998

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

By:
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Technical Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
FHWA-JPO-99-038		

4. Title and Subtitle	5. Report Date
INTELLIGENT TRANSPORTATION SYSTEMS FIELD OPERATIONAL TEST CROSS-CUTTING STUDY ADVANCE TRAVELER INFORMATION SYSTEMS	September 1998
	6. Performing Organization Code Booz•Allen & Hamilton Inc.
7. Author(s) Jennifer Noonan, Oliver Shearer	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 System 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

Advanced Traveler Information Systems (ATIS) Cross-Cutting report summarizes and interprets the results exclusively of several Field Operational Tests (FOTs) that have traveler information components. The FOTs considered in this report include: Atlanta Kiosk, Genesis, Seattle Wide-Area Information For Travelers, TravInfo, TravLink, Trilogy, Atlanta Driver Advisory Service, Advanced Driver and Vehicle Navigation, Driver Information Radio Experimenting With Communication Technology, Herald II, Idaho Storm Warning System, TravTek, Travel-Aid and Transit En-Route Information. The analysis and results presented in this report are categorized as impacts, user response, technical lessons learned, institutional challenges and resolutions and cost to implement. The Traveler information systems faced a wide variety of institutional challenges. This report highlights the successes and problems these tests encountered while attempting to develop the technologies appropriate to establishing and implementing ATIS.

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

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	27	

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

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EXECUTIVE SUMMARY

In America's highly mobile society, travelers have an increasing desire and need for accurate, timely information to help them decide on their destinations and reach them quickly and safely. Advanced Traveler Information Systems (ATIS) can serve this need. Traveler information falls into two broad categories: pre-trip and en-route. This information may be distributed using several existing and evolving communications technologies. Public agencies have historically collected the real-time information, although information distribution may be by either public or private channels. This report summarizes and interprets the results of several Field Operational Tests (FOTs) that have traveler information components.

Both pre-trip and en-route traveler information had generally positive impacts. The availability of pre-trip information has increased driver confidence to use freeways and allowed commuters to make better informed transit choices. En-route information and guidance saves travel time, helps a traveler avoid congestion, can improve traffic network performance, and is more efficient than paper maps or written instructions. Unfortunately, studies have shown that many people are still unaware of the existence of ATIS.

Users had positive responses to the pre-trip information services and liked and found value in the en-route information. Pre-trip information systems that are very portable and easy to use enjoyed greater market value than fixed or cumbersome systems did. Users appreciated traffic information that gave them a choice of routes but often did not change their travel behavior. Commercial users responded very positively to the availability of the information. Users found en-route systems to be generally safe to use -- particularly voice-direction systems, and beneficial in saving time and avoiding congestion.

The technical performance of these systems varied greatly depending on the type of system. Most pre-trip systems did not introduce cutting-edge technology but rather new configurations of existing technologies. These new configurations worked well after some initial data integration problems were rectified. En-route systems had a wider range of technologies. Some personal communication devices were difficult to read because of poor back lighting. The in-vehicle devices tested performed well. The personal computers (PCs) used in vehicles also functioned as intended, although some problems arose in connecting the devices to the vehicles. Other en-route systems were more akin to prototypes than commercial products and exhibited a prototype's gestation problems.

Traveler information systems faced a wide variety of institutional challenges. These challenges included legal issues, business process issues, and the partnering roles of the public and private participants. Common legal issues included protecting copyright and proprietary information, tort liability for the accuracy of the information, and licensing and confidentiality agreements. Many tests encountered challenges in forging an effective partnering arrangement between the public and the private participants because of differing views on the form of the partnership and its guiding principles.

Those tests that addressed the issue of costs reported information that is now somewhat outdated. In general, users indicated a willingness to pay for the systems and information as long as they perceived value in what they were purchasing.

This report highlights the successes and problems these tests encountered while attempting to develop the technologies appropriate to establishing and implementing ATIS.

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 was 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 Advanced Traveler Information Systems (ATIS).

INTRODUCTION

Advanced traveler information includes static and real-time information on traffic conditions, and schedules, road and weather conditions, special events, and tourist information. It can be offered with value added options like sports scores, stock quotes, yellow pages and current news. ATIS is classified by how and when travelers receive their desired information (pre-trip or en-route) and is divided by user service categories. Operations essential to the success of these systems are the collection of traffic and traveler information, the processing and fusing of information - often at a central point, and the distribution of information to travelers. Important components of these systems include new technologies applied to the use and presentation of information and the communications used to effectively disseminate this information.

Traveler information systems distribute information using several communications technologies. The most widely used are wireless broadcast, electronic data lines to remote terminals, and telephone advisory messages. Traveler information is displayed as icons on map databases, as alphanumeric text messages, and as recorded messages accessed by phone.

Collecting traffic information has historically been the task of public authorities although private firms distributing traffic information to radio and TV often use their own means to collect information. Public authorities using various combinations of loop detectors, cameras, probes, and data from other authorities can generally access more comprehensive and/or accurate traffic information and centralize it in a Traffic Management Center (TMC). The growing trend in traveler information systems is to fuse the public sector data with value added private sector data/services and disseminate it from a central point. There are a variety of business models being discussed among both public and private participants across the country.

Apart from transit based ATIS systems, most systems rely on the quality and availability of other ITS infrastructure components. The presence of Advanced Traffic Management Systems (ATMS), where data is gathered and fused, is essential for effectively disseminating real-time traveler information to the public. In many ways issues involved in ATMS development also have a direct effect on the success of comprehensive ATIS systems.

Pre-trip is traveler information is provided as a trip is being planned or about to be embarked on. En-route traveler information is delivered to travelers in private vehicles and en-route transit information is provided to travelers using public transportation.

A pre-trip travel information service allows travelers to access real-time intermodal transportation information at home, work, and other major sites where trips originate. Information on traffic conditions, ride matching and reservations are conveyed through these systems to provide travelers with current travel conditions and to offer options to help plan their travel. Based on this information, travelers can select their preferred departure time, route and modes of travel, or perhaps decide not to make the trip at all.

