Overview: ATIS research at the Institute of Transportation Studies, UC Davis.

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ADVANCED TRAVELER INFORMATION SYSTEMS: OPPORTUNITIES AND RISKS

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Abstract

Containing traffic congestion is a serious international problem. Advanced traveler information systems (ATIS) have been proposed as one of many solutions to this problem. ATIS could improve system travel times and speeds by providing drivers with real-time traffic information. It could also provide pre-trip information. In order to design systems that will be useful to the traveler, it is imperative that we understand how travelers would react to different kinds of information in different situations. This paper describes research being conducted at the University of California, Davis to address these issues. The areas of research include: impact of ATIS on route choice, human factors and safety, pre-trip information systems, real-time rideshare matching and rural ATIS systems.

Introduction

ATIS has the potential for improving the transportation environment. For example, it could alleviate congestion by providing travelers with real time traffic information. It could also provide information to travelers before the trip, to influence mode choice and departure time to avoid congestion. However, in order to be able to design ATIS systems that are useful to the traveler and to the system providers, we need to understand how travelers would react to different kinds of information in different situations.

Research being conducted at UC Davis to address these issues, can be divided into four major categories: ATIS implications for travel demand, human factors and safety, advanced public transportation systems (APTS) and rural ATIS systems. Research in the travel demand area looks into the impact of ATIS on traveler's route choice behavior. Research in the human factors and safety area has focused on driver distraction and workload due to provision of driver information systems in cars. Two research areas are being explored under APTS: pre-trip planning information systems and real-time rideshare matching as more user-oriented alternatives to conventional

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transit and driving. In the rural ATIS area the focus is on evaluating a traveler information system being installed in the Yosemite national park and surrounding areas. Research in each area will be described as a way of identifying opportunities and risks associated with ATIS.

ATIS Implications for Travel Demand

Research in this area is being conducted to address the following issue: if information systems and/or services, which can provide accurate up-to-date information, are made available to drivers on-board their vehicles, or to travelers at home or at high demand locations such as office complexes or shopping centers, what will be the effect on travelers behavior? Part of this research has focused on investigating the effect of information on route choice behavior. Our efforts in this area have employed two state-of-the-art approaches undertaken in parallel.

Route Choice Survey

The first approach utilized sophisticated Computer Aided Telephone Interview (CATI) surveys of Los Angeles area morning commuters, with a follow-up mail survey to a large subgroup of the original sample which was customized for each survey recipient (Abdel-Aty et al., 1995a). The goals of this series of surveys were: to investigate what routes commuters were using, identify the characteristics of these routes, determine how much information drivers have about their routes and if they have alternative routes, investigate what socio-demographic and route specific characteristics influence drivers to use alternative routes, and how the availability and perceived accuracy of existing information affect route choice. The CATI survey obtained the respondents' primary and secondary commute routes, road segment by road segment. A Geographical Information System (GIS) was used to generate theoretical minimum travel time paths as alternative routes and incorporated into the customized mail surveys. Both the CATI and mail surveys utilized Stated/Revealed Preference (SP/RP) methods to investigate route and information use. Analysis of the mail survey is currently underway. The major findings of these studies are discussed in other papers (Abdel-Aty et al., 1994; Abdel-Aty et al., 1995b; Abdel-Aty et al., 1995c).

Simulation Experiments

The second approach is to use computer simulation as a data collection tool to investigate drivers' information use and learning with an Advanced Traveler Information Systems (ATIS). The computer is used to simulate a hypothetical traffic network which creates the decision framework into which subjects are placed. In the first year of this research project, an experiment to collect sequential route choice data under the influence of ATIS was performed using a PC-based simulation (Vaughn et al., 1993a; Vaughn et al., 1993b; Abdel-Aty et al., 1993b; Yang et al., 1993). The experiment collected information on drivers' pre-trip route choice behavior at three levels of information accuracy - 60, 75 and 90 percent, utilizing a simple binary choice framework in which subjects could choose either a freeway or alternative side street. The experimental factors which were controlled in this first experiment included the accuracy level, stops on the side road route, presentation of a justification or rationale for the advised route, feedback of actual and alternative travel times, and identification of route as a freeway. The main findings of this first experiment was that drivers can rapidly identify the accuracy level of information being provided, and that they adjust their behavior accordingly. There was also evidence which indicated an accuracy threshold level, below which, drivers will not follow advice, and above which, drivers readily follow advice. It was found that female subjects agreed with advice more often than males, that less experienced drivers agreed more often than experienced drivers, and that a "freeway bias" exists with drivers much more willing to follow advice to take a freeway route. The model of route choice behavior had a prediction rate which was 79 percent accurate and also indicated that strong memory effects existed in the updating of the perception of information accuracy. This finding indicates that subjects placed more emphasis on the accumulation of past experiences as opposed to just the latest experiences. Analysis of the experimental treatments revealed that subjects compliance with advice increased with increasing system accuracy, by providing subjects with feedback and a decision rationale, but that intersection stops on the side street route significantly reduced advice compliance.

