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Formal Evaluation of the *ADVANCE* Targeted Deployment

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Christopher L. Saricks
Evaluation Manager
Argonne National Laboratory/Center for Transportation Research
9700 S. Cass Avenue
Argonne, IL 60439
VOICE: (708) 252-8335
FAX: (708) 252-3443

Paul A. Belella
Booz • Allen & Hamilton, Inc.
8201 Greensboro Drive
McLean, VA 22102
VOICE: (703) 883-9887
FAX: (703) 883-9885

Frank S. Koppelman
Professor of Civil Engineering and Transportation
McCormick School of Engineering
Northwestern University
Evanston, IL 60208-3109
VOICE: (708) 491-8794
FAX: (708) 491-5264

Joseph L. Schofer
Professor of Civil Engineering and Transportation
McCormick School of Engineering
Northwestern University
Evanston, IL 60208-3109
VOICE: (708) 491-8795
FAX: (708) 491-8795

Ashish K. Sen
Professor of Urban Planning and Policy
Professor of Mathematics, Statistics and Computer Science
Urban Transportation Center
University of Illinois at Chicago
1033 W. Van Buren, Suite 700 South
Chicago IL 60607
VOICE: (312) 996-2175
FAX: (312) 274-2286

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ABSTRACT

The Advanced Driver and Vehicle Advisory Navigation Concept (*ADVANCE*) advanced traveler information system (ATIS) demonstration project in northeastern Illinois was re-scoped in late 1994 from its originally-planned deployment of 3,000 - 5,000 in-vehicle navigation units to a so-called "targeted" deployment in which up to 75 vehicles were equipped with devices enabling them to receive real-time traffic information. These devices included 1) global positioning system (GPS) transmitters/receivers that enabled the vehicles while in the *ADVANCE* study area to serve as dynamic traffic probes as well as recipients of location data; and 2) navigation units that employed a comprehensive map data base and average (static) link travel times by time of day, stored on CD-ROM, which together computed efficient (least duration) routes between any origin and destination in the northwest portion of the Chicago metropolitan area. Experiments were designed to dispatch these equipped vehicles along links at headways or frequencies comparable to what would have been observed had full deployment actually occurred. Thus, within the limitations of this controlled environment, evaluative experiments were conducted to assess the quality of several of the key sub-systems of *ADVANCE* in the context of structured performance hypotheses. There was particular concern about the ability of equipped vehicles 1) to both generate and receive time-saving reroutes in congested corridors, 2) to transmit (together with fixed detectors and anecdotal police and motorist reports) to a Traffic Information Center (TIC) timely and accurate information about road conditions and incident-related congestion that in turn would generate reliable link and route travel time estimates useful in real time, and 3) to provide an informational package and structure having both appeal and utility for drivers generally familiar with routes and traffic conditions in the study area. The expandability and transferability of the TIC architecture and the quality of its user interface, the inherent safety of real-time in-vehicle navigation, and the lessons learned from the *ADVANCE* deployment were also evaluated.

Focused on-road tests began on June 1 and continued through December 14, 1995, followed by a period of data evaluation, documentation of results, and development of conclusions about the findings and usefulness of the project. This paper describes the tests, discusses development of the overall evaluation plan and the evaluation management concept which guided them, and reports on issues and results of data analysis known at time of writing.

BACKGROUND

The Advanced Driver and Vehicle Advisory Navigation Concept (*ADVANCE*) demonstration project is a public and private sector operational field test of an Advanced Traveler Information System (ATIS) in an approximately 300 square mile region in the northwestern suburbs of Chicago, IL. The public sector participants are the Illinois Department of Transportation and the Federal Highway Administration (FHWA). Motorola and the Illinois Universities Transportation Research Consortium (IUTRC) are the major private sector participants, referred to as the Parties to the *ADVANCE* agreement. Commencing in 1991, *ADVANCE* has been a cooperative effort to evaluate the performance of a Dynamic Route Guidance System (DRGS) that provides real-time traffic information to drivers of *ADVANCE*-equipped vehicles. Development work on the system was completed by the end of March, 1995 and system integration testing completed in June, 1995. Evaluation tests were conducted from June through December, 1995 and documentation of the results of the full evaluation is expected to be finalized by August, 1996.