Advanced pre-trip traveler information system devices focus on providing real-time traffic information but often bundle it with transportation and traveler services information. Traveler services include transit schedules, route guidance and yellow pages. Many pre-trip information systems can also be accessed en-route.

The content of en-route information as described by the ITS National Program Plan should provide driver advisories to convey information about traffic conditions, incidents, construction, transit schedules, and other mode choice options to drivers of personal, commercial, and public transit vehicles. This service also includes in-vehicle signing, which provides the same types of information found on highway signs today but would be displayed directly in the vehicle. Full deployment of in-vehicle signing would also include customized information, such as warnings of hazardous road conditions (e.g., fog, ice) or the safe speed for a specific type of vehicle (e.g. , autos, buses, large trucks). [1]

An en-route transit information system provides information to transit riders after their trips have started. This information includes arrival and departure times, information on transfers and connections, information on other regional transportation services, and information on

[1] *National ITS Program Plan*, Vol. II, March 1995, p.5

related services, such as park-and-ride lot availability. This information can be provided on-board a transit vehicle, at a transit stop or transit center, and at other locations, such as park-and-ride lots, through various media.[2]

Pre-trip and en-route traveler information services share many overlapping issues with common solutions applicable to both. There are also some unique aspects to each service. The FOT initiatives have provided a platform to isolate and study these measurable issues. This paper will focus on the lessons learned from FOT's that addressed these issues.

This report was prepared using material gathered as part of Booz Allen & Hamilton's work to provide evaluation oversight support for the FHWA's 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.

This report interprets the results of a group of tests that have common themes 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.

When specifically focusing on pre-trip traveler information findings this report includes the FOTs: Atlanta Kiosk, TravInfo, Trilogy, Genesis, Seattle Wide-Area Information for Travelers (SWIFT) and TravLink. The nature of many of the products these tests used to disseminate pre-trip information is such that they could also be used en-route via cell phone, personal digital assistant, or pager.

Other FOTs, namely, Advance Driver and Vehicle Navigation (ADVANCE), TravTek and Atlanta Driver Advisory Services (ADAS) tested the feasibility of the technologies enabling en-route dynamic route guidance. They also studied various aspects of traveler behavior with improved information. These tests looked at the feasibility of communication to vehicles from wide area advisories, two-way messaging and local area advisory systems. Another FOT, Driver Information Radio Experimenting with Communication Technology (DIRECT) is also studying low-cost methods of communicating to motorists and tracking modified travel behavior, but has not finalized its evaluation.

The FOTs, HERALD II, Idaho Storm Warning System, and Travel-Aid focused on communicating weather and road condition information en-route. HERALD is studying the feasibility of AM subcarrier broadcast to transmit information in challenging terrain and potentially interfering environmental conditions. Idaho Storm Warning System and Travel-Aid communicated visibility, road and weather conditions via Variable Message Signs (VMS) and were focused on obtaining reliable data from sensors to report accurate conditions and safe speed limits.

FOTs Considered In This Analysis

The following descriptions include six ITS FOTs that included pre-trip traveler information findings. A few tests continued in some form of operation after the test period.

Atlanta Kiosk

The Atlanta Kiosk project began as part of the ITS deployment effort in Atlanta that coincided with the 1996 Olympic Games. The Atlanta Traffic Management System now known as NAVI**GA**TOR links information from the traffic

[2] *Review and Assessment of En-Route Transit Information Systems*, April 1995, p.14

surveillance system and the Atlanta ITS Showcase server. The Kiosk project installed computer systems in kiosks located in public locations mainly in Atlanta but also at various traveler information centers on Georgia's interstate highways. The kiosks display traffic information from the ATMS/transit schedule and status information from the Metropolitan Atlanta Rapid Transit Authority (MARTA) Transit Information Center (TIC). They also display traveler information from the Atlanta Traveler Information Showcase server, airlines, the Weather channel, the Atlanta Regional Commission, and the Georgia Department of Industry, Trade and Tourism.

Over 115 of the projects original 140 kiosks are currently deployed and maintained by GeorgiaNet, a state agency that markets electronic access to public information. Test personnel conducted data collection during the 1996 Olympic Games period in July and August of 1996. Since the evaluation ended, the entire system has been overhauled and is no longer operating from individual modem links, but from a web browser on the internet. New evaluation data is being collected assessing the new system and a final evaluation report is being finalized.

Genesis

This test was the second of three Minnesota Guidestar tests that shared traffic information from the Minnesota Department of Transportation (Mn/DOT) TMC in downtown Minneapolis. The Genesis project was to determine the effect of real-time traffic information on traveler behavior. Incidents, congestion, and planned events were broadcast to commercially available pagers and Personal Digital Assistant (PDA) users in a portion of the Twin Cities area of Minnesota. The coverage area was later expanded. The raw traffic data from the Mn/DOT TMC was also provided to the Travlink and Trilogy FOTs. Operation of this system ended in January 1996.

Seattle Wide-Area Information For Travelers (SWIFT)

The primary goal of the project was to assess the performance of a large-scale, urban ATIS in the Seattle area. Traveler information services included traffic, incident reports, rideshare matching, and transit schedules. SWIFT provided travel information via FM-subcarrier high speed data systems to travelers carrying one of three user devices. Testing ended in September 1997.

The three user devices included digital watches, in-vehicle devices, and PCs. The digital watches provided personalized SWIFT traffic data including expected delay times based on the users' normal commuting routes. SWIFT is currently broadcasting to a limited number of test watches, and eventually expects Seiko to deploy a commercial watch with this service. The in-vehicle navigation units received traffic incident data and filtered out incidents not relevant to the current trip. The navigation system included a Global Positioning System (GPS) that determined vehicle location and provided relative directions to a selected destination chosen from its yellow page directory. The notebook PCs displayed a map showing incident icons and text descriptions that detailed the incident type, roadway affected, and direction. Bus schedules and locations and rideshare matching were also available from the PCs.

