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Consumer Research on Advanced Traveler Information Systems: TravInfo Field Operational Test

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ABSTRACT

The paper describes the evaluation framework of the TravInfo project, a field operational test of the San Francisco Bay Area advanced traveler information system. The purpose of the evaluation study is to measure changes in individual travel patterns that result fi-om the TravInfo project and to assess traveler acceptance of and preference for advanced traveler information technology. The anticipated effects of TravInfo on Bay Area travelers were described using some of the economic concepts of supply and demand relationships between information providers and information users. Consumer choice concepts were investigated to better understand the impact of ATIS on travel choices with real-time traveler information and to establish a conceptual framework in which the TravInfo evaluation study could be conducted. In the case of the TravInfo field operational test, the short-term impact of advanced traveler information systems on travel behavior would be difficult to measure because changes in travel behavior is time related. It is unlikely that any significant behavioral changes under TravInfo could be detected during the three year operational test period. The key to an ATIS technology evaluation is the ability to project the future state of advanced technologies; however, the current models do not provide long-term predictive capabilities. Further research is needed in the development of models which can realistically replicate the future state of technology and of the consumer market.

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1. INTRODUCTION

Advanced Traveler Information Systems (ATIS) are believed to be beneficial to both transportation system performance and individual travelers. The tangible benefits of ATIS include reduced travel time and cost. The intangible benefits are improved driving conditions, a help in reducing stress and anxiety. This paper is concerned with an evaluation framework of the TravInfo project, a federally sponsored field operational test (FOT) of the advanced traveler information system in the San Francisco Bay Area. The goal of the TravInfo project is to compile, integrate and broadly disseminate timely and accurate multi-modal traveler information through commercial products and services, providing a competitive range of prices and capabilities among which consumers can choose [1]. The unique aspect of the TravInfo project is its open-access database and its architectural protocols that allow private firms to retrieve the data free of charge and re-package it for its ultimate dissemination to travelers through broadcast means (media) and via products developed by "Value-Added-Resellers" (VARs). This paper presents a methodological framework of the TravInfo FOT evaluation study in the area of traveler response to ATIS.

The motivating factors for the TravInfo FOT were growing traffic congestion, concern for environmental degradation, the need to improve traffic safety and the desire to better utilize the existing infrastructure and to stimulate the local economy by supporting ATIS innovation in the San Francisco Bay Area. The TravInfo FOT is aimed at an understanding of the effects of multi-modal ATIS on travel behavior regarding route diversion, departure time and mode shift. The basic premise of the TravInfo FOT is that real-time multi-modal traveler information will influence travelers to change their travel behavior so that Bay Area transportation facilities can be more efficiently utilized.

The key element of the TravInfo project is evaluation of ***traveler response*** which is aimed at measuring changes in individual travel patterns that result from the TravInfo project, and traveler acceptance of and preferences for the ATIS technologies. Within the traveler response study, there are three basic components that need to be measured; changes in supply conditions of information systems, changes in demand for information services and changes in travel behavior. The paper is thus aimed at an understanding of consumer (traveler) behavior in the light of ATIS technology innovation.

The objective of this paper is to describe the evaluation framework of the TravInfo project concerning traveler response to ATIS and to interpret the anticipated effects of TravInfo using some of

the economic principles of commodity providers and commodity consumers. The research questions addressed in the paper are: (1) what are the supply and demand relationships between information providers and information users that can be expected to develop under TravInfo; (2) what are the existing consumer market theories and choice models that would further our understanding of this relationship; **(3)** how can these theories and models be applied to the evaluation of ATIS products and services. While conventional marketing research deals with the issue of how best to develop and expand a product market, market research in the evaluation of ATIS generally deals with the issue of how best to measure consumer response to new technology products and services. Recognizing the number of information user groups that exist in the TravInfo ATIS market such as public agencies, research organizations, and private firms needing access to the ATIS database, the present paper focuses on those ATIS products and services for which consumers are the primary user group.

The paper begins with an overview of previous studies conducted in consumer behavior research and is followed by an anticipated supply and demand consideration of the TravInfo project. Models for estimating information acquisition and for predicting travel choices applicable to the TravInfo evaluation study are described in this paper.

2. PREVIOUS STUDIES

ATIS research to date has generally focused on travel choice models; very few studies have attempted to understand consumer behavior in the areas of information acquisition and distribution. Recently several studies have expressed the concern that the technical feasibility of ATIS does not guarantee consumers will desire, use and purchase ATIS products and services. It is therefore worthwhile to try to estimate how ATIS technologies might be accepted before going on to refine the human factor details of ATIS products and services [2]. The present FHWA research program has set a task in which driver acceptance of ATIS technologies is considered and, to a limited extent, empirically tested.

The goal of this task is to identify the facets of these technologies that have a low probability of being accepted by users, allowing future project resources to concentrate upon aspects of the technology that are more likely to be accepted by the driving community. Three surveys developed for obtaining user information requirements for the design of ATIS were conducted via large sample surveys, in-depth interviews and usability studies [3]. A Delphi survey of experts' opinions on market

penetration and expected impacts associated with the implementation of ITS technologies, including ATIS, has been documented [4]. A survey of experts in ITS and ATIS development, designed to collect information on the market for ATIS and on development issues related to the ATIS market, was conducted [5]. However, these studies do not provide a conceptual framework based on which TravInfo ATIS technology evaluation studies can be performed. Large sample surveys and surveys of experts do not provide the most suitable means for in-depth consumer investigations into issues such as why consumers behave the way they do, use or do not use traffic information, and how they use information. Although focus group interviews are a highly effective means of obtaining in-depth feedback concerning such "why" questions, focus group techniques have seldom been used in ATIS consumer research in the past. Research on consumer purchasing habits in relation to information technology should be an integral part of traveler behavior study. In this paper, we investigated methods for estimating the potential market for traveler information technologies using consumer market concepts.