As an extension of this previous simulation work, a new PC based travel simulator has been designed and a new set of experiments were designed and carried out (Vaughn et al., 1994a). Some limitations of the previous experiments included the simplicity of the choice set in the binary framework, the limit to a pre-trip information context, and a limited investigation of socio-demographic and travel characteristics imposed by the use of university students as test subjects. This new set of experiments was developed to expand the simulation and experimental design complexity to account for these previous limitations.

The simulation is an interactive PC program. The screen display is composed of three main windows: a network window, an information window, and an instruction window. The network window displays a hypothetical traffic network, composed of three primary routes from an origin to a destination. The primary routes are composed of a freeway route and two arterial routes. These primary routes are cross connected with a series of surface streets creating a network of 34 roadway links and 23 intersections (or potential decision points). The travel environment is generated by a stochastic assignment of travel speeds and stop delays to the network links and nodes. A random incident generator is used to assign an incident of random severity to the network for each travel day. The information and instruction windows are used to simulate an in-vehicle information system. Participants use keyboard arrow keys to represent driver route choices in the network for a sequence of 20 travel days (trials).

A hundred subjects were randomly recruited from the Sacramento area, categorized by commuter type (SOV/carpool), gender, age, education level and driving experience. Preliminary analysis of data collected in this set of experiments is described elsewhere (Vaughn, et. al., 1994b).

Human Factors and Safety

In-vehicle route guidance systems are one category of ATIS, which consist of display devices in the car which provide drivers with the most favorable route to the destination. There is a concern that providing this information could lead to distraction from the driving task. To address this concern, a series of simulation experiments have been conducted jointly by the U. C. Davis and Hughes Aircraft Corporation. The basic focus of the experiments was to evaluate the attentional demand, workload and user perceptions of alternative route guidance systems.

The first 2 experiments were conducted in a high-fidelity fixed base simulator that has been developed by the Hughes Aircraft Corporation (Srinivasan et al., 1994a). This simulator is equipped with three screens for a total field of view of 170 degrees. On these screens, computer generated images, such as roadway segments, traffic control devices, pedestrians and roadway traffic, are projected. The movement of these objects is synchronized with the vehicle movement generated by the driver.

Both the experiments used a within subject experimental design to evaluate the distraction, workload and perceptions associated with paper maps, visual electronic devices and audio route-guidance devices. The order of presentation of the route-guidance devices was counterbalanced to reduce order effects.

<u>Experiment 1</u>

The first experiment was conducted in November of 1992, with 9 males and 9 females between the age of 30 and 40, recruited from the Los Angeles area (Srinivasan et al., 1992; Srinivasan et al., 1994b; Srinivasan et al., 1994c). Subjects were asked to use one or a combination of guidance systems to navigate from an origin and a destination by following a predetermined route.

Four route guidance systems were tested: heads-down electronic route map, paper map, heads-up turn-by-turn guidance display (HUD) in combination with heads-down electronic route map, voice guidance in combination with heads-down electronic route map. The electronic map was a six inch liquid-crystal display located in the instrument panel to the right of the driver. The map showed the network in green with the intended route highlighted in red. The driver's vehicle was shown by an icon (arrow) in the center of the map. The location of the destination was shown by a 'star'. The map was always heading up (i.e. the map rotated in such a way that the driver was always heading up the display).

The basic design of the paper map was similar to the full scale electronic map, with the obvious difference being that the position of the driver was not tracked. The size of the paper map was 11" X 17".

A pre-recorded female voice was used as the voice guidance system. Two messages were given for each turn. The distance (from the next turn) at which the first message was given, depended on the type of road. The second message was always given 200 feet before the turn. An example of the content of the first message was: "In 400 feet, turn right onto Zuma". An example of the content of the second message was: "Turn right onto Zuma".