TravInfo

TravInfo is an open-access traveler information system for the San Francisco Bay Area. TravInfo provides a free public service of real-time traffic information through a phone line. Data is also disseminated in a digitized form through both modem-based landline data server and FM subcarrier-based wireless data broadcast systems. The project is based on an open architecture philosophy, and there are very few restrictions to participation.

Additional services are available through radio broadcast and the internet by way of information service providers. Traffic information is drawn from multiple public and private sources. Commuters can also access multi-modal services, including transit and rideshare information. The project's objectives are to provide benefits to traffic operations and travelers, and to stimulate the deployment of privately offered advanced traveler information products and services. The test is ongoing through December 1998 and a permanent deployment is being negotiated.

Travlink

Travlink used Automatic Vehicle Location (AVL), Computer-Aided Dispatch (CAD), and Automatic Vehicle Identification (AVI) systems on Metropolitan Council Transit Operations (MCTO) buses in Minneapolis and surrounding suburbs, to collect and distribute real-time bus schedule information and traffic information.

The goal of Travlink was to increase the efficiency and use of transit services along the I-394 corridor and to measure the feasibility of full deployment of a CAD AVL transit system throughout the metropolitan area. The project corridor was a newly reconstructed freeway that was designed to include transit and ridesharing capabilities. A primary objective of the project was to test the extent to which improvements in the quality and availability of transit information can positively influence individuals to consider transit alternatives. The test concluded in 1996.

Travlink disseminated data to a computer on-line service using videotext terminals and PCs, as well as "smart" kiosks, electronic signs, and display monitors. Under the Orion project, a separate CAD AVL transit management system is being deployed in the Minneapolis area using lessons learned in the test, but traveler information will be disseminated through a privately run center. This system was given to Duluth, Minnesota where Mn/DOT is assessing the costs of reconditioning it and deploying it in the Duluth area.

Trilogy

Trilogy demonstrated in-vehicle systems and FM-subcarrier data technologies that provided traffic information to drivers in the Twin Cities area of Minnesota. The project provided real-time travel information about the condition of the metropolitan highway system to a sample of commercial delivery fleets, bus transit operators, and private citizen commuters via in-vehicle navigation devices. It evaluated the effects of the information and devices on the users and the surface transportation system.

Trilogy used a graphically oriented, map display in-vehicle system. This dash-board mounted system displayed a moving map showing incident and traffic information icons as well as real-time traffic volume and occupancy data. Although the project has ended, the project's data source will be made available if a market for travel and traffic information should develop. Using lessons learned in the Trilogy test, a radio broadcast, a cable TV broadcast, and the Sidewalk web page all continue to distribute Mn/DOT's real-time traffic data.

The following are brief descriptions of the eight FOTs evaluated for en-route traveler information systems.

Atlanta Driver Advisory Service (ADAS)

The ADAS was a comprehensive ATIS. The ADAS was designed to provide information including congestion, incidents, weather, sports scores, current movies, traveler services, in-vehicle signing, and two-way messaging. The project provided information to drivers of approximately 170 specially equipped vehicles in the Atlanta, Georgia, metropolitan area. The main objective of the test was to evaluate the performance of the wide area driver advisory system, the two-way messaging system, and the local area driver advisory system.

A major part of the information provided to the vehicles was generated by the ATMS operated by the Georgia Department of Transportation (GDOT). The ATMS monitored traffic conditions and incidents occurring on several key interstates. The ATMS used a system of video imaging detection cameras. Congestion and incidents were disseminated to travelers using the Atlanta Showcase resources. During the data collection period, some of the detection devices did not operate reliably so much of the data collection was done manually. ADAS operators entered additional information including weather, sports scores, and movies.

The components that made up the overall system included a system controller in the TMC, the Subcarrier Traffic Information Channel Subsystem, the Two-Way Messaging Subsystem, the Local Area Transceivers Subsystem, and the In-Vehicle Subsystem.

The ADAS demonstrated a technical capability to:

- The ADAS successfully presented traffic information in the vehicles. ADAS could accept congestion and incident information from the ATMS and use that information to calculate traffic conditions for a particular segment of the highway system. ADAS successfully transmitted this information using an existing FM radio station. The in-vehicle receiver was able to decode and display the traffic information on the screen in the car.

- The ADAS was also successful in displaying traveler services maps in the vehicles. The ADAS developed and coded the maps showing what services were available at an intersection. The system could determine a moving vehicle's position and send the appropriate map to the vehicle. The in-vehicle receiver successfully received the map and displayed it at predetermined locations.

Advance Driver and Vehicle Navigation (ADVANCE)

The ADVANCE FOT demonstrated the use of an in-vehicle advanced traveler information system in the northwest suburbs of Chicago, Illinois. It was expected to be the first large-scale dynamic route guidance system deployment in the U.S., resulting in the distribution of 3,000 in-vehicle devices. The ADVANCE system provided drivers with a fast route to their destination over the arterial streets using an in-vehicle traveler information and route guidance system. The system provided route guidance information using a static database of travel times and dynamic information on traffic conditions.

In late 1994, based primarily on the projected market limitations of what was likely to be an expensive system, the project partners scaled back the project scope and agreed on a targeted deployment of 75 prototype in-vehicle systems. Operational testing took place using 30 vehicles between June 1995 and December 1995.

Driver Information Radio Experimenting with Communication Technology (DIRECT)

The DIRECT test is deploying and evaluating several alternative low-cost methods of communicating travel information to motorists in the Detroit, Michigan metropolitan area. The system sends travel information to a group of test vehicles and then tracks the vehicles during their commute. The tracking information will be analyzed to understand actual traveler behavior and the modifications travelers make based on improved knowledge. The field evaluation phase of the test began in April 1996. The Final Evaluation Report is anticipated by October 1998.

