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

# TravInfo Evaluation Plan: Update 1

**Youngbin Yim**
**Asad Khattak**
**Mark Miller**
**Randolph Hall**
**Stein Weissenberger**

**UCB-ITS-PWP-94-3**

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.



MARCH 1994

**ISSN** 1055-1417

## Contents

## List of Figures

# 1. INTRODUCTION

TravInfo is a public/private partnership formed to provide wide-spread dissemination of real-time information on transportation conditions and travel options. A fundamental premise is that a public surveillance and database system, designed to open-architecture standards, will be an effective stimulus for private sector innovations in ATIS (Advanced Traveler Information Systems) technologies and, ultimately, their deployment.

TravInfo is a Field Operational Test of a centralized database providing easy access to real-time travel information on all modes of transportation in the Bay Area. TravInfo will test the thesis that comprehensive and timely information on the Bay Area's complex transportation system will result in reduced congestion and traffic delay.

The goals of Travinfo are to:

1) Implement a system to integrate and broadly disseminate timely and accurate traveler information throughout the Bay Area.

2) Stimulate and support deployment of a wide variety of **ATIS** products and systems, encouraging a competitive market with products providing a range of prices and capabilities.

3) Evaluate the effects of TravInfo on a broad array of issues, including entrepreneurial response to providing and using improved travel information, and changes in transportation system performance.

4) Test the value and effectiveness of a public/private partnership.

When complete, TravInfo will incorporate:

1) Information sources from the state-of-the-art surveillance systems, including loop detectors, closed-circuit TV cameras, and probe vehicles.

2) Publicly accessible databases designed to open architecture standards, enabling third-party delivery of traveler information.

3) Systems for communicating with travelers in pre-trip and enroute stages.

The overall project structure is illustrated in Figure 1.1.

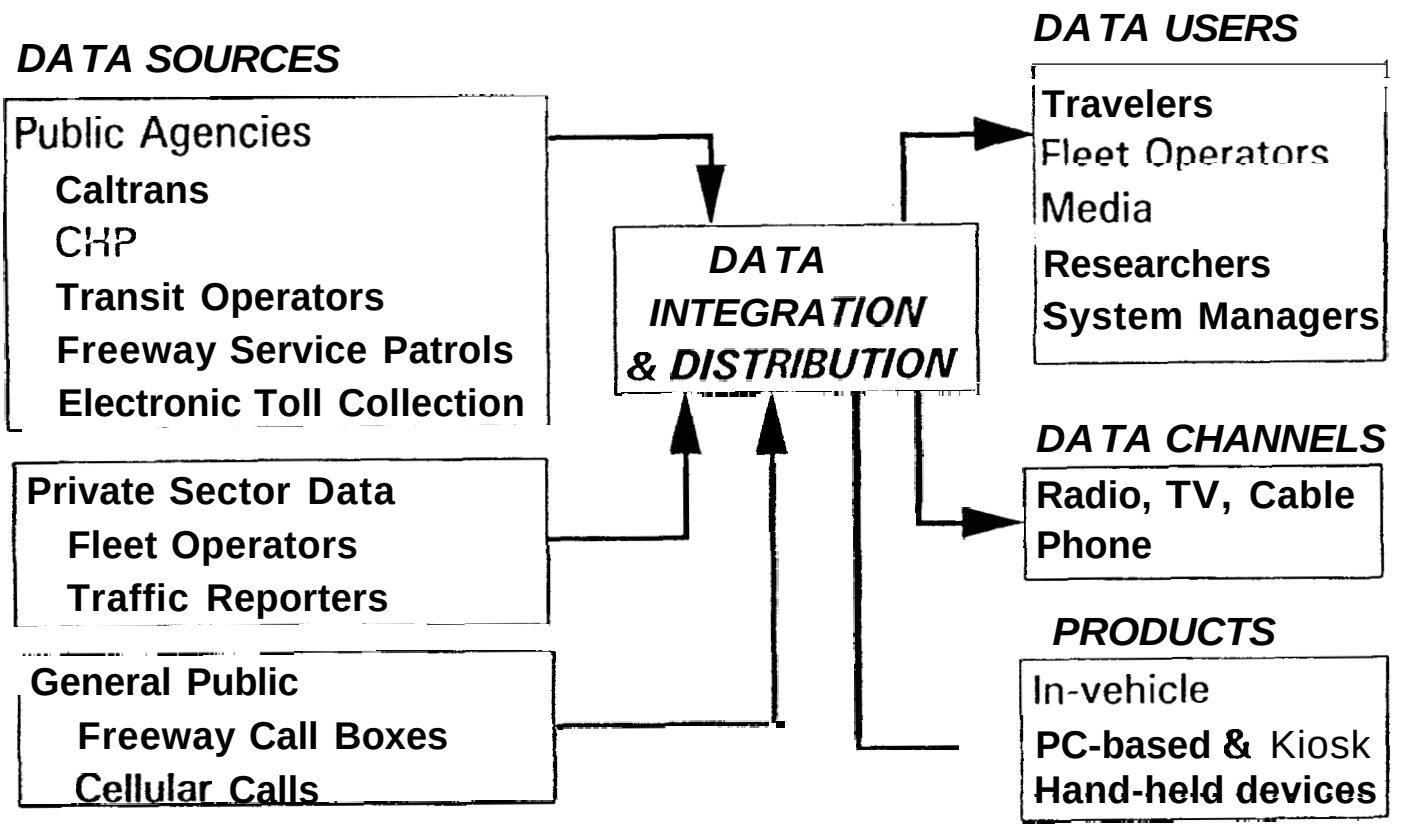



**Figure 1.1. TravInfo System Overview**

## 1.1 Project Evaluation

The evaluation project will be conducted in accordance with the report, "Bay Area ATIS Testbed Plan" (PATH research report UCB-ITS-PRR-92-1), which provides guidelines for experimental design, site selection, and recruitment of study participants. The principal elements **of** the evaluation will be:

1) Assessment of traveler response;
**2)** Institutional evaluation;
3) Technology assessment evaluation;
**4)** System performance evaluation.

The traveler response component of the evaluation study will be aimed at measuring changes in individual travel patterns that result from the TravInfo project, and traveler acceptance and preferences for the TravInfo technologies. The benefits of TravInfo to Bay Area travelers are expected to be reduced travel time and reduced travel costs. The survey research method will be used to assess traveler response to, and perception of, the TravInfo project and the various information sources and devices made available to the public. Transit riders, private vehicle operators and fleet vehicle operators will be surveyed.

The success of the TravInfo project depends largely on the institutional arrangement of private and public partnership and coordination among business organizations and agencies, The effectiveness of institutional arrangements and the management approach will be assessed in terms of the success of TravInfo in meeting its goals and objectives, and through interviews with a wide spectrum of public and private participants. Observations will be made at advisory and management board meetings and workshops to examine group dynamics and institutional effectiveness. Changes necessary to make improvements in institutional arrangements and management approaches for the TravInfo project will be suggested.

The technology assessment component of the evaluation study will be directed at determining which technologies are most promising for improving travel conditions in the Bay Area within the framework of the open architecture system. Information technologies will be evaluated based on surveys of travelers and private sector providers. This information will be analyzed with respect to a taxonomy of technologies, to determine which classes of technologies are most effective. Finally, the technology assessment will measure the performance of the TravInfo hardware and software, with respect to such factors as reliability, operability, and functionality.

The system performance aspect of the evaluation study will be concerned with the system wide benefits of the TravInfo project in the Bay Area. Coupled with survey results, a combination of traffic simulation modeling and direct measurement will be used to assess changes in system level performance. The models employed will explicitly represent information type, content, and format, and will be used to estimate Measures of Effectiveness **(MOEs),** such as vehicle hours of delay, traffic volume and vehicle emissions.

## 1.2 Overall Test Responsibility

California PATH will be responsible for evaluation **of** the TravInfo project. PATH is a consortium of California Universities formed to advance IVHS research. Institutional considerations and the effectiveness of the public/private partnership are a key component of the TravInfo project. These aspects of TravInfo will be monitored as part of PATH's overall evaluation plan.

Evaluation of the TravInfo field operational test will be conducted by PATH independently from the TravInfo project team. Mitre has been retained by FHWA to assure the quality and independence of each evaluation. Figure **1.2** shows the relationships between evaluators and evaluation team. PATH will serve **as** an evaluator. The evaluation team has been formed. The role of the evaluation team is to provide technical advice to the evaluator. Additional responsibilities of the evaluation team include: a) represent and report to Partners, b) address evaluation questions and make decisions, c) continues in existence throughout the evaluation, providing technical oversight, d) plays an active role, maintaining evaluation momentum, and e) reviews all evaluation documents prior to submission to Partners. The chair of the evaluation team is Shara Lynn Kelsey of Caltrans New Technology. The evaluation team consists of members of the Steering Committee, Management Board, and a technical advisor, and five members of a peer review panel.

Y.B. Yim of PATH will serve as overall manager for the evaluation **tasks** of the project to be performed by PATH researchers. Yim will report to Stein Weissenberger, who will be responsible for coordination with PATH's overall research and testing program in Advanced Traveler Information Systems. Asad Khattak will be responsible for the traveler response component of the study. Mark Miller will be responsible for technology assessment and Stein Weissenberger and Randolph Hall will be responsible for the system performance evaluation. Y.B. Yim will be responsible for the institutional evaluation, in addition to her duties as overall project manager.

## 1.3 Overall Project Schedule

The entire project will cover 3 years, beginning June 1, 1993, and ending June 31, 1996, and will be coordinated with the TravInfo implementation schedule. The evaluation schedule is based on the assumption that the final TravInfo system would become operational on June 1, 1995, an interim version of TravInfo would be operational on June 1, 1994, and that specific tasks outlined in this plan are subject to modification as the TravInfo project evolves over time. The schedule for the evaluation study is shown in Figure 1.3.

## 1.4 Organization of Report

The report is divided into five parts. In Section 1, the conceptual framework of the TravInfo evaluation project is presented. Section *2* describes the traveler response component of the evaluation plan. The institutional component of the evaluation is presented in Section 3. Section **4** describes technology assessment of the TravInfo project and commercial products and services using TravInfo. The system performance evaluation is described in Section *5*.

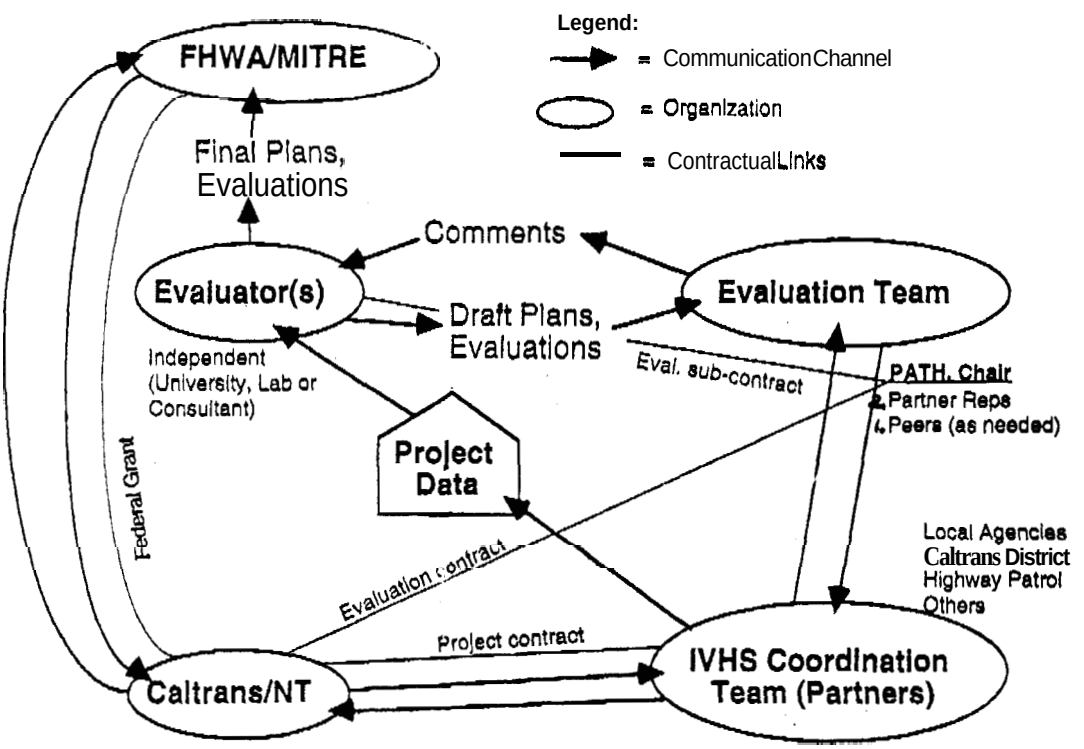



**Figure 1.2. Field Operational Test Evaluation Process**

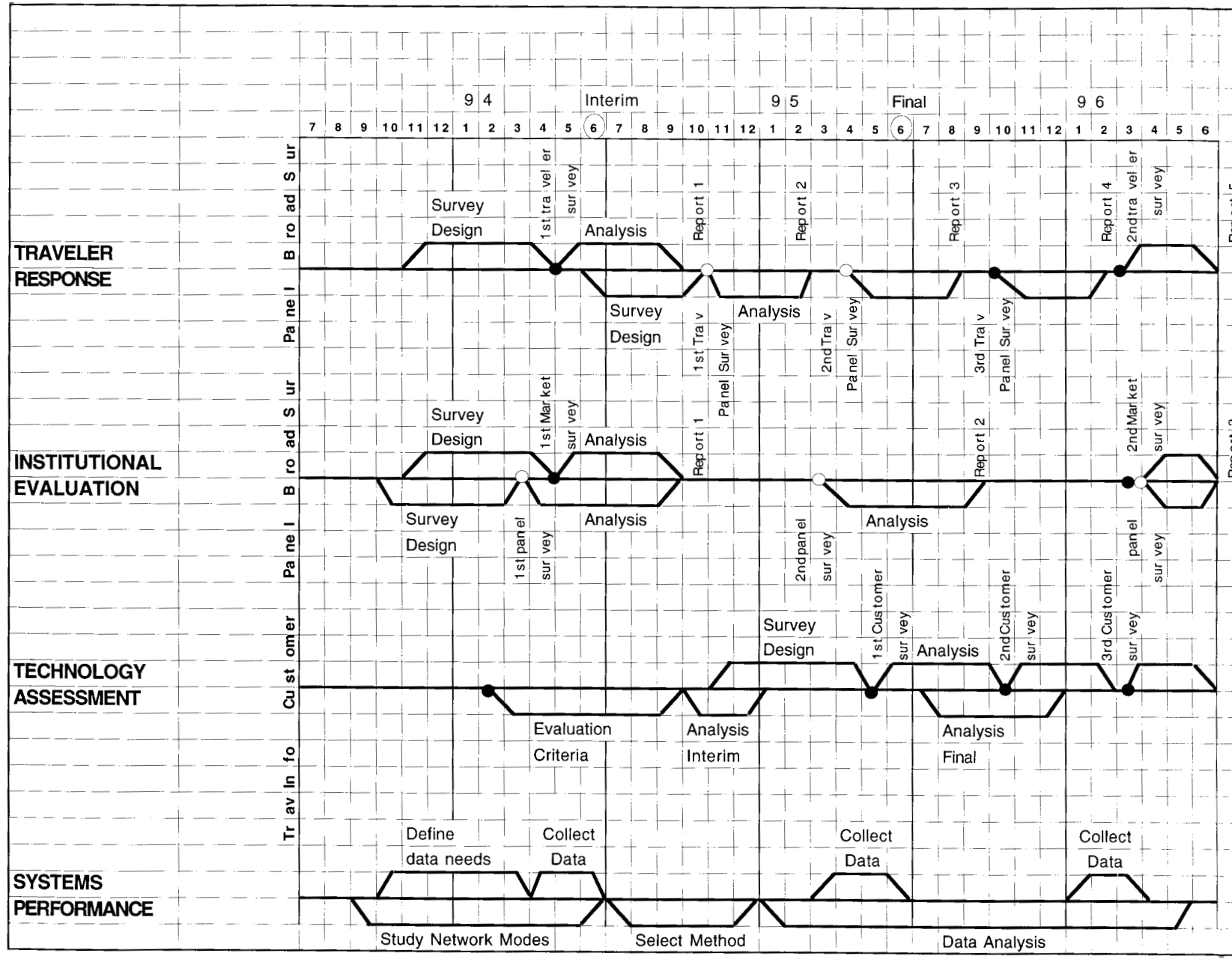



**Figure 1.3. Overall Evaluation Schedule – Critical Path Method.**

# 2. TRAVELER RESPONSE

## 2.1 Evaluation Goals and Objectives

The goal of the traveler response portion of the study is to develop and implement a plan for evaluating TravInfo impacts. To reduce recurring and non-recurring congestion, improve air quality, and reduce driver anxiety, the TravInfo demonstration project will deploy Advanced Traveler Information Systems (Markowitz and Sweeney, 1993; Khattak et **al.,** 1992). Specifically, real-time traffic information will be disseminated through an open architecture database accessible to private information vendors who can process and supplement it. This is likely to improve the quality of information available to the general public through radio traffic reports, Highway Advisory Radio (HAR), Changeable Message Signs (CMSs), public voice access, kiosks, as well as stimulate private ATIS developers, such as ETAK, to disseminate the information through personal ATIS devices, e.g., in-vehicle and pre-trip information systems and hand-held devices. The specific objectives of the traveler response study are to:

- Evaluate traveler behavior impacts of ATIS technology in terms of changes in travel choices; and based on behavioral surveys, assess the benefits of ATIS technologies.

- Determine the profile of individuals who access, acquire and use information available through TravInfo technologies.

## 2.2 Overall Test Responsibility

The PATH research team, led by Asad Khattak, will be responsible for evaluating the traveler response component of the study.

## 2.3 Overview of Evaluation

**A** synthesis of discussions with members of the TravInfo team and previous research on ATIS impacts (e.g., Ben-Akiva et al., 1991; Khattak, 1991; Al-Deek, 1991; de Palma and Lindsey, 1992) has provided the following insights and helped identify research issues:

- User benefits of ATIS technologies can be classified as tangible and intangible. The tangible benefits relevant to the TravInfo behavioral evaluation are travel time savings and delay reduction, increased vehicle occupancy, increased use of public transit, improved travel time reliability and reduced

possibility of getting lost. The intangible benefits are relatively harder to measure and include reduced anxiety and stress lower driver fatigue and increased awareness of travel options. The research issue is to capture the extent of these individual level benefits attributable to TravInfo and convert them to monetary terms.

- The level of benefits depends on travelers' willingness to access, acquire, process and use information. Therefore, a research issue is to explore the role of information and other factors in travelers' decision making process.

- The travel time benefits from changes in travel decisions seem significant in incident situations. Given the current state of information technologies (e.g., traffic reports received through radios and cellular telephones) and implementation of other measures meant to reduce travel and encourage transit use, a key research issue is whether there are significant additional benefits due to TravInfo.

TravInfo technologies are divided into publicly available systems and privately owned devices. The privately owned devices will require monetary and time investment on the part of the user. Therefore, accessing travel information through personal devices involves the extra step of purchasing the technology. Consequently the willingness to pay for personal ATIS devices is an important decision needing investigation. However, the core of the traveler behavior issues deals with how individuals use the acquired information to derive travel time and other benefits.

To assess behavioral changes due to TravInfo, several surveys will be conducted. At the beginning, a set of auto and transit user surveys focussing on a specific corridor will be implemented. Because TravInfo is a multimodal system, it is important to study mode choice changes. Such changes are more likely to occur in certain corridors, particularly the Bay Bridge corridor was selected because it offers (a) strong transit alternatives and importantly, BART is not be affected by traffic incidents. Note that Khattak and Le Colletter (1993) found that in the Golden Gate Bridge corridor most transit services were also affected by incidents, consequently limiting the potential for mode diversion, (b) data on network performance are available on the Bay Bridge, (c) there are some alternative routes in the corridor (albeit with limited capacity) which can serve as relievers in case of incidents (e.g., San Pablo road), (d) some tourist population can be captured. Another advantage is that we will be able to capture auto users (these are the people who may shift to transit with TravInfo technologies) as well as monitor changes in perceptions of transit users. Questionnaires will be distributed at the Bay Bridge by handing them out to

individuals as they stop to pay toll during the peak and off-peak. In addition, transit surveys will be distributed at BART stations.

## 2.4 Description of the Test

After a consumer acquires an ATIS device or decides to access an improved publicly available traveler information service, the next step is to understand how might he or she use the information. Given that travelers perform relatively complex tasks of making several pre-trip and en route decisions (including driving tasks such as avoiding collisions and maintaining speed), some amount of learning will be necessary before travelers can fully utilize the services offered by ATIS technologies (Schofer et al., 1993). Thus, there may be a learning curve which would differ across ATIS attributes and performance, transportation system characteristics, contextual factors (such as trip type) and individuals. The use of publicly available or privately owned TravInfo devices will also depend on learning from travel experience. For example, commuters may learn about new modes or routes suggested by ATIS. If the travel experience on the suggested new mode or route is positive (e.g., compliance with ATIS advice reduces travel time), then individuals will be more likely to rely on ATIS.

In the following sections we will discuss the role of information and a methodology for evaluating traveler behavior. We refine the behavioral hypotheses developed during earlier studies. (Ben-Akiva et al., 1991; Khattak, 1991; Khattak, Schofer and Koppelman, 1991; Khattak, Kanafani, and Le Colletter, 1993; Khattak and Le Colletter, 1993; Khattak, Al-Deek, and Thananjeyan, 1993)

To evaluate the effectiveness of ATIS technologies, we need to understand the factors which influence traveler behavior — particularly, the effect of information on behavior (Figure 2.1). Individuals' choices are influenced by attributes of the alternatives and their own characteristics (socioeconomic and personality) as well as by the information acquired through direct and indirect contact with the environment. Individuals' perceptions regarding system characteristics, their preferences among alternatives and situational factors such as work related constraints determine observable choices.

The ATIS technologies tested in TravInfo will influence en route decisions which include destination choice, route diversion and return choice, trip chaining and rescheduling of activities as well as pre-trip decisions which include mode, destination, departure time, route, trip chaining decisions and rescheduling of activities.

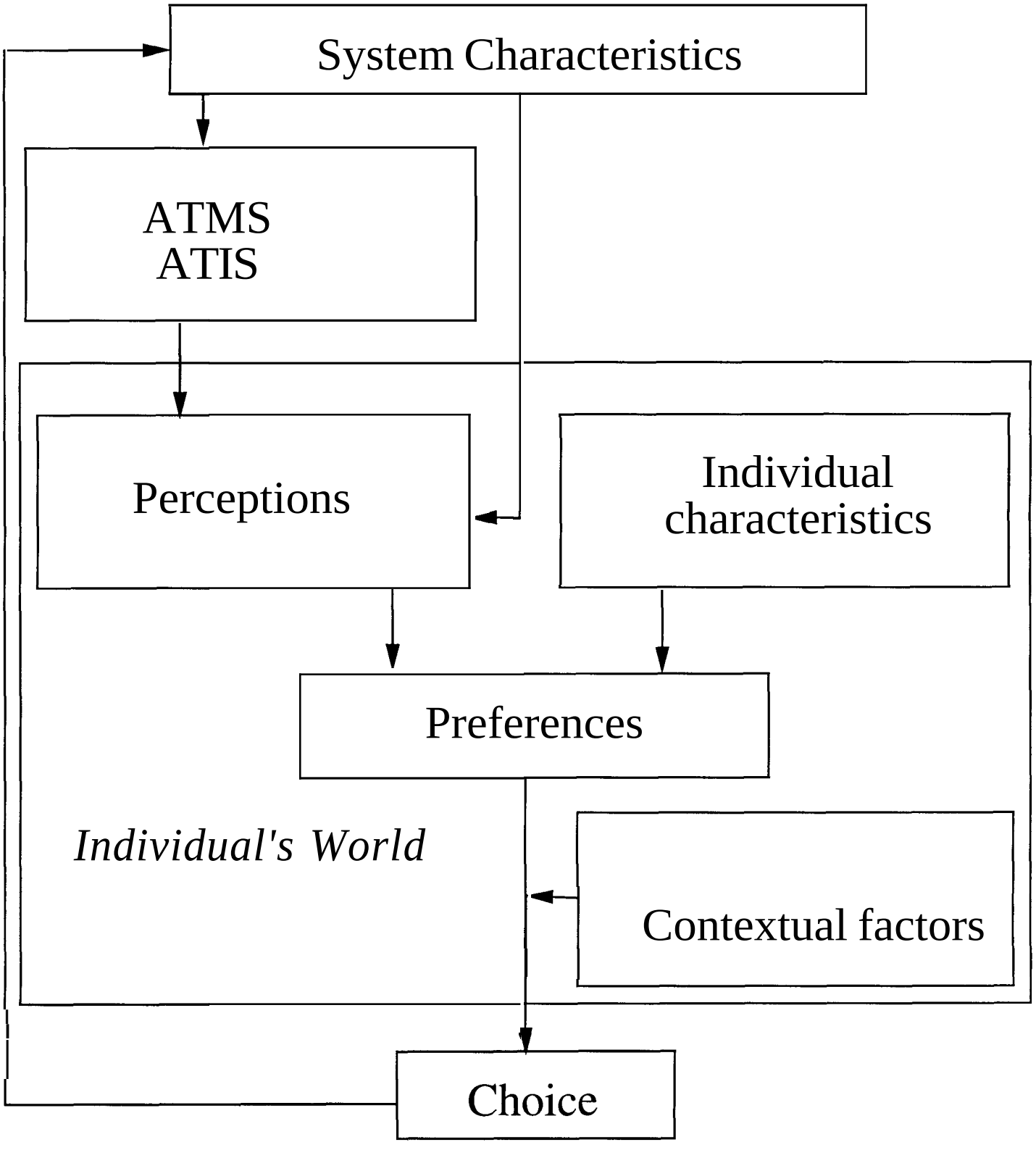



**Figure 2.1. Traveler Decision Making Process.**

Information is a critically important aspect of decision making. Information processing theories state that, to achieve certain objectives a person may acquire information (either actively or passively) from various sources, such as electronic media and newspapers, and use stored knowledge in the memory (experience) to evaluate alternatives. To simplify decision making, individuals use heuristics (simple decision rules such as choose the minimum distance route). The consequences of a person's choice, after it is made, then provides a feedback (learning) and may influence similar decisions in the future.

Individuals receive and process useful information from the environment and disregard irrelevant information. The processing and use of information depends on the following aspects of information:

- **Content or meaning of information.** The content of information is critically important for supporting travel decisions. For example, information about a freeway incident may support en route diversion and travel time information about alternate (arterial) routes may support return (to the freeway) decisions.

- **Format or presentation style of information.** Some presentation styles may be more effective than others. For example, terse messages may be preferred compared with conversational style. Further, some people may find map-based information more useful than others.

- **Nature of information.** Whether the information is static or dynamic may have a significant influence on decisions. For example, static information about long-term road maintenance operations may induce fewer behavioral changes compared with real-time information about unexpected events.

- **Type of information.** The effect of qualitative information (non-numerical) and quantitative (numerical) information may differ: qualitative descriptions of congestion such as "jammed"and "operation at posted speed limits," may have less influence on route choice than quantitative estimates of travel times in minutes.

- **Prescriptive information.** The information system may provide prescriptive information (e.g., advice on best mode) in addition to descriptive information. Behavioral responses to prescriptive and descriptive information may vary. For example, in incident conditions, a traveler's probability of taking an alternate mode may increase when told to divert compared with when he or she is given incident information only.

In addition, travelers are more likely to rely on (and desire) relevant, accurate, timely, credible and reliable information. These and related aspects of information are:

- **Accuracy or precision of information.** Accuracy refers to whether a phenomenon is true or false. A statements such as "there is congestion ahead" disseminated through ATIS is accurate if the users can verify it (e.g., by visual observation). However, verification of such statements is often complicated because of time and space constraints imposed on the individuals. For example, a traveler may be unable to verify the length of expected delay by observing congestion because he or she is unable to see the beginning of the queue.

- **Future validity of information.** Real-time information becomes old with time; however, in many instances it may be as much as 15 minutes old by the time it is disseminated. Reduction in data processing time and short-term prediction of recurring and incident congestion (if done properly) may improve future validity.

- **Relevance of information to decisions (completeness).** Ideally, information presented to individuals should support their travel and activity decisions. Providing information about travel conditions on options that are infeasible for a particular traveler is undesirable.

- **Specificity of information.** Information may be spatially or temporally specific. Information such as "accident at ___ exit ramp" is more spatially specific compared with "accident ahead" or "accident on ____ freeway." Similarly, information such as "incident will clear in X minutes" is more temporally specific compared with "incident will clear soon." It is expected that individuals prefer more specific information.

- **Level of information detail.** In certain contexts higher levels of information detail can support decision making. For example, when an incident occurs, individuals may require not only travel time and delay information, but also information on the nature of the incident (number of vehicles involved, injuries), exact location of the incident and actions taken to clear it (e.g., responses by patrol vehicles, emergency medical services and the fire department).

- **Consistency with which information is disseminated.** Individuals may not respond to information which varies significantly across similar events or

conditions. For example, when describing two similar incidents, highly detailed information may be provided in one case and not in the other. Travelers are likely to prefer consistent information.

- **Timeliness of information.** Information should be made available whenever it is needed by the traveler, i.e., by updating real-time information frequently.

The reliability of ATIS **is** a critical factor which will determine whether users will rely on it. A simplified ATIS consists of data collection, data processing and information dissemination components. Reliability of the system is defined **as** the probability that the device performs adequately over a time interval. The objectively measured reliability of ATIS is given by **a** structure function f which is a function of n-component random variables ($X_i$). For example,

$X_1$ = 1, if the data collection system performs adequately during (0,t); 0 if not.
$X_2$ = 1, if the data processing system performs adequately during (0,t); 0 if not.
$X_3$ = 1, if the information dissemination system performs adequately during (0,t); 0 if not.

The structure function is $f(X_1, X_2, \ldots X_n) = X_1X_2 \ldots X_n = \min \{X_1, X_2, \ldots X_n\}$
If all ATIS components perform adequately, then $f(X_1, X_2, \ldots X_n) = X_1X_2 X_3$
$f(1,1,1) = 1$; for all other combinations = 0
For **a** series structure (assuming independence), reliability is $R(p_1, p_2, p_3) = p_1 p_2 p_3$
For example, if $p_1 = 0.99, p_2 = 0.98, p_3 = 0.95$, then R = 0.99 x 0.98 x 0.95 = 0.92

This would give an objective measure of reliability. The perceptions of system reliability will influence decision making; for example, high objective reliability may result in greater dependence on ATIS.

There is a need to understand the dynamics of travelers' response to new transportation technologies in a real-life context. TravInfo provides an opportunity to investigate behavioral changes such as mode diversion and departure time change in the field. The unique feature of the TravInfo ATIS technologies is the availability of information to the general public as well as a select group of individuals. In this regard it is important to understand how various factors impact traveler behavior over time: ultimately changes in behavior will influence the success or failure of new transportation technologies.

Generally, travel decisions are not made autonomously but in a certain context. There are interdependencies among decisions of various household members. Further, there are interdependencies among various decisions of the same person. For example, mode choice decisions are made conditional on destination decisions, Travel and activity and patterns and the factors which influence them may change over time, however, not enough research has been conducted to understand the dynamics of behavior. There is day-to-day variability in travel patterns and of course behavior may change significantly over longer time periods. Further, the effect of TravInfo ATIS technologies may not be instantaneous. That is, the true nature of the effect of TravInfo technologies may become more visible after some time. Alternatively, the effect of the technologies may diminish over time because the novelty effect may wear off over time. We hope to understand these dynamics and changes in travel patterns through panel surveys.

### 2.4.1 Key Assumptions

Survey research has certain limitations that need to be recognized. Firstly, it is not an exact science and the results depend to a large extent on the judgement of the researcher. We will follow the principles of good survey design; however, the principles are often rules of thumb and do not guarantee complete validity. There are biases that are inherent in surveys of this type. For example, self selection bias is a major problem. It can be addressed, to some extent, by including certain type of questions. If we suspect that people with little or no interest in transportation issues are less likely to respond to our survey, then we can include questions asking about the level of interest in transportation. The responses can then be weighted in favor of people who show less interest (since they are under represented in the sample).

### 2.4.2 Confidentiality and Other Incentives

The surveys will maintain complete confidentiality of the responses. It is felt that without providing confidentiality a high response rate is difficult to obtain. To increase the response rate, modest monetary incentives will be offered. BART passes, and Bay Bridge toll ticket books are examples of incentives that are under consideration.

## 2.5 Experimental Design

A "before and after" panel study design will be used to understand traveler response. The large surveys will be conducted before and after the TravInfo ATIS implementation (Figure 2.2). The before study will establish "base" travel conditions and recruit people for a panel, which is a set of individuals who will be recruited for repeated questioning. The panel surveys will be conducted to study in-depth the changes in behavior over time.

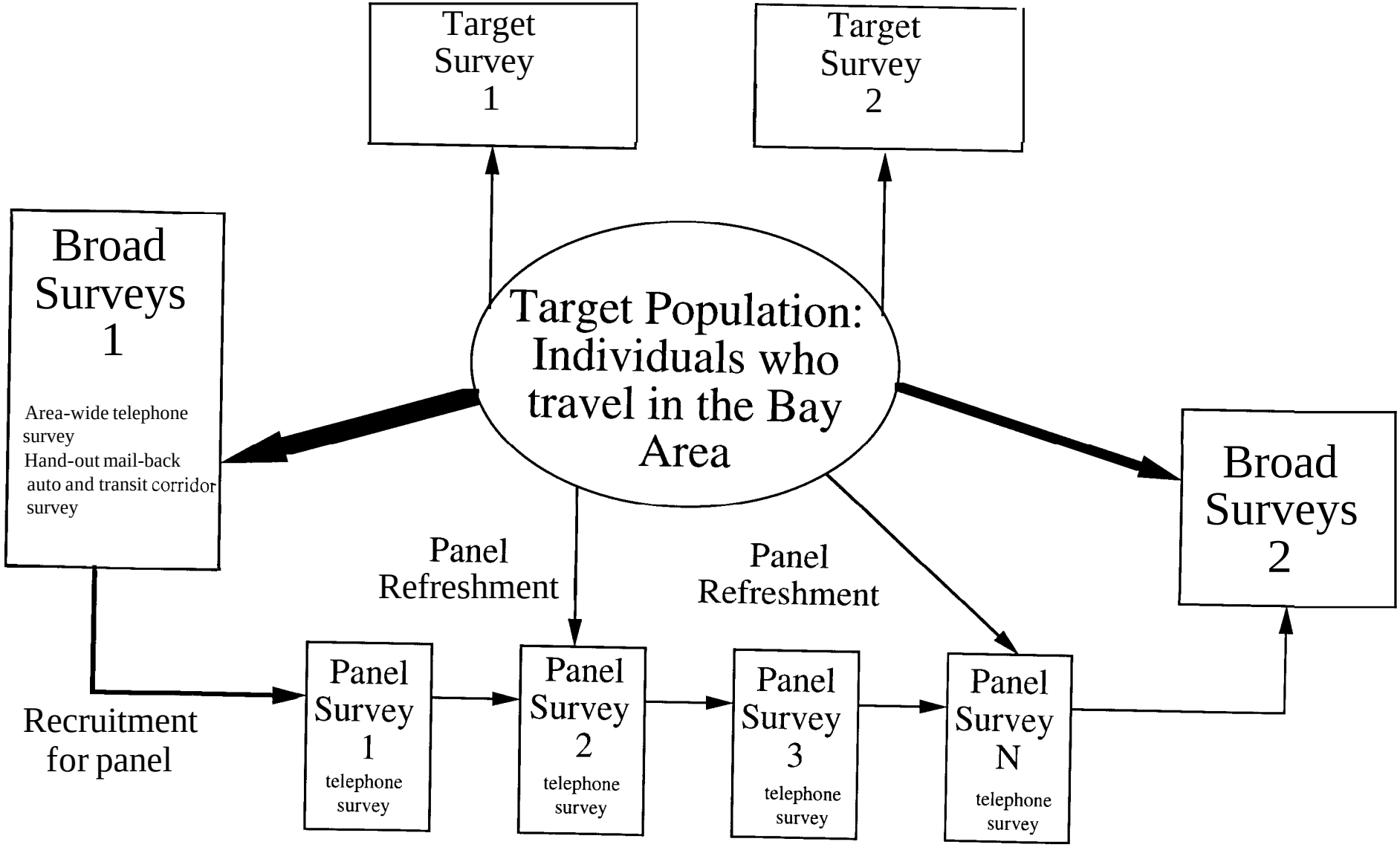



**Figure 2.2. Conceptual Design of Traveler Behavior Surveys.**

Only by following individuals?behavior over time and consequent benefits can the impact of information technologies on travel decisions be understood at a deeper level. Other advantages of a panel are greater accuracy compared with cross sectional studies and analytical sophistication in analyzing data.

The Bay Area population surveys for market assessment are discussed in Section **3** and the customer surveys through vendors are discussed in more detail in Section **4.**

A combination of "true panel" (where participants are asked the same questions repeatedly) and "omnibus panel" (where participants are asked different questions in successive waves) will be used. The questions about trip patterns and socioeconomic characteristics will be repeated, whereas questions about impacts of various technologies will vary.

### 2.6 Data Collection

To analyze traveler response? the required data consists of traveler behavior (choices such as destination? route diversion/return, and rescheduling)? transportation system performance (aggregate measures of delays and travel times) and information system performance (information content, format, validity and consistency, etc., disseminated through personal ATIS devices and publicly available systems such as CMSs and **kiosks).** These data will be processed to evaluate behavioral changes due to the information system. The analysis will allow the evaluation of ATIS impacts on travel decisions, providing an assessment of the benefits and insights into ATIS design and implementation.

#### 2.6.1 Sampling Method

Sampling can be subdivided into the following, not necessarily mutually exclusive? steps:

- Definition of the population
- Selection of a sampling procedure
- Determination of the sample size
- Collection of data from the designated individuals

The target population for the corridor behavioral surveys consists of travelers who will use the TravInfo technologies and services during peak and off-peak. Commuters and non-commuters are included in the sampling population. The non commuters include shoppers? people running errands (e.g., doctor visit) and recreational travelers.

The criteria used for evaluating sampling options are:

- Satisfaction of target population conditions
- Representativeness of the sample
- Response rate expectations
- Time required for surveying
- Cost of surveying

**Hand-out mail-back surveys.** While handing out questionnaires at the Bay Bridge and BART stations satisfies most of the aforementioned criteria, one source of potential bias is that ridesharers will not be captured. This may be acceptable because they are already using "transit." The cost for conducting the survey is low (judging from the response to the Golden Gate Bridge survey (35%) we could distribute about 5000 questionnaires); however, considerable time is needed for survey implementation (moreover, Caltrans response to distribution of the questionnaires at the Bay Bridge is "lukewarm" due to the extra congestion caused by survey distribution). Further, the sample may not be representative of the whole region. There is a tradeoff between sample representativeness and the ability to demonstrate benefits in a multimodal system (some corridors in the region do not offer a high level of transit service). However, to determine the generalizability, we will compare the responses with the area-wide survey. (An alternative approach is to conduct a telephone survey of the East Bay counties combining the transit and Bay Bridge surveys. Counties that generate more trips across the Bay Bridge will be targeted; the advantages are a more representative sample, ability to capture ridesharers, and shorter time in survey implementation.)

**Telephone panel surveys.** Telephone interviews will be used for the panels. The main advantage of using a telephone survey is that it facilitates the implementation of a complex questionnaire design by allowing easy skips. An information diary will be included. The main advantage of a telephone interview is that there will be no restrictions on the length of a page (and the amount of questions that can be asked on one line--a restriction imposed in conventional paper questionnaires). The questions regarding the effect of various information attributes on specific trips clearly exceed the page limit. This advantage outweighs the high cost of telephone interviews.

The sample size issue is complex because if the population variance is not known, then the researcher must estimate it. Given that we do not have a good sense of the population variance on important variables, we cannot apply the equation for sample size because it has two unknowns (the sample size and the variance; the equation for sample size is $n=(z^2/H^{2)}\,s^2$, where z is the degree of confidence desired in the result [Type I error] and H is the degree of confidence that the estimate is within x% of the true population value

and $s^2$ is the population variance). Often, the sample size is decided based on other consideration such as budget constraints and historical evidence (what other researchers have done). Based on the budgetary constraints, our judgement and rules of thumb (at least 30 observations for each parameter estimated in behavioral models), it is expected that the two main surveys will have sample sizes of at least 1000 (note that the before survey will have two components, the Bay Bridge and the transit survey, The intermediate panel surveys and target surveys will have a sample size of at least 500 (formal calculation of sample size will be reported in a separate document).

### 2.6.2 Design and Structure of Surveys

In the context of the survey, an information diary focussing on what information is received from various sources and its effect will be included. Specifically, we will enquire about the content of information, format, nature, type, specificity, level of detail, future validity, timeliness, and relevance of information, and whether it had advice on the best course of action.

Further, questions about mode, route, departure and arrival times, trip purpose at destination and location where trip started (e.g., home or office) and where the trip ended will be asked in the diary (Figures 2.3 and 2.4). Then stated preference questions related to ATIS (included in the "before" traveler behavior surveys) will be intertwined with reported preferences. The information aspects (content, format, nature, and type) will be varied systematically. These questions will allow us to assess the reported impact of information received before and during the trips and the anticipated response to ATIS. Importantly, it will help explore day-to-day variability in travel behavior and help evaluate benefits.

The general structure for the survey will be as follows:

- Normal travel patterns;
- Perceptions of usual and alternate mode and route attributes such as travel times and reliability;
- An information diary;
- Stated preference questions regarding willingness-to-pay for ATIS attributes and performance characteristics and anticipated changes in behavior;
- Changes in travel patterns (e.g., mode diversion, departure time diversion and destination change) due to information about recurring and incident delays;
- Attitude toward information acquisition and use;
- Socioeconomic attributes and personality.

Day of the week_____

| Trip No. | Trip Location | | Purpose at Destination | | | Mode Used | | | Departure Time | Arrival Time | Route(s) Used | Before starting trip | | | | | | During trip | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | Travel info received from: | | | Effect of information on trip | | | Travel info received from: | | | |
| | Location trip started | Location trip ended | To work or home | Shopping/errands | Other (*specify*) | Car/van | Bus/rail | Other (*specify*) | | | Name(s)/numbers of main roadways | Observation | Highway Radio | Other | No effect | Some effect | Major effect | Observation | Highway Radio | Telephone | Message sign |
| 1 | home | | | | | | | | AM PM | AM PM | | | | | | | | | | | |
| 2 | | | | | | | | | AM PM | AM PM | | | | | | | | | | | |
| 3 | | | | | | | | | AM PM | AM PM | | | | | | | | | | | |
| 4 | | | | | | | | | AM PM | AM PM | | | | | | | | | | | |
| 5 | | | | | | | | | AM PM | AM PM | | | | | | | | | | | |
| 6 | | | | | | | | | AM PM | AM PM | | | | | | | | | | | |
| | | | | | | | | | AM PM | AM PM | | | | | | | | | | | |
| | | | | | | | | | AM PM | AM PM | | | | | | | | | | | |
| | | | | | | | | | AM PM | AM PM | | | | | | | | | | | |
| | | | | | | | | | AM PM | AM PM | | | | | | | | | | | |

**Figure 2.3. Sample Information Diary for Panel Survey.**

## Travel Diary

*Please tell us about your travel activities. The first trip on each day should be your trip from home and the last trip should be your return trip home. We are interested in not only the final destination of trips but also in the intermediate stops.*

**Example: Ms. Joan's Travel Diary**
Ms. Joan leaves home at 8:00 AM in the morning and reaches work at 8:20. She then goes for shopping at 1:00 PM and returns to work afterwards. After work, she goes for exercise to a gymnasium and finally goes home at 6:10 PM. Before and during her trips she receives travel information from various sources. Ms. Joan will fill out the travel diary shown below.

Day of the week Wednesdav

| Trip No. | Trip Location | | Purpose at Destination | | | Mode Used | | | Departure Time | Arrival Time | Route(s) Used | Before starting trip | | | During trip | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Location trip started | Location trip ended | To work or home | Shopping/errands | Other (*specify*) | Car/van | Bus/rail | Other (*specify*) | | | Name(s)/numbers of main roadways | Travel info received from: Observation | Radio/TV | Other | Travel info received from: Radio | Car phone | Other |
| 1 | ıome | work | ✓ | | | | ✓ | | 8:00 (AM) PM | 8:20 (AM) PM | I-580 and I-80 | | ✓ | | | ✓ | |
| 2 | work | shpng. mall | | ✓ | | | | ✓ | 1:00 AM (PM) | 1:10 AM (PM) | University Ave. | ✓ | | | | | |
| 3 | hpng. ıall | work | ✓ | | | | | ✓ | 1:30 AM (PM) | 1:40 AM (PM) | University Ave. | | | | | | |
| 4 | ıork | gym. | | | ✓ | | ✓ | | 5:00 AM (PM) | 5:15 AM (PM) | I-80 | | | | ✓ | | |
| 5 | ıym. | home | ✓ | | | | ✓ | | 6:00 AM (PM) | 6:10 AM (PM) | I-580 | | | | | | |

**Figure 2.4. Example of Travel Diary.**

## 2.7 Data Reduction and Analysis

The survey data will be analyzed in a SPSSPC environment. SPSSPC is a software which can be applied to various statistical analyses of survey data.

### 2.7.1 Statistical Methods for Analysis

The data from surveys will be used to relate behavior to attributes of alternatives, individuals and information. Initially, simple statistical techniques such as frequency analysis and cross tabulations will be used to analyze the data by testing traveler behavioral hypotheses and studying differences between revealed and stated preferences. For example, in the case of response to an incident on a commuter's usual route, the travel time benefits from route diversion can be explored simply by looking at normal travel time and additional delays on both the usual and alternate route. Multivariate models of behavior (e.g., mode, route and time diversion propensity) will be estimated to explore the effects of several variables simultaneously. The multivariate approach compensates for inter-dependencies among explanatory variables and allows exploration of interaction effects. Two such methods are discussed below.

Discrete choice analysis will be used to quantify the effect of information and other factors on behavior. For example, the effect of several variables on the diversion decisions will be examined by estimating diversion choice models based on respondents' reported experience of a recent delay.

To analyze information diary data, structural equations will be used. They can link more than one dependent variable (e.g., diversion from the usual route and return to the original route). Further, they allow linking of variables at two or more distinct points in time. Therefore, contemporaneous effects of information (observable immediately after ATIS implementation) and lagged effects (observable after a relatively long time period such as the next day) can be explored.

The following models will be specified. If there are p dependent variables, then the equation system can be represented as follows:

$$y^* = By^* + Gx + z$$

where $y^*$ is a (p x 1) vector of dependent variables, B is a (p x p) matrix of causal effects among the $y^*$ variables (the diagonal is zero because a variable cannot be causal to itself), G is a (p x m) matrix of regression effects of the (m x 1) x independent variables, and z is a (p x 1) vector of disturbance terms.

The final product will be models of traveler behavior. They will indicate the preferences of travelers regarding changes in travel patterns due to ATIS and other factors. The models will allow us to understand and predict behavior in the presence of ATIS. Importantly, they will also help us evaluate tangible and intangible ATIS benefits. Suppose that we are evaluating the benefits of mode diversion in incident conditions. The most tangible user benefits of a switch to public transportation is a reduction in travel time. The savings are simply the travel time on the usual route to or from work, plus the actual length of delay, minus the travel time when using public transportation. In case of BART the transit travel times will be unaffected by the unexpected congestion. We would compare the how many people switched to public transit and their time savings before the implementation of TravInfo and after its implementation. Any increase in the number of people switching to transit or travel time savings can then be attributed to TravInfo. Furthermore, the time savings for each switcher will be extracted from the survey and converted into monetary value. The money value of time would be based on the personal income of each respondent and on the magnitude of the savings achieved. Annual benefits can also be estimated from the survey data. (Khattak and Le Colletter, 1994)

### 2.8 Evaluation Tasks and Test Schedule

The "before" surveys will be pretested in April 1994. After finalizing, they will be distributed in May (before the summer). The execution will be completed by June 1994. The surveys will be coded and error checked and the initial analysis will become available in September 1994. The panel surveys will start by the end of the year and continue periodically. The results will be analyzed soon after each panel survey is conducted (within three months). The panel surveys will continue until 1996. That is also when the broad "after" surveys will be conducted. All results will become available by the end of 1996 (Figure 2.5).

The survey instruments will be submitted for review by FHWA. The findings will be made available in the form of PATH working papers and final reports. The papers will also be submitted to conferences and refereed journals for peer review. This is expected to result in refinement and enhancement of the study.

#### 2.8.1 Pre-Test Activities

Develop a test evaluation plan and detailed survey plan including a specific list of questions and target population (June 1993—February 1994).

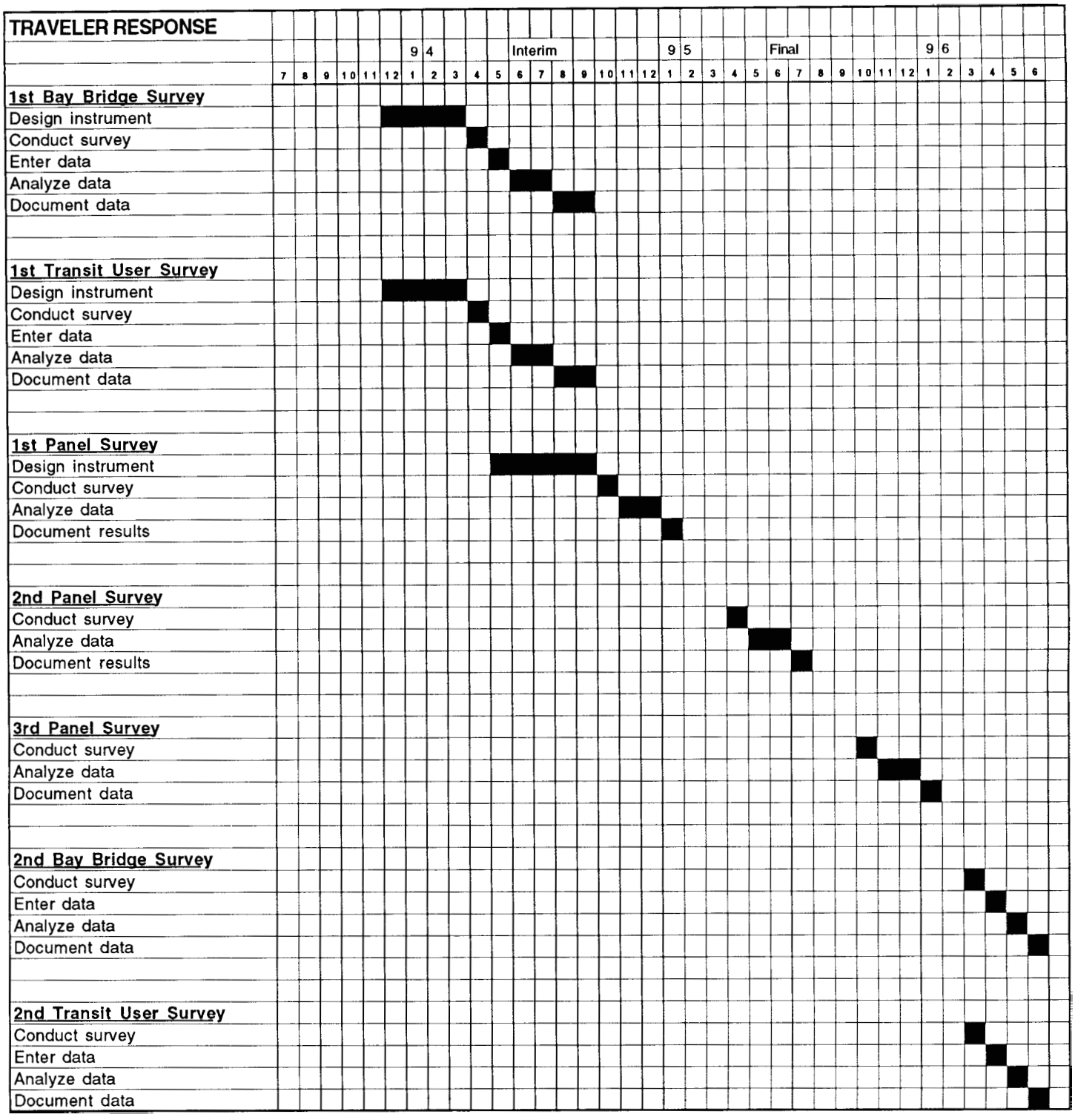



**Figure 2.5. Traveler Response Evaluation Schedule.**

### 2.8.2 Evaluation Test Activities

a) Pretest surveys (March 1994)
b) Execute three initial large-sample surveys:
   1) Bay Area population telephone survey by random digit dialing,
   2) mail-back survey of Bay Bridge motorists, and
   **3)** mail-back survey of transit users (April—May 1994);
c) Analyze initial survey results and document in working paper (September 1994);
d) Execute three panel surveys (October 1994, October 1995, April 1996);
e) Analyze panel survey results (ongoing, November 1994—May 1996).
f) Execute three second large surveys (March 1996)
g) Compare results to initial large sample survey (April—May 1996)

### 2.8.3 Post-Test Activities

Document the traveler response component of the study (January—May 1996).

The previous sections have developed a conceptual and methodological framework for evaluation of behavioral impacts of the TravInfo project. The framework allows a detailed evaluation of the TravInfo technologies. The major contribution of the study will be in evaluating the benefits of new technologies in the short-term and the long-term. For example, we will be able to evaluate the benefits from mode (auto to transit) and route diversion (to relatively uncongested alternatives). We will be able to explore whether the effect of new technologies wears-off with time or it increases (possibly depending upon the performance of the ATIS, among other factors). Further, the behavioral models will give a clearer understanding of what information is needed to best support traveler decisions. The models developed in this study can be used to evaluate the potential for planning technology applications in other California locations.

## 2.9 Deliverables

The preliminary results of the traveler behavioral surveys will be delivered first. These will be summaries of each survey and will present simple relationships explored through bivariate statistical analysis such as cross tabulations. The findings will be regarding the evolution of behavioral responses (e.g., changes in travel patterns due to TravInfo technologies over time).
Then, a more detailed final report covering the impacts of TravInfo on travelers will be prepared (this will be part of a broader final report covering the entire evaluation). It will present the benefit assessment as well as discrete choice models and the structural

equations analysis. The models will relate behavior to attributes of information received from ATIS technologies, attributes of alternatives and characteristics of the individuals.

## 2.10 References


1. Al-Deek H. (1991). "The Role of Advanced Traveler Information Systems in Incident Management," Ph.D. Dissertation, UCB-ITS-DS-91-5, Department of Civil Engineering, Institute of Transportation Studies, University of California, Berkeley, CA.

2. Ben-Akiva, M., A. dePalma, and I. Kaysi (1991). "Dynamic Network Models and Driver Information Systems," Transportation Research A, Vol. 25A, No. 5, pp. 251-266.

3. Churchill, G. (1987). Marketing Research Methodological Foundations, Fourth Edition, The Dryden Press, Chicago, Illinois.

4. dePalma, A., and R. Lindsey (1992). "The Potential Benefits of a Combined Route Guidance and Road Pricing System: An Economic Analysis," Paper presented at 71st Annual Meeting of Transportation Research Board (revised May 1992), Washington, D.C.

5. Khattak A. (1991). "Driver Response to Unexpected Travel Conditions: Effect of Traffic information and Other Factors," Ph.D. Dissertation, Civil Engineering Department, Northwestern University, Evanston, Illinois.

6. Khattak A., J. Schofer, and F. Koppelman (1991). "Factors Influencing Commuters' Enroute Decision Behavior in Response to Delay," Transportation Research Record, 1318, 125-136.

7. Khattak, A., H. Al-Deek, Y. Yim, R.W. Hall (1992). "Bay Area ATIS Testbed Plan," PATH Research Report UCB-ITS-PRR-90-01, Institute of Transportation Studies, University of California, Berkeley.

8. Khattak A., A. Kanafani, and E. Le Colletter (1994). "Stated and Reported Route Diversion Behavior: Implications on the Benefits of ATIS," Presented at the 73rd Annual Meeting of the Transportation Research Board, Preprint No. 940394, Washington, D.C. (to be published, Transportation Research Record).

9. Khattak, A., H. Al-Deek, and P. Thananjeyan (1994). "A Combined Traveler Behavior and Transportation System Performance Model with ATIS," PATH Research Report, Institute of Transportation Studies, University of California, Berkeley.

10. Khattak A., and E. Le Colletter (1994). "Stated and Reported Diversion to Public Transportation Under Incident Conditions: Implications on User Benefits of ATIS," PATH Research Report, Institute of Transportation Studies, University of California, Berkeley. (Accepted for presentation at the 4th Annual Meeting of IVHS America, Atlanta, Georgia; submitted to Transportation Research for review).

11. Markowitz, J. and L. Sweeney (1993). "TravInfo: Bay Area Intermodal Traveler Information System," presented at the Third Annual Meeting of IVHS America, Washington, D.C.

12. Schofer J., **A.** Khattak, and F. Koppelman (1993). "Behavioral Issues in the Design and Evaluation of Advanced Traveler Information Systems," Transportation Research, Vol 1C, No. 2.

# 3. INSTITUTIONAL EVALUATION

## 3.1 Evaluation Goals and Objectives

The goal of the institutional study is to evaluate the effect of institutional, legal, and market issues on the operational testing and deployment of TravInfo.
The evaluation objectives are:

1) To measure the effectiveness of the TravInfo institutional arrangement and management approach in meeting their goals from the organizational, jurisdictional, and behavioral perspectives;

2) To assess the economic impact of the TravInfo project regarding stimulating market demand of ATIS products and services, providing a stable regulatory environment for the initial TravInfo customer base, attracting private-sector investment capital into the TravInfo project, and maintaining a healthy competitive environment.

3) To assess public acceptance of and preference for TravInfo technologies through public opinion polls and market research.

## 3.2 Overall Test Responsibility

The PATH research team, Y.B. Yim and Randolph Hall, will be responsible for evaluating the institutional arrangement of the TravInfo project.

## 3.3 Overview

The TravInfo field operations test is directed by the Management Board (MB) composed of the Metropolitan Transportation Commission, Caltrans District 4 and the California Highway Patrol. Caltrans Headquarters New Technology Division, Federal Highway Administration, Federal Transit Administration, PATH, and the Chair of the Steering Committee will serve as ex-officio members of the Management Board. The Management Board has created a TravInfo Advisory Committee with membership open to any firm or agency that wishes to participate. Within the Advisory Committee, the Steering Committee was formed with 15 individuals nominated by the Advisory Committee and selected by the Management Board. The members of the Steering Committee are composed of roughly one half from the private sector and the other half from the public sector. Within the Steering Committee, four Working Groups were created; 1) Interim

Capability, 2) Technology, **3)** User/Market and Outreach, and **4)** Legal and Institutional Issues. The group leaders are from the Steering Committee but anyone can join the Working Group (Figure **3.1).**

Management approach: The Management Board is the policy setting body for all TravInfo test activities, responsible for reviewing and approving procedures for the conduct of tests, and setting access restrictions to databases. The Management Board has the ultimate authority for approval of TravInfo expenditures and consultants' work. The Advisory and Steering Committees have no direct authority for setting policies or procedures for the field operational test but do advise the Management Board on all issues. The full-time project manager retained by the Management Board is responsible for the day-to-day activities of the project including supervision of consultants, liaison to the Advisory Committee and progress reports to the Management Board.

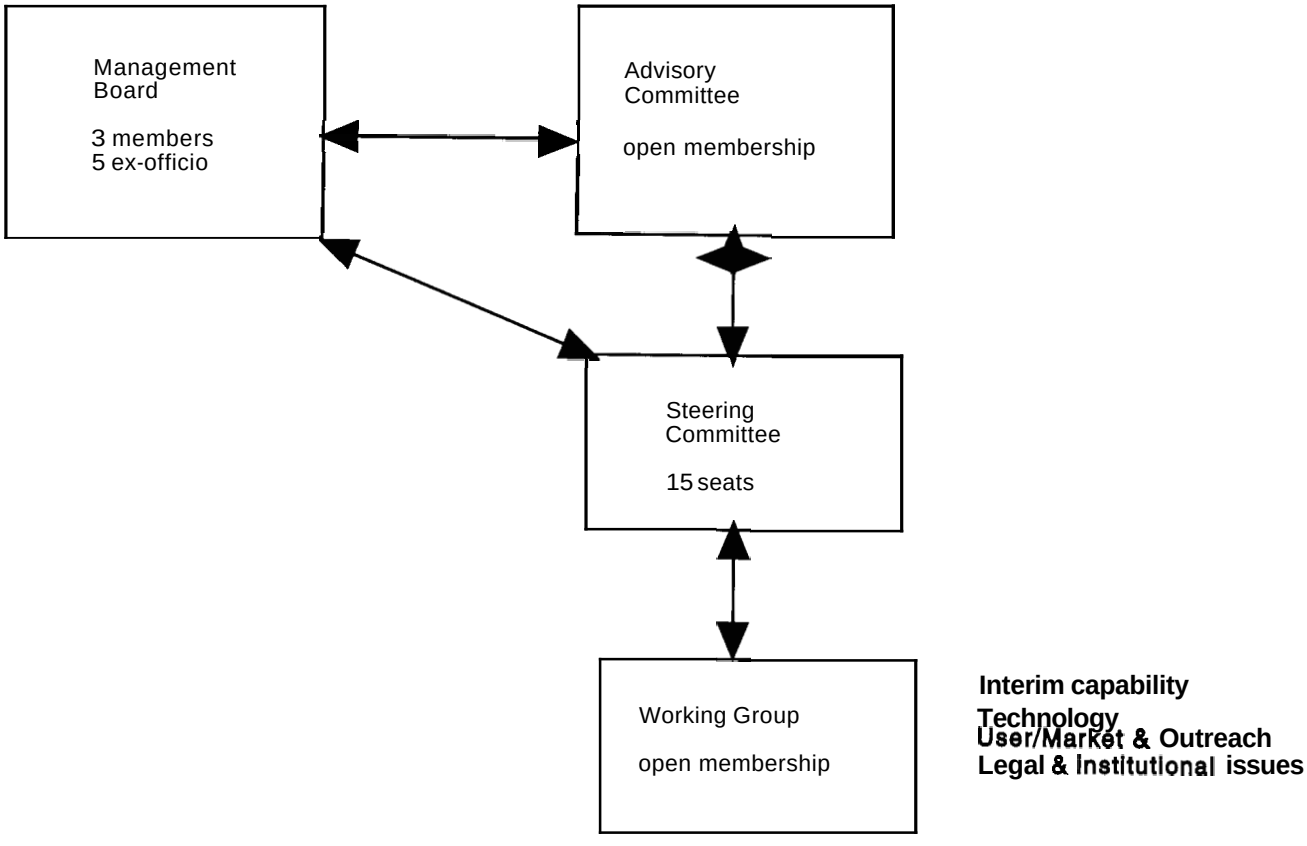



**Figure 3.1. TravInfo Organizational Structure.**

Institutional concept: The TravInfo Field Operational Test will be implemented through a public/private partnership based on a flexible institutional arrangement. The TravInfo institutional system is based on the premise that the success of the TravInfo project depends on the active participation of public, private, and academic partners. Unlike other IVHS public/private partnerships, the TravInfo Advisory Committee will have open membership and will promote an open access architecture to encourage all ATIS vendors to compete in the Bay Area market.

The purpose **of** the Advisory Committee is to capture a wide range of knowledge from the broader ATIS community, thus enabling more effective deployment of ATIS technology. The TravInfo management plan is intended to exploit the unique experience and to share knowledge of both the private and public sectors, while giving primary managerial responsibility to the public sector. The experience gained from the new institutional approach with a field operational test of a regionwide, multimodal ATIS project is expected to be invaluable to the communities in other parts of the country as they deal with the need to form partnerships with a broad array of government agencies to provide funding for IVHS deployment. (Bay Area Ad Hoc IVHS Committee, 1992)

Public sector role: The public sector role is to develop a multi-modal Transportation Information Center (TIC) that will integrate and disseminate real-time and accurate transportation information to users. Users include general public, public agencies, and commercial vendors. To allow for expansion capability of the system and to facilitate technology transfer to other regions in the country, TravInfo will utilize an open access architecture for all aspects of the information systems as well as any specific collection or dissemination systems that are developed and owned by the public sector. Functionality and interface requirements of the open access system will be specified ***so*** that users of TravInfo can easily interface their system with TravInfo database. The public sector will gather and disseminate detailed, up-to-date information on all transportation modes and facilities. Access to the data will be as open and easy as possible without violating the privacy that individuals expect regarding their individual travel decisions.

Private sector role: The private sector role is to advise the TravInfo system architecture team and the Management Board on providing input into the design and implementation of TravInfo. The private sector is expected to respond to the assurance of easy access to quality travel data by developing and deploying a variety of new ATIS products and services. The Management Board will work with private firms to assure open access to the TIC's data through a variety of media such as cellular digital packet data (CDPD), FM subcarrier, TV SAP channel broadcast, and a paging system. It is expected to open the market to a wide variety of ATIS devices. TravInfo will also encourage development and deployment of ATIS products and services ranging from inexpensive hand-held and in-

vehicle devices to sophisticated computer-based devices that provide dynamic route guidance linked to business listings similar to the Yellow Pages.

### 3.4 Description of the Test

The evaluation **tasks** for the institutional element of the study will be carried out in three parts: 1) the organizational structure of the project, 2) economic impact assessment of TravInfo, and **3)** market response to TravInfo products and services.

#### 3.4.1 Organizational Structure

The effectiveness of the institutional arrangements and the management approach will be evaluated in terms of the success of TravInfo in meeting its goals. Evaluators will act as observers at meetings of the Management Board and Advisory Committee to examine group dynamics and institutional effectiveness. TravInfo project participants from the public and private sectors will be individually interviewed to elicit their perceptions regarding the institutional effectiveness of TravInfo, identifying both the strengths and the weaknesses of the managerial structure. Private sector participants will be interviewed regarding the effectiveness of TravInfo in supporting ATIS products and the general responsiveness to private sector concerns, including liability and intellectual property issues. The study will identify institutional barriers which might stand in the way of TravInfo implementation and market penetration of ATIS products. Based on this information, the evaluators will prepare suggested changes in institutional arrangements and management approaches.

The institutional arrangement and management approach will also be evaluated based on the effectiveness of the TravInfo institutional system regarding public-public and public-private partnerships. Also on the manner in which various institutions relating to each other will influence the effectiveness of the management approach and implementation of the TravInfo project. The study will test the extent to which the TravInfo organizational structure facilitates active involvement and cooperation between public agencies and between public and private institutions.

From the jurisdictional point of view, public-public cooperation is necessary in the development of TravInfo policies that are agreeable to local and regional public works and planning agencies, transit authorities, ride-sharing operators, air-quality management and metropolitan planning agencies. Bridging institutional differences can greatly enhance the attractiveness of TravInfo.

The public-public dimension is concerned with the cooperation of other public agencies for the improvement of Bay **Area** transportation. Jurisdictional relationships within the transportation sector deals with transportation policies. The success of the TravInfo project relies on a comprehensive approach to regional transportation policies with an integrated data collection and dissemination service. **If** transportation authorities do not cooperate in designing and implementing the TravInfo program, it will not be possible for the Management Board to complete the project. Public-public cooperation is necessary in the development of TravInfo policies that are agreeable to local and regional jurisdictions. The public sector coordination will be involved with various program implementors including state and local public works departments, transit authorities, ride-sharing, air-quality, and metropolitan planning agencies, as well as private sector vendors, and service providers. Bridging institutional differences could greatly enhance the attractiveness **of** TravInfo. (Horan, **1992)**

The relationship between the public and private sectors is also an important factor influencing the success of TravInfo. Although the preferred model for a public-private venture is not yet available for this study, the issue is concerned primarily with what are the appropriate roles for the public and private sectors in the distribution of TravInfo information and maintenance of the system. The TravInfo project in the context of the roles of the public and private sectors will be compared with a range of models from a strongly private-oriented to a strongly public-oriented partnership arrangements.

The effectiveness **of** inter-organizational arrangements and procedures between the public-public and public-private partners will be evaluated using the following criteria: (1) broad acceptance of the TravInfo project by local governments and avoidance of the type **of** institutional resistance that often occurs with major transportation improvement projects; (2) adherence to the project schedule; **(3)** the ability of TravInfo to nurture development of ATIS products and services; **(4)** the degree to which TravInfo interfaces and databases are accepted in other regions of the country; (5) the ability of TravInfo to satisfy the requirements of private product and service providers.

The effectiveness of the institutional arrangement is also influenced by the management capability and negotiating ability among the partners. The TravInfo organizational structure and inter-organizational coordination will be documented and analyzed on the basis of: **(1)** the leadership capability of the Advisory Committee and Management Board, (2) the interface between public-public institutions and between public agencies and private organizations, and (3) the project management ability of the Management Board.

To evaluate the impact of public participation, the process of developing the TravInfo database will be monitored. The positive and adverse effects of public participation will

be assessed. The process of making decisions on the requirements of environmental impact reports will be documented to evaluate the public participation element of the study.

### 3.4.2 Economic Impact Assessment

The economic impacts of the TravInfo project will be evaluated according to the expected benefits of the project. The major benefits of the project include: 1) market demand and public awareness of TravInfo, 2) provision of employment opportunities, **3)** standardization of ATIS projects and services, and '4) improved understanding of the advanced traveler information systems. One **of** the potential barriers that stands in the way of market penetration **of** ATIS is the need to demonstrate significant social benefits to justify further investments. (Whitworth, 1994)

**Benefit 1.** Stimulated market demand and awareness.

The availability of timely and accurate information about the Bay Area multi-modal transportation systems will stimulate the development and deployment of a wide variety of ATIS products and services. (Bay Area Ad Hoc **IVHS** Committee, 1992)

Measure of effectiveness:

a) An increase in the number of new ATIS products and services entering the Bay Area market;

b) An increase in the number of firms interested in third-party, value-added products and services using TravInfo.

**Benefit 2.** Creation of new employment opportunities in California.

A large number of ATIS vendors are willing to both participate in the TravInfo Advisory Committee and to compete in the Bay Area ATIS market. ATIS products under TravInfo will migrate to other regions and the TravInfo project will create new jobs in California, especially in the service sector.

Measure of effectiveness:

a) An increase in the number **of** jobs created in the service sector of telecommunications and electronics using TravInfo;

b) An increase in migration of ATIS products using TravInfo to other regions.

**Benefit 3.** Standardization of ATIS products.

TravInfo will establish a common framework within which ATIS products can be developed and industries can adopt TravInfo standards for their products and services in the Bay Area.

Measure of effectiveness:

a) The traveler information is formatted and summarized in ways useful to ATIS commercial vendors and to the general public;

b) The TravInfo organizational structure provides incentives to the private sector to participate in the process of designing and implementing the TravInfo Traveler Information Center (TIC).

**Benefit 4.** Improved understanding of institutional issues.

One of the major national concerns regarding the future success of ATIS is the lack of detailed understanding of the types of information and products that consumers want and are willing to pay for through either direct purchase or public investment. There is also no clear understanding of the appropriate collection and dissemination. A major contribution of the TravInfo Field Operational Test will be improved understanding of these issues, which will benefit other ATIS and IVHS programs nationwide.

Measure of effectiveness:

a) The TravInfo organizational structure allows for a vigorous partnership among the public, private, and academic sectors, yet allows each sector to work on its own without interference from the other partners;

b) Increased participation by the ATIS community in all policy issues and all aspects of system architecture, design, and implementation;

c) Increased awareness of TravInfo among the general public through a public relations and advertisement campaign which will be undertaken prior to and during the operations **of** the FOT.

### 3.4.3 Market Response

Bay Area travelers will be tested in terms of a) their willingness to utilize TravInfo services, b) their awareness of, preference for, and acceptance of the advanced traveler information devices under TravInfo, and c) the changes in their travel behavior because of TravInfo. To assess the short-term impacts of ATIS deployments, a before and after experimental design will be used. Comparisons between the before and after cases will allow the effects of the deployment to be distinguished from other changes occurring in the Bay Area.

To study the market behavior of the ATIS products and services under TravInfo, two broad surveys will be used before and after the implementation of the TravInfo system. Longitudinal panel surveys of travelers will also be used to understand the market demand of TravInfo.

### 3.4.4 Test Location and Duration

The test site will be the San Francisco Bay Area over a three-year period. Interviewees will also include public and private sector representatives from outside of the Bay Area.

### 3.4.5 Key Conditions

Bay Area public agencies and private industries must cooperatively work together in the design, development, and implementation of the TravInfo project.

### 3.4.6 Key Assumptions

a) Market demand: There will be a significant number of entrepreneurs wishing to use the TravInfo database.

b) Regulatory requirements: Environmental laws will be complied with; however, TravInfo is not expected to have an adverse impact on the Bay Area environment. Negative declaration will be granted.

c) Intellectual property: The information in the TravInfo database is in the public domain. Data will be accessible to both public agencies and private companies. A major premise of IVHS and of TravInfo is that anything that is developed with federal funds including databases, software, inventions, and systems design is available for the state to reproduce and authorize others to use for government purposes.

d) Use of TravInfo: Bay Area travelers will utilize TravInfo services. Drivers in the Bay Area will equip their cars and use the system regularly, and travelers will be exposed to an array of services supporting multi-modal travel. The extent to which travelers will use TravInfo depends on the quality of information and the method by which the information is disseminated.

e) Perception of TravInfo: TravInfo will be favorably received by Bay Area travelers because they believe that TravInfo is an effective way to improve travel conditions.

f) Deployment of TravInfo: A significant number of Bay Area travelers will be exposed to TravInfo services. Exposure to TravInfo will depend on supply and demand for products and services. Exposure to TravInfo services will depend on the cost of devices, types of services, needs of customers, and the format and availability of information.

### 3.4.7 Key Constraints

The San Francisco Bay Area comprises nine counties, 99 cities, and **25** public transit agencies. Coordination among these agencies and solicitation of their participation in the TravInfo project will require a significant amount of time. It can potentially delay the project schedule.

The key constraints associated with the large-scale surveys are: 1) a minimum number of survey respondents to guarantee statistically valid results, **2)** the high cost of conducting extensive survey work for both large-scale and panel surveys, and **3)** the obtaining of a sufficient number of survey respondents who have purchased ATIS products or devices. (Yim, 1990)

### 3.4.8 Security Considerations

No security problems are anticipated either in the organizational structure or in directing the project.

### 3.4.9 Safety Considerations

Safety considerations will be directly associated with the ATIS product and services. Vendors will be responsible for complying with the federal and state regulations. New safety standards for ATIS products and services are anticipated.

### 3.4.10 Privacy Considerations

Privacy concerns will be associated with the level of participation by travelers in the TravInfo project and the confidentiality of marketing strategies of the TravInfo product. Some travelers would be sensitive to government agencies having this information and their perception of its potential misuse. A study of Bay Area motorists suggests that when asked about electronic tags for an automated toll collection service less than 15% of motorists will be concerned with privacy issues. (Yim, 1990) Private companies will be highly sensitive to disclosure of their marketing-related data, including the quantity of devices sold and any information about their customer profile.

### 3.4.11 Potential Impacts on the Operational System

The future operation of the TravInfo project will benefit from the improved organizational arrangement and management approach.

## 3.5 Data Collection

For the evaluation of the organizational structure, the major sources of data will be from meeting notes and memoranda prepared by participating agencies, and from three longitudinal panel surveys of the active participants in the TravInfo project. The survey sample will be taken from a pool of the TravInfo project participants serving on the Management Board, Steering Committee, Advisory Committee or on the Working Group. The panel surveys will be conducted in person or by telephone and the participants will be interviewed by the PATH researchers. The panel size for each survey will be 30-50.

The initial survey will be conducted within a year after the project began, the second survey will be conducted after the installation of the interim system, and the final survey will be conducted after the installation of the final system.

These surveys will address the perceived direction of the TravInfo project and the expected outcome of the project. The survey will also elicit expert opinions on suggested changes in institutional arrangements and management approaches. Confidential views on successes and failures of TravInfo will be assessed from these interviews.

The data sources for the economic impact assessment will be from the protocols and reports voluntarily filed by vendors needing access to the TravInfo database. Vendors and service providers will be encouraged to file statements with detailed descriptions of the technology and of how the information will be used, along with marketing plans and

prototype devices. In addition, providers will be encouraged to file quarterly statements specifying the number of users and any deviations from the initial plan.

For the market response to the TravInfo project, public opinion polls and market research will be conducted before and after operationalizing the final TravInfo system. These studies will help identify the factors influencing traveler decisions that might be most affected by TravInfo. The market response data will be gathered through a number of surveys; broad surveys of the Bay Area population; target surveys of motorists using Bay Bridges and Transit patrons using BART; panel surveys of Bay Area travelers; and customer surveys of ATIS products and services using TravInfo database. (*See* Section 2 for the description of target surveys.) For the Bay Area population survey, the telephone survey method will be used. (Yim, 1991) The sample population will be taken by random digit dialing and the sample size of the completed interviews will be 1,000 per survey.

### 3.6 Data Reduction and Analysis

The information obtained from meeting minutes, notes and memoranda will be organized in three categories: a) management, b) agency coordination, and c) public and private sector interaction. The analysis of data under these categories will provide details of what brought the project to its current state. To trace the evolution of the TravInfo project, the documentary evidence of the evolution of the project will be traced using minutes of meetings and memoranda by participating agencies. Based on these, hypotheses will be formulated regarding key barriers to and opportunities for cooperation and coordination in the management of the project.

The specific roles played by individuals and agencies will be defined, reviewed and traced over the life of the project. Critical issues on which the success of the project depends will be identified and the ways in which those critical issues are resolved will be described. It is likely that the several participating agencies hold different expectations regarding TravInfo. Conflicts arising among participating agencies will be described and analyzed. Based on this institutional history, recommendations will be made for maximizing the effectiveness of future working relationships within the TravInfo project. If appropriate, guidelines will be drafted which might help facilitate institutional cooperation and coordination in the future.'

### 3.7 Evaluation Tasks and Test Schedule

The key evaluation activities are listed below and the schedule is shown in Figure 3.2. The test will begin in June 1993 and end in June 1996.

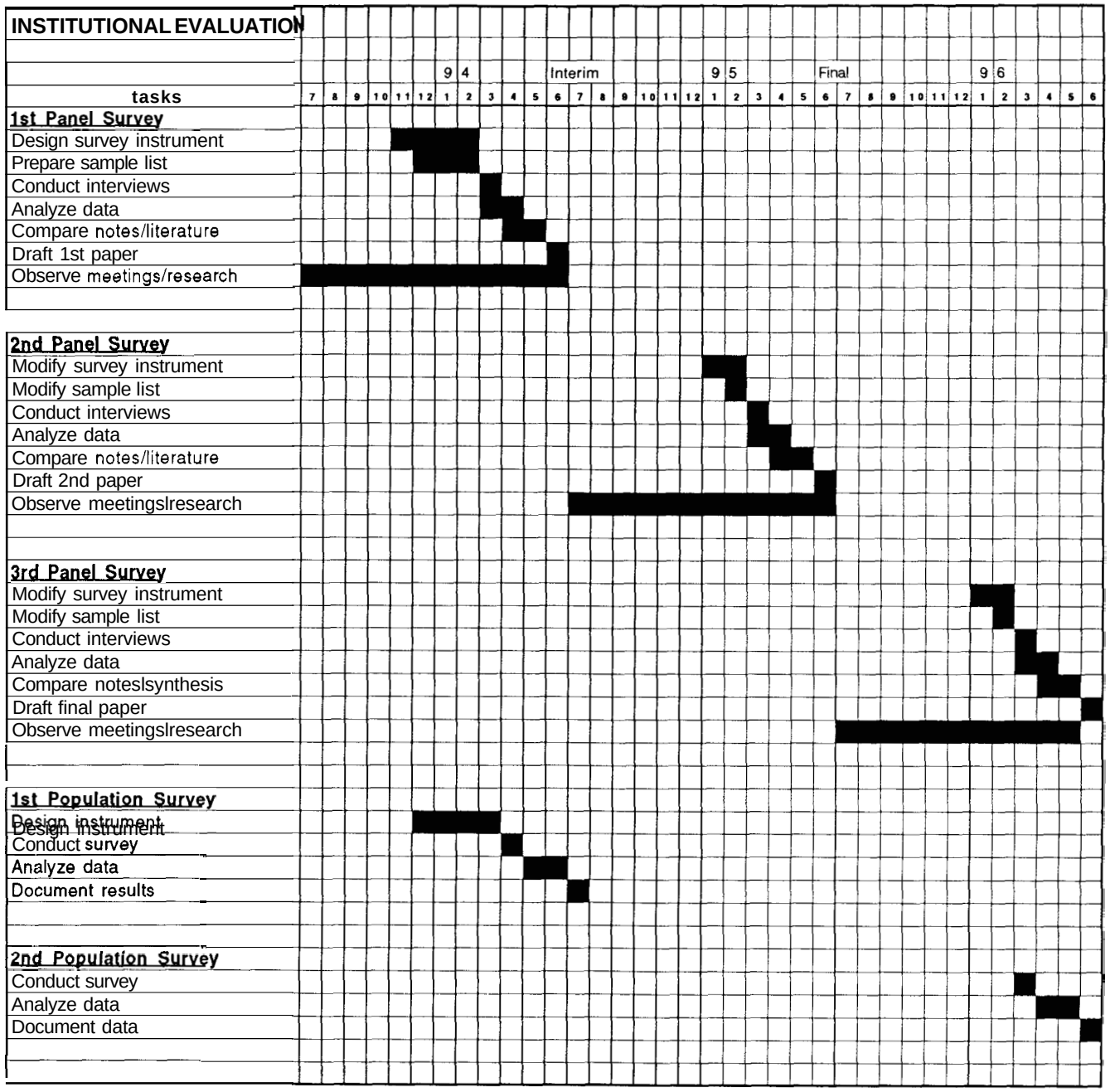



**Figure 3.2. Institutional Evaluation Schedule.**

### 3.7.1 Pre-Test Activities

a) Develop an institutional evaluation plan and a format for interviews, set up an interview schedule, and list meetings to attend (June 1993—Feb 1994);

b) Develop a test evaluation plan (June—August 1993) and a detailed survey plan, including a specific list of questions and the target population (September 1993).

### 3.7.2 Evaluation Test Activities

a) Attend Management Board and Advisory and Steering Committee meetings as an observer (July 1993—June 1996);

b) Interviews with TravInfo project participants:

(1) Conduct the initial wave of interviews with project participants and prospective TravInfo partners.
Design the survey instrument (October 1993—February 1994).
Prepare a list of participants to be interviewed (February 1994).
Conduct the first panel interviews (March 1994).

(2) Document the findings from the initial observations in a working paper (June 1994).

(3) The second wave of interviews.
Revise the survey instrument (January—February 1995).
Revise the list of participants to be interviewed (February 1995).
Conduct the second wave of interviews (March 1995).

(4) Document the findings from the second wave in a working paper (June 1995).

(5) The final wave of interviews.
Revise the survey instrument (January—February 1995).
Revise the list **of** participants to be interviewed (February 1995).
Conduct the second wave of interviews (March 1995).

(6) Document findings from the second wave in a working paper (June 1996).

c) Bay Area population survey:

(1) Execute the initial large-sample telephone survey (April 1994).

(2) Analyze the initial survey results and document them in **a** working paper (May—June 1994).

(3) Execute the second large-sample survey (March 1996).

(4) Analyze second large-sample survey and compare the results to the initial large sample survey (April—June 1996).

### 3.7.3 Post-Test Activities

**a)** Document the institutional evaluation in a research report (March—June 1996).

b) Document the traveler response component of the study (January—March 1996) and the findings of the study.

## 3.8 Deliverables

Working papers will be prepared to report on the preliminary results of the data analyses. The final report will be prepared by June 1996.

## 3.9 References


1. Bay Area Ad Hoc IVHS Committee, "TravInfo, Bay Area Intermodal Traveler Information System," October 16, 1992.
2. Horan, T.A., "Evaluating IVHS: Key Issues in Institutional and Environmental Assessments of IVHS Technologies," in Transportation. Information Technology and Public Policy: Institutional and Environmental Issues in IVHS, J.L. Gifford, T.A. Horan, and D. Sperling, Editors, Asilomar Conference, 19923.
3. Yim, **Y.,** "Electronic Toll Collection Systems (ETC) User Survey," PATH Research Report UCB-ITS-PRR-91-12, 1991.
4. Whitworth, P., "Market Issues in the Development of In-Vehicle Advanced Traveler Information Systems," Transportation Research Board 73rd Annual Meeting, January 9-13, 1994.

# 4. TECHNOLOGY ASSESSMENT

## 4.1 Evaluation Goals and Objectives

The goal of the technology assessment component of the TravInfo evaluation project is to assess the performance of the TravInfo system from the perspective of the Traveler Information Center (TIC) and from that of the individual products and services using the system.

### 4.1.1 Traveler Information Center

The objective is to measure the performance of the TravInfo TIC system (hardware and software) relative to such factors as timeliness, accuracy, reliability, operability, maintainability, and functionality. Measures of effectiveness will include the following:

a) Ease of TIC accessibility
   - average waiting time

b) TIC response times by time-of-day
   - time required from incident report receipt to dissemination of data to output source, including all data fusion/integration;
   - total time required for data to get from input source to output/dissemination source

c) TIC operations by time-of-day
   - number of data queries
   - size of data query messages

The performance of the operation of each of the TIC's functional components will be assessed. Issues to be addressed in the evaluation are as follows:

General inauiries of the TIC:

- What is each functional component of the TIC?
- How does each functional component plan to operate?
- Will each component have performance specifications?
- To what extent does each functional component perform as intended within specifications, relative to measures of effectiveness such as accuracy, response times, frequency of failures?

- How does each functional component operate, including number and size of queries?
- What is the operation of the TIC from the perspective of system operators through surveys and interviews?

Specific inauiries of the TIC:

The specific components to be evaluated are: (1) communications input interface, **(2)** data fusion, and **(3)** communications output interface.

The issues for the communications input interface are:

- With what ease/difficulty are new data sources added on and allowed to access the TIC?
- How many access points, i.e., communication ports, to TIC will there be? How is this determined, e.g., by data source type (freeway, transit, private vendor)?
- What are the waiting times and other queuing-type measures for data sources to access TIC?
- How do such measures differ by time-of-day and data input type, i.e., what is the system load and performance during travel peak-periods?

The issues for the data fusion are:

- Current state is "black box," requiring detailed description of functional components and their intended operation to facilitate PATH providing data collection requirements for evaluation purposes.

The issues for the communications output interface are:

- With what ease/difficulty does information egress from the TIC?
- How many egress points, **i.e.,** communication ports, from TIC will there be? How **is** this determined, e.g., by data destination type (public, private sector)?

- What are waiting times and other queuing-type measures for data to egress from the TIC?
- How do such measures differ by time-of-day and data destination type, i.e., what is system load and performance during travel peak-periods?

### 4.1.2 Individual Products and Services

The objective is to measure the degree to which products and services serve to improve the overall travel environment in the Bay Area. Such new products and services are brought to market by organizations referred to as Value Added Resalers (VARs) since such groups will supplement the value associated with the travel-related information they obtain from the TravInfo system and pass it along to the individual traveler by various means of communication, such as radios, cellular phones, and other in-vehicle devices. The performance of the VARs' products and services will be measured by means of surveys of the VARs' customer bases. The use and usefulness of the products and services are the general measures of effectiveness (MOEs) through which these devices will be assessed. The product and services will provide data in the form of advisory information and their use by the customer is a two-part task, comprised of listening to the information and following its advice. The information's usefulness is measured in terms of the degree to which an individual both perceives and observes improvements in his/her traveling experience as evidenced in travel time or delay changes. Specific MOEs include the following:

a) Number of current (at the time the survey is implemented) owners
b) Degree of customer satisfaction
   - frequency of use
   - change in frequency of use over time
   - frequency of information accuracy, timeliness, and reliability
   - level of perceived improvement in travel time, delay, speeds, and travel time predictability
c) Number of owners who discontinued use
d) Degree of former customer dissatisfaction

Assuming that the surveys are representative of the VAR customer base, the overall performance of a product or service associated with a particular VAR or VAR-type will be based on a statistical analysis of the survey responses frequency distribution. For example, the percentage of survey respondents affirming satisfaction with a product will be the measure of the effectiveness for that product's performance.

## 4.2 Overall Test Responsibility

The PATH research team, led by Mark Miller, will be responsible for collecting data on market penetration of products and services under TravInfo and analyzing the data for technology assessment. MTC's Architecture Design & Integration (ADI) consultant will

be responsible for furnishing data related to the TravInfo system architecture and functional specifications.

### 4.3 Overview

TravInfo will implement a comprehensive regionwide traveler information system with an ample collection of devices and techniques to collect and disseminate information to travelers before and during their trips. The public sector component of TravInfo consists of the TIC (which will integrate and disseminate transportation information to the general public), public agencies, and commercial vendors. Individual TIC components, i.e., hardware, software, communication processors and interfaces to the outside "world" (Caltrans, CHP, CVO's, private vendors), the "nuts and bolts" of the system, will be maintained by the public sector.

The Bay Area's entrepreneurial talent, expertise in electronics and communication, and corporations in defense-related industries seeking investment opportunities with domestic markets create extraordinary potential for developing new ATIS products. Letters of intent to broadcast TravInfo data over both **FM** subcarrier and TV Second Audio Program (SAP) channels as well as an expressed interest in cellular digital data packet systems have been received from Bay Area firms. Moreover, other firms have indicated that their personal, portable information devices are soon to be marketed in the region. The TravInfo project will allow vendors to test their systems in the real world and will generate valuable information on consumers' willingness to pay for specific capabilities and features. Individual devices and the overall ATIS market will be documented and published ***so*** that all interested parties may have access to the results.

### 4.4 Description of the Test

Three basic elements of the technology evaluation plan are concerned with: 1) performance of TIC, 2) market response to new products and services under TravInfo, and **3)** performance of individual products and services using Travinfo in terms of their functionality, reliability, maintainability, and operability. Although a principle of TravInfo is open access, there will still be a need to determine which technologies are most promising for improving travel conditions or guiding the traveler. Consumer response to new products and services will show, to some extent, which technologies have demonstrated a potential for full deployment. The information from vendors will also provide additional insights into the market penetration of the TravInfo database.

Private sector information providers will be encouraged to file an information statement prior to obtaining special access to the database. The statement would provide a detailed

description of the technology and how the information would be used and possibly a prototype device might be provided. In addition, providers will be encouraged to file a quarterly statement specifying the number of users and any deviations from the initial plan. Obtaining this information from private service providers at this level of detail, i.e., number of units sold and in use, may prove quite challenging given the privacy considerations of the service providers. However, an alternative plan may be to indicate an approximate number of users, i.e., by range or category. This method would safeguard the privacy concerns of the service providers, yet still provide needed information for evaluation purposes. For those service providers utilizing dedicated communication lines, it will, nevertheless, be easier to furnish this information than for those service providers and consultants utilizing dial-in data lines from whom it will be more difficult to provide certain information. Probably the most sensitive information to be obtained with respect to the outside vendors is the number of units sold and in use in the field.

The TIC performance will be tested relative to several measures of effectiveness, including the following:

- accessibility of information
- response time of information dissemination
- accuracy of reports disseminated
- adequacy and problems of open architecture
- number and size of accesses

The final component of the overall technology assessment test will measure the response to individual vendors' products by travelers who purchase these products or who access publicly available information. Traveler response to the products and services will be quantified in terms of their usefulness and effectiveness.

### 4.4.1 Test Location and Duration

The test site will be the San Francisco Bay Area over a three-year period.

### 4.4.2 Key Conditions

Under other efforts, Bay Area roadways will be equipped with automated data collection systems including loop detectors, fiber optics, ramp metering, and video cameras. The TravInfo project will rely on the existing infrastructure and near-term technologies for surveillance.

### 4.4.3 Key Assumptions

**a)** The TravInfo project will provide practical experience to private vendors who utilize a variety of communication techniques.

**b)** Technologies associated with private sector vendors are effective in improving Bay Area travel conditions.

**c)** The TIC provides for readily accessible, reliable, and accurate information, as well as speedy response times.

**d)** Advanced systems technologies will be applied to add value to the transportation information through data fusion, interpretation, and presentation. This activity will refine, adapt, implement, and integrate a wide variety of state-of-the-art fusion techniques. This will involve a mix of available commercial systems and development activities. The techniques to be considered are: 1) map-based display and data management, **2)** predictive traffic modeling, **3)** image interpretation, and **4)** evidential reasoning.

**e)** The implementation of the TravInfo system development phases (system definition and architecture, baseline system, data fusion and system enhancement, and advanced technology applications) will not be strictly sequential. Depending on the aggressiveness of individual initiatives, significant overlay will occur among phases.

**f)** There will be a large number of vendors willing to enter the Bay Area market with various products and services.

### 4.4.4 Key Constraints

The key constraints are: 1) the time and budget required to test the near-term technologies, **2)** the capacity **of** the existing communication channels for technology implementation, **3)** the high cost of testing ATIS technologies, **4)** the ability to acquire sensitive proprietary information such as market data, and 5) the ability to gather valid statistics given unknown levels of market penetration.

### 4.4.5 Security Considerations

Security considerations include the protection of and access to vendors' proprietary information on technology application and subscribers. Physical and electronic access to the TIC is to be considered also. Arrangements will be worked out with the vendors to mitigate their concerns.

### 4.4.6 Safety Considerations

Safety considerations may be associated with ATIS products and services. Vendors will be responsible for complying with federal and state regulations.

### 4.4.7 Privacy Considerations

Privacy considerations will be associated with users' travel habits and the use of TravInfo services. To protect individual's privacy concerns, no individual names will be associated with data obtained.

### 4.4.8 Potential Impacts on the Operