DIRECT
Operational Field Test Evaluation
Natural Use Study

Part 4: Recommendations for Expanded Deployment

Submitted to:
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August 1998
Contract No. 94-1519 DAB

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EECS-ITS LAB-DT98-001

Contents

Abstract

The following abstract is a restatement of the report introduction.

The DIRECT project compared four low-cost driver information systems. Of the four that were compared, the RDS approach proved superior to the others in toggling reliability and voice quality. The DIRECT project planned to expand the implementation of the radio driver information systems in the final (expanded fleet) stage to get a better understanding of how to improve the service provided by this most highly-rated system. An interesting clue to the drivers needs for information was uncovered in the driver survey and tracking data. The drivers often used the information to avoid highway construction areas. The expanded fleet project proposed herein exploits such insights, as well as other major developments.

Our DIRECT experience convinced us that using two subcarriers from an FM station was not feasible due to: 1) the additional cost to lease the additional subcarrier from all participating stations; and 2) the changes it would require in RDS receivers. Hence we now propose a simplified information system, referred to as Route Specific Traffic Alerting System (RSTAS), which uses only the single RDS subcarrier.

During the DIRECT project we also learned of another synergistic exploitation of the RDS radio: delivering emergency warnings via Emergency RDS (ERDS). Both the Michigan State Police and the Detroit Police Departments (as well as MDOT authorities) have become enthusiastic about the contribution to safety of these warnings. Research conducted by the National Transportation Safety Board and the National Institute for Occupational Safety and Health suggests that unless preventative measures are taken, the number of fatalities in highway work zones will continue to increase as highway construction, repair and maintenance spending increases. From 1982 to 1988, highway construction spending rose from $32 billion to $52 billion (61.5%) while the number of highway work zone fatalities rose by 62.7% from 489 to 780. (1)

Consequently, our Expanded Fleet proposal not only takes advantage of all the things learned during DIRECT, including developments elsewhere in the country, but adds an entire new safety thrust. A major benefit of the expanded fleet project will be to evaluate how well the two new services can improve traffic flow around construction sites and improve the safety at the work sites. The drivers will experience emergency warning and route-specific traffic alert services that go way beyond the functionality of the basic traffic services they were exposed to in the initial evaluation. This is an opportunity to define the benefits from low-cost systems that could be widely deployed to expand the functionality of MDOT's new surveillance capabilities.

1. Introduction

The DIRECT project compared four low-cost driver information systems. Of the four that were compared, the RDS approach proved superior to the others in toggling reliability and voice quality. The DIRECT project planned to expand the implementation of the radio driver information systems in the final (expanded fleet) stage to get a better understanding of how to improve the service provided by this most highly-rated system. An interesting clue to the drivers needs for information was uncovered in the driver survey and tracking data. The drivers often used the informatron to avoid highway construction areas. The expanded fleet project proposed herein exploits such insights, as well as other major developments.

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2. Goals of the New Services

Two new services will be deployed Route Specific Traffic Alerting System (RSTAS) and Emergency RDS (ERDS. The goals for the Emergency Warnings are:

a. Contribute to public safety by warning of extreme weather conditions. bridge ahead is actually icy (not just "might be icy"), construction vehicle in lane ahead, construction workers present. emergency vehicle is approaching, etc. ERDS will reduce the incidences of drivers being surprised by stopped traffic on expressways, which is a frequent cause of rear-ending accidents.

b. Contribute to safety of MDOT workers and drivers of emergency vehicles, by warnings to vehicles in vicinity. This is especially important for MDOT (and other) work zone workers.

The major goal of the Route Specific Traffic Alerts is to increase the number of drivers who are aware of exception (non-recurrent) incidents and queues built up by construction conditions along their planned route, and to give them accurate (and unique) information that will help them make the best pre-trip or enroute changes. Much research shows that most serious drivers (commuters, etc.) will react to pre-trip information; the same research shows that only a minority have to date reacted to enroute diversions--many simply sit it out. Nevertheless, that minority who take more responsibility than the others is an important potential contributor to reducing the impact of incidents. Also, increased awareness of construction zones via RSTAS will support the present use of TV, Internet, and pre-trip phone calls regarding construction and incidents.

In the upcoming years, MDOT will benefit from the deployment of the two new services by:

1) Improved safety of construction workers from both ERDS warnings and RSTAS alerts

2) Developing a way to help drivers be aware of and negotiate around the extensive construction that is upcoming in Michigan, and

3) Improved exploitation of the surveillance infrastructure investment.

3. Goals of the Expanded Fleet

The Expanded Fleet project is a crucial step toward operational deployment of the two new services, and has as its goals:

1. DEMONSTRATE THAT THE EMERGENCY WARNINGS USING ERDS WORK AS PLANNED:

A) Demonstrate that the emergency transmitters work on emergency vehicles without interference to other systems, and that they are received reliably on vehicles in the vicinity.

B) Demonstrate that multiple emergency vehicles in a given area can be coordinated so that vehicles receive only one warning, rather than a multiplicity.

C) Demonstrate that Police, Fire, EMS, and Emergency Management communities welcome this contribution to safety.

D) Demonstrate that drivers can receive warnings of unexpected difficulties or tie ups at construction work zones that should increase the safety of construction workers at the site.

Comments: The FCC must eventually agree to allow use of the 87.9 MHz frequency as a special set-aside frequency for ERDS. Demonstrating the success of the "multiple vehicle" scenario is perhaps the most challenging aspect for ERDS.

2. ADDRESS THE STILL UNMET NEED FOR IMPROVED TRAFFIC INFORMATION BY AN IMPROVED EXPLOITATION OF THE TAXPAYERS INVESTMENT IN SURVEILLANCE INFRASTRUCTURE.

Comrnents: To date, MITSC has delivered 3-level speed diagrams; Etak and CUE are gearing up to provide more incremental speed profiles. Our proposal of providing minute by minute (automatically generated) delay times and exit and re-entry exchange numbers is both more clever and more directly useful for determining reaction decisions. These paging-type "alerts" also improve the ability of drivers to get around the construction-constricted areas, which is important in light of the upcoming increase in this activity in Michigan and elsewhere.

Elsewhere in the country projects such as Trilogy in Minneapolis, the Model Deployment in San Antonio, Texas and the TravInfo project in the California Bay area have demonstrated the ability to convey pertinent traffic information to drivers, but require a bandwidth (hence transmitter and receiver cost) which is not sustainable. None of these projects have led to continuing, sustainable in-vehicle traffic information.

3. DEMONSTRATE THAT THE ROUTE SPECIFIC TRAFFIC ALERTING SYSTEM (RSTAS) USING RDS WORKS AS PLANNED.

A) Demonstrate that the loop sensor inputs at MITSC can be used, along with new software. to automatically generate delay times due to incidents, along with exit and re-entry interchange numbers.

B) Demonstrate that drivers will benefit from information on changes in highway work site conditions that may results in more efficient travel as a result of route modifications. and should also improve the work site safety due to increased awareness on the part of the drivers.

C) Demonstrate that the auto companies, the radio manufacturers, and the traffic authorities can agree on a common protocol for delivering the delay time and the exit and re-entry numbers for the incidents.

D) Demonstrate that the radio manufacturers are willing to write software for their radios that enable the RSTAS function.

E) Demonstrate that a majority of FM stations are willing to carry the traffic alerts without a fee during the test; possibly requiring a fee when operational.

F) Demonstrate that motor clubs have an interest in offering this travel service, if demonstrated to be feasible.

Comments: Deploying RSTAS is more difficult than ERDS since more parties must be involved: radio manufacturers, FM stations, and traffic sensor sources. While there are no conceptual technical uncertainties, the goal here has significant challenge.

4. EXPOSE A REASONABLE NUMBER OF DRIVERS (200) TO THE EMERGENCY WARNINGS, AND ASSESS THEIR PERCEIVED VALUE

Comments: A reasonable number of participants is required to assure that the joint event--emergency vehicles or “icy bridge” (or extreme weather) and equipped vehicle present--occurs during the test period. The assessment will be done by mailed survey form and phone contact. If funds are available, models and external data can be used to predict the safety impact of the ERDS resulting from the warnings.

5. EXPOSE A REASONABLE NUMBER OF DRIVERS TO THE TRAFFIC ALERTS AND ASSESS THEIR PERCEIVED VALUE AND POSSIBLE WORK SITE SAFETY IMPROVEMENTS, AND THAT THE COMBINATION OF DELAY TIMES, EXIT AND RE-ENTRY INTERCHANGES, AND PAPER MAP IS THE BEST POSSIBLE DRIVER INFORMATION.

Comments: A reasonable number of participants is required to assure that the joint event--a pre-trip or enroute incident and an equipped vehicle--occurs at least a few times during the test period. The assessment will be done by mailed survey form and phone contact. The survey results can be compared with the earlier DIRECT systems to show comparative levels of improvement. If funds

are available, models and external data can be used to predict the safety impact of the RSTAS resulting from the increased awareness of problems.

The driver information provided here is unique, and has attracted the respect of a wide range of knowledgeable parties.

6. MDOT, IN COLLABORATION WITH THE UM, AUTOMOBILE MANUFACTURERS AND SUPPLIERS, EMERGENCY SERVICE PROVIDERS, INDEPENDENT SERVICE PROVIDERS, ETC. CAN EMERGE AS A NATIONAL LEADER IN THE DEPLOYMENT OF SUCCESSFUL, SUSTAINABLE LOW-COST ATIS.

Comments: The level of cooperation attracted by the two new services exceeds any previous ATIS experience by MDOT or the UM.

3.1. Expanded Fleet Project Overview

The University of Michigan (UM) is proposing to develop, test, and evaluate the aforementioned RDS-based motorist information system, composed of the emergency warning and route-specific traffic alert services, as a revision of the DIRECT Expanded Fleet. The overall goal of the test is to have up to 200 drivers experience, for a period of 3 months, both emergency warnings and route specific traffic alerts. We propose to deploy a total of up to 50 emergency transmitters, and to enlist about 6 FM stations for the traffic alerts. A six month period of construction of the two systems will be followed by two cycles, each three months long. of up to 100 drivers (up to 50 from each of two automobile manufacturers). The active test portion of the project will in turn be followed by two months of analysis and reporting for a total project duration of 14 months.

3.2. Two New Services: ERDS AND RSTAS

In line with the recommendation to build upon the results from the Base Fleet evaluation, UM is organizing and facilitating a group effort to develop and test a low-cost radio-based motorist information system based upon RDS technology. The system provides two services: automatic emergency warnings and route-specific traffic alerts. The in-vehicle component of the system is an RDS radio programmed with new application software based on non-proprietary protocols. Radio manufacturers can easily develop their own version of the application software and load it into the RDS radio at a dealership or during the manufacturing process. In brief, the two new services:

- provide traffic and weather-related emergency warnings to the public (both in-vehicle and at home or work) without a use fee,
- provide route-specific traffic alerts, perhaps for a low fee,

- increase the demand for complementary value-added services that provide more detailed event and routing information,
- broadcast data in a format that will support value-added dynamic route guidance services. and
- support a standard nationwide (possibly international) approach consistent with the Intelligent Vehicle Initiative (M).

The emergency warnings are delivered in voice via low-power portable FM transmitters operating at 87.9 MHz, hereafter referred to as the public safety emergency frequency (see Figure 1). These transmitters are located on emergency vehicles, on road-maintenance vehicles. at active construction sites, etc. To access the service, a motorist simply needs to have an RDS radio that has the application software. The newly programmed RDS receiver periodically peeks at the public safety emergency frequency and switches the radio to receive the localcast message when the carrier is present. The application software will turn on the radio if need be to provide the warning. Likewise the CD player or cassette, if used, will be paused. The voice messages can be recorded in advance or by an on-site operator. This component of the proposed system, which has been developed by Federal Signal Corporation in conjunction with Delco, is ready for deployment.

The route-specific traffic alerts are delivered via clever use of the standard RDS subcarrier (see Figure 2). Terse text messages describing current incidents on expressways or arterials are prepared at a Transportation Management Center or Independent Service Provider using the best existing information sources. Participating commercial FM stations then include the messages as part of the data stream in their RDS subcarrier. To access the service, a motorist must have an RDS radio with a two-line text display, which may eventually be supplemented or replaced by a text-to-voice device, the application software, and a customized data file describing the motorist's frequently traveled routes. The customization for the traffic alerts will be provided by a motor club (or equivalent) for a nominal annual fee. The newly programmed RDS receiver compares the stored list of route segments with the broadcast list of route segments with an incident. When a match occurs, the driver is notified by an audible chime and two lines of text describing dynamic escape and re-entry points and delay time, i.e., the information a driver needs to decide whether to divert or to continue on. The Independent Service Provider would also prepare a customized paper map showing alternate routes that the motorist could take in response to an incident. As with the Emergency Warning service, the application software can "wake up" the radio to provide the alert if desired. This component of the proposed system, which is under development at the University of Michigan, must be further developed prior to deployment.

RDS radios are standard on several 1998 car models in the U.S. Moreover, the provision of the two new services, especially in-vehicle safety warnings, could provide sufficient reason to equip all new car radios with RDS within a few years. Given the perceived need for the two services, the potential availability of in-vehicle equipment, and the simplicity and low-cost of the RDS delivery mechanism, it is expected that the services will rapidly propagate to other metropolitan areas.

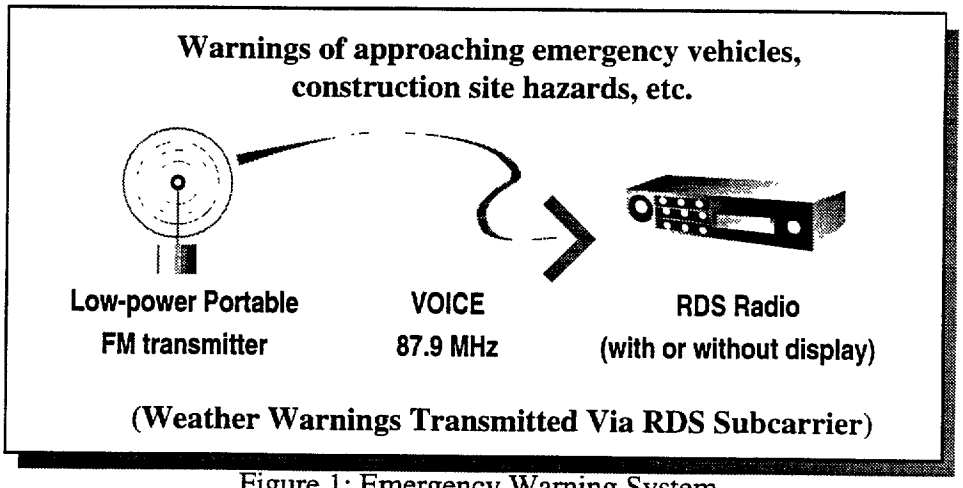

Figure 1: Emergency Warning System

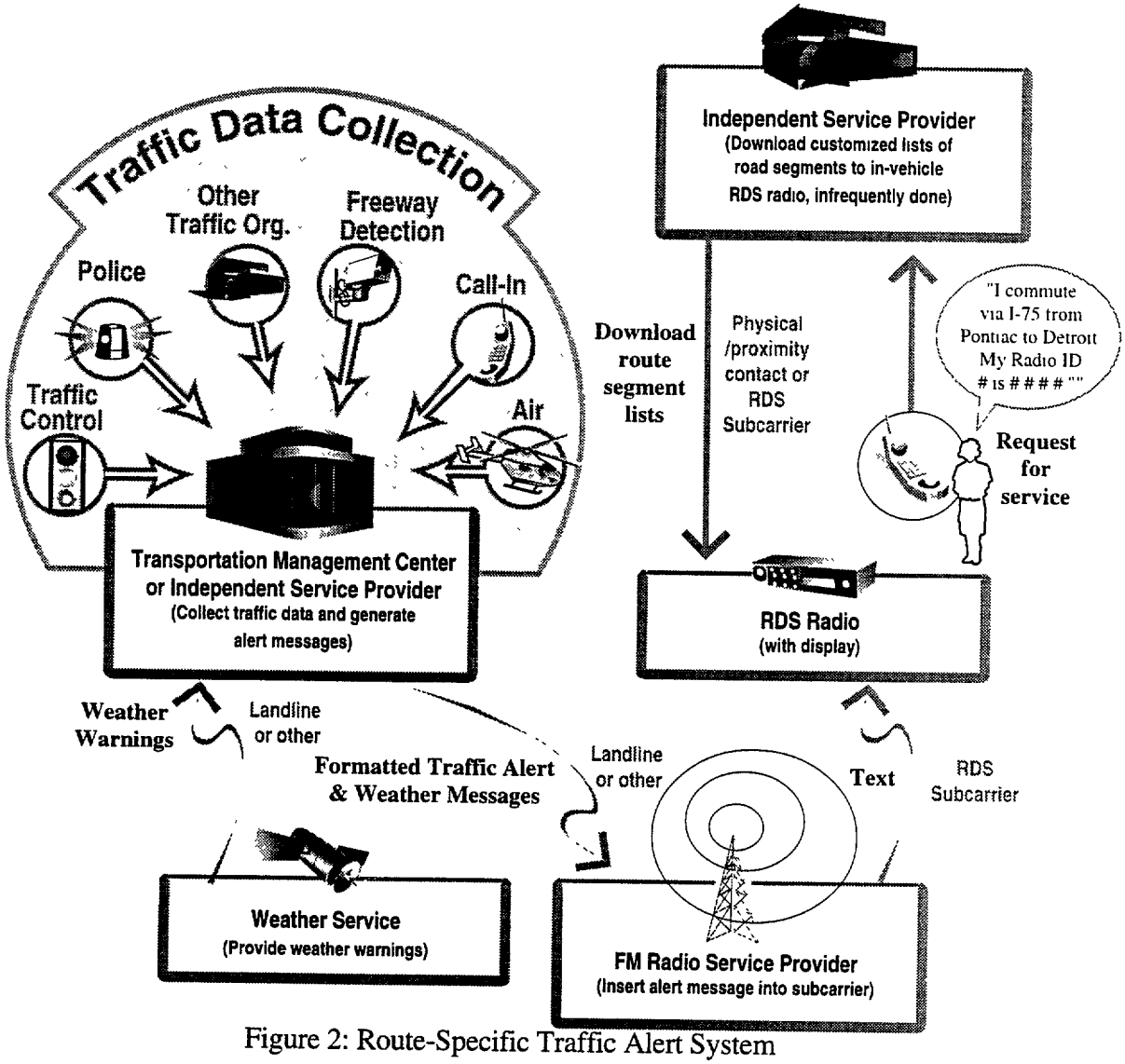

Figure 2: Route-Specific Traffic Alert System

4. Partnership Approach

This proposal is based on the expectation that MDOT and the other project partners listed below will provide the in-kind services and/or cooperation described below. The cost of these tasks are not included in the proposed UM budget given above.

4.1. University of Michigan (UM)

The University of Michigan will take the lead in pulling the partnership together and managing their cooperation. This will require taking responsibility for the following activities:

- **Coordinate & Administer Project**

  0 Coordinate activities of project partners.

  - UM will coordinate the plans and activities of the various organizations contributing to the deployment.

  - Conduct regular project meetings.

    - UM will host regular meetings to keep project participants aware of and involved in progress.

- **Design System**

  - Develop application software and protocols

    - Although a number of components of the system are currently available, e.g., the emergency warning localcast transmitters and associated in-vehicle software. the traffic data collection capabilities, etc., software development efforts to support three functions are required:

  - Develop delay-time estimation software

    - UM will write software that will access current dynamic MDOT data tiles coming from the deployed loops to generate delay times that will be displayed on the RDS display as part of the route-specific traffic alert service. The exit number ahead of current end of queue will also be automatically generated, since that will change as time passes. The re-entry number will be inserted by the MDOT operator, since that does not change during the incident.

  - Incorporate severe weather warnings

- UM will write or adopt software to provide severe weather warnings in conjunction with the route-specific traffic alerts to be distributed via the participating FM stations. Current RDS procedures include a method for delivering emergency weather alerts. so this should only require adopting existing software and procedures.

- Integrate existing UM message generation software with MITSC software

  - UM will write software to integrate existing message software (written under the planning project) to the message computer at MITSC, which will feed all cooperating FM stations. This task involves creating a circular array for the different current incidents, creating the ability to insert and delete new incidents. Incidents whose delay times go below ten minutes will automatically removed from the array. to facilitate reliable operation.

*Develop application software and procedures to customize the system

  - UM will produce and download the customized lists of routes that each subject needs to access the route-specific traffic alert function.

- **Design distribution to FM stations**

  - UM will design and implement a system to distribute the traffic alerts to the participating FM stations. A single message computer will be used at MITSC. Telephone lines using data modems will be fed in parallel to each of the participating FM stations.

- **Build, Test, & Maintain System**

  - Build system
    - UM will build the system per design.

  - Test system and modify as needed
    - UM will test and modify the built system as needed.

- **Maintain System**

  - UM will monitor, by some manual means, for proper operation of the radios, and provide rapid maintenance when necessary.

  - Customize System & Orient Participants

  - Install ERDS and RSTAS software in an appropriate RDS radio

    - UM will install the integrated ERDS/RSTAS application software in each participant's vehicle radio. Downloading will be through physical access to the RDS receiver.

- Program each driver's radio for his/her specific frequent routes (up to 5 per driver)
    - UM will customize each subjects' software so that they can access the traffic alert service. This involves writing subject-specific lists of route segments and downloading them to the vehicle radio. Downloading will be through physical access to the RDS receiver.
- Orient subjects to the two services.
    - UM will orient subjects to the purpose, function, and use of the two services.

- **Design Evaluation**
    - Establish goals, methods, and measures.
        - UM will establish evaluation goals, methods, and measures in conjunction with other project partners.
    - Select a test area
        - UM will study possible test areas and select the best one(s). A prime goal of the test site(s) is to allow a significant concentration of participants who commute via freeways (to allow testing of the route-specific service) and ERDS transmitters (to allow testing of the emergency warning service).
    - Develop subject recruitment methods and materials.
        - UM will develop subject selection criteria and methods, and a driver recruitment questionnaire, in conjunction with the automobile manufacturers, who will then carry out the actual recruiting.
    - Develop data collection protocols and instruments.
        - UM will develop an evaluation questionnaire. UM will also develop measures of the technical performance of the two services being tested.
    - Pretest instruments and modify based on the results.
        - UM will test, and modify as needed, all data collection protocols and instruments.

- **Collect Data**
    - Identify subjects and their routes (from driver recruitment questionnaire).

- UM will deliver the route information to AA4 Michigan for creation of custom paper maps and will use the information to customize the in-vehicle software file for each subject. (The subjects will be recruited by the automobile manufacturers. Moreover. no MDOT "clearance" of drivers will be necessary as participants will not be driving MDOT vehicles.)

- Administer evaluation questionnaire.

  - UM will distribute questionnaires to, and collect them from. study subjects at the end of their three-month experience.

- Collect technical system performance data.

  - UM will collect data on the technical performance of the MITSC-based and in-vehicle portions of the route-specific traffic alert service and the ERDS transmitters.

- **Analyze Data & Report on Findings**

  - Analyze data

    - UM will analyze the collected data to answer the empirical questions identified in the evaluation plan and to describe the technical performance of the services.

  - Make deployment recommendations

    - UM will write a report detailing the background, methods, results, and conclusions from this study will be produced. The report will permit study replication as well as a full and complete understanding of the data, analyses, and conclusions drawn. The report will generate improvement suggestions and recommend a deployment plan that could be exported to any metro area in the country.

4.2. Michigan Department of Transportation

MDOT will carry out the following tasks.

1) Fund University of Michigan efforts

   - UM has a number of design and evaluation tasks that need to be funded for project success (see below).

2) Provide information so that UM can write delay estimation software (see below)

- UM requires access to expressway monitoring data and assistance in developing software that will take existing data and estimate delays due to incidents (see below).

3) Install & maintain delay/message software in MITSC

- Once delay estimation and traffic alert message generation software has been written (by UM), it must be installed in a computer at MITSC and maintained for the duration of the project.

4) Procure project-related equipment

- Specialized equipment is required by the project. MDOT is expected to procure about 20 ERDS transmitters for placement on public vehicles and at construction sites (10 fixed site transrnitters @ $2,000; 10 vehicle mounted transmitters at $1,500), 6 RDS encoders for radio stations (@ $1,500), a portable computer for on-site use in customizing subjects' radios (@$l,500), and modems/leased lines for dissemination of the route-specific traffic alerts to about six participating FM stations (7 months each @$100/month). An additional 30 ERDS transmitters are expected to be procured through other sources and installed on police and EMS vehicles.

5) Install and maintain ERDS transmitters at MDOT sites

- About 20 mobile low-power FM transmitters for the emergency warning service are to be deployed on certain highway maintenance vehicles, and at certain highway construction sites, etc.

6) Operate the existing expressway surveillance system

- The project requires access to data from the existing expressway surveillance system.

7) Operate the route-specific alert service

- An existing or additional MXTSC operator must be given the task of entering incidents into, and deleting incidents from, the "current incident file" in support of the route-specific traffic alert service, i.e., for any incidents that occur, the five data items in the route-specific information packet must be produced and sent to participating FM stations. This activity includes monitoring for severe weather warnings and incorporating these in the data stream.

8) Review project status

- MDOT will review project status and provide appropriate input.

4.3. Federal Signal Corporation

Federal Signal Corporation will carry out the following tasks. UM estimates the value of this in-kind contribution to be about $32,500.

1) Supply ERDS software to automotive suppliers

- Federal Signal Corporation will supply ERDS software to the Automotive Suppliers at no charge. This software must then be customized by each manufacturer as needed.

2) Advise on installation of ERDS transmitters

- Federal Signal Corporation will advise project partners on the installation of ERDS transmitters.

3) Provide ERDS transmitters at a discount

Federal Signal Corporation will supply 50 ERDS transmitters for this project at a discount.

4.4. Automobile Manufacturers

Two Automobile Manufacturers will each carry out the following tasks. UM estimates the combined value of this in-kind contribution to be about $270,000.

1) Recruit drivers

- Each Automobile Manufacturer will recruit their employees for participation as subjects in the project. The suppliers of these companies may also be asked to participate.

2) Arrange for vehicles

- Each Automobile Manufacturer will arrange for vehicles to be used in the project. These vehicles might be corporate vehicles or personal vehicles of the subjects.

3) Provide RDS radios and install in vehicles

- Each Automobile Manufacturer will provide appropriate RDS radios for vehicles to be used in the project. These radios must have all needed memory, etc. required to support the two services to be tested. The radios also need an added external connector to allow installation of project software. Each Automobile Manufacturer will also install the radios in the vehicles to be used during the project and deinstall the radios as necessary.

4.5. Automotive Suppliers

Two Automotive Suppliers will each carry out the following tasks. UM estimates the combined value of this in-kind contribution to be about $115,000.

1) Write route-specific traffic alert software

- Each Automotive Supplier will write route-specific traffic alert software using their own proprietary RDS code, and using the protocols that are currently being pursued by the technical committee.

2) Write ERDS software

- Each Automotive Supplier will write ERDS software using their own proprietary code.

3) Integrate the software for the two services

- Each Automotive Supplier will each integrate their own software for the two services into their own unified application, still proprietary to each of the suppliers.

4.6. Automobile Association

An Automobile Association will carry out the following tasks. UM estimates the value of this in-kind contribution to be about $22,000.

1) Provide custom maps for up to 200 drivers

- An Automobile Association will provide each of the up to 200 participating drivers a paper map that shows a unique number for each expressway segment (link between two exits). The drivers will be asked to write segment lists of both to and fro for each frequent route to be included. The Automobile Association will furnish a custom map for each frequent route that emphasizes interchange numbers, which are shown on the RDS display, and the road surrounding that frequent route that could be used for diversion.

2) Provide staff time and advice

- An Automobile Association will provide staff time and advice to the project. Such an organization has extensive experience regarding what drivers desire. and already furnishes traffic advice and data. This experience will help implement the route-specific traffic alert service.

4. 7. Police/Fire/EMS

Police/Fire/EMS departments will carry out the following tasks. UM estimates the combined value of this in-kind contribution to be about $20,000.

1) Install transmitters (about 30 total)

- Selected Police/Fire/EMS departments will install ERDS transmitters on vehicles selected by the project. The purchase cost of the transmitters will be borne by the project, but will be a discounted price relative to retail.

2) Maintain transmitters

. Selected Police/Fire/EMS departments will provide routine maintenance for the project-related ERDS transmitters.

4.8. FM Stations

Commercial FM radio stations will carry out the following tasks. UM estimates the combined value of this in-kind contribution to be about $59,400.

1. Install and maintain a project-supplied RDS encoder

Each participating FM station will install and maintain a project-supplied RDS encoder at their station.

2. Operate the RDS subcarrier

Each participating FM station will carry the array of current incidents, with each containing the escape exit number, the delay time, the re-entry interchange number, and (possibly) the clearance time when available.

5. After the Beta Test

During the 14 month Beta test an ever-increasing number of parties will become aware of the uniqueness and effectiveness of the two new services. This, along with the expected positive reaction by the test participants, is expected to lead to the two services becoming operational on a continuing basis. ERDS is expected to attract permanent support based on its contribution to safety. RSTAS is expected to become a travel service offered by one or more motor clubs. which would charge an annual fee, which would in turn permit payment of some fees to both the FM stations and the MITSC information source. It is expected that metro areas around the nation having surveillance infrastructure will deploy the two services innovated here.

6. References

(1) “Safety Study: Highway Work Zone Safety.” National Transportation Safety Board. PB92-9 17005, NTSB/SS-92102. May 1992.