Herald II

The Herald II project is an ATIS in the remote, rural and harsh environmental conditions in Colorado and Iowa. The project disseminates important traveler information in difficult-to-reach areas using a subcarrier on an AM broadcast radio station. The objective is to build and test an AM stereo infrastructure through which 4-5 traveler messages will be tested. Herald II will not test the accuracy and timeliness of traveler information, but the feasibility of the communications media. Phase I of the test consisted of a communication technology feasibility study funded entirely by the ENTERPRISE group. Phase II is the actual FOT and began operation in April 1998 for six weeks. A final report by year end 1998.

Idaho Storm Warning System

This rural test is evaluating a system that warns motorists about adverse weather conditions. The system consists of a group of sensor systems that provide visibility and weather data coupled to a set of VMS located along the highway. The system operates along a stretch of Interstate 84 in Idaho and northern Utah. The primary goal of the system is to reduce the number and severity of visibility-related multiple-vehicle accidents along this section of I-84. Testing of the system components began in 1994. Due to a lack of visibility events in the early winters of the test and because of equipment operation problems, the data collection period has been extended. An Interim Report is expected in the Fall of 1998 and the Final Report is due August 31, 2000.

TravTek

The TravTek FOT contained a series of field tests, experiments, and analytical studies focused on ATIS and ATMS concepts. Three main components were: 100 specially-equipped vehicles, information collected and processed at the Orlando TMC, and customer information and services provided by the TravTek Information and Services Center (TISC). Each in-vehicle system had a two-way communication link to the TMC and the TISC via a hands-free cellular phone. The vehicles received a broadcast of traffic information from the TMC and broadcast to the TMC their locations and travel times across TravTek traffic links. The vehicles were configured three ways: providing yellow pages services only, providing added route guidance and planning capabilities, or including all services and navigation features plus display of real-time traffic information and route planning around congestion. The test was conducted in Orlando, Florida, from November 1991 to June 1994.

Travel-Aid

This operational test's objective is to improve safety and reduce accidents across the 40-mile Snoqualmie Pass along I-90 north of Seattle, Washington. Accident rates in this area during the winter months have been recorded five times higher than the average throughout the year. Travel-Aid transmits suggested speed limits along with traveler advisory messages via VMS. An in-vehicle system was initially planned as part of the operational test, but has been discontinued. The Travel-Aid weather stations and radar detectors provide information to the TMC and augment the existing traveler information system of advisory radio, 1-800 SNOW INFO, and the Washington Department of Transportation (WSDOT) web page. Preliminary field testing is currently underway, with a final evaluation report expected in September 1998.

Transit En-Route Information

En-route transit information systems are starting to be developed in the U.S. as the implementation of AVL systems with improved collection and distribution of data make real-time information available. Projects integrating traffic and transit information, particularly to promote the shift from Single Occupant Vehicles (SOV) to High Occupancy Vehicles (HOV), include the FOT Travlink and the California Smart Traveler project. One way to encourage modal shift is by providing drivers with guidance to park and ride lots and including real-time information on public transit services.

European studies have identified that service "reliability and punctuality are perhaps the most important requirements influencing the perception of a public transport system." The presence of en-route traveler information systems can significantly contribute to this perception.[3]

FINDINGS

The following sections present the findings of this report organized in five categories:

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

IMPACTS

The impacts and effects of real-time pre-trip and en-route traveler information have generally been positive with a few exceptions. Real-time pre-trip traffic conditions in Minneapolis gave users more confidence to use the freeways, which they had inaccurately perceived to be constantly congested. Fewer drivers chose alternate arterial routes due to the accurate freeway information they previously could not access.

Non-commuters with a fixed destination use pre-trip traffic information in conjunction with other services. Tourists and locals in the Atlanta area access traveler information for choices such as tourist attractions, restaurants and hotels, as well as their choice of route or mode of transportation. SWIFT's hand held computers with real-time bus schedules were popular with Seattle's transit riders. These riders have no choice of alternate route but appreciated knowing if they needed to take the local bus that had just arrived or if an express bus would soon follow.

ADVANCE evaluators concluded that turn-by-turn navigation is not only an effective method of information presentation, but that by allowing more efficient navigation and less off route or lost time, such systems can potentially reduce a driver's exposure, thereby reducing overall crash rates.

TravTek saved users time en-route by providing turn-by-turn route guidance directions. In three field experiments comparing turn-by-turn route guidance to consulting a paper map or a transcribed list of instructions, the route guidance was found to reduce travel time by approximately 12 percent. TravTek participants who could access real-time traffic information did not measure actual travel time savings but evidence suggested they were more successful in avoiding congestion.

[3] Ibid., pg. 60

En-route traveler information systems have been projected to improve overall traffic flow. TravTek showed that with improvements to traffic information infrastructure, in-vehicle route guidance systems have the potential to measurably improve traffic network performance, in part because drivers will use such systems. Modeling suggested that non-users will also experience substantial benefits if TravTek-like systems reach even modest levels of market penetration.

In tests where travelers received information en-route there are a limited number of measured impacts, mainly from tests using in-vehicle systems. En-route in-vehicle systems as a whole were determined as safe or safer than conventional driver information sources such as paper maps and written directions. The advisory sign tests are still in the process of being deployed, yet already using preliminary data gathered, they have identified specific risks in adverse conditions that intended travel warning signs could substantially mitigate.

En-route tests compared the variety of devices for their safety in the vehicle and then compared characteristics among them to assess the safest combinations (i.e. voice prompts with maps, turn-by-turn directions with symbols). The turn-by-turn guidance display used in TravTek measurably reduced demands on drivers' visual attention. Users perceived that the voice guide helped them drive more safely and as a supplement to the visual display the voice guide improved driver performance.

