Understanding Traveler Responses to ATIS

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INTRODUCTION

An important element of the U.S. Intelligent Vehicle Highway System (IVHS) program is Advanced Traveler Information Systems. Current research being performed by the Institute of Transportation Studies at the University of California at Davis (ITS-Davis) is investigating the impact of Advanced Traveler Information Systems, or ATIS, on travel demand. The goal of the project is to understand how people will adopt ATIS, learn its use, devise rules for travel planning and how all these relate to travel demand. This paper presents an overview of the four major research activities currently undertaken at the University of California at Davis to study the behavioral relationships of drivers and ATIS, and presents current research results from two of these activities.

In order to assess the potential impact of ATIS on travel demand, predictive models of route, mode and destination choice and trip timing in the presence of information must be developed. New and innovative techniques will be required to collect the appropriate data to estimate these models. Many researchers in the transportation field are turning to the use of computer simulation and stated preference techniques to solve data availability problems when studying ATIS. At ITS-Davis we are pursuing an integrated approach to data collection needs by utilizing computer simulation, both revealed and stated preference survey techniques, computer aided survey, group survey (carpools/vanpools and households) and structured experimental design, both individually and in combinations. The four areas of research discussed in this paper include: the development of an Urban Travel Demand Simulation Laboratory as a set of data collection tools; the use of a driving simulator (located at Hughes Aircraft Company) to study the impact of ATIS display technology and design on driver performance and investigate drivers preferences for display type and information level; the use of a structured route choice experiment to study the effects of information on sequential route choices; the use of revealed and stated preference survey techniques to study route choice processes.

The development of an Urban Travel Demand Simulation Laboratory is currently underway at ITS-Davis. This is an innovative Laboratory proposed to create a realistic travel environment in which urban residents can be interviewed. The objective of this laboratory is to study responses to, and the desired attributes of ATIS by individuals, carpool/vanpool members, or by household members. Subjects will be placed in a realistic simulated urban environment and the impact of ATIS on travellers route choices, trip timing, and mode and destination choices will be analyzed. ATIS information will be presented to potential users, travel choices solicited, transportation events simulated, and further choices solicited. The simulation lab will include multiple-screen computer displays, a stochastic simulator to generate random transportation events on a large scale urban highway and transit network, and a Geographic Information System supplying a geographical database and display.

ITS-Davis has recently completed experiments utilizing the Hughes driving simulator to determine if drivers are distracted from the driving task while being required to process route guidance information. A range of driver interfaces for presenting route guidance information were explored including heads-up display, heads-down electronic map, digitized voice and paper map. In addition to driver preferences for the devices, data were obtained on driving performance (ie. reaction times to external events and driving errors) and subjective workload with each device. A subsequent series of experiments is currently underway to further assess device safety and driver performance (Srinivasan, et al. 1992).

Two other recently completed projects include the use of a simple micro-computer simulation experiment of route choice under ATIS to study drivers learning and adaptation processes (Vaughn et al.), and the completion of a two-wave computer aided telephone interview (CATI) survey designed to collect detailed information on commuters main and alternative routes. Descriptions of these activities and results are provided in the following sections.

INVESTIGATION OF SEQUENTIAL ROUTE CHOICE PROCESSES

This section describes the experimental analysis techniques and modelling efforts applied to sequential pre-trip route choice behavior data. This effort is the first step in a process to develop a basic understanding of the factors which influence route choice and how ATIS will affect drivers' behavior over time.

An experiment to investigate drivers' learning and pre-trip route choice behavior under ATIS was performed using an interactive route choice simulation experiment carried out on a PC. The experiment was developed through a collaborative effort between the Institute of Transportation Studies and the Psychology Department at the University of California at Davis.

Subjects are told that they have purchased a new "Traffic Watch Device" which will provide them with traffic information prior to their route selection. The subjects are also told that the device will not always be accurate, but are not given any indication of its overall accuracy. Subjects are instructed that their main task is to minimize their overall travel time by deciding when, and when not to follow the advice provided by the traffic information system. When the subjects are ready to begin, they are presented with a screen indicating that it is trial day number one and instructed to press the space bar when they are ready to receive advice. The screen display was simple and is approximated in Figure 1. Upon pressing the space bar, the advice for that day is presented along with a simulated freeway link, a side road link and an origin and destination.

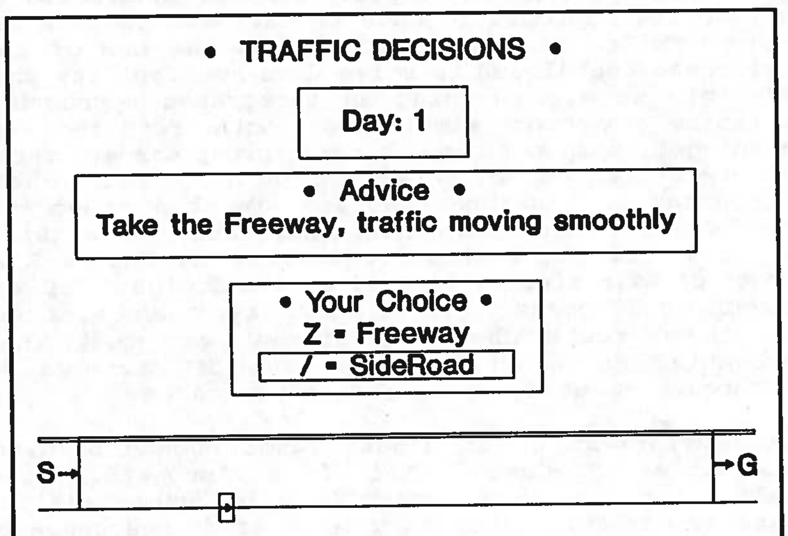

Figure 1 Typical Screen Display of Simulator

When the subject selects a route, a red blinking curser (depicted above by the box on the side road link) moves across the screen from the starting point (S) to the goal (G). The speed at which the curser moves represents the average travel speed on that link for that travel day. In the figure above, the double line link represents the freeway and the single line link represents the side road.

The simulation was developed such that various treatments could be applied and then data could be collected under these different conditions. The treatments which could be applied to the simulation included the following:

1	Accuracy:	The accuracy level of the advice provided to subjects could take on values of 60%, 75% or 90%.
2	Stops:	A simulated stop on the side road route could be applied.
3	Rationale:	A justification statement as to why the subject should follow the advice could be provided.
4	Feedback:	Feedback could be provided at the end of each trial in the form of actual simulated travel times on the two routes for that trial.
5	Freeway:	An identification of the routes as Freeway and Side Road (as shown above) as opposed to simply routes A and B.

6 Road: The display could provide the simulated origin and destination with the two route links as shown in figure 1, or with no network display provided and the travel time simulated by a blinking box located in the center of the screen.

Three separate experiments were carried out to collect data under various conditions. The first experiment was used to investigate accuracy requirements of ATIS. Three separate groups of 23, 25 and 29 subjects were run through the simulation at three levels of accuracy, 60 percent, 75 percent and 90 percent. In the second and third experiments the information accuracy was held constant at 75 percent while other experimental conditions were varied.

All of the experiments subjected drivers to 32 simulated days in which they were to choose one of two possible routes. For each travel day an amount of delay was randomly assigned to each of the two routes. The units of delay assigned to a particular route are proportional to the travel time experienced on the route. The delay was distributed over the 32 trials such that the mean delay for each route was equal but the variance differed. In this manner, routes with potentially faster travel times but with a greater amount of uncertainty (as one might expect on a freeway) can be compared to routes with slower travel times but with a greater amount of certainty (similar to surface street routes). Upon completion of 32 sequential simulated days, subjects were asked to rate their potential for purchasing a traffic information device, their perceived accuracy of the device, and their own ability at selecting routes when compared to the information device. The computer program automatically recorded and stored data from each subject. Test subjects were all undergraduate students in the Psychology Department at the University of California at Davis.

The analysis suggests that, initially, drivers are predisposed to following the route advice. The average agreement with advice over time shows that for the first few trials drivers accept the advice approximately 78 percent of the time independent of the accuracy level of advice being provided. The findings also suggest that drivers can perceive the level of information accuracy and that they do so rather rapidly. Within the first eight of thirty-two sequential trials, the average agreement with advice moved in the direction of the level of accuracy provided. At 75 and 90 percent levels of accuracy, the average agreement with advice increased over the remaining 28 trials, while at the 60 percent level of accuracy, the average agreement declined from the initial rate to approximately 60 percent (system accuracy). These trends are graphically predicted in Figure 2. These finding indicate the importance of the accuracy of information provided by ATIS and show that drivers can quickly discern the level of accuracy being provided. Previous research (Bonsall et al. 1990, 1991, Khattak et al. 1991, 1992) has also indicated the importance of system accuracy on compliance with advice. Analysis of the route choice decision times of drivers found that there was a very rapid drop in the decision times over the first 8 of 32 trials and that then times remained relatively constant over the remaining 24 trials. This finding, and the fact that average acceptance rates of advice approximated the accuracy of the system, seem to indicate that drivers could sense and adapt quickly to the level of accuracy being provided by the system. Average decision times were the greatest for information provided at 75 percent accurate. This indicates that subjects were more readily able to identify the level of accuracy for low levels as well as high levels but took a greater amount of time to discern the moderate level of accuracy.

Previous research by the authors (Abdel-Aty et al. 1992) has shown that a basic understanding of drivers' route choice behavior is necessary in order to develop predictive models of drivers' en-route diversion choice. Analysis of this experimental data resulted in the discovery of some interesting relationships regarding the basic factors which may contribute to diversion behavior. Analysis of variance techniques were used to analyze the data collected in the route choice simulation (Vaughn et al 1992). The ANOVA results have given an indication of which variables have significant effects on subjects' willingness to follow route advice, their decision time and their potential usage of an information system. The findings provide evidence that males will accept route advice more often than females over a range of accuracies, and that inexperienced drivers will follow route advice more often than experienced drivers. In contrast to these findings, when asked about potential usage of such an ATIS device, females were more likely to purchase an information device when accuracies were at 60 percent and 75 percent, but at 90 percent accuracies, males were more likely to purchase a device. This indicates that while males accept advice more readily at all accuracy levels, they are not as willing to purchase such a device unless the system is very accurate. A similar finding related to driving experience also exists. While inexperienced drivers were more likely to follow the advice being given, they also reported being less likely to purchase such an information device. This may be the result of less frequent drivers feeling that the savings gained from such a device would not outweigh the costs due to their limited driving. Conversely, more experienced and more frequent drivers' perceive a net gain and responded as more likely to purchase a device although they do not follow the advice as often. The ANOVA also revealed that drivers will follow advice to take the freeway more readily than advice to take the side road, and that they are quicker to respond to freeway advice indicating that a "route bias" exists.

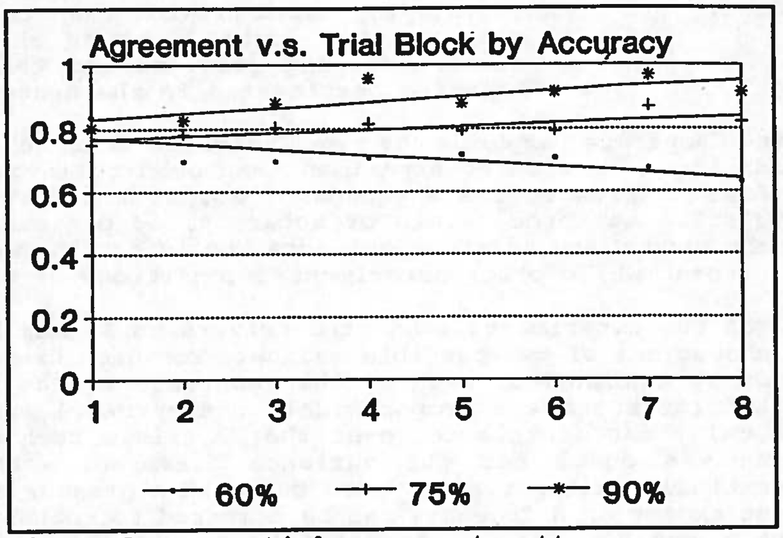

Figure 2: Sequential agreement pattern

ANOVA techniques were also used to analyze the effects of the simulation's experimental factors. The most significant factor influencing information compliance was feedback. Significant improvements in compliance were observed for subjects receiving feedback as to whether route selection was correct. The application of stops on the side road also had significant effects on compliance. For subjects exposed to stops on the side road route, significant reductions in compliance were observed due to a increase in the rejection of side road advice. This finding indicates the importance of route specific attributes in the route choice decision process and the need to develop a method to identify these attributes in order to adequately model route choice mechanisms. The Road factor was an attempt to measure the effects of the physical layout of simulation. The findings indicate that when the more realistic display of the road network is provided, as opposed to an abstract display, the compliance with advice increased significantly. This finding points to the importance of improving the level of realism in simulations designed to study driver behavior.

The efforts to develop a model of route choice behavior which incorporates the learning processes of drivers had mixed results (Vaughn et al. 1992, Yang et al. 1993). A model was developed which included drivers' updated perceptions of route delay and information accuracy, but the model was not significantly different from a model which excluded these perceived attributes. The model includes the advised route as a independent variable, and since subjects followed the advice so readily, the model may simply be predicting that subjects will select the advised route and therefore predicts about 79 percent correct which is equivalent to the average acceptance rate of advice. More analysis is required using different updating schemes before conclusive results can be made about the effects of experiences on sequential trials. Future research efforts will include attempts to formulate more realistic information updating schemes, and to extend the research and modelling effort to a more realistic traffic network environment.

ROUTE CHOICE SURVEY

The problem of route choice for a commute trip could be defined as follows: given the characteristics of the trip, i.e. departure time, origin, destination, etc., choose the best route through the transportation network in terms of some criterion. This best route most often is thought of as the one which minimizes travel disutility (e.g. travel time or distance, or some simple formula of generalized travel cost). In reality, the problem of route choice faced by an auto driver is very complex because of; the very large number of possible alternative routes through the road networks, and the complex patterns of overlap between the various route alternatives. Since, travelers are not always capable of choosing the fastest route, and if travel time is uncertain, they could acquire information that helps to select a better route. Therefore, an objective of this study is to find the most promising approach for improving drivers' route choice through providing better information.

To probe into drivers' route choice behavior, a route choice survey of Los Angeles area morning commuters was conducted as part of the project. The survey was designed to investigate how much information drivers have about their routes, their awareness of alternate routes, their awareness of traffic conditions which could affect their route choices, and to provide data that support the estimation of route choice models. The survey, undertaken in May and June, 1992, offers detailed information on each individual's route(s), which facilitates rigorous analyses of route choice behavior to unveil the decision mechanisms underlying route selection, and to determine what is needed for an ATIS system to be most effective and efficient.

A mail-out/mail-back survey instrument was initially designed. It required several branchings, increasing the level of complexity, potentially jeopardizing the response rate and response accuracy. Therefore, it was decided to perform a computer-aided telephone interview (CATI) survey. A CATI survey allows interviewer/respondent interaction and automatically handles branchings with complete reliability and lower interviewer error. It is also believed to yield a higher response rate.

The survey targeted a random sample of households located in the area covered by the South Coast Air Quality Management District, which includes most of the contiguously populated areas of Los Angeles, Orange, San Bernardino and Riverside Counties in California. The sampling, based on a Mitofsky-Waksberg cluster sampling design, covered both listed and unlisted numbers. The Mitofsky-Waksberg sampling reduces the number of unproductive dialings, and improves efficiency. Income, vehicle ownership, gender split, household own-rent percent and the commute mode, in the four counties, were among the variables compared with the 1990 census, 1990 California Statistical Abstract (CSA), and 1991 California Statewide Travel Survey (CSTS). Using t-statistics to test the null hypothesis, that the mean values from the sample are not different from the corresponding values in the 1990 census, CSA and CSTS, was not rejected in most cases at the 0.05 level of significance, which validate the sample, and prove that the sample represents to a large extent the population.

Initial analysis using general descriptive statistics showed several trends in the commuters' route choice decisions. Only 15.5% of the respondents reported that they don't always follow the same exact route to work, which indicates the potential benefit from an information system. Primary routes were more likely to have freeway segments than secondary routes and the majority of the multiple route users use their alternative routes between 20 and 40 percent of the time.

The desire to decrease the trip time, receiving traffic reports, and time the commuters depart their homes, were among the factors reported for changing the primary route. High income and high level of education were among the socio-demographic factors for using more than one route. Other factors, such as the commute distance, didn't seem to have any significant effect on using alternative routes.

Respondents that perceive traffic conditions on their usual route as bad or substantially different from day to day, were more likely to listen to traffic reports either before their departure, during driving, or both. The data also suggest that respondents that reported heavy traffic conditions on their freeway segment were more likely to receive traffic reports before leaving their homes. An interesting result was that more females listen to pre-trip traffic reports than males, while more males listen to en-route reports than females. Generally, pre-trip information showed a significant effect on the commuters' choices to use the same route to work every day.

For simplification at this early stage of the modeling effort, route choice is characterized as binary, i.e. whether the individual follows the same route to work every day, or he follows more than one route. The purpose of the effort is to identify the factors that lead a commuter to use single or multiple routes to work. The approach pursued here is the use of a conventional binary logit model formulation. It could be assumed that an individuals perceived utility for a specific choice is a function of the perceived attributes of the alternative, and an individuals characteristics. The random utility theory used in estimating the logit model, assumes that an individuals choice is based on the utility gain experienced by the individual for a particular choice. If an individual perceives a certain gain (e.g. avoiding congestion) for choosing not to follow the same route to work, then the perceived utility of this choice is larger than that of the alternative.

To try to understand the effect of information on route choice behavior, a logit model was developed which included variables that indicate whether or not the respondent receives traffic information. Information variables are most likely to be endogenous, that is the respondent could be already a multiple route user (and familiar with alternative route(s)) and listen to traffic reports only to decide which route to take in this particular day. Therefore, receiving traffic reports would not be an explanatory variable to estimate whether the respondent uses one or more routes to work. Receiving reports was used as a dependent variable, and the binary logit formulation was used to estimate the probability that the respondent often listens to traffic reports before leaving home to work. The model is presented in table 1, and shows that all the coefficients have high t-statistic values and is self explanatory. The model shows that people who perceive no variation in traffic conditions on their usual commute route are less likely to listen to traffic reports while driving. People with long distance commutes and/or people who reported uncertainty in travel time as a major problem, are more likely to listen to these reports. A gender dummy was used and indicates that females are more likely to receive pre-trip information.

A model was also developed to estimate the probability of the respondent following the same exact route to work every day (table 2). Receiving pre-trip traffic reports were used as an instrumented explanatory variable to avoid possible endogeneity - the variable was generated by the system using the model shown in table 1. The model shows that receiving pre-trip information increases the likelihood of using multiple routes to work. Also, income and number of driving days increase the utility of using multiple routes, while frequently making stops on the usual route decreases the utility of using more than one route.

Table 1: Logit Model Coefficients
Dependent Variable: Whether or not the respondent often receives traffic reports before leaving home to work.

		ß	t-statistic
$ß_0$	Receiving reports constant	-0.9677	-5.648
X_{ij1}	No variation in traffic conditions dummy	-0.3461	-2.297
X_{ij2}	Female dummy	0.3556	2.440
X_{ij3}	Uncertainty of travel time dummy	0.7199	3.401
X_{ij4}	Distance from home to work	0.0269	4.106

<u>Summary Statistics</u>
Log Likelihood at zero = -604.427
Log Likelihood at convergence = -547.241
Likelihood ratio index around zero = 0.1

Table 2: Logit Model Coefficients
Dependent Variable: Whether or not the respondent always follow the same exact route to work.

		ß	t-statistic
$ß_0$	Multiple routes constant	-2.8962	-3.829
X_{ij1}	Household income	0.3478	4.041
X_{ij2}	Receiving pre-trip information (instrumented)	0.6103	2.255
X_{ij3}	Number of days drove to work in the last 2 weeks	0.0459	0.893
X_{ij4}	Make stops on most frequent route	-0.5264	-2.205

<u>Summary Statistics</u>
Log Likelihood at zero = -508.769
Log Likelihood at convergence = -297.774
Likelihood ratio index around zero = 0.415

To assess commuter flexibility in changing routes, an appropriate statistical modeling technique is needed. A Poisson distribution can be used to characterize the number of route changes per month. The results of the Poisson regression are presented in table 3. An estimation of whether the respondent both uses alternative route(s) and listen to traffic reports before leaving home, were predicted using a binary logit formulation, and used in the Poisson regression as a latent variable.

Table 3: Poisson Model Coefficients
Dependent variable: number of times per month changing route to work based on pre-trip reports.

		ß	t-statistic
β_0	Constant	2.217	5.281
X_{ij1}	Perceived Variation in traffic conditions dummy	0.275	1.794
X_{ij2}	Perceived accuracy of traffic reports	-0.198	-3.209
X_{ij3}	Make stops on most frequent route	-0.251	-1.943
X_{ij4}	Driving time on last trip using the usual route	0.006	2.175
X_{ij5}	Freeway user dummy	0.408	2.537
X_{ij6}	Male dummy	-0.204	-1.882
X_{ij7}	Carpool dummy	-0.163	-0.882
X_{ij8}	Estimation of whether the respondent uses alternative routes and listen to traffic reports before leaving home (latent variable)	0.467	5.187

<u>Summary Statistics</u>
Log Likelihood at zero = -358.18
Log Likelihood at convergence = -256.35
Number of observations = 206
s^2 = 0.284

Turning to the specific estimation results, using alternative route(s) and receiving pre-trip traffic reports (variable estimated using binary logit model) has a strong positive impact on the number of route changes per month. Commuter's perceptions also have an effect, that is, if the respondent perceives substantial variation in traffic conditions from day to day on his primary route, then they are likely to make more route changes per month. If information is perceived to be inaccurate, then it will have a negative effect on the number of changes.

Travel time of the most frequently used route has a positive impact on the number of route changes per month indicating that longer commutes make travelers more likely to change routes. A possible explanation can be that time-consuming commutes lead to a greater awareness and use of alternate routes.

Freeway users are more likely to use alternate routes, possibly as a means to avoid congestion. Carpool and male dummies had a negative impact on the number of route changes per month. A possible explanation is that carpoolers make the decision en-route which is less likely to be affected by information the members of the carpool receives before leaving to work. Since males are less likely to listen to pre-trip information (as discussed earlier), therefore it is reasonable to expect the negative impact. It is found also that making stops on the primary routes decrease the likelihood of using multiple routes.

<u>Summary</u>

These initial findings suggest that commuters who receive traffic information are more likely to use multiple routes, and that drivers can quickly ascertain the quality of advice being provided. Interesting gender differences are also apparent with the survey indicating that females listen to pre-trip information more than males, but the simulation findings showing that males follow advise more often but would be less likely to purchase an information system. The evidence that information, congestion, traffic variability and route attributes significantly effect commuters use and choice of alternative routes, and the relative low levels of multiple route use in a region as notoriously congested as Los Angeles, suggest that well designed, accurate, widely disseminated, traffic information could significantly impact commuters' route choice behavior and travel demand.

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