The dependent variables included: subjective workload, eye fixation data and brake reaction times to external events. Workload and navigation errors indicated the voice guidance/electronic map combination to be the best, and the paper map to be the worst. The electronic map was second best. Subjects performed slightly worse in the HUD/electronic map combination than the electronic map. Based on the comments given by the subjects, there were two design issues which could have contributed to the relatively poor performance of the subjects with the HUD (Srinivasan et al., 1992; Srinivasan et al., 1994b). Results from the reaction time models were less consistent. The best electronic device varied depending on the type of external event, although the paper was the worst (with the longest reaction time).

Experiment 2

The second simulation experiment was conducted to address additional issues regarding the design of route-guidance systems that arose as a result of findings from experiment 1. The questions that were addressed included:

1. will audio-guidance alone perform as well and be perceived as favorably as the audio-guidance in combination with electronic map,
2. is a heads-up-guidance display superior to a heads-down-guidance display, given the same display format,
3. will a modified guidance display (compared to the one used in experiment 1) perform better and be perceived more favorably.

To address these issues, five route guidance systems were tested: (i) paper map; (ii) heads-down-electronic map; (iii) heads-up-guidance display alone (iv) heads-down-guidance display alone; and (v) voice guidance alone. The paper map, the heads-down-electronic map and the voice guidance messages were identical to those that were used in experiment 1. The guidance display was different from that used in the first experiment (Landau et al., 1994). The display showed speed in miles per hour, the name of the street on which the vehicle was currently traveling, the name of the next decision street and the distance in tenths of miles or feet to the decision point. There were several cues to indicate closure distance to the turn. A vehicle icon (amber in color) moved up the currently traveled street (a vertical green line with an arrow at the top). As the vehicle approached the decision point, the distance to this maneuver changed to indicate closing distance. When the driver was more than 400 feet from the turn, an amber triangle indicated whether the driver should turn right or left at the next turn. The units of this distance value changed from tenths of miles to feet within 400 feet of the turn. When this change occurred, a large green arrow with an elongated tail replaced the small amber triangle previously displayed. The geometry of the decision intersection was maintained in that both variations of 'T' and fully crossed intersections were indicated. When the vehicle icon reached the intersection point and the vehicle made a turn, a new display was presented (Landau et al., 1994).

Seventeen male subjects between the age of 19 and 35 participated in the experiment. The same simulated roadway network used in the first experiment was employed in the second experiment. However, changes to the driving scenarios included removal of the lead vehicle and the addition of a scanning task in the external visual scene. Coral colored squares of an outline form were presented on the left and right edges of the roadway. Subjects were asked to monitor these squares for a change in shape: squares rotated 45 degrees to become diamonds. As soon as drivers detected the change, they were asked to push a button on the left or right of the steering wheel hub depending on whether the diamond appeared on the left or right side of the roadway (Landau et al., 1994). This task was introduced to increase and more uniformly distribute subject workload and increase the sample size of subject reaction times so that the distraction attributable to the interfaces could be identified with greater precision.

As in experiment 1, workload ratings were collected after the subjects completed trials in each route-guidance system. Response time data were also recorded for the scanning task.

The data analysis indicated that voice guidance was associated with the shortest response times, followed closely by the heads-up-guidance display and the heads-down-electronic map. The paper map was associated with the longest response times. Response times while using the voice-guidance system, the heads-up-guidance display and the heads-down-electronic map were significantly shorter than when using the paper map and the heads down guidance display. The data from workload and perception ratings showed similar results. The voice-guidance system, the heads-up-guidance display and heads-down-electronic map were associated with lower workload and were more preferred in comparison to paper map and heads down guidance display.

The results indicate that there is no optimal navigation device. Display location seems to be an important factor, however, it interacts with display format: subjects performed significantly worse with the heads-down-guidance display in comparison to heads-up-guidance display, although they performed quite well with the heads-down-electronic map. Despite its complexity, some subjects expressed preferences for the map because it indicated the number of blocks to the decision point unlike the guidance display and the voice-guidance system.