In the growing number of cities where real-time pre-trip and en-route traveler information is available to the public, many people are still unaware of its existence and its potential benefits. Increased public awareness and more widespread availability of phone services, kiosks, and other pre-trip traveler information products may produce measurable changes in traveler behavior and in traffic patterns.

One test conducted a survey of over 200 commuters, the majority of whom were unaware of the test's phone service. Of those who knew about the service, nearly 75 percent had never called. This survey concluded that individual incidents did not affect traveler behavior significantly. Although a fair proportion of commuters obtain traffic information, few actually utilize it. The conclusions of the survey give the explanation that commuters generally do not believe that changing their travel plans will result in shorter travel times.[4]

The following evaluation findings were made based on the individual tests:

- In the ADVANCE project dynamic route guidance was demonstrated to provide the potential for motorists to reduce travel times by 4 percent and potentially more under conditions of non-recurrent congestion.

- The TravTek studies projected a 37 percent reduction in wrong turns and 32 percent reduction in vehicle stops using the system. Other projected benefits of the TravTek system included an approximate 5 percent reduction in travel distance, an 11 percent reduction in fuel consumption and a 6 percent reduction in emissions.

- The Idaho Storm Warning project in its Phase I evaluation established that in low visibility situations, vehicle speeds decline by approximately 10 mph on average and more as visibility decreases. They also found that there is a greater variety of individual vehicle speeds during low visibility or that standard deviations of individual speeds are higher by 2-3 mph compared to those during normal conditions. Although drivers slow down, they do not slow down uniformly and the variation in

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[4] R. Koo, et. al, *TravInfo Evaluation Traveler Response Element: Phase 1 Results of the Target Study*, December 1997

speed creates more risk in low visibility. This data is expected to have implications on the use of VMS messages during Phase II, to reduce variability among individual vehicle speeds as well as reducing the overall mean speeds in low visibility conditions.

- The ADVANCE safety evaluation measured significant eye glance data to support their finding that the Mobile Navigation Assistant (MNA) in-vehicle device did not adversely affect driving safety when compared to conventional navigation methods (i.e. paper maps or direction lists). Users ranked both the MNA without auditory and the MNA with auditory above conventional directions based on their relative safety.

USER RESPONSE

Available evaluations from the tests studied the effectiveness of real-time information to alter travel behavior, the ease of accessing information using various devices, the usefulness of information in daily life, and travelers willingness to pay for information.

User responses to using pre-trip traveler information systems were generally positive. Some responses were influenced by early system related technical problems and minor ergonomic problems. The following evaluation findings were made based on the individual tests:

- Users are generally appreciative of traffic information that gives them a choice to make decisions regarding their travel behavior as long as they perceive the information to be accurate, timely and inexpensive. Of the Travlink PC users, 57 percent agreed or strongly agreed that the information was accurate and reliable, and 34 percent were neutral. Others felt that the information was not as good, or not any better than what they could receive via television and radio traffic reports.

- Genesis project users with personal digital assistants reported they were generally easy to use. Sixty-five percent said they used the system daily.

- Pre-trip information systems will be used more by people who regularly travel as part of their everyday activity. In particular, commercial users, who use the road network as part of their jobs, responded to the information attributes very positively. The Trilogy project's information became the number one source of traffic information among the project's commercial users.

- Pre-trip information doesn't necessarily cause people to change their travel behavior. Knowing the conditions may give travelers more confidence in their original travel plans instead of chancing alternate routes. Trilogy users reported taking alternate routes less frequently than before because of reliable information that the freeway was in fact the better choice. They believed that Trilogy gave them better information to make intelligent route choices, yet ironically it was frequently not to change route at all.

- The consumer electronics product costs for kiosks, VMS, pagers, phones, PCs, PDAs and in-vehicle systems will each be affected by trends in communications, electronics, and the computer industry. Communications technology and its costs affect how this information will be disseminated. Some traveler information will always be free to the public, but value added information bundled to include services like customized traffic reporting, movie listings, sports scores, stock quotes and/or news may have subscription fees.

  The trends in car computer systems will change the way all these devices are used in the vehicle and could evolve into combined units with multiple capabilities.

- There is a willingness to pay for some travel information systems; however, market penetration by "high-end" systems according to FOT results, would be limited until costs decrease. Mean price estimates for the Dynaguide II system used in the Trilogy project from May 1995 through December 1996, ranged from $425 to $522 with monthly service charge estimates around $28. Willingness to pay these prices ranged from 16 percent in the early survey to 24 percent in post surveys and increased with exposure to the system among high-use drivers. The chart below shows current in-vehicle systems on the market and their approximate prices (See Table 1).

Current prices as of April 1998 available in limited areas and vehicle models.	
Accura Satellite	$2000
BMW On-Board	$2800
JAMES, Journey Assistance & Mapping Exploration System	$2995
Lexus Navigation System	$2250
Mercedes Benz Navigation System	$2495
GuideStar Information System	$2800
Alpine Voice Guidance Navigation System	$2910
PathMaster	$1995
CARin	$2500

Table 1 — Commercial In-Vehicle Navigation Systems

- For the Atlanta Kiosk, no comparisons were made between the kiosk and other systems with regard to absolute or comparative values. Respondents clearly showed some willingness to pay a small amount (25-50 cents) for information per kiosk use. This willingness increased with the availability of a printed product. The Travlink evaluation did not provide any value data.

Users liked using many of the en-route systems and found value in using them. Tests gave documented time and effort savings. Travelers avoided congested areas more often when they could access real-time traffic information. En-route systems as a whole fared as safe as or safer than conventional driver information such as paper maps and backseat drivers. Voice prompts and clear symbol displays were favored over detailed maps. The following evaluation findings were made based on the individual tests:

- User acceptance of traffic information via PCs was mixed. Negative opinions from users are believed to be a result of technical and data throughput problems. User responses indicate that, for PC-based systems to be accepted and paid for, they must be perceived as more accurate and timely than pre-trip information provided by television and radio traffic reports.

- TravTek participants regularly used the system on over 40 percent of their trips. One study showed that rental car users relied on the TravTek system for up to 80 percent of their total trips taken. The evaluation reported that while users viewed local information, navigation, and route guidance functions as useful, they did not perceive the traffic information provided by TravTek helped them avoid congestion.

- ADVANCE drivers stated that they felt more aware of their surroundings when using the mobile navigation assistant with voice than with any other driving condition.

- The ADAS project found that better training and a clearer understanding of what they were trying to accomplish might have created more interested participants. Without clear understanding, poor performance of the system during its initial stages also seemed to discourage some drivers. These findings were collected before the project finished and report the apparent user's perspective on ADAS system performance, not a user acceptance analysis.

TECHNICAL LESSONS LEARNED

Pre-trip traveler information systems are not introducing cutting-edge technology into the world of traffic and transportation. They are introducing new technical configurations and system integration concepts to the transportation community. As a result, cross-cutting evaluation addresses system performance issues by device types, including device reliability, availability, and performance issues directly related to system development.

Findings include the following:

- The systems used for pre-trip information are generally reliable and perform well. The test systems were generally based on proven designs that had been previously used successfully in other markets.

- In a few cases, these systems were fielded for testing before all of the technical problems were solved. Problems that did arise were generally attributed to systems or data integration, which plagued the early tests, due to complexities of data fusion and system integration.

- Traveler information system design should ensure that users will not be burdened with messages they do not wish to receive or read.

The following paragraphs discuss the findings related to specific device types.

Personal Communications Devices

The personal communications device tests, which were adaptations of products that were commonly available on the market, performed very well. Personal communication devices include pagers, handheld computers, watches and cell phones. The pagers in Genesis were very reliable; however, the personal digital assistants, which required significant modification for this test, were never completely operational to satisfy their intended purpose. Thus far, the SWIFT project watches have not experienced any significant problems. The only recurring condition that affected handheld or portable systems was a need for backlighting when trying to read data characters in bright light conditions.

One problem with SWIFT that was also observed to some extent with Genesis and Trilogy is user-identified problems with deleting messages or data. The designs for these systems appear to have not fully taken into account the need for data to be cleared after a certain amount of time or based upon other criteria.

In-Vehicle Devices

The in-vehicle devices in the Trilogy and SWIFT test performed very well. With Trilogy and SWIFT, there was an early recurring problem with deleting old messages; the overall system design allowed for a memory buffer input rate that could not be dumped fast enough.

A critical item with regard to technical performance of in-vehicle systems appears to be installation, which must be done carefully to avoid erroneous connections. Different cars can pose different levels of difficulty installing these types of systems correctly.

PCs

The PCs used in Travlink and SWIFT performed satisfactorily when treated as stand-alone systems. There were some technical problems that occurred in both of these tests that are typical of new development efforts. For SWIFT PCs, user feedback identified connection problems with some machines. In Travlink, there were a number of videotext errors that created negative feedback with a small number of users. It is not known whether these were development-related, or caused by faulty components.

Kiosks

Neither Atlanta Kiosk nor Travlink tests have provided any direct results on the technical performance of their kiosk systems. No numeric data on performance or reliability is available for either test.

Atlanta deployed 140 kiosks for the test and 104 are currently operational as a legacy program. There were some early problems with system component and communications failures; however, there is no indication that any components of the kiosks in Atlanta are inherently defective.
The Travlink project deployed less than 10 kiosks. The Final Evaluation Report does not indicate specific technical problems. There are plans to re-use the kiosks in Duluth as part of the Mn/DOT Guidestar Orion project for Duluth public transit.

En-Route Systems

The en-route test results had many successful technical accomplishments although most of the in-vehicle units tested were closer to prototypes and will be significantly altered as commercial products. Some of the specific findings are listed:

- The Herald II project demonstrated that AM subcarrier broadcast has very good reception in the mountains as well as in urban areas although they found that lightning was a significant challenge to the AM broadcasts.

- ADAS demonstrated the technical capability to send a two-way message (simulated mayday) from a vehicle to a computer in the TMC, and to send a response from the TMC to the vehicle while in motion although the information delivered in the test at times lacked complete coverage of the area's traffic congestion.

- TravTek technical results included the following issues:

  — Reliability was largely attributable to the distributed architecture. The availability of the system was in excess of 96 percent throughout the project across all subsystems. Yet, lacking timely incident information, the system was often unaware or late in posting incidents.

  — TravTek partners invested significantly more time and effort into supporting the accuracy of the navigation databases than they had originally planned. At the time of the test, no infrastructure was in place to support sharing resources such as an up-to-date map database, planned road construction data, and parking lot data.

  — The evaluators recommended that ITS developers should schedule end-to-end testing of the systems before they are released to the public. As an example, the TravTek system shake-down took three months more than anticipated, partially because end-to-end testing had not been accomplished before the date the field test began.

- The ADVANCE evaluation concluded that:

  — Advances in technology will be required to meet the requirements of similar systems in the future, particularly relating to speed of user interface, transmitting high amounts of data, improving how trips are planned, and providing technology that works in the variety of environments found in vehicles.

- More research is needed with respect to data fusion, incident detection and route planning algorithms.

- In dynamic route guidance, relatively few probes are needed to accurately characterize traffic conditions on a given link on an arterial network (less than 5 per 5-min period).

- For a full implementation of en-route transit information systems, areas must have installation of and experience with advanced public transportation systems, specifically advanced vehicle location systems. Their customer needs must also be well understood. The operational tests identified in the User Services Development Plan under the *National ITS Program Plan* are not operating on a regular basis.

INSTITUTIONAL CHALLENGES AND RESOLUTIONS

ATIS has a wide and varied set of institutional challenges. The most fundamental issues revolve around the public-private partnerships and the dissemination of data among them. The business models workshops and other forums that bring together regional ATIS initiatives articulate the most progressive issues and the successes to date in deployment, but there are some significant lessons learned in the FOTs.

ITS projects have fostered many new institutional relationships and ways of doing business for transportation agencies and private sector partners. Institutional issues addressed here include legal issues, business processes, and public-private partnerships.

Legal Issues

Legal issues unique to pre-trip traveler information systems were not required to be addressed in the evaluation reports, yet common problems within various tests included copyright and proprietary information issues, licensing agreements, and confidentiality agreements. Two other legal issues that continue to arise are safety in using systems while driving and the proper use of publicly collected traffic information when distributed by private interests. These issues have been prevalent in other types of ITS projects as well.

One significant legal issue being faced is the potential tort liability for distributed information that is either false, inaccurate, or unreliable and may be blamed for a particular accident or damages of some kind. TravInfo realized possible tort liability regarding use of the content of the database by registered participants. The question was whether registered participants that access the database might attempt to hold the project liable in the event of erroneous, unreliable or lost data. TravInfo protected itself by including disclaimers of liability and a warranty in the terms and conditions of the Registered Participant Agreement. Since the TravInfo database is in the public domain, a potential problem exists if information is accepted from a private source.

The Contracts departments of the state agencies and private firms were not designed to handle “partnership agreements” that did not have the binding power of a contract. This caused other legal issues regarding responsibilities, product deliverables and enforcement of agreements.

Another issue questioned the ownership and proprietary nature of data for further use once it has been processed at the public agency level. Transportation agencies are beginning to take a hard look at how they will conduct business in the future. This is because traffic and transportation information (accidents, incidents, construction), normally collected by public agencies for internal use, is now being delivered in various forms to private hands for re-sale under commercial market conditions.

Obstacles in carrying out agreements for the Travlink project pertained to proprietary issues and property rights, copyright and ownership, license agreements and confidentiality, and the ability to carry out the agreements under Minnesota enabling legislation.

Business Processes Issues

Business processes addressed a paradigm shift in the way public transportation agencies conduct their operations, and whether that change is for the public good.

A business issue specific to TravInfo was the decision to make the California Department of Transportation (CalTrans) Traffic Operations System (TOS) the primary source of information instead of pursuing a more independent and diversified path.
Schedule problems with the TOS have delayed major operations deployments. Complications in CalTrans contracting procedures have slowed down full development of the TOS.

The issue of publicly funded collection of traffic information packaged for re-selling by commercial agencies for a profit raised a question of whether benefits to the public outweigh any potential economic motives. In the TravInfo scenario, collecting traffic information at public expense for re-sale versus no-cost public access via an affordable medium such as a telephone advisory service was a major issue. Some participants did not want the information made available to the public without being re-packaged and sold via the market. Others, primarily in the public sector, supported public access. Test partners in TravInfo decided that the public sector would collect and process the data, and the private sector would add value, including privately collected data and the development of consumer products and services. The TravInfo Traffic Advisory Telephone Service (TATS) would remain free of charge.

One of the lessons learned in the Genesis project was developed through the participants' experience in the negotiation process. Participants felt that the freeform negotiation process that was used could have proceeded more smoothly if the parties had a better understanding of each other's contracting history and mindset, as well as what they wanted to derive from the project. Factors that surfaced were differing contracting requirements and/or perspectives of federal and state agencies, and the fact that the partners may not share a common framework for negotiation.

Public-Private Partnership Issues

Public-private partnership issues revealed themselves in various ways in these tests. Different perspectives of the public and private sector were manifest in the form of issues and stumbling blocks that interfere with smooth project administration. Discrepancies typically arose over forms of organization, management structure, and implementation tools. In a new approach for many participants, projects have been structured with both public and private partners as part of the project management team.

Each side of a public-private partnership needs to understand the principles and ideals that govern the other. There is a need for team-member consensus regarding development approach and the technical tools to be used. An understanding of the full range of technical obstacles, specifically with regards to systems displays and integration is vital.

The following perspectives were commonly among many of the tests. Although technology and methods of delivery were different, all were focused on the same basic mission of providing pre-trip traveler information to individual users.

- State and local transportation and planning agencies in certain areas were anxious to explore the concept of providing traveler information.

- All six pre-trip projects were under the oversight of state transportation agencies; two under the auspices of the Mn/DOT, two under the CalTrans, one under WSDOT and one under the GDOT.

- The tests were managed by public agencies, but they existed under written partnership agreements with private firms.

- Under the test arrangements, the bulk of expenditures were borne by public agency funds (federal, state and local). A smaller amount came from the private firms. Non-public entities contributed a set amount of "in-kind" funding not based on cash outlays, but was considered a contribution to project costs. In some cases, private firms donated or allowed their systems to be used on a temporary basis, or donated staff labor.

- The private sector partners were generally involved to get a better idea of the market potential for traveler information. They also wanted to establish stronger business relationships with the DOTs and to enhance their experience base in ITS. The responsibility of the private sector entities was to develop, field, and test the systems, while assessing the potential value and benefits of these systems from both a public and private viewpoint. The public sector was interested in feasible benefits to the transportation network.

- The private sector perspectives were often not clear to the public sector, and few of the private sector participants had any real experience understanding the public sector's roles. Differing approaches had as much, or even more influence on the course of the projects as other factors such as technical development or feedback from system users. Issues arose over written agreements, enforcement, roles and responsibilities, and deliverables that delayed development and test schedules. Successful public-private partnerships must address issues in contracting terms and conditions; enforcement of agreements with partners; proprietary nature of data; and expectations from the arrangement.

- The FHWA perspective focused on sponsorship, program, and evaluation support in accordance with the ITS program and Federal Transportation legislation. FHWA provided up to 80 percent of the funding and the balance was provided by state agencies and other project partners.

Genesis was one of the first tests to experiment with public-private partnerships. An early lesson learned with this test was that the viability of the partners needs to be determined in advance. For example, a supplier of the early PDAs proposed for the project became insolvent, which caused problems for the development contractor.

Travlink's interviews revealed positive and negative impacts of using a partnership approach compared to traditional contracting arrangements. The positive benefits included:

- Creativity and flexibility

- The ability to share information and resources

- The ability to share risks

- The ability to test leading-edge technology

- The funding potential associated with private sector contributions

Negative impacts included:

- The inability to control the private vendors and enforce their end of the agreement

- The lack of profit for private vendors

- The difficulties associated with team decision making

- The length of time involved in developing and executing the agreements.

SWIFT also experienced hurdles with regards to public-private partnerships and conflicting goals, expectations and perceptions. Other issues that impeded the SWIFT project included patents, copyrights, roles, and responsibilities.

TravInfo's experience lends itself to a variety of public-private partnership discussions. TravInfo promoted wide participation, but also created a layered management structure that has, at times, made progress laborious. The project relies heavily on a cooperative and non-adversarial working culture, which is noteworthy given the size and scope of the project and the level of public-private participation.

Specifically, in addition to the project management, TravInfo was influenced by a Management Board (public representation only), a Steering Committee (public and private representation), and an Advisory Committee (public and private representation). The Independent Evaluator's opinion is that this organization is effective; however questions have been raised regarding the authority boundaries of the Management Board and the Steering Committee.

For Travlink, administrative stumbling blocks included turnover of key staff in the middle of the project, internal staff resource problems, buy-in from senior level management, as well as the structure of project management. Often the collective decision-making process required excessive time to execute agreements.

General recommendations based on the TravTek evaluation lessons learned included a selection of sufficient and quality leadership, not only in identifying a program manager, but also leaders of technical and evaluation efforts and the onsite system manager in charge of 24-hour operations. They suggest that good leaders will seriously consider the lessons learned by others and capitalize upon them. Leadership helps the individual partners focus on group objectives and fosters a cooperative, team approach toward obtaining them.

The TravTek evaluation results also suggested that evaluation considerations should be included from the beginning of a system design. It strongly recommended that system designers and builders share a vision of what will make their system a success. Evaluation can be used to enable the design team to think in terms of measurable success criteria. Success criteria could then be selected to include consideration of partner objectives, but also of the needs of the ITS community for knowledge necessary to successful deployment. Institutional issues recommendations drawn from the ADVANCE project include providing the greatest effort possible to make sure that key project leaders are retained from the point of project conception to completion; making the project manager's role distinct and separate from those of the project partners; and organizing administrative-type committees among the major parts that can handle important non-engineering issues.

COST TO IMPLEMENT

Since the FOTs began in 1991, new issues have come into focus such as identifying communications technologies and the feasibility of ATIS. Funding outside of the FOT initiatives, including the Federal Model Deployment Initiative awards have promoted further development of ATIS systems and have addressed developing issues as well as new issues not currently addressed by FOTs. The private sector has shown interest in developing business models to use advance traveler information as part of several profit making products and services.

The TravTek evaluation noted that the private sector should anticipate the costs to maintain accurate navigation databases and local jurisdictions must work together if information infrastructures that can support cross-jurisdictional traffic management initiatives are to succeed.

The need to collect public sector life cycle costs has been identified among all ATIS services. As commercial products begin to emerge, the private sector has been reluctant to discuss costs.

Participants who used the TravTek system said they would pay for it if it were available. Median estimates of willingness-to-pay for a TravTek-like system in a new car were about $1,000. This data becomes more meaningful when it can be assessed with the current products on the market that provide similar services.

SUMMARY

The following paragraphs summarize several lessons learned from the ATIS field tests. These lessons may be considered by participants in future deployment efforts.

- The pre-trip traveler information systems projects reviewed in this evaluation were successful demonstrations of various technologies and configurations of technologies that can be deployed to provide pre-trip traveler information to large numbers of users.
- Users generally reacted favorably to having the capability to receive accurate, real-time traffic information before they began trips. Frequency of use will depend on the system's portability, accuracy, timeliness, and daily cost. Increased public awareness of these options will increase the number of users of available services and make evaluation of these services more accurate.
- Pre-trip traveler information systems that have been introduced in these projects appear to perform well technically. However, pre-deployment development practices (systems testing and integration) need to be more efficient to minimize technical risk in order to succeed commercially.
- Each side of a public-private partnership needs to understand the principles and ideals that govern the other. There is a need for team-member consensus regarding development approach and the technical tools to be used. An understanding of the full range of technical obstacles, specifically in regards to systems displays and integration is vital.
- The appropriate role of public agencies in providing traffic information for re-sale by commercial interests is still without complete consensus. Lessons will be drawn as present business models mature, as federal grant money ceases, and as future models are proposed.
- Public-private partnerships can work but they are difficult and costly to implement. Project management structure may be a contributing factor since it influences the quality and timeliness of most decisions.
- ITS system tests and current deployments provide new models of intra-agency working relationships, and innovative ways of doing business with commercial firms.
- Market research, user-system prototyping and user training should be included in ITS projects to ensure the systems are well received.

- Communication between designers, developers and integrators is essential as is communication between partners both public and private.

- En-route data has the potential to reduce the perceived barriers for customers or potential customers to use public transit and to shift SOV drivers to public transit or HOVs.

- ADVANCE and TravTek have demonstrated the feasibility of in-vehicle traveler information. Turn-by-turn route guidance with voice prompts ranked highest in user ease, popularity and safety over the other combinations of in-vehicle devices tested.

- Idaho Storm Warning System and Herald II are continuing their work to alert drivers to safe speeds in adverse conditions. Both the VMS and the AM subcarrier broadcast are proving to be successful media. DIRECT should contribute significant evaluation results later this spring.

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Publication No. FHWA-JPO-99-038
HVH-1/9-98