3. ECONOMIC CONCEPT OF INFORMATION DISSEMINATION AND ACQUISITION

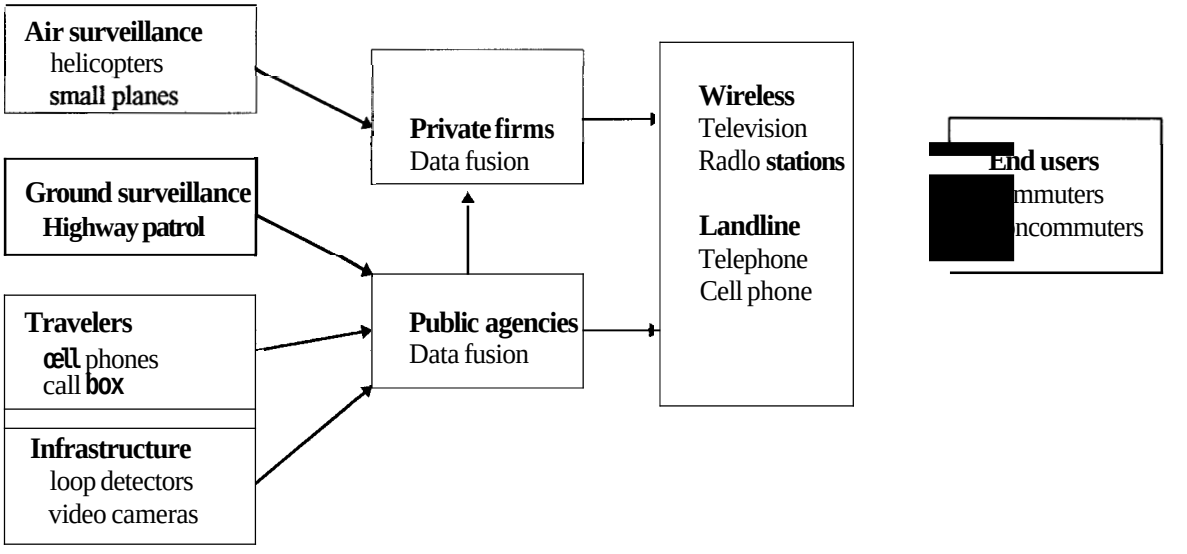
Economists are interested in understanding the changes in a variable which affect other variables. Similarly, in the TravInfo evaluation study, the interest is in measuring changes in the supply condition of information that might affect the *quantity* of information demanded. In this respect, two conditions of demand functions can be examined; 1) a shift in an individual traveler's demand for information acquisition as a result of new information being introduced via TravInfo and **2)** changes in market demand as a result of changes in information acquisition behavior. The supply and demand relationships of the TravInfo project are examined in this section.

3.1. Current and Future State of Information Flow

Bay Area traffic information is currently provided by a unified public/private partnership in which both parties collect the information, fuse it independently and disseminate it to end users using both private and public means [6]. Caltrans and the California Highway Patrol (CHP) collect traffic data through loop detectors, video cameras, cellular calls and surveillance vehicles; the data are fused through the

Computer Aided Dispatch (CAD) and are disseminated to private traffic reporting firms to be broadcast or to be made available through cellular or conventional telephones. Traffic data are also collected by private firms through helicopters and small planes. Traffic reporting is mostly by means of commercial radio, and television channels and by cellular and conventional telephone. Through these media, travelers receive on-time traffic reports which are updated every 15 minutes. The present state of the traffic information flow is shown in Figure 1.

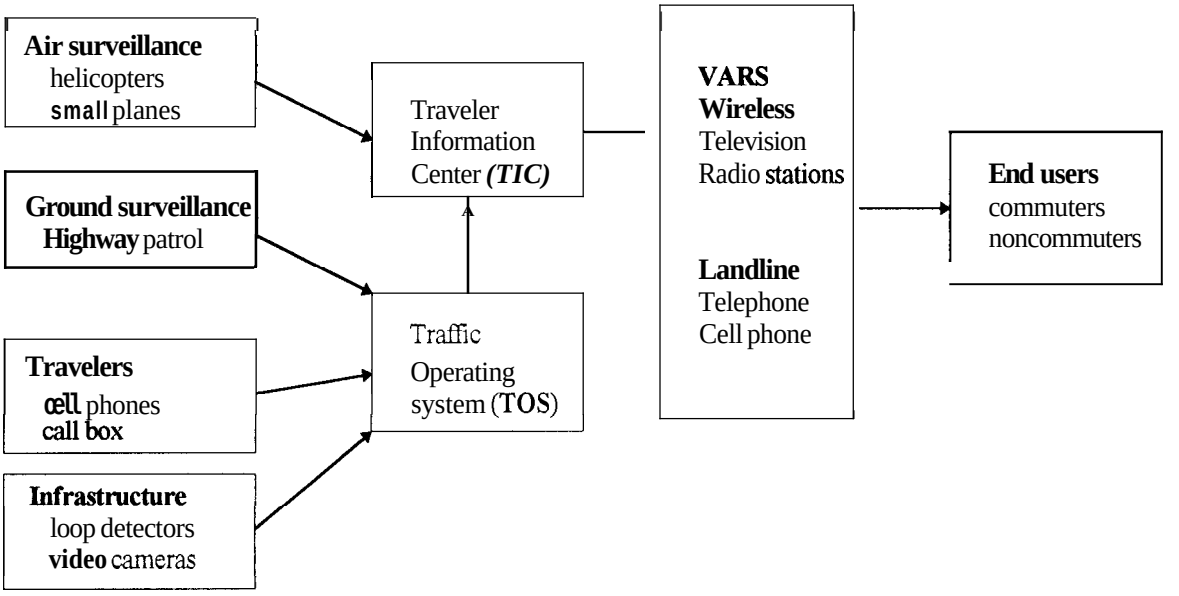
Figure 1. Pre-TravInfo Traffic Information Flow



With TravInfo, data will be fused at a centralized location, the traveler information center (TIC), and then standardized before dissemination through the traveler advisory telephone service (TATS) and through commercialized dissemination means such as wireless data broadcasting. The proposed information flow under TravInfo is shown in Figure 2. TravInfo is intended to modify supply conditions of information service so that information demand conditions can be altered. TravInfo is expected to provide more and better information through a variety of means, including cable television, commercial FM radio and in-vehicle devices specifically tailored to those customers needing

personalized traveler information. In such a case, the question is, what is the expected demand for information in respect to the new information services being introduced in the Bay Area market? The expected demand conditions, as the TravInfo project envisions, is herewith presented, borrowing the economic concepts of the supply and demand relationships of a commodity.

Figure 2. Post-TravInfo Traffic Information Flow

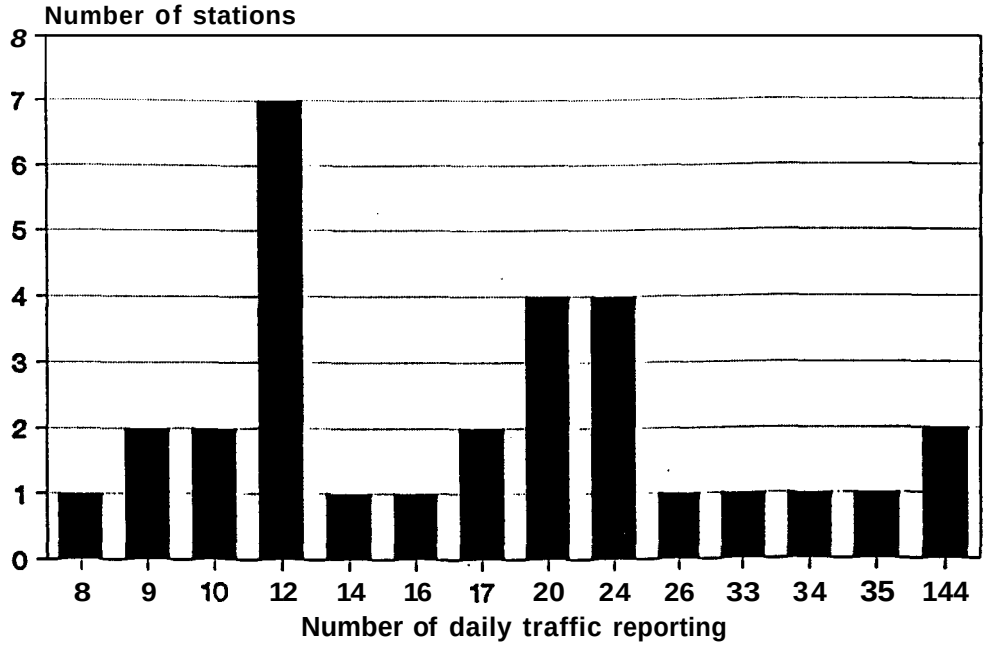


3.2. Changes in Information Supply

In the San Francisco Bay Area, the supply of traffic information is mostly through radio broadcast. A large volume of traffic information is provided through *62* Bay Area radio stations. Radio is the most accessible, most voluminous and most up-to-the minute medium of information available to the public today. Two private companies gather traffic data and either broadcast traffic reports directly through the radio stations or furnish the data to radio stations for internal broadcasting. Recent surveys of 35 Bay Area radio stations serving the San Francisco Bay Area indicated that the vast majority of the

stations broadcast information for morning peak hour traffic conditions and one third of those interviewed provide services throughout the nine county Bay Area [7]. Less than ten percent of the stations interviewed provide all day traffic reporting. The survey also showed that the frequency of traffic reporting is not associated with the station programming which suggests that there is little or no difference in the cross section of information consumers among the Bay Area population. The daily supply of traffic information reporting through radio in the Bay Area region is shown in Figure 3.

Figure 3. Frequency Distribution of Radio Traffic Reporting



The supply of traveler information (excluding transit information) currently available can be conceptualized with respect to the price of production and the quantity of information provided. The conceptualized supply curve of the present information service is relatively steep because the quantity of information provided is somewhat fixed by the small number of providers (Figure 4). However, the cost of providing information varies according to the individual firm for information dissemination as exemplified in the case of the commercial radio and the cellular telephone media. The marginal cost to supply information via commercial radio is lower than the cost by cellular providers per unit of output. Traffic information via radio is free to the user but not to the provider who bears a cost. The Marginal

Cost (MC) per unit of output of information supply via radio is lower than that of cellular providers because of the difference in the costs associated to the technologies. Radio is a mass medium from a point to public where as cellular is a point to point and hence inherently more costly. (For traffic information, a cellular phone call costs $1 in the Bay Area.) The conceptualized current traffic information supply curve is derived from the quantity of information supplied to the Bay Area market by the individual suppliers (m); therefore, the total market supply is given by the horizontal summation of the supply curves of each supplier [8]:

$$S_1 = \sum_{m=1}^{n} q_1 m$$

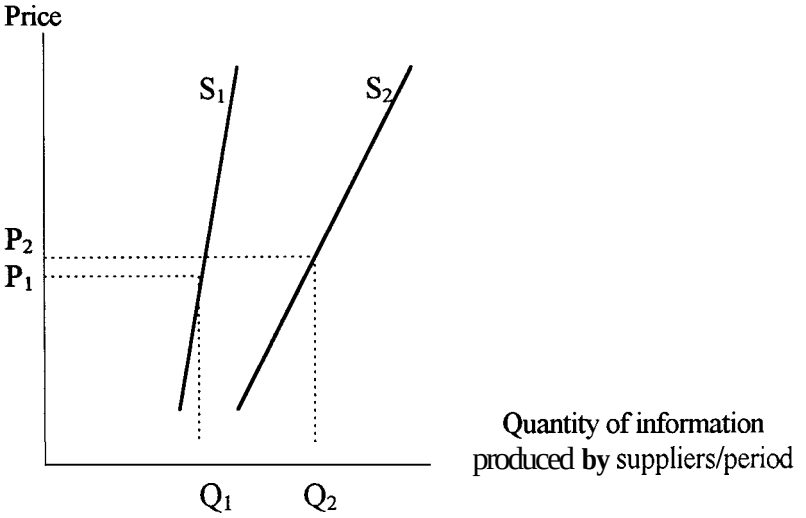
Where m = individual suppliers of traffic information
q = quantity of information produced by individual suppliers

The Post -TravInfo supply curve is expected to shift from S_1 to S_2 because the quantity of information supplied will increase through additional media (means) with a multiple level of information content. There is not only a shift in the supply curve from S_1 to S_2, but that S_2 is less inelastic than S_1 (slope is less steep) in that there are more providers of information. If the price goes up from P_1 to P_2, more information will be provided under S_2 than S_1. The supply curve of the Bay Area market after TravInfo is expected to be in the shape of S_2 and the expected total market supply is given by:

$$S_2 = \sum_{m=1}^{n} q_2 m' \qquad (3.1)$$

Where $n' > n$ and the number of firms providing information to the market is expected to be very large, it is also assumed that advanced technologies will enable a reduction in marginal cost for a unit of output that is superior to the output in S_1. At the same time, a greater number of value added new information devices are expected to become available in the market.

Figure 4. Conceptualized Information Supply Curve Before and After TravInfo



3.3. Changes in Information Demand

Three demand conditions are expected to prevail as a result of the changing supply conditions with TravInfo: 1) current information will be substituted for by new information produced using TravInfo; **2)** demand will increase due to an increase in frequency of information acquisition; **3)** demand will increase due to an increased capture rate of new consumers who had never before used traveler information. It is anticipated that when new information whose attributes provide more utility per dollar is introduced in the Bay Area market, travelers will obtain a higher utility because of the availability of the new information and the attributes it provides.

To elaborate on the first scenario, consider that there are two information bundles disseminated through two different types of media: product X is offered through a two way communication system such as a cellular telephone or in-vehicle device and product Y is offered through a one way communication system such as commercial radio. If TravInfo offers opportunities for the suppliers to improve the quality of information and that information is superior to that presently available, i.e, personalized real-time information without an increase in the cost of information, consumers will shift their purchase habits from bundle A to bundle B without being constrained by consumer income because they will acquire the information through the same or different means (Figure 5). Consumers will have the same indifference curve because their household income has not changes. Therefore, demand for Y is expected to decrease from Y_1 to Y_2 and demand for X is expected to increase from X_1

to X_2, because the "value" of information per dollar to each traveler with **X** is greater than the value of information per dollar with **Y.** The value of information in this case can be defined as the amount of information useful to each traveler. The cost of information could include the direct cost of purchasing in-vehicle devices and subscription fees for information services and the indirect cost could be due to the time consumers spend to capture the relevant information via television viewing or radio listening. Consumers do not pay directly for commercial radio information but the cost of radio information is high if the ratio of relevant information and irrelevant information is considered. Consumers need to listen to more irrelevant information in order to get one unit of relevant information; the value of this excess listening time needs to be taken into consideration.

The second scenario is that as the value of information increases through TravInfo, individual consumers will increase the frequency of their demand for information acquired, e.g., fi-om once a week to every day. The increase in each individual's demand for new information will shift the market demand curve upward, since the market demand for information is the sum of the demand for that information by each consumer. Market demand (D^*) for new information is the sum of demands (d) for information acquired through each individual medium ($m_1, m_2, \ldots m_n$):

$$D' = \sum_{m=1}^{n} dm \qquad (3.2)$$

Where **d** = information acquired by individual consumers
m = individual medium

The third scenario is that market demand is expected to increase because the improved quality of information with TravInfo offered at the same or lower cost than what is offered today will attract new customers. The capture rate of consumers will be higher with TravInfo than the capture rate with the current information service. Demand for information is also expected to increase because consumers will have greater choices of information goods (contents and means) since more firms will enter the market with new and innovative products (Figure 6). The competition will bring the cost of information down. The effect of a shift in the demand curve depends on the shape of the short-run supply curve. In the case of TravInfo, the supply of information is expected to be elastic and thus the price of information will rise slightly if at all in response to the shift in demand.

Figure 5. Changes in Utility Curve by Introducing New Information

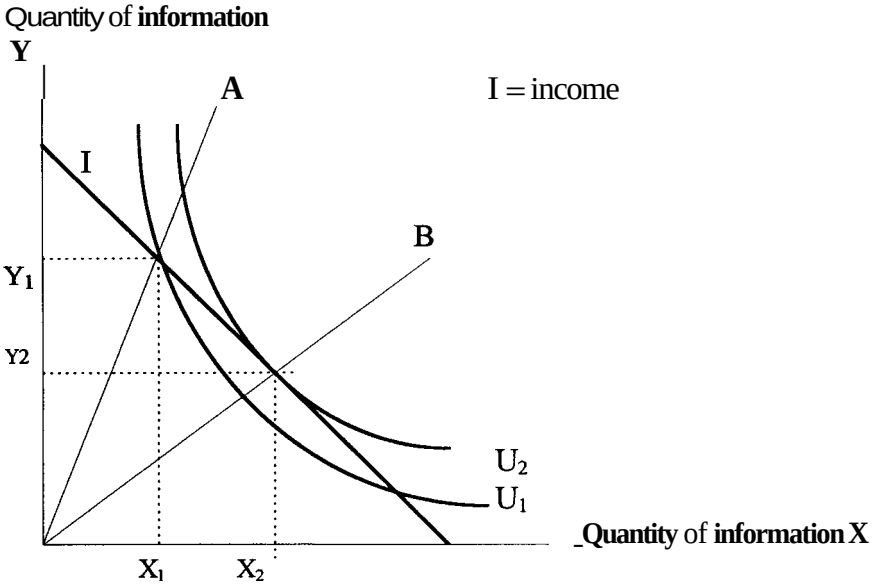
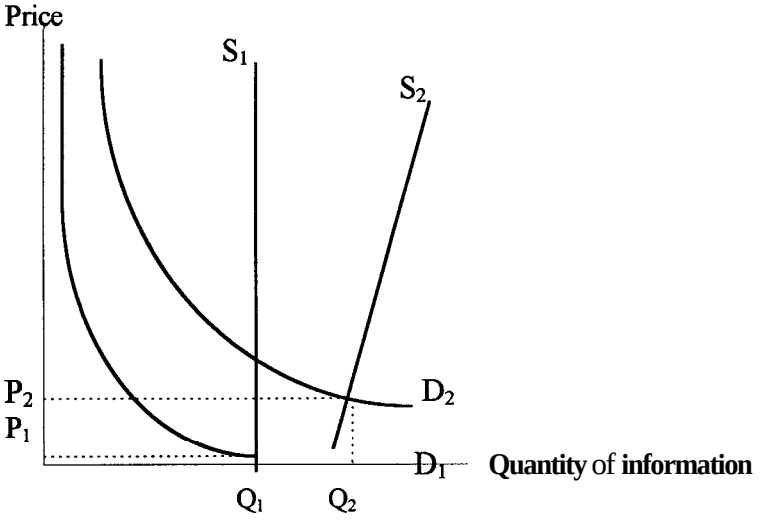


Figure 6. Conceptualized Supply and Demand Relationships Before and After TravInfo



3.4. Impact of TravInfo in the Short-Run

During the three year period of the TravInfo FOT, it is unlikely that in-vehicle devices will be deployed to the extent that they will result in significant changes in consumer demand for traffic information will

occur through in-vehicle devices. The likelihood is that traffic information services will be improved through commercial radio and television, and cellular and conventional telephones. Therefore, a slight upward **shift** in the demand curve is expected in the short-run. The impact of TravInfo is expected to be far more significant in the long-run since the awareness of new information will occur as products become available. One of the challenges associated with the prediction of the TravInfo market in the short-run is how to estimate market demand for new information when supplier products, such as in-vehicle devices, are not available in the present market and, therefore, consumers are not aware of what the products are like.

New traveler information provided under TravInfo must be perceived as "better" than the information currently available to the consumer. To be able to attract consumers, new and improved information and more convenient means of accessing information must be offered. In ATIS product development, including in-vehicle devices and TATS, ATIS providers must try to modify consumer purchase habits by offering a product that has major advantages over existing products (e.g., Fastline, radio and television broadcasts). TravInfo will have the ability to provide better information, but the unknown factor is whether or not the quality of information and interface mechanism, the means to access information through TATS and new ATIS products, will be superior to that of the existing system. The awareness of new information and changes in the perception of information is an evolving process. The changes in the quality of information perceived may not prevail in the short-run.

This paper thus far has described the conceptual relationships between the supply and demand scenarios expected from the TravInfo project. The next section focuses on the market demand for traveler information and how that demand relates to travel behavior.

4. CONSUMERS OF TRAVELER INFORMATION

To evaluate the impact of TravInfo on travel behavior, it is necessary to identify the potential consumer base for new information services and to determine the profile of the individuals who access, acquire and use the information available through ATIS technologies and to define the parameters that influence consumer demand for travel information. The market evaluation study is concerned with consumer acceptance, awareness of and willingness to pay for the benefits of ATIS products and services. The research interest in TravInfo is to measure the changes in consumer behavior with

respect to new information which is made available. In the Bay Area, TravInfo will standardize the content of information, hence the quality of information will be uniform and the database access will be free. Then private vendors can resell the information through their own products or services.

As stated earlier, the broad question pertaining to TravInfo is how to estimate the impact of ATIS on travel behavior. Before embarking on this issue, the key concern of the evaluation study is how the ATIS market will behave in relation to the demographic and geographic characteristics of the land use and activity patterns and the associated transportation networks of the Bay Area. The information provided by TravInfo is in effect a new product that consumers may not be aware of even though the new information is available through conventional media such as radio and television.

4.1. Information market prediction model

For the TravInfo evaluation project, it is important to assess how many travelers will become aware of new information services to the degree that they will seriously consider using them. The market prediction models of product purchase potential assume that acquisition of information will occur if consumers are aware of the new information and if the information is available to them [9]. *Awareness* of new information is dependent on advertising and outreach programs. *Availability* of new information is dependent upon the suppliers' business decisions concerning the distribution strategies of these services made available to travelers. An outreach program is not only concerned with the advertisement of the availability of new information but is also intended to change the image or perception of new information under TravInfo. The TravInfo project will have a two year large scale outreach program during the FOT period.

Awareness of new information will influence consumer choices in the use of and access to Bay Area advanced traveler information. The expected consumer demand for new information is thus a function of the awareness of information (a'_w), the availability of information (a'_v), the value of information to individual travelers (λ'_i) and the information acquisition rate of individual travelers (a'_q). For the TravInfo evaluation project, it is necessary to measure the differences in the awareness of

traveler information and the consumer perception of the quality of information before and after TravInfo becomes operational. The expected results of the TravInfo outreach program are that $a'_w > a_w$, $a'_v > a_v$, $\lambda'_i > \lambda_i$, $a'_q > a_q$, where a_w, a_v, λ_i, and a_q represent the conditions before TravInfo. Therefore, the conditional probability of the consumer base of new information is $P'_m > P_m$ where P_m is the probability of the consumer base of the current information. The conditional probability (P'_m) of the customer base of new information by the individual medium can be expressed as:

$$P'_m = \sum_{m=1}^{n} \lambda_i (a'_w)(a'_v)(a'_q) \qquad (4.1)$$

Where

λ_i = value of information acquired through medium i

a'_w = awareness of new information

a'_v = availability of new information

a'_q = acquisition rate of new information through medium *i*

a'_i is defined as the percentage of travelers who will *evoke* the new information and a'_i is the percentage of the traveler population served by providers. The measure of a'_q is the rate of acquisition determined by the frequency for a given period of time. Acquisition probability of individual travelers per information unit depends on the value of the information to the traveler; economists have assumed that consumers are utility maximizing individuals. In the following section, the concept of individual utility maximization and its relationship to travel behavior are investigated.

4.2. Information Probability of Individual Travelers:

An individual's demand for information type (X) depends on the shape of the utility function and on all prices and on the individual's income. Considering individual travelers, it is assumed that each traveler is a utility maximizing individual who will make the choice among goods which will yield the greatest benefit to that person. The conjecture is that when TravInfo introduces a new information good, B, in the competitive market whose attributes provide more utility per dollar than the existing information good, A, an individual traveler will choose B if possible because it yields a higher utility to the person than does a similar expenditure on information A. To be more specific, under the *Cetri Paribus* assumption, individual travelers maximize their utility from acquiring traveler information and thus any information whose price (P_i) exceeds its marginal value to the individual traveler, $Mu_{,}$, will not be acquired. (If $P_i > Mu_{x_i}$, $X_i = 0$ and if $P_i \leq Mu_{x_i}$, $X_i > 0$.) It can be restated that if the benefit-cost ratio, λ, is not positive, travelers will not acquire information [8]:

$$\lambda = \frac{MB_{X_i}}{MC_{X_i}} \qquad (4.2)$$

Where MB = marginal benefit of X_i

MC = marginal cost of X_i

The utility function of an individual traveler (U_1) depends on travel options that are available to that traveler. Among automobile users who can not increase utility by acquiring information because they do not have the choice to take alternate routes, to take transit, or to change their departure time, the

new information introduced to the market has no value. Of all the commuters who drive or take transit to work during morning peak hours only a certain segment of the population may rely on morning traffic information prior to departing home or while driving or taking transit.

The commuters who may acquire information can be categorize with respect to their pre-trip and en route travel options: Pre-trip travel options are to: 1) take alternate route, **2)** take alternate mode, 3) change departure time, **4)** cancel the trip. En route travel options are to: 1) take alternate route, **2)** change destination, **3)** change mode, i.e., park an automobile and ride transit, and **4)** delay arrival time by making an intermediate stop. Therefore, we can develop a typology of information consumers. The examples are:

1. The consumer type (Cd_1) who has the option to change arrival time ***(At),*** take alternate routes (r) and to take transit (T);
2. The consumer type (Cd_2) who has the option to change arrival time and take alternate routes but does not have the option to take transit ;
3. The consumer type (Cd_3) who has the option to change arrival time but does not have other options;
4. The consumer type (Cd_4) who has the option to change travel mode but does not have other options;
5. The consumer type (Cd_5) who has no travel option but to take an automobile;
6. The consumer type (Ct_1) who has the option to change arrival time, take alternate routes and to drive to work;
7. The consumer type (Ct_2) who has the option to change arrival time or to take alternate routes;
8. The consumer type (Ct_3) who has the option to change arrival time or to drive to work;
9. The consumer type (Ct_4) who has the option to change arrival time but has no other options
10. The consumer type (Ct_5) who has no travel option but to take transit.

Table 1 shows the value of information with respect to travel options being available to each consumer type prior to departure and en route. The utility functions of individual travelers with each information content need to be determined from surveys and observations.

In light of the TravInfo project, it is necessary to evaluate what percentage of Bay Area travelers actually have travel options available to them and what content of information has any relevance to individual travelers. Availability and awareness, acquisition of traveler information and travel options available to travelers can be evaluated through a large scale randomly sampled survey of the Bay Area traveler population. Through surveys , it is also possible to determine the geographic distribution of the travelers who have travel options and of those who do not. With the survey data, marketing strategies for information distribution can be formulated specifically to target each segment of the traveler population since awareness of information is only useful if travel options are available.

Table 1. Value of Information with Respect to Travel Options

Travel Options	Cd_1	Cd_2	Cd_3	Cd_4	Cd_5
Pretrip					
take alternate route	●	●			
arrive late	●	●	●		
take transit	●			●	
Enroute					
take alternate route	●				
change destination	●	●	●	●	●
park & ride	●			●	
Travel Options	Ct_1	Ct_2	Ct_3	Ct_4	Ct_5
Pretrip					
take automobile	●		●		
take alternate route	●	●			
arrive late	●	●	●	●	

5. MEASUREMENT OF TRAVEL BEHAVIOR

In the traveler response evaluation study, the concern is with the shift in travel choices after information is acquired; whether or not the individual who acquired the information took any of the travel options available to him. The interest of the TravInfo evaluation study is in measuring to what extent consumers change their behavior after the acquisition of information in the context of pre-trip planning and en route diversion choices. The relationship between the way that information is acquired and how it is used is not clearly understood. Most studies thus far have focused mainly on the modeling of consumer travel choices and on survey research. The findings among the surveys varied significantly depending on the geographical locations of the samples taken; the survey results were not directly pertinent to the TravInfo traveler response evaluation. For that reason, the TravInfo evaluation study will require a series of large scale surveys before and after TravInfo becomes operational. In this section, the discussion is focused on the data categories that are necessary to evaluate the changes in traveler behavior for the TravInfo study.

5.1. Travel Options and Consumer Choices

In the travel behavior study, the concern is with the probability of travel choices that travelers make with the new information. Suppose we consider dependent variables are travel choices that individual travelers make and independent variables are associated with information consumption such as awareness of information (a_w), availability of information (a_v), value of information measured in travel time savings/cost of information (v_b), and household income (I_h). Then we can construct several models and they can be tested with empirical data.

The recent survey of Golden Gate Bridge users regarding pre-trip response to unexpected traffic congestion found that nearly 40% of those surveyed did not change their travel plans, approximately one quarter of the sample departed earlier than usual, 10% departed later than usual, 2% took transit and **2%** canceled the trip [10]. What is suggested in this survey is that Marin County travelers preferred departure time choice because transit and route options are severely limited as compared to other parts of the Bay Area and perhaps their arrival time is somewhat flexible. East Bay travelers might have responded differently as may have South Bay travelers. Evaluation of the

variations in travel choice is necessary to better understand the overall impact of advanced traveler information services on Bay Area travel patterns.

5.2. Application of Logit Model for TravInfo Evaluation

In addition to the simple statistical analysis for the TravInfo survey work, the Logit model can be utilized to estimate the probability of travel choices. Based on the utility maximization concept, the utility of each travel option can be expressed as:

1) take alternate route (r),

$$Ur = \beta_1 a_{wr} + \beta_2 a_{vr} + \beta_3 v_{br} + \beta_4 I_{hr} + e_r$$

β_1, β_2 and β_3 are scalar parameters and e_r is the unobserved component of utility for each alternative and varies with respect to the individual traveler's differing views of information accuracy and relevance to each trip.

2) take alternate mode (m),

$$Um = \beta_1 a_{wm} + \beta_2 a_{vm} + \beta_3 v_{bm} + \beta_4 I_{hm} + e_m$$

3) change departure time (d), leave earlier (de) and leave later (da) than usual,

$$Ude = \beta_1 a_{wde} + \beta_2 a_{vde} + \beta_3 v_{bde} + \beta_4 I_{hde} + e_{de}$$

$$Uda = \beta_1 a_{wda} + \beta_2 a_{vda} + \beta_3 v_{bda} + \beta_4 I_{hda} + e_{da}$$

4) cancel the trip (c),

$$Uc = \beta_1 a_{wc} + \beta_2 a_{vc} + \beta_3 v_{bc} + \beta_4 I_{hc} + e_c$$

In most cases Multinomial Logit models could be used for estimating the probability of choosing each travel option for the TravInfo project. Should the traveler has three travel

options, alternate route, alternate mode and cancel the trip, the probability that the traveler chooses the alternate route is:

(5.1)

$$P_r = \frac{e^{\beta_1 a_{wr}+\beta_2 a_{vr}+\beta_3 v_{br}+\beta_4 I_{hr}}}{e^{\beta_1 a_{wr}+\beta_2 a_{vr}+\beta_3 v_{br}+\beta_4 I_{hr}} + e^{\beta_1 a_{wm}+\beta_2 a_{vm}+\beta_3 v_{bm}+\beta_4 I_{hm}} + e^{\beta_1 a_{wc}+\beta_2 a_{vc}+\beta_3 v_{bc}+\beta_4 I_{hc}}}$$

The probability of each travel option P_m , P_{de} , P_{da} , **and** P_c , given that these options are available, can be estimated using a similar formula. However, limitations of the model should be realized including, the cost of operating the model; certain assumptions in the model, i.e., the independence from irrelevant alternatives (IIA) property, may also not be realistic in many circumstances [113.

5.3 . Description of TravInfo Experimental Design

The traveler response component of the evaluation study is aimed at measuring changes in individual travel patterns that result from the changes in information acquisition behavior and distribution strategies [12]. The discernible benefits of TravInfo to Bay Area travelers are expected to be reduced travel time and reduced travel costs and these benefits will be measured according to the utility of information influencing travel choices. The travel behavior study is a survey oriented to collecting information and developing models appropriate for estimating the probability of different travel behavior with respect to available travel options and traveler information.

A combination of "pre-and-post test" and "multivariate time series" methods are proposed to test a sample population in a controlled environment. To assess the near-term impacts of the TravInfo project, a "before and after" experimental design will be employed. Comparisons between the "before" and **"after"** cases should allow the effects of the TravInfo deployment to be distinguished from other changes occurring in the Bay Area. The first wave of a large scale survey is scheduled for October **1995,** approximately three months prior to the actual implementation of the TravInfo project for the Post-TravInfo baseline study. Prior to the first wave of the large scale survey, six focus group interviews will be conducted to address the consumer market issues of ATIS and to construct hypotheses that need to be tested using the survey research method.

The experimental design of the survey research includes descriptive and performance-monitoring survey methods. The surveys include: 1) two separate cross-section surveys of the Bay Area population, called "broad area surveys," *2)* three longitudinal surveys of the population geographically targeted to capture travel behavior under non-recurrence congestion, called "target panel surveys," **3)** three separate cross-section customer surveys through vendors, called "VAR customer surveys," and **4)** two separate cross-section surveys of the TATS patrons, called "TATS user surveys. It is assumed that the majority of the travelers responding to the broad area surveys, target panel surveys, and TATS user surveys would not have in-vehicle ATIS devices. All travelers responding to the VAR customer surveys will be equipped with ATIS devices.

The broad area surveys will be conducted within three months before and **18** months after TravInfo goes into operation. The pre-TravInfo target survey will be conducted concurrently with the pre-TravInfo broad area survey. Two target panel surveys will be conducted at least six months after TravInfo. Three VAR customer surveys through vendors and the TATS surveys will be conducted after TravInfo, roughly 9 months apart.

Sampling method

The initial broad area survey and target survey will serve two purposes: to define baseline attitudes, opinions and travel behavior with respect to TravInfo and to recruit individuals for a panel to assess changes in travel behavior under incident conditions. For these purposes a sample of 1,000 randomly selected individuals throughout the Bay Area and a sample of 1,200 randomly selected individuals in the geographically targeted area will be interviewed.

The potential respondents will be contacted via a random digit dialing process for households throughout the seven-county Bay Area. This process ensures that all households that have a telephone are included in the sampling pool, regardless of whether or not their telephone number is listed. Since over 95% of Bay Area households have a telephone, the exclusion of non-telephone households from the sampling pool does not pose a serious problem for the representativeness of the resulting sample population.

Survey administration

The survey administration method is selected on the basis of the information type that is desired. A mail technique is chosen for the initial VAR customer surveys through vendors because the type of information desired is primarily the reporting of product performance, travel behavior and demographic characteristics of the customers. Confidentiality of customer information is also a factor in the selection of the mail technique. A telephone interview technique has been selected for the broad area and target panel surveys. A telephone interview is preferable for attitudinal or opinion information where spontaneous responses are desired. In the case of simply reporting travel behavior over some period of time, as in a travel diary, a mail technique is employed.

The variables considered in the baseline survey design of the TravInfo traveler behavior study are:

1. General travel behavior: commuter trips, trip purpose, travel mode, travel time, and travel cost
2. Information acquisition and perception: means for acquiring information and perception of information
3. Travel choices made in response to traveler information: the use of information under incident conditions, response to information, awareness of traffic congestion, benefits of information to individual travelers
4. Demographic profiles: age, sex, occupation and industry, education, household information including income and the number of employed persons, motorized vehicles, licensed drivers

In the Bay Area, the frequency and the content of traffic information vary significantly among the traffic information providers. Therefore, consumers generally have preferred means for acquiring information and also preferred sources of information. Considering the travel options and consumer types discussed earlier, in addition to the statistical analysis, the Mutinomial Logit model will be used to determine the probability of travel options chosen by Bay Area travelers.

7. CONCLUSIONS

The paper described the TravInfo FOT evaluation framework dealing with traveler response to ATIS using some of the economic concepts of supply and demand relationships in information distribution and acquisition. Consumer choice theories were investigated to help better understand the impact of TravInfo on the travel choices made with ATIS. The key variables to be considered in the evaluation study were presented and existing models were investigated to establishment the conceptual framework in which the evaluation study could be conducted.

The effectiveness of the TravInfo project on travel behavior will be measured using the ***comparative static*** *analysis* method to assess Pre- and Post-TravInfo conditions. Both Pre- and Post-TravInfo studies in consumer response to TravInfo and travel behavior of Bay Area travelers will use the identical data collection and analysis methods for easy comparison of the *before* and *after* effects of TravInfo. The baseline study will establish the current state of the information acquisition, the use of information and travel choices with the information.

Over the three year period of the TravInfo FOT, it is doubtful that TravInfo technologies will be deployed to the extent that significant changes in travel behavior can be detected. During the FOT period, the supply of information may improve to the extent that travelers might have easier access to telephone information services and have more up-to-date traffic reporting. Demand for information services is evolving over time with respect to business decisions and marketing strategies as well as to the awareness of information and its marginal benefit increases per traveler as the quality of information improves. Therefore, it is unlikely that TravInfo will have any significant change on travel behavior in the short-run. For that reason it is highly desirable to evaluate the long-term effects of TravInfo. The key to an ATIS evaluation is the ability to project the future state of ATIS technologies. Unfortunately, most of the predictive tools available today fall far short of what is needed for the technology evaluation studies necessary to assess the long-term effects. Further research is needed in the area of development of models that realistically predict the future consumer market environment that will result from the deployment of new and innovative ATIS technologies.

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