Title

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Publication Date
1996-07-01

CALIFORNIA PATH PROGRAM
INSTITUTE OF TRANSPORTATION STUDIES
UNIVERSITY OF CALIFORNIA, BERKELEY

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California PATH Research Report
UCB-ITS-PRR-96-21

This work was performed as part of the California PATH Program of the University of California, in cooperation with the State of California Business, Transportation, and Housing Agency, Department of Transportation; and the United States Department of Transportation, Federal Highway Administration.

July 1996

ISSN 1055-1425

COMMUTERS' NORMAL AND SHIFT DECISIONS IN UNEXPECTED CONGESTION: EN ROUTE RESPONSE TO ADVANCED TRAVELER INFORMATION SYSTEMS

Volume 2

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First submitted on March 18, 1996; in revised form on July 18, 1996

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EXECUTIVE SUMMARY

This paper is a continuation of the our efforts to understand Advanced Traveler Information Systems (ATIS) impacts on travelers. The objective of this study is to understand how people deal with unexpected congestion during the *enroute* stage and how might they respond to ATIS. Travelers' route selection decisions were investigated through a survey of Bay Area automobile commuters. We investigate the effects of various factors, such as sources of congestion information (radio traffic reports versus observation), traveler and trip characteristics, route attributes and environmental conditions on traveler response to unexpected congestion. By using stated preferences (hypothetical scenarios), we explore the response to future ATIS technologies. A feature of the survey is that it intertwines stated and reported preferences and by doing so, it enables us to judge the validity of the stated preference responses.

We found that of those who at least once became aware of unexpected congestion *after* beginning their trip, about half were on their way from home to work and half from work to home. Half learned about the congestion by observation alone, while only one tenth from radio reports alone. Four tenths learned about the congestion from both sources. While travelers initially expected this congestion to add 20 minutes to their trip, in many cases this delay was actually as long as an hour. 20% had an opportunity to take an alternate route after learning of the congestion, and most of these took it. Half of those who took an alternate route eventually returned to their original route before completing the trip. Further, 3,5% could have taken public transit and only 0.5% did so. When faced with the hypothetical situation of having an ATIS device give them information, respondents were inclined not to change routes unless the device specifically advised this or gave specific information about delay times on the usual route.

The responses are further analyzed using multivariate models. The results are similar to the ones obtained in the pre-trip paper. They indicate that the currently available real-time traffic information broadcast through the electronic media provides a basis for making travel decisions. Further, individuals were willing to use ATIS. However, a majority of them would not necessarily follow ATIS advice, possibly due to behavioral inertia. More specific findings and their implications for ATIS design are discussed in the paper.

ABSTRACT

Advanced Traveler Information Systems (ATIS) are being developed to provide travelers with real-time information about traffic conditions. To evaluate the benefits of ATIS products and services, questions concerning potential market, usage, and travel response must be addressed. This paper focuses on en-route travel response to ATIS. The main objective is to explore how travelers deal with unexpected congestion and how they might respond to qualitative, quantitative, prescriptive and predictive information. Data on travelers' route switching decisions are obtained through a survey of California Bay Area automobile commuters. The effects of various factors, such as sources of congestion information (radio traffic reports versus observation), trip characteristics, and route attributes on traveler response to unexpected congestion, are investigated. Future response to ATIS technologies is explored using stated preferences, i.e., hypothetical ATIS scenarios.

A combined reported and stated preference model of traveler response is developed. The results show that expected delay on usual route, travel time on alternate routes, perceived congestion level on alternate routes, and information sources are important determinants of travel decision changes in response to unexpected delays. The modeling methodology identifies the effect of experience and behavioral inertia on choices, and captures inherent biases in the stated preference responses. Overall, travelers are more likely to respond to specific quantitative delay information.

Keywords; Advanced Traveler Information Systems, Combination of Revealed and Stated Preferences Data, En-Route Commuter Behavior, San Francisco Bay Area.

I. INTRODUCTION

Advanced Traveler Information Systems (ATIS) provide real-time information to travelers about traffic conditions, accident delays, transit schedules, parking availability, road works, and route guidance from origin to destination. By acquiring information, travelers are expected to make safer and more efficient travel decisions. To evaluate the benefits of ATIS products and services, questions relating to the market, usage, and travel response must be addressed.

This paper focuses on the effect of ATIS on en-route switching decisions, as opposed to pre-trip choices addressed in Khattak et al. 1996 (1). The broader study addresses the potential pre-trip and en-route travel response to ATIS, using a detailed survey of San Francisco Bay Area commuters in the Golden Gate Bridge corridor. We use similar modeling methodologies for understanding pre-trip and en-route travel behavior and address the following research questions:

I. Will the use of ATIS influence usual travel behavior? If so, how?

3. Do significant variations exist in travel response to alternate types of ATIS?

Section 2 presents the background of this research. Section 3 presents the survey design, and summarizes the sample used for modeling. Section 4 presents the modeling framework and Section 5 provides the estimation results. Finally, Section 6 concludes the paper.

2. RESEARCH BACKGROUND

A variety of en-route information sources are under implementation worldwide. See for example Whitworth (6) for ATIS developed in the USA, and Murashige (3) for ATIS developed in Japan. En-route information is provided by traffic information broadcasting services, en-route telephone information services, in-vehicle navigation. route guidance systems and variable message signs. Soon ATIS will provide en-route real-time information. based on the current and predicted network situation. Furthermore, depending on the system, en-route information can be prescriptive and/or descriptive: 1. Prescriptive information advises travelers to make a specific choice (i.e. take an alternate route); 2. Descriptive Information provides travelers with qualitative or quantitative information on travel times, congestion delays, incident location, etc.

Travel response relates to the trip-making behavior of ATIS users. The effect of information on travelers' decisions depends on its content. format or presentation style, and nature, i.e.. whether it is static, dynamic or predictive (1,4,5). The effects of prescriptive information can be captured through compliance behavior, while the effects of descriptive information are represented by a choice among travel alternatives. Since alternate types of ATIS trigger different travel responses, it is important to study the effect before the actual development and/or deployment.

On repetitive commute trips, individuals follow their preselected travel pattern. If the travel conditions differ from the expected and travel time exceeds certain thresholds, then they might decide to switch travel pattern. The choices open to travelers acquiring en-route information include route diversion and switching destination, mode and/or parking choice. This paper focuses only on the en-route decision to divert to an alternate route when travelers, through different types of information sources, become aware of unexpected traffic congestion.

User response to ATIS has been modeled using data collected either from travel simulators (see Koutsopoulos et al. (6) for a review on existing travel simulators and related modeling efforts) or travel surveys. This research is based on the "Congestion in the Bay Area" behavioral survey (7). Mail-back questionnaires were distributed to peak period automobile commuters crossing the Golden Gate Bridge in February of 1993. Two unique features of this survey should be emphasized:

1) It involved the collection of both Revealed Preference (RP) data on actual en-route travel response to unexpected congestion, and Stated Preference (SP) data in instances where the response to hypothetical ATIS scenarios was reported. The relationship between traveler response to qualitative, quantitative, predictive delay information, and prescriptive information given by hypothetical ATIS can be modeled in combination with real-life (reported) behavior.

3) The survey provided data on attributes of alternative choices (routes). These data are needed to develop a route choice model which is sensitive to network performance and congestion delays, as well as ATIS characteristics.

3. THE DATA

This section describes the questionnaire design, sample statistics, and the availability of travel information in the Bay area.

3.1 Questionnaire Design

The questionnaire was designed to capture real-life responses to unexpected congestion and hypothetical responses to ATIS scenarios.

Reported Situation: Revealed Preference

The “Reported Unexpected Delay Response” explores a real-life scenario. Respondents were asked to recall the most recent occasion in which they became aware, en-route, via radio or through their own observation, of unexpected congestion along their usual route. They were asked whether they switched to an alternate route. Detailed data about the context (weather, trip direction, expected and experienced delay duration, etc.) was obtained.

Stated Preference Scenarios

To increase the realism the hypothetical ATIS situation was tied with the reported situation. Five ATIS scenarios were presented. Respondents stated their preference on a four-point scale ranging from “definitely take the usual route” to “definitely take the alternate route.”

Qualitative Information. In the first scenario the ATIS provided qualitative information. Respondents were asked to report whether they would take their normal or their alternate route if they were alerted of a similar delay situation by a “special in-vehicle device” which gives “accurate” information on delays. The specific message displayed by the device (represented to the respondent as a picture of a television screen with text) was "unexpected congestion on your usual route." This situation was equivalent to the available information in the Bay Area at the time of the survey.

Quantitative Information. Two hypothetical situations explored the response to quantitative information. The first situation was similar to the previous scenario, except the device displays the "the expected length of delay on your usual route (your expected delay [in the reported preference situation]) at the present time." Note that by this stage the respondent had reported the expected length of time added by the delay in the reported situation and this was used to anchor the hypothetical question. The second situation provided information for both usual and alternate route: "The device tells you the length of delay at the present time and provides information regarding present travel times on your best alternate route."

Predictive information. The hypothetical situation explored the effects of predictive information. Respondents were asked what they would do in terms of route switching if "the device tells you the length of delay at the present time, and accurately predicts the length of delay it will cause 15 and 30 minutes into the future."

Prescriptive Information. The hypothetical situation explored response to recommendations on taking the best alternate route. The specific message was "the device gives you the message unexpected delay on your usual route and suggests that you take your best alternate route."

3.2 Sample Statistics: En-Route Response to Unexpected Traffic Congestion

A total of 1492 individuals reported that they encountered unexpected congestion. Table 1 summarizes their characteristics. Fifty-five percent were home-to-work trips. Forty eight per cent of the travelers learned of delay by observing congestion while driving, 24% by their own observation and then by radio reports, 11% by radio only and 23% by radio and then by their own observation. Most travelers initially expected congestion to add less than a half hour to their trips, and later found that the delay was more than their initial expectation. Despite the acquired information, only 17% of the travelers switched to an alternate route. The RP claims in our data seem credible because a significantly smaller portion of the population indicated diversion in RP (16.3% of the sample) compared with Chicago (42.5% of the sample), as expected (8). Note that the Golden Gate Bridge corridor has fewer alternate routes than downtown Chicago, therefore we expect fewer people to divert in the San Francisco area.

Table 2 summarizes the travelers' responses to the stated preference experiment. When faced with the hypothetical situation of having an in-vehicle ATIS device giving accurate delay information on the same trip, a majority of respondents were willing to use this information. Twenty seven percent of travelers would switch to the alternate route when qualitative information is provided to them. This increases to 52% under quantitative information for the usual route, 55% under predictive information for the usual route, 58% when delay information on usual route and travel time on best alternate route are available, and 6 1% under prescriptive information to take the alternate route.

Availability of Travel Options and Information in the Bay Area

The travel options available in the Golden Gate Bridge corridor are as follows. Transit alternatives include ferry services and bus services across the Bridge (9). The bus services are subject to the same uncertainty of congestion as the automobiles, and the ferry service is mainly advantageous to those within close proximity of its departure point. The main feasible surface route from the north into the largest attraction, downtown San Francisco, is the Bridge. The route options are mainly on either side of the Bridge. Therefore, route switching behavior could be performed either between the travelers' origin and the Bridge or between the Bridge and the destination.

Most radio stations and some television channels broadcast qualitative real-time traffic information on selected freeway links in the San Francisco Bay Area. The information is based on visual observation and surveillance by cameras and helicopters. Moreover, congestion information is also obtained from other sources, such as patrol vehicles and cellular phone users. At certain locations, monitoring and surveillance is done through detectors. The information disseminated through the electronic media often pertains to recurring bottlenecks at entrance to bridges, including the Golden Gate Bridge, and bottlenecks created by incidents. When describing incidents on television, their approximate locations are generally shown on a map. At the time of the survey in 1993, the publicly available media in the Bay Area did not disseminate point-to-point travel times or predictive travel information. Overall, the information available in the Bay Area is qualitative and partial.

4. MODELING FRAMEWORK

A unique aspect of this research is the estimation of ATIS user response from a combination of two data types: 1) revealed preference (RP data), where the actual behavioral response to unexpected delay is reported and 2) stated preference data (SP data), where traveler behavior in hypothetical ATIS scenarios is reported. RP and SP data are combined to address the validity issue inherent in using SP data (10).

The hypothetical situations provide realistic contexts because they are related to real-life experiences. However. the "anchoring" of the respondents to the RP situation may reduce the effect of the information sources, and lead to the same choices as the actual behavior. For example, if a respondent agrees with having taken an alternate route in the revealed preference situation, then he or she may indicate a higher (than actual) willingness to divert to alternate routes in hypothetical scenarios. Such preference inertia or justification bias will be captured in the model estimations (See Morikawa (1 1) for an extensive discussion of potential biases incurred in SP experiments).

The utility maximized by each traveler in the RP context is given by:

$$U_{RP} = V_{RP} + \varepsilon$$

where V_{RP} is the systematic utility function influencing the RP decisions; and

ε represents the random utility components influencing the RP decisions.

The utility maximized by each traveler in the SP context is given by:

$$U_{SP} = V_{SP} + \nu$$

where V_{SP} is the systematic utility function influencing the SP decisions, and

ν represents the random utility components influencing the SP decisions.

We assume that the non-measured components of the RP utility (ε) and the SP utilities (v) are independently and identically Gumbell distributed, and the level of noise in the data sources is represented by the variance of ε and v. We define μ^2 to be the ratio of the variances:

$$\mu^2 = \text{var}(\varepsilon) / \text{var}(\text{v})$$

and therefore the SP utilities can be scaled by μ :

$$\mu U_{SP} = \mu V_{SP} + \mu \text{ v}$$

so that the random variable ($\mu\nu$) has a variance equal to that in the RP utility (ε). It is possible to use both RP and SP observations in a logit estimation procedure that requires equal variance across observations. Note, however, that the SP utilities are scaled by an unknown constant μ which needs to be estimated. In the following sections we will discuss the specification of the systematic utilities in the RI?, the SP, and the combined model.

We define our systematic utilities as follows:

$V_{RP} = a'w + \beta'x + \delta'c$ (1)

$\mu_i V_{SP_i} = (a_i'w + \beta'x + \gamma'z)\mu_i$ (2) where *i* denotes the specific ATIS scenario.

Vectors w represent the dummy variables for the alternative specific constants of each model. All relative coefficients (a . a_i) are unconstrained. The SP constants capture the influence of each ATIS scenario on travelers' decisions. Therefore the comparison of the RP and the SP constants will give us the en-route switching propensity due to information provided by ATIS.

Sharing β in both RP and SP models implies that trade-offs among attributes included in x are the same in both actual travel behavior and the SP behavior. In our model the x vectors represent all travel related coefficients, such as travel time, expected delay, and congestion level on alternate route. These variables are not affected by the information provision, but are actual characteristics of the alternatives.

Vectors c are specific to the RP model and include the cause of delay and information source variables used in the RP context.

Factors inherent in Stated Preferences are represented by z with the corresponding coefficients γ . In this study, a variable representing the actual choice, included in **z**, captures the effect of inertia or justification bias. The experience variables are related to the actual delay reported in the RP situation. in the combined model the coefficients γ are restricted to be the same among the five SP models, assuming the same marginal contribution of z to the SP utilities.

5. MODEL SPECIFICATION AND ESTIMATION RESULTS

This section first presents the specifications for the RP and SP portions of the combined model, and then discusses the model estimation results.

5.1 Reported Situation

The RP portion of the model describes travelers' decisions when they become aware of unexpected congestion on their usual route. A binary logit model is estimated with the dependent variable being the choice among "switching to an alternate route" and "do not change travel pattern."

The following section describes the specification of the variables. The variables included in the model are: 1) Travel time, 2) Expected delay, 3) Congestion on alternate route, 4) Knowledge of travel times, 5) Trip direction, 6) Cause of delay, and 7) Existing information sources.

1) Travel time. Travel time is included as a generic variable. The reported usual travel time is used for estimation with the "do not change" (or stay on usual route) alternative.

The reported travel time on alternate route is used with the “change to the alternate route” alternative. (A dummy variable, described below, is included to indicate cases where travel time on the alternate route is not reported.)

2) Expected delay. The expected delay on the usual route is included as an alternative specific variable in the “do not change” alternative. More specifically the natural logarithm of the expected delay minus 1 minute, is used in the estimations. Using the logarithm implies that travelers have a reduced sensitivity to increasing delays. Since the minimum reported expected delay is 2 minutes, we assume that a delay of 1 minute or less will not cause any traveler to change his/her travel pattern. By using the difference (delay - 1 minute) we assure that the probability of diversion becomes zero when delay approaches zero.

3) Congestion on alternate route. The congestion level of the alternate route is a dummy variable that takes the value 1 if the alternate route is usually congested or heavily congested, and 0 if not congested.

4) Knowledge of Travel Time. To capture the effect of knowledge and experience on choice behavior, a dummy variable is created. The knowledge dummy is 1 if travel time of the alternate route is unknown, and 0 otherwise.

5) Trip Direction. A dummy variable is created for the trip direction. It takes the value of 1 for the home-to-work trip and 0 for the opposite direction.

6) **Cause of delay.** To capture the effect of the cause of delay, two dummy variables are created. One dummy variable accounts for accidents and another for bad weather conditions. The base case is all other causes of delay, including construction. disabled vehicle. etc.

7) Information sources. Travelers can receive unexpected delay information from the following sources:

1. own observation;
2. first by their own observation and then by radio traffic reports;
3. first by radio traffic reports and then by their own observation; and
3. only by radio traffic reports.

Dummy variables for the last three information sources are constructed, leaving the own observation of delay as the base case.

5.2 Stated Preference

The SP portion of the model examines commuter response to ATIS. The utility function of each SP model is given in equation (2). The stated preference is a categorical dependent variable, denoted by y, and represented by:

y = 1 if the response is “definitely take usual route”;

y = 2 if the response is "might take usual route";

y = 3 if the response is "can't say";

y = 4 if the response is "might take best alternate route"; and

y = 5 if the response is " definitely take alternate route".

The dependent variables have five categories, therefore four threshold values, θ_1, θ_2, θ_3, θ_4, can be identified in the utility scale. The probabilities are given by:

P(y=1) = P($\mu U_{SP} < \theta_1$),

P(y=2) = P($\theta_1 \leq \mu U_{SP} < \theta_2$),

P(y=3) = P($\theta_2 \leq \mu U_{SP} < \theta_3$),

P(y=4) = P($\theta_3 \leq \mu U_{SP} < \theta_4$),

P(y=5) = P($\theta_4 \leq \mu U_{SP}$)

Since the SP utility functions have an intercept, one of the four threshold parameters is not identifiable. so the first one is arbitrarily set equal to zero.

The probability that the choice indicator falls into each category is given by:

P(y= 1) = P($\mu U_{SP} < 0$) = 1 / 1 + e $^{-(0-\mu V_{SP})}$ – 0

P(y=2) = P($0 \leq \mu U_{SP} <$ 8,) = (1 / 1 + $e^{-(\theta_1-\mu V_{SP})}$) - (1 / 1 + $e^{-(0-\mu V_{SP})}$)

P(y=3) = P($\theta_1 \leq \mu U_{SP} < \theta_2$) = (1 / 1 + $e^{-(\theta_2-\mu V_{SP})}$) - (1 / 1 + $e^{-(\theta_1-\mu V_{SP})}$)

$$P(y=4) = P(\theta_2 \leq \mu U_{SP} < \theta_3) = (1/1 + e^{-(\theta_3 - \mu V_{SP})}) - (1/1 + e^{-(\theta_2 - \mu V_{SP})})$$

$$P(y=5) = P(\theta_3 \leq \mu U_{SP}) = 1 - (1/1 + e^{-(\theta_3 - \mu V_{SP})})$$

The SP model specification is similar to the RP model specification. Travel time, expected delay, congestion on alternate route, and knowledge of travel time variables are shared among RP and SPs. The SP model differs from the RP model in terms of the absence of the actual cause of delay (which was tested and found statistically insignificant in the SP scenarios) and the actual information sources (fixed as ATIS in the SP scenarios).

The SP models include three new variables. A dummy variable that captures inertia/justification bias is included in the SP experiment; The variable takes a value of 1 if the alternative route was chosen under the RP situation and 0 otherwise. It is expected that travelers who switched routes in the RP situation, are likely to report taking an alternate route in the SP scenarios to justify their prior actual choice. To capture the effect of knowledge regarding traffic conditions, given travelers actual choice. two variables are created: 1) A variable equal to the actual delay experienced if the respondent switched routes in the RP situation. It is expected that the more delay the traveler experienced on the alternate route, the less likely he or she is to switch to the alternate route in the SP scenarios. 2) A dummy variable equal to 1, if the actual delay experienced was higher than the initially expected delay on the usual route, and 0 otherwise. It is expected that travelers who used their usual route and experienced more delay than expected will be more prone to switch in the SP scenarios. The bounds of the SP scenarios are unrestricted among the SP models.

5.3 Estimation Results

Table 3 presents the results of the combined RP and SP models. A common scale coefficient is used for the SP models. We estimated a model with 5 scale coefficients, one for each scenario, but found that the restricted model had better fit, using the Akaike Information Criterion (see 12). The base case is the change route alternative. A positive sign implies increase in diversion propensity with increasing value of the variable.

RP constants (α)

The alternative specific constants reflect the average effects of omitted variables in the model. Compared to the base "do not change" alternative in the RP model, people on average are *not* inclined to change their usual route (all else being equal). This reflects the presence of behavioral inertia despite the presence of unexpected delay. Also it may reflect the limited availability of alternate routes in the Golden Gate Bridge corridor. Interestingly, this result is consistent with Khattak et al. (8) who find that on average, downtown Chicago drivers are inclined to take the usual route rather than their best alternate route in unexpected delay situations.

SP constants

The alternative specific constants in the SP models reflect the effects of omitted variables as well as the effect of information type presented by ATIS. Specifically, the differences between SP and RP constant terms reflect the effect of the relevant ATIS scenario. All the parameter estimates increase and become positive with the introduction of ATIS, meaning that ATIS overcomes the resistance to changing travel decisions in unexpected delay situations. This result coincides with that of Van der Mede and Van Berkum (13). The more elaborate information on delay on the usual route (from qualitative, to quantitative, to predictive), the more likely travelers are to take the alternate route. This result is consistent with Bonsall (5), Madanat (14), and Murashige (3), who find that the amount of information given to travelers plays a significant role in their switching behavior.

ATIS' suggestion to take the best alternate route in an unexpected delay situation results in increased probability of route change, as expected. This means that a priori people have a propensity to comply with ATIS suggestions. A similar result was found in the comparable pre-trip analysis by Khattak et al. (1). In real-life however, compliance will likely depend on the outcome of ATIS advice (e.g., whether individuals' travel experiences are positive when they follow ATIS instructions (see for example Bonsall (15)). Furthermore. quantitative information for both usual and alternate route has the maximum effect on travelers' decisions to switch to an alternate route. This reflects the travelers' preference to make an informed decision rather than comply with ATIS instructions.

Restricted coefficients among RP and SP (p)

Travel time is negative and statistically significant, meaning that travelers will choose the alternative with the lowest expected travel time. This result is consistent with Mannering (16), Stephanedes et al. (17), Mahmassani et al. (18), and Abclel-Aty et al. (19).

The effect of non-reported travel time on the alternate route is modeled through the travel time dummy variable. This variable captures the individual's lack of knowledge / experience regarding travel time. The sign is negative because, as expected, travelers are less likely to switch to unfamiliar or unused alternatives.

The longer the expected delay on the usual route, the more likely travelers are to change route.

Perceived congestion on the alternate route slightly reduces the possibility of taking an alternate route, as expected. This result complements the finding of Abtel-Aty et al. (20) that the perception of bad traffic conditions on the usual route increases the frequency of en-route changes. Therefore, the transportation network conditions play a significant role in the development of switching propensity of travelers.

Specific RP model coefficients (δ)

The source of information has a significant effect. Travelers are more likely to switch to an alternate route when they became aware of the delay by radio only, or when they become aware of the delay first by radio and then by their own observation, compared with observation and then radio, or observation only. This may be explained intuitively: at the time travelers observe a delay it may be too late to switch routes, especially in a network such as the Golden-Gate Bridge area. For example, if incident location is on the bridge and travelers are already on the bridge, they cannot take an alternate route. This result coincides with Heathington et al. (2 1) who found that frequent diverters are influenced slightly more by traffic reports than by visual observations, but it opposes the "myopic view" type of behavior found by Polydoropoulou et al. (22), where travelers switch to an alternate route when they see congestion ahead. Also, Mahmassani et al. (18) found that drivers who listen to radio traffic reports are more prone to divert. Thus the effect of information source on travelers' behavior can vary among transportation networks and across information acquisition contexts.

Drivers are less likely to switch to an alternate route on their home-to-work trip. This result coincides with Jou and Mahmassani (23), who found greater route switching propensity in the evening commute relative to the morning journey to work in Texas.

Accident as a cause of delay is statistically insignificant. However, weather as a cause of delay reduces route diversion probability. This might be explained by the fact that adverse weather affects the whole transportation network; travelers tend to stay on their usual route, with the expectation that route diversion may not save travel time. This coincides with the study of Khattak and de Palma (24), in which commuters were reluctant to change routes during adverse travel conditions in Brussels, a finding that was attributed to limited alternative route availability and to weather affecting traffic conditions on all routes.

Specific to the SP models (γ)

The variables that capture the relationship between revealed and stated behavior are highly significant. The first variable captures behavioral inertia and/or justification of past behavior. This variable -- "Justification Change Route" -- is positive as expected, meaning that people who switched to an alternate route in the RP situation are more likely than others to switch in the SP scenarios.

Two variables capture the effect of RP experience. Travelers who actually switched to an alternate route and experienced long delays were more likely to stay on their usual route in the SP scenarios (negative sign of coefficient). Travelers who actually stayed in their usual route but experienced longer delays than they had initially expected were more prone to switch to the alternate route in the SP scenarios (positive sign of coefficient). Further implications of the above results are discussed in the following section.

6. CONCLUSIONS

We have explored automobile commuters' en-route switching in response to unexpected congestion. The modeling technique permits joint estimation of reported and stated preference data, accounting for biases inherent in the SP responses, and identifies the effect of ATIS on route switching propensity. The results show that with accurate delay information, commuters can overcome their behavioral inertia when faced with unexpected congestion.

There is significant heterogeneity in response to various types of ATIS messages. Travelers' propensity to take alternate routes increased with prescriptive information (although some were still unwilling to comply); However, the most significant increase occurred when quantitative real-time and/or predictive information was provided on both the usual and alternate routes. It seems that travelers prefer to be made aware of conditions on the alternate routes and then make their own diversion decisions rather than receive diversion advice. Also, travel information on alternate routes is critical to diversion decisions because the lack of experience with alternate routes discourages diversion. Acquiring real-time alternate route information in a traffic management center often translates to network-wide surveillance, particularly on major arterial streets.

Heterogeneity in SP responses suggests that ATIS is a double-edged sword when it comes to managing traffic congestion. A properly designed ATIS that accounts for heterogeneity can lead to a more dynamic readjustment in the use of alternate routes with surplus capacity. However, if the response to various types of ATIS messages is not well understood then it can cause either a spatial transfer of congestion, or worse, lead to increased congestion. Traffic operations managers and ATIS designers must account for the different responses that specific ATIS messages might cause in incident situations. They must also recognize that a large portion of travelers may not heed ATIS advice and will not comply.

We have assessed the effects of ATIS by developing and estimating behavioral models of travelers' response to ATIS--a response based on the attributes of the alternatives and the information provided to travelers. These types of models can then be directly implemented in traffic simulations, enabling the assessment of alternate types of ATIS on transportation system performance. Finally, this study identifies the effect of hypothetical ATIS on travelers' behavior. The validation of travelers' behavioral response to ATIS will come from field operational tests and deployment of ATIS technologies.

Acknowledgments - We would like to thank the Volpe National Transportation Systems Center for its generous financial support, and Walter Gazda at the Volpe Center for his useful comments in this research effort. The survey was funded by the PATH Program in the New Technologies Division, California Department of Transportation.

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Table 1: Reported Behavior: En-route Response to Unexpected Traffic Congestion

Survey Question	Frequency %
Trip Direction	
Home to work	55
Work to home	45
Information Source	
Observation only	48
First observation then radio	24
Radio only	11
First radio then observation	23
Other	2
Reason for Congestion	
Disabled vehicle	12
Accident	36
Bad weather	36
Construction/road work	11
Don't know the reason	17
Due to some other reason	14
Expected Length of Delay	
O-5 min	7
6-10 min	21
1 l-15 min	23
16-20 min	15
21-30 min	23
>30 min	10
Actual Length of Delay	
O-5 min	6
6-10 min	16
1 l-15 min	19
16-20 min	17
21-30 min	19
3 l-50 min	11.4
>50 min	10.5
Reported Response	
Not change	83
Change route	17

Table 2: Stated Behavior - En-route Response to Unexpected traffic Congestion

ATIS Scenarios	Frequency %
Qualitative Information	
Definitely take usual route	39
Might take usual route	17
Might take best alternate route	10
Definitely take alternate route	17
Can't say	17
Quantitative Information - delay on usual route	
Definitely take usual route	26
Might take usual route	12
Might take best alternate route	14
Definitely take alternate route	38
Can't say	11
Quantitative Information - delay on usual route/ travel times on alternate route	
Definitely take usual route	19
Might take usual route	6
Might take best alternate route	18
Definitely take alternate route	40
Can't say	17
Predictive Real-Time Information	
Definitely take usual route	24
Might take usual route	10
Might take best alternate route	14
Definitely take alternate route	41
Can't say	11
Prescriptive Information: Switch to an alternate route	
Definitely take usual route	21
Might take usual route	9
Might take best alternate route	18
Definitely take alternate route	43
Can't say	9

Table 3: Combined RP and SP Model

Variables	Coefficients	t-statistics
Constant RP - Current Info	-1.02	-5.1
Constant SP1 - Qualitative Info	1.36	2.1
Constant SP2 - Quantitative Info Usual Route	1.68	2.2
Constant SP3 - Quantitative Info Alt. Route	1.97	2.2
Constant SP4 - Predictive Info	1.79	2.2
Constant SP5 - Prescriptive Info Alt. Route	1.88	2.2
Travel Time (min)	-0.003	-1.8
Log (Expected Delay- 1 min)	0.011	0.5
Congestion Level on Alternate Route	-0.11	-1.6
Travel Time Dummy	-0.62	-2.4
Home to Work trip Dummy	-0.07	-1.8
Cause of Delay		
Accident Dummy	-0.029	-0.2
Bad Weather Dummy	-0.88	-3.6
Information Source		
Observation-Radio Dummy	0.18	0.6
Radio	0.97	3.0
Radio-Observation Dummy	0.94	3.5
Justification Change Route	0.91	2.3
Actual delay on alternate route	-0.10	-1.8
Dummy (Actual > Exp. Delay) usual route	0.16	2.2
Scale coefficient	1.77	2.4
Theta 1 - SPI	0.81	13.6
Theta 2 - SP1	1.59	19.7
Theta 3 - SP1	2.22	22.8
Theta 1 - SP2	0.62	11.1
Theta 2 - SP2	1.07	-15.4
Theta 3 - SP2	1.70	29.5
Theta 1 - SP3	0.57	10.1
Theta 2 - SP3	1.06	14.8
Theta 3 - SP3	1.74	20.4
Theta 1 - SP4	0.42	7.8
Theta 2 - SP4	1.25	15.5
Theta 3 - SP4	2.08	21.8
Theta 1 - SP5	0.54	9.4
Theta 2 - SP5	0.94	13.4
Theta 3 - SP5	1.82	20.7
Log Likelihood (convergence)	-6354.8 1	
Number of Observations	485 1	