Experiment 3

The third experiment was conducted in a table-top simulator that is located in the Institute of Transportation Studies at the University of California. These experiments focused on comparisons between alternative route guidance formats within different categories of route guidance systems (Srinivasan et al., 1994d). Subjects were asked to follow a predetermined route between an origin and a destination. Three categories of route guidance systems were considered: electronic route map, turn-by-turn guidance display and audio guidance. The following issues were addressed: (i) message content and format for visual displays, and (ii) voice generation method and voice model (synthesized speech vs. male/female recorded speech).

A Silicon Graphics Indigo2-Extreme computer system was used in conjunction with Designer's Workbench software from Corypheaus, Inc. to develop a driving simulator. The 19" inch monitor of the silicon graphics systems was used to display the driving scene (four lane divided highway) and the dashboard. The dash board included a speedometer and a rectangular area (2.4" X 3.8") allocated for displaying the visual route guidance systems (Srinivasan et al., 1994d).

Each subject had two tasks to perform. The primary task was a tracking task, which was intended to be a substitute for a real world driving task. The tracking object was a black cross-hair which was located just above the dash board in the driving scene. This object moved towards left or right in the driving scene in a random manner. The top of the dashboard had a black triangle. By moving the mouse towards left or right, the subject was able to move the dashboard and the triangle relative to the tracking object. The subjects's task was to align the top of the triangle as close to the vertical line of the cross hair as possible.

The second task was to press one of the 3 mouse buttons (left, middle or right) to display their decision to turn left, go straight through or turn right at a particular intersection. The subjects were asked to press these buttons as soon as possible, after the appearance of a display, as they approached intersections. Subjects were asked to perform this task (pressing the mouse button) based on information obtained from either the visual route guidance system, or audio route guidance messages. Data was collected on the response time to the pressing of the mouse buttons and tracking error (defined as the distance between the tracking object and the top of the triangle).

The analysis of the data from the experiment found that text-only based displays were least preferred and also resulted in largest tracking error. A combination of text, arrows and symbols to display guidance information was preferred compared to text-alone option. It was also found that displaying turn street name was important for route following. Some subjects also felt the need to have some sort of indication when there is a block to go before the turn, apart from the turn street name and the distance to the turn. Most subjects had difficulty in understanding complex streets with the synthesized speech. However, this did not significantly affect their performance in the tracking task or the response task (Srinivasan et al., 1994d).

Further research is being planned to include a route replanning capability that requires the driver to interact with the interface during the course of the experiment. Route replanning will be conducted in a variety of experimental scenarios that are intended to represent both system generated requests for replanning and subject initiated requests as well. Another objective is to study the implications of providing traffic information as part of the route guidance and replanning functionality.

Pre-Trip Information Systems

The availability of pre-trip information allows users to modify their mode, route, destination, departure time or a combination of these so as to maximize their utility of travel. To be effective the pre-trip information system should provide the users with adequate, relevant, accurate and timely information using effective display formats and appropriate interfaces. Therefore, it is vital to first identify what information travelers would like to obtain and how they would like this information to be presented. To investigate these issues, the objectives of this project include:

a. Determination of user needs and functional requirements for pre-trip information systems.
b. Determination of user attitudes and preferences for alternative display formats.
c. Determination of user preferences for different types of interfaces.
d. Development of guidelines for the design of pre-trip information systems.

In order to identify user needs, a typology of pre-trip information usage was developed. This typology defined a set of situations, constraints, users, and other variables representing a range of information system users, uses, and scenarios where pre-trip information is likely to be utilized (Kowshik et al., 1994b).

User satisfaction and attitudes toward pre-trip systems will depend to a large extent on the ability of the media to provide relevant information and allow easy and efficient interaction with the system. Different technologies and consequently different types of interfaces clearly pose limitations on how information can be conveyed. A study of the capabilities of various possible interfaces such as the computer monitor, speaker, telephone, and television was conducted. The different interfaces were assessed for compatibility of input and output options and its versatility in allowing different display formats. Based on this assessment, it was found that the computer monitor with a touch screen or a mouse based input interface is the most versatile combination allowing a wide range of data display formats such as text, tables, images, maps, diagrams, and speech.

Based on the pre-trip information typology, and an assessment of capabilities of interfaces, it was decided that a computer monitor with a touch screen based input interface would be appropriate for an information kiosk. However, for the purpose of conducting prototyping experiments, a computer based prototype using mouse as an input interface was developed. This prototype incorporated a wide range of scenarios where pre-trip information is likely to be utilized. The prototype provides the user with sufficient information to allow the user to modify the mode, route, departure time, destination or a combination of these (Srinivasan et al., 1994e).

The pre-trip information system prototype is a menu based system and provides users with customized trip information tailored to suit their origin and destination and departure time. The trip options include mode choice options of bus, car and carpool, and route choice (or bus line in case of transit, etc.) options for each of the modes. In addition, the user can also access information regarding several destination categories such as banks and restaurants (Srinivasan et al., 1994e).

This prototype has been used to investigate user needs and preferences for alternative display formats. A limited number of subjects were requested to use the information system under three travel scenarios (Srinivasan et al., 1994e). They were requested to give their comments on the information provided by the system in relation to what they felt was 'useful' information. Interviews were also used to elicit the subjects' opinions on how they wanted the information to be presented. These qualitative experiments provided a framework for obtaining critical information regarding users' information needs under different conditions. User comments regarding system layout and display formats were used to refine the prototype.

The refined prototype will be used for performing further experiments. A larger sample of subjects will use the system under nine different travel scenarios ranging from simple mode choice decisions to mode, route, departure time, and destination choice decisions. The time spent by each subject on different information screens will be analyzed to study their search patterns and information content requirements. Subjects will be categorized as commuters, non-commuters, and people not familiar with both the travel options and area. The subjects will also be classified by transit use and socio-economic variables. The scenarios have been designed to allow analysis of the differences in information content and requirements for different categories of trip makers under different scenarios.

These experiments provide valuable information regarding information content requirements of different categories of users under different travel scenarios. This will allow the identification of different target audience and development of customized pre-trip systems that serve the needs of the target audience most efficiently.

Further research work is required to address institutional issues associated with the acquisition and integration of multi-modal data obtained from multiple sources and the application of multi-media technologies to provide pre-trip information. Additional work is also required to forecast the direction and scale of effectiveness of pre-trip information in influencing individuals' trip making behavior and to develop quantitative measures that would allow the comparison of their effectiveness with respect to some objective standard.

Real-Time Rideshare Matching

Ridesharing is one of the strategies commonly employed to manage travel demand. However, it has traditionally been perceived as being inflexible and requiring a lot of planning compared to other commuting alternatives such as solo-driving. Potential ridesharers are first required to provide information such as names, telephone numbers, home and work locations, and work start times. Rideshare agencies match their information with other participants to identify potential carpool partners. The dissemination of rideshare matching information has been done almost exclusively via mail. The significant amount of time required for mailing match lists and contacting carpool partners, together with the need to commit to a regular weekly arrangement often lead to many ridesharers dropping out of such programs. The flexibility of ridesharing arrangements could be improved by implementing a real-time rideshare matching system.

Real-time ridesharing is defined as a *one-time match obtained for a one-way trip* either the same day or the evening before. It would allow travelers to review rideshare options, identify best matching riders, reserve rides in advance, register details for immediate an travel request, and help in the formation of carpools at park-and-ride lots while taking real-time demand into account. More importantly, a real-time matching system will make ridesharing possible for commuters who do not have a regular commute schedule in terms of departure times and destination locations. Further, the most important breakthrough that ATIS will bring to ridesharing is that matching information could ultimately be available in the vehicle. Therefore, the availability of a real-time rideshare matching system could significantly increase the market potential of ridesharing since the system would provide more options, and thereby increase rideshare opportunities.

Although real-time rideshare matching is not fully operational in the United States, field operational tests are being conducted in Texas, California and Washington. The California Department of Transportation (Caltrans) is conducting two real-time rideshare matching projects - in the Los Angeles "Smart Traveler" project and the Sacramento Area Real-time Rideshare Matching Demonstration.

U. C. Davis has completed service concept development roles for the Sacramento real-time rideshare matching field operational test. As part of this work, similar innovations such as casual carpooling were studied. In casual carpooling, carpools are formed on a voluntary, one-time basis, with no prior reservation or arrangement. This form of carpooling has proven to be effective for commuting on the San Francisco-Oakland Bay Bridge (Beroldo, 1990) and the Washington D.C. area Shirley Highway (Kihl, 1992), where HOV lanes allow carpoolers to save time and money.

Focus groups were conducted with Sacramento area commuters to ascertain potential users' reactions to the concept of real-time ridesharing, and gauge the potential demand for such services (Franz, 1993). The focus groups showed widely differing reactions to the concept of real-time ridesharing. The first group, composed of current carpoolers and potential carpoolers, generally reacted positively to the concept. The second group, composed of potential carpoolers and single-occupant drivers, expressed serious doubts regarding the feasibility of real-time ridesharing. The user needs identified from the focus groups include screening of participants for criminal and insurance status, information security, matching system reliability, system access, flexibility in the matches provided, and a uniform compensation scheme. Preliminary functional requirements were then developed from these user needs (Kowshik et al., 1993).

System design and implementation of the real-time rideshare matching service is being conducted by Sacramento Rideshare, the regional ridesharing agency for Caltrans District 3. The service is being initially provided to employee members of Transportation Management Associations in the Sacramento area, and will be used mainly for commute trips. This public-private partnership intends to maximize the chances of success of the service, with wider implementation planned in the future.

This field operational test is now poised to allow users to obtain real-time matches using a data base of real-time drivers. The test will operate through June 1995 and is being evaluated with respect to system performance and efficiency, initial and operating costs, impacts on user behavior, user and non-user satisfaction, and inducement of new rideshare users. System performance and participation level studies, and user and non-user surveys are being conducted as part of the evaluation effort (Kowshik et al., 1994a). It remains to be seen whether this application of advanced technology will meet travelers requirements and gather sufficient public interest to warrant further investment.

The YATI System: A Rural ATIS

To date, ATIS research has focused almost exclusively on deployment in urban settings. In fact, there is hardly any literature documenting the results of any ATIS implementations in rural locations.

Researchers at U.C. Davis are currently evaluating a rural ATIS known as the Yosemite Area Traveler Information (YATI) System. This project is being federally funded as a two year field operational test. The YATI System, which will begin operating in 1995, will supply Yosemite area travelers with current weather and travel conditions, the status of parking, lodging, and camping facilities, alternative Park destinations, travel modes, and routes to the Park. This information will be conveyed via: changeable message signs (CMS), highway advisory radio (HAR), a multi-media database accessible through information kiosks and computer bulletin boards, and a touchtone telephone database.

The YATI System is being designed with the goals of reducing traffic congestion, improving air quality, enhancing mobility and preserving/promoting tourism in the Yosemite region. An evaluation plan has been developed which assesses the effectiveness of YATI from user, system, and Park perspectives (Gard and Jovanis, 1994a). A classical before-after experimental design is being used in the evaluation. Baseline measures (of travel conditions, Park perceptions, and visitor awareness) before YATI implementation will be compared with comparable measures after implementation.

A variety of data collection techniques are being utilized to collect this information. Surveys of system users will reveal the perceived accuracy, usefulness, and accessibility of information. Field measurements (of vehicles, pedestrians, transit usage) will reveal the demand for services and the impact on the Park. Several supplemental data collection techniques (e.g. in-person surveys, system accessibility and reliability tests) will also be used. Baseline measurements were taken during the summer of 1994 (Gard and Jovanis, 1994b).

The findings from the evaluation of the YATI System will assist in the design of future rural ATIS. Components of the system which are especially useful or cost-effective will be identified. The underlying causal mechanisms behind changes in travel behavior due to YATI will be investigated. Improvements in conditions in the entire Yosemite region which are attributable to YATI will be identified.

Summary

Travel decisions are made in a variety of situations - in the home, in the vehicle, at work, outside the vehicle and in recreational activities. ATIS can provide information to influence mode and departure time decisions in a number of ways - multi-modal pre-trip information, driver route guidance and route choice information, rideshare matching information, and recreational destination and travel condition information. The research being conducted at U.C. Davis represents an attempt to investigate all these facets of travel, with the overall emphasis being on better understanding travel behavior in the presence of ATIS. Although several other applications of information such as Advanced Traffic Management Systems, Advanced Vehicle Location Systems are also being implemented, these applications typically concentrate on improving system efficiency and performance. Ultimately, improvements in congestion will depend on changing individual travel behavior, since the most advanced management systems are useless without people willing to use them.

The proliferation of ATIS commercial products with little or no user needs, market demand or user acceptance evaluation, emphasizes the value of research described above. Evaluation of these aspects, which has been conducted in each project described above, will lead to better and more user-friendly ATIS devices and services. Given a better understanding of where our likely successes, decision makers (both public and private) can make more informing decisions about levels and types of investment.

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