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As described by Ligas and Bowcott in a paper presented at the 1995 Annual Meeting of ITS America (1), *ADVANCE* has over the past year undergone reconfiguration to a targeted deployment approach, involving a relatively small number of equipped vehicles and execution of specific evaluations in a controlled environment. Test plans were developed by members of the *ADVANCE* consortium to investigate and publicize the performance, utility, and acceptance of the system's ATIS components and features. These plans addressed 1) the architecture and user interface of the Traffic Information Center (TIC); 2) the algorithms and data bases for traffic-related functions (TRF); 3) the use by and response of drivers familiar with the network in the *ADVANCE* area to the system's automated in-vehicle mobile navigation assistant (MNA); 4) the capability of the system to generate timely and *time-saving* reroutes by dynamic processing of information received from vehicle probes, loop detectors, and incident reports; 5) the implicit safety of the MNA system; 6) lessons learned during project life; and 7) the creation of a source of information about the project easily accessible to a broad spectrum of users.

The vehicle-based tests used paid as well as volunteer drivers and were conducted with as few as eight and as many as 22 vehicles, all of which were either owned or rented by the project. The paid driver tests were run only on weekdays with vehicles deploying from the *ADVANCE* Project Office in Schaumburg, IL. However, the issuance of project vehicles for two-week periods to households of area-familiar drivers recruited to participate in the evaluation meant that probe data were generated and collected on both weekdays weekends during the periods in which the (volunteer) familiar driver tests were being conducted.

EVALUATION PLAN

The Evaluation Plan emphasizes the innovative features of the *ADVANCE* system, especially the use of GPS-quipped probe vehicles to provide real-time travel data, and addresses several important topics:

a) *Assessment of the degree to which the architecture and operational practices of the TIC meet present and future needs of participating agencies.* Daily operations of the TIC were monitored by De Leuw, Cather & Co., who also examined the response of operators and the causes and remedies of system breakdowns. Specific aspects evaluated against pre-defined measures of effectiveness included performance of the hardware and software comprising the system and possible system design alternatives, the system's expandability (inclusion of additional functions) and transferability to other geographic areas, its cost efficiency with respect to staff and other requirements compared to possible alternatives, and the human factors aspects of TIC operation.

b) *Evaluation of the performance of the components of the Traffic-Related Functions (TRF) Subsystem and the relative usefulness of the probe vehicles vs. the in-pavement loop detectors in improving real-time traffic data.* The related field tests, managed by University of Illinois at Chicago faculty, used paid drivers operating *ADVANCE* system-equipped vehicles. The vehicles drove pre-determined routes for which their traversal times for each link were recorded at the TIC along with arterial loop detector data. These were analyzed to determine the performance of key TRF components. These components include: fusion of data received from probes and detectors into a travel time prediction algorithm; construction of both the default static forecasts and the on-line dynamic forecasts; estimation of the number and frequency of probe traversals required for

reliable travel time updates; and the relationship among vehicles' travel times on a link as a function of turning movement and directionality. The data collection phase of the TRF evaluation was completed on August 25.

c) *Determination of whether, and to what extent, dynamic route guidance, as implemented in the ADVANCE system, can provide significant improvements in travel times to drivers.* This test had two central facets: yoked-driver timing and incident detection timeliness. In the yoked driver tests, pairs of equipped vehicles operated by paid drivers were driven at identical start times between a pre-selected origin and destination. One member of each pair followed routes planned and updated in real time through the communications link with the TIC, while the other followed a fixed (or static) route defined by the MNA using only its embedded map and travel time data (i.e., no TIC communications). A large number of equipped vehicles acting as probes pre-deployed ahead of the pair along alternative routes between each planned origin and destination to provide frequent travel time updates to the TIC. The objective was to determine whether and how frequently the member of the pair in full communication received information that actually saved time. In the incident detection evaluation, pre-staged and roving field vehicles were dispatched in real time to the scene of either a reported incident or known actual (or simulated) construction delay. If an actual delay condition existed, these probe-equipped vehicles traversed the affected area in the effort to generate a reroute from the TIC when it was still useful to do so (i.e., before the incident or construction site had been cleared). The reliability of the algorithm that identifies construction and incident delays by means of loop detector data and data fusion was also evaluated with data collected from these traversals. Tests were conducted during periods of both recurrent and non-recurrent and incident-related congestion (both naturally-occurring incidents and staged incidents were used), and managed by faculty of Northwestern University.

d) *Evaluation of the potential contributions of in-vehicle route guidance concepts to reduce congestion in urban areas from the perspective of familiar driver's behavior, perceptions, and valuations of the ADVANCE's advanced traveler information system (ATIS) services.* This series of tests, conducted beginning in late July with most intense activity during October and November, made use of families living in the test area that had volunteered to drive ADVANCE-equipped, project-supplied vehicles for a two-week period, and who were willing to fill out both baseline and post-test surveys and to maintain drivers' logs noting malfunctions, problems, reroutes and responses thereto. Subsequently, several of these families participated in focus groups that examined their respective experiences and reactions. This test and the follow-on focus groups were also managed by Northwestern University.

e) *Evaluation of driver-vehicle-MNA interaction to examine potential safety implications for ADVANCE as well as other ATIS projects.* The Volpe National Transportation Systems Center (VNTSC) is managing during late spring, 1996 a test conducted by the University of Iowa that uses drivers in specially-instrumented vehicles whose operating profiles cover the full range of normal driving activities while being monitored by a test director and observer. Records of each driver's experience will be collected for subsequent evaluation with respect to safety implications. Equipped vehicles will not be supported by real-time information from a TIC, however, as the functions of the ADVANCE TIC were terminated in January, 1996.

f) *Compilation, description and analysis of lessons learned from the project since its inception and during the targeted deployment.* Various organizations involved with the project over its lifetime, under the guidance of De Leuw, Cather & Co., are contributing white papers recounting and summarizing the aspects of the deployment and its components most useful and instructive for ITS tests and deployments conducted elsewhere in the future. Several of these white papers have been submitted and are now in review.

g) *Creation of an information source that can be readily used by organizations interested in ITS projects.* This informational data base, prepared by Argonne National Laboratory, has been installed on Internet with a Uniform Resource Locator address of

<http://beijing.dis.anl.gov/ADVANCE/>

and currently contains past and present plans, descriptive and analytical documents, and reports generated during the lifetime of the project, all of which are downloadable. A graphical user interface for accessing animated illustrations of several of the evaluation field tests is also under construction on the *ADVANCE* page.

Many of the test plans originally developed to examine these facets of *ADVANCE* assumed that the originally-planned deployment of up to 5,000 MNA-equipped vehicles would take place. When this did not occur, theoretical bases of many of the tests had to be re-examined and, if still feasible within the new constraints, test scopes had to be downscaled consistent with there being a) many fewer vehicles deployed and b) incomplete realization of the MNA product as originally specified. The evaluators believe that they succeeded, despite major time restrictions, in re-scoping most tests into a framework capable of verifying or rejecting hypotheses, thanks in great measure to their long-standing intimate knowledge of the various *ADVANCE* sub-systems.

DEVELOPMENT OF EVALUATION STRUCTURE

It became apparent early in 1995 that the re-scoping of *ADVANCE* would necessitate development of an evaluation program and management plan different from that drafted late in 1993. Moreover, the contract for Evaluation Manager had not yet been signed with Argonne National Laboratory (Argonne), the organization selected to fulfill that responsibility. Because the needed reformulation of the evaluation testing and management scheme could not be postponed until such a signed contract was in place, the Federal Highway Administration (FHWA) requested Booz • Allen & Hamilton assume the role of Interim Evaluation Manager. In this role, Booz • Allen was tasked with re-focusing the evaluation to make it consistent with the thrust of the ITS National Program, while directing the expeditious completion of evaluation and test planning requirements.

Booz • Allen is currently under contract with FHWA to provide evaluation oversight support services for the ITS Operational Test Program, of which *ADVANCE* is a component. The Booz • Allen team began its task at *ADVANCE* headquarters in April, 1995. The team worked closely with each of the *ADVANCE* participants to identify test and data requirements, and to develop comprehensive procedures for managing test planning, execution and reporting. Using the *ADVANCE* Evaluation Program Plan (2), and information regarding the technical, administrative, and organizational issues of evaluation as gained through extensive interviews with each of the *ADVANCE* participants, an evaluation management framework and action plan were developed to

address the myriad technical and non-technical aspects of the *ADVANCE* Operational Test Evaluation. These efforts yielded the Evaluation Management Plan (3), a conceptual document intended to serve as the cornerstone evaluation strategy. The Evaluation Management Plan identifies the roles and responsibilities of the test program participants, delineates the data management requirements, provides a resource management plan for the test vehicle fleet, and includes detailed schedules for the completion of each evaluation task. This document, in concert with the *ADVANCE* Evaluation Program Plan, and extensive cooperation between staff and each of the evaluators, served as the foundation upon which test plans were developed to direct data collection and management, analysis, and task management efforts for each of the individual tests.

Early in May, the evaluation management contract was signed with Argonne. By prior agreement, the Booz • Allen team remained in place to fulfill its responsibilities and conduct an orderly transition to Argonne's management; this was accomplished by mid-June. Argonne as Evaluation Manager has subsequently endeavored to ensure that all tasks are conducted in complete consistency with the scope and schedule of the plans developed by Booz • Allen & Hamilton and the respective evaluators.

EARLY PROBLEMS AND THEIR RESOLUTION

The Chicago region experienced in 1995 one of its hottest summers on record. Although paid driver discomfort could be alleviated by using air-conditioned vehicles, some of the electronic components of the in-vehicle systems, specifically the CD-ROM drives, were mounted in locations (such as the trunk) that could not be cooled from the passenger compartment. As a result, these drives experienced functional difficulties, attributed largely to the high-temperature environment in the trunks of some of the vehicles. These components were frequently exposed to temperatures in excess of 65 degrees Celsius, although the drives themselves were not certified for functioning above 60 degrees. Late in June, drives in all test vehicles were replaced by drives type-certified to 65 degrees Celsius. Shortly thereafter, the repeated, systematic drive failures and degradation of MNA performance due to the extreme heat conditions ceased.

Availability of both vehicles and drivers to perform the tests in accordance with their design loomed as possible problems in early June. Initially, only 15 to 18 equipped vehicles were fully under the control of the project (as many as 22 were needed for some tests). Moreover, hiring of paid drivers for all tests was the responsibility of each evaluator's institution, and only a dozen or so had been recruited and hired as of June 1, many of whom would be unavailable from late August onward. Through a combination of hard work and good fortune, in particular the intensive and dedicated driver recruitment efforts by the evaluators, neither of these problems materialized. Argonne secured eight additional vehicles through a rental agreement, while a pool of some 25 paid drivers became available to the project well before the vehicle-intensive tests began in August.

TEST BASES AND CONDUCT

The MNA in-vehicle performance tests conducted by the university members of the *ADVANCE* consortium were structured to validate and verify key design aspects of *ADVANCE*. In this section, each of these tests and its associated procedure are discussed.

Traffic Related Functions

The Traffic Related Functions (TRF, hereafter "Functions") consist of a set of algorithms designed to convert the various data streams communicated into the TIC to travel times used by the MNA in both its static route planning and dynamic rerouting functions. Two types of travel times are generated:

1. *Static estimated averages*, for each day-type and time period within a day, of travel time on each link in the coded network. These estimates were used by the MNA as default values in the absence of real time information. Initially, static estimates are computed using a network model, but after sufficient data on actual link traversal times have been reported by probes these estimates are refined by means of an updating procedure.
2. *Dynamic (real-time) estimates of travel time*. If traversal times received from probes differed--due to incidents, recurring congestion, or some other identifiable cause--from static estimates by a pre-determined margin, they were broadcast from the TIC to MNA-equipped vehicles and replace the static estimates. Dynamic estimates were provided for both current and predicted travel times for 5, 10, and 15 minutes into the future on the affected links.

The computation of both revised static and real-time dynamic estimates requires several steps. The purpose of Functions evaluation is to assess the quality of the output of each of these steps. Thus, there are several components in the Functions evaluations, each of which can be assigned to one of two categories: those that relate to input data and those that relate to outputs.

The following components relate to the quality and usefulness of input data.

Quality of Probe Reports

An experiment assessed accuracy of link travel times and other real-time link data sent to the TIC by vehicle probes. Passengers (data loggers) in equipped cars manually recorded link traversal times later compared with electronically-saved probe estimates. Approximately 800 report comparisons showed that more than 85% of the differences in link travel times were 5 seconds or less. Comparison of logged and probe-reported link lengths, travel speeds, congested distances, and congested times also indicated a very high degree of accuracy in electronic data: of just under 51,000 probe reports generated and examined during an 11-week test period, fewer than 300 (about half a percent) were found to be suspect, whether in relation to measured speed, effective link length, or both. Introduction of reasonable threshold criteria in probe data screening could easily eliminate suspect reports from the data base used to generate potential re-routes.

Data Screening

A number of Functions procedures have been devised to screen out observations resulting from unusual driver behavior and the effects of irregular circumstances such as incidents or rail crossing delays. A test designed to check how well these procedures and functions work had drivers record unusual occurrences on a pre-printed log. The logs were later compared to post-screen data to determine if probe reports were uniformly properly handled--left in when they should have been and deleted as appropriate. Results indicated that, for the most part, identification of unusual situations was reliable, but that the situation identified most correctly under the given screening criteria was a malfunctioning MNA, not, for example, the presence of an incident condition giving rise to slow link traversals.

Frequency of Probe Reports

A test was conducted to determine what frequency of probe traversals on a given link is necessary to provide reliable real-time estimates of travel time. Vehicles were dispatched along the same link or set of links at differing headways. Preliminary results indicate that the average margin of error of link travel time, at least during off-peak periods, apparently does not decrease rapidly after the number of traversals per unit time has exceeded a (relatively) low value. If verifiable after more analysis and for other travel volumes, this result would indicate that very high levels of probe deployment may be unnecessary to achieve reliable travel times.

Tests that assessed the quality of *outputs* of Functions algorithms are as follows.

Assessment of Data Fusion Algorithms

A subset of both arterial and freeway links in the *ADVANCE* area is detectorized. Loop detector observations are converted through a TIC-based algorithm to travel times, which in turn is fused with other information to produce real-time travel time estimates for the detectorized links. Tests using systematically-collected probe traversal data were applied to the algorithms for both conversion and fusion to determine their reliability.

Relationships among Travel Times

Because most link traversals involve "through" movements, there is a shortage of data points for traversals involving turning movements at the end. It often becomes necessary to estimate a link's travel times involving turns by using through-movement travel times for that link. Tests were conducted using probe traversals with a large number of left and right turns to determine the accuracy of the Functions estimation algorithms for turning-movement travel times.

Assessment of Static Estimates

Tests evaluated the quality of both travel time estimates generated by a network flow model for the *ADVANCE* region and those obtained after updating these static estimates with real data.

Travel Time Prediction

Tests evaluated the reliability of the algorithm that predicts link travel times up to 15 minutes into the future using static profiles and real-time probe traversal data.

Incident Detection

Tests evaluated the capabilities of the incident detection system, which utilizes data from fixed detectors and probe vehicles for arterial roadways, and algorithms constructed to process data received from fixed detectors for expressways. Anecdotal data from the Northwest Central Dispatch reporting system in the primary instrumented arterial corridor served as validation source for arterial fixed detector, probe vehicle, and data fusion algorithms, while anecdotal data from emergency traffic patrols, motorist cellular phone reports, and Illinois DOT incident reports were validatory for the expressway algorithms. Both actual and simulated incident conditions were evaluated, the latter accomplished by repeated probe traversals of temporary road construction sites. While all other Functions tests were performed under direction of the University of Illinois-Chicago, this test was directed by Northwestern University. It is discussed in greater detail in a subsequent section.

Evaluation experiments have been conducted by paid drivers over a small subsection of the *ADVANCE* network such that the frequency of coverage using very few cars could effectively simulate that of 3,000 or more equipped cars traveling the network in normal daily service and thus provide a limited but verifiable emulation of the originally-planned full deployment.

Dynamic Route Guidance--Yoked Driver

The objective of the Yoked Driver Study was to determine, to the maximum extent feasible under limiting conditions, whether dynamic route guidance (DRG), as implemented in *ADVANCE*, could provide useful route guidance to drivers based on information about current travel times which differ from historic travel times due to recurrent or non-recurrent (construction- or incident-induced) congestion. Creating an effective way to provide dynamic route guidance and the provision of real-time travel time information to drivers in support of in-vehicle route planning was a fundamental objective of *ADVANCE*.

Experimental (dynamically routed) and control (statically routed) vehicles traversed multiple link sets connecting 5 origin-destination (O-D) pairs in the *ADVANCE* test area; the O-D pairs were separated by staging areas where test vehicles could assemble and drivers could take rest breaks between each O-D pair test. O-D pairs were selected to target congested roadways and expected construction projects, and to assure the availability of several alternate routes between origin and destination.

Three vehicle types--dynamically-guided, statically-guided, and probes--were used in this test. The key test vehicles were the yoked triad: two dynamically-guided vehicles, D1 and D2 (for redundancy to reduce the risk of MNA failure), each equipped with *ADVANCE* MNAs receiving real-time data relayed from the TIC, and the static vehicle, S, having the on-board route guidance system but no dynamic information because its RF modem was disconnected. Drivers of D1, D2 and S positioned their vehicles at or near the origins, entered destinations, and used the MNA to plan routes. Probe drivers followed defined routes from maps designed to assure complete and timely coverage of the links in the arterial street network between origin and destination. Their route plans and schedules provided a minimum of three travel time reports on each link in this network during the O-D test.

All vehicles were dispatched from the staging area at specified times. Departure times for the test triad were delayed sufficiently to permit the probes to progress through the network to generate dynamic data. Vehicles in the triad departed at one minute intervals and drivers were instructed not to follow each other intentionally.

Test managers in the Traffic Information Center (TIC) were in contact with each driver by cellular telephone to initiate each O-D run, divert vehicles to incidents, and troubleshoot. A driver-field manager supervised the start and completion of each O-D test.

Seventy-three "normal" O-D pair tests were conducted over a period of 5 weeks. To determine if real-time information would result in diversions around incidents, roadway accident reports from the Northwest Central Dispatch Center were monitored in the TIC for the purpose of identifying potential obstructions to which nearby vehicles in the test fleet could be dispatched. However, during field testing no incidents of sufficient magnitude and duration occurred within

the temporal and geographic limits of the tests. To enrich the data set, 19 "incidents" were simulated over a five day period by instructing probe drivers to slow to minimum safe speed over a predefined roadway link known to be a part of the normal O-D routing. In all cases dynamic data were generated by probe vehicles traveling along planned routes ahead of the test vehicles; on some routes, dynamic data also came from fixed detectors.

Test outcomes of interest were (1) different routes between D1 and/or D2 and S; and (2) significantly different travel times between D1 and/or D2 and S. Qualitative review of initial results has showed only occasional differences in routings in the normal (non-incident) O-D tests, and relatively small differences in travel times.

The incident simulation runs were more instructive. A total of 356 route planning attempts were made during the 19 O-D runs. The ratio of number of different routes produced to the total number of planning attempts for an O-D pair, a measure of the variability of the routings, ranged from 6 to 24%. The fraction of planning attempts that resulted in diversions away from the link on which the incident was simulated ranged from 8 to 76% of the total attempts. These results suggest that, under certain circumstances, it is possible to divert vehicles away from incidents with dynamic information. Analysis of the remainder of the data from this test is underway.

Incident Detection

The purpose of this subtest was to assess the capability of the automatic incident detection (ID) algorithms to identify incidents by comparing the ID algorithm outputs to anecdotal reports to determine the detection and false alarm rates, and the time to detect performance of the algorithms. The field study was executed in three parts. The first part consisted of continuous collection of arterial fixed detector data from an instrumented corridor over a two-month period, and comparison with anecdotal Northwest Central Dispatch (NWCD) incident reports for the same period and locations. The second part involved the dispatching of probe vehicles to areas of reported incidents, and operating the probes through the incident area to record travel time data. On cue from other incident detection sources, vehicles staged at strategic locations within the NWCD jurisdiction were driven to and through an area of naturally occurring incidents as many times as possible while the incident effects were present. Drivers recorded incident descriptive characteristics including number of vehicles involved, incident location, and effects on traffic flows and patterns. The vehicles later returned to the same site at the same time of day, on the same day-type, and drove through the area to collect data during non-incident conditions (likely during successive days while awaiting another incident). The third portion required the probe vehicles to traverse links within the test areas undergoing construction in order to determine the effect of construction conditions on the detection algorithm. Probe and detector data, as available, were collected for each site. For each of these portions, a comparison of link travel times, speeds, congestion times, and volumes and occupancies (where available) between construction and non-construction periods was to be made and a summary of the relationship between known incident conditions and incident alarms to be prepared for each algorithm for which there is data detailed by day, time and levels of congestion. A comparison of elapsed time to detect incidents from all sources was also to be made.

The hypotheses being tested by this experiment target performance standards for the detection algorithms, and are as follows: 1) that the number of false incident alarms in the arterial environment, based solely on fixed detector data, can be held to 20 percent of the total number of incident reports; 2) that the number of false incident alarms indicated as actual incidents in the arterial environment, based solely on probe data, can be held to 20 percent of the total number of reports for those cases where the alarm is based on a minimum of two probe reports in a five-minute period; 3) that the use of fused (probe and detector) data will result in more favorable detection and false alarm rates than either probe or detector data individually; and 4) that there is a probe fleet density level that can be identified that will result in an arterial incident detection performance that is equivalent to the performance of a fixed detector-only system.

Initial results indicate that probe vehicles are capable of identifying a large fraction of incidents on one or more of the impacted links (the incident link and immediate upstream links). In some cases, the effect of an incident is detected from changes in traffic flows in both directions on the incident link. However, initial analysis indicates that the level of false alarms may be so great that, in the absence of an external confirmation, false alarms will dominate the incident reports. Initial results for the fixed detector data are similar to those for probe vehicles providing that the incident is located near the loop detector.

No results have been obtained for fused incident detection as very few incidents provide simultaneously-generated data from fixed detectors, with which only one arterial in the study area was equipped, and probe vehicles in operation through an incident site on that same arterial.

Analysis of the fleet density needed to provide adequate coverage to obtain results equivalent to those obtained through the use of fixed detectors will be based on different assumptions of the density of fixed detectors, a variable which dramatically influences their effectiveness.

Familiar Drivers

The objective of this task was to use the revised deployment plan for *ADVANCE* to evaluate the potential contributions of in-vehicle route guidance concepts to congestion avoidance in urban areas from the perspective of familiar drivers' behavior, perceptions, and valuation of *ADVANCE* follow-on concepts. The study consisted of a small-scale field experiment in which 80 *ADVANCE* recruit households were provided the opportunity to use MNA-equipped project vehicles freely for a two-week period. Participant households were surveyed prior to using the vehicles, asked during use to record instances in which they re-routed from original plan during a trip, and asked after use to complete an exit survey. They were informed before the test that they would be invited to participate in focus groups after the test period to share their experiences with and attitudes toward the navigation system.

The evaluation covers the collection of data on the participants' demographic and travel characteristics, their behavior when the *ADVANCE* unit was available to them, and their qualitative and projective assessments of the general concept of in-vehicle static and dynamic route guidance. Analysis of the results aims to provide guidance for the future development of, and likely benefits from, in-vehicle information systems for familiar (resident) drivers, with the goal being the identification of logical future deployment paths of such ATIS concepts, including needs for additional field testing and evaluation.

It was expected that familiar and unfamiliar drivers will respond differently to ATIS, manifesting substantially different information needs. While simple static navigation functions are likely to be especially valuable to visitors, familiar (*i.e.*, resident) drivers can be expected to know the network well, and thus will present different requirements for and perceptions of ATIS concepts. As a result, the benefits they are likely to receive from ATIS applications will differ from those experienced by unfamiliar drivers. *ADVANCE*, even in its limited deployment, has offered some opportunity to capture familiar driver assessment of the concepts of both static and dynamic route guidance. While the limited functionality of the *ADVANCE* MNA gave rise to user criticisms and dissatisfaction, it was possible to separate assessments of the specific *ADVANCE* implementation from the general concept of in-vehicle static and dynamic navigation systems, and thereby to work with familiar drivers to develop a projective assessment of such concepts. Specifically, familiar drivers were provided a basis to develop important qualitative insights into:

- Patterns of utilization of and compliance with route guidance information and other available *ADVANCE* features.
- Assessment of in-vehicle static and dynamic route guidance concepts, including the importance of various functions; ideas about and preferences for enhanced and new functions; driver work load, distractions, and perceptions of safety; and overall valuation of such concepts and their components.

Immediately prior to each two-week usage period, participating households received training in the use of the *ADVANCE* unit during a 1.5-hour orientation session at the project office. Here they were briefed on the overall project and on the capabilities and limitations of the MNA in a neutral fashion so that they could begin effective use immediately on receiving the equipped vehicles. In order to receive a vehicle, participants had to complete a baseline survey measuring demographic characteristics, driving habits, attitudes, and experience. At the conclusion of the usage period, each household completed a second, exit survey. After exit survey results were compiled and subjected to preliminary analyses, most participants were asked to participate in focus groups.

In addition to written instruments, electronic information about usage patterns was collected from TIC-generated log data files and MNA memory cards. All data collection helped formulate a projective evaluation of generic future ATIS designs. The baseline and post-use surveys were administered to up to two household members who were to use the vehicle. Participants were also asked to document, through the use of driver logs, any diversions taken from pre-planned routes, regardless of whether they were prompted to re-route by the MNA, by their own visual observation, by broadcast traffic reports, or other reasons.

Safety assessments conducted during this experiment focused on user perceptions of the safety of use of a generic in-vehicle route planning and guidance system, using the *ADVANCE* MNA as a baseline. It was not the intent of the study to attempt to provide a comprehensive assessment of the safety of use of this, or any like in-vehicle ATIS system.

Surveys were analyzed quantitatively (to the extent feasible and logical) while both surveys and focus groups were analyzed qualitatively to yield assessments, future desired/required feature concepts, user perceptions, and valuation of ATIS functionality in terms of specific features and performance. Quantitative studies employed univariate analyses, cross-tabulations and analyses of

variance (ANOVA). Multivariate relationships were explored through the estimation of a series of choice models.

Familiar drivers generally rated the *ADVANCE* unit favorably; they found the short test period to be sufficient to assess the system, and liked it well enough to keep it if they could. Comparison of ratings of the separable features of the *ADVANCE* MNA in terms of performance and importance showed that the driver interface was both important and favorably rated, while response time (startup, route planning) was important and the *ADVANCE* system was viewed as too slow. Drivers perceived essentially no safety risk associated with the potentially-distracting effect of the user interface.

Ease of destination entry was important to users, and a variety of suggestions were made to avoid the small touch-screen keyboard of *ADVANCE* in the input process. There was a discrepancy between importance and performance for aspects of the route planning feature. As expected, familiar drivers knew their routes, and felt they were better than those provided by *ADVANCE*. In future systems they sought a route planner which gives them more control and better reflects their own criteria and knowledge, while still providing the benefits of real-time information.

Further analyses will link perceptions and preferences for future systems to driver demographics, experiences, and attitudes.

PROJECT STATUS

As of December 28, 1995, all field and in-situ (at-the-TIC) data collection had been completed except for the VNTSC-sponsored safety analysis to be conducted by University of Iowa staff. In mid-January, 1996, the TIC was phased out and the radio frequency base station for TIC-to-vehicle transmissions dismantled. Delivery of evaluation test reports to the Argonne Evaluation Manager is proceeding approximately on schedule; as of February 15, six of eleven evaluation reports have been received for review in draft form and two have been processed through the review cycle to the final (pre-publication) draft stage. Findings reported in the preceding sections of this paper covered only those field tests for which draft reports are in hand. Once all eleven evaluation test reports, plus the white papers to be prepared for the "Lessons Learned" tasks, have completed the full review process, the Evaluation Manager will prepare an overview and executive summary of the evaluation and its results, with the individual test reports attached as appendices. Although not necessarily in final published form, the substance of this document will be complete and its overall findings available for broader public consideration by October, 1996. Moreover, all documents generated by the project and animated illustration of many of the test elements will be available by mid-autumn on the Internet page cited above.

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solely responsible for the accuracy of the information presented. The report does not constitute a standard, specification, or regulation. Its contents do not necessarily reflect the official policy of any of the *ADVANCE* parties, nor does any mention of manufacturers or products constitute an endorsement by the *ADVANCE* parties or the evaluation manager.

ENDNOTES

1. Joseph F. Ligas and Syd Bowcott, "*ADVANCE: Initial Deployment*," in *Intelligent Transportation: Serving the User Through Deployment--Proceedings of the 1995 Annual Meeting of ITS AMERICA* (Washington, DC: ITS America, 1995), pp. 291-295.
2. Booz • Allen & Hamilton and De Leuw, Cather & Company, "*ADVANCE Evaluation Program Plan*," Document no. 8400.ADV.03 (Schaumburg, IL: *ADVANCE* Project Office, July 17, 1995).
3. Booz • Allen & Hamilton, Inc., "*ADVANCE Evaluation Management Plan*," Document no. 8450.ADV.00 (Schaumburg, IL: *ADVANCE* Project Office, August 2, 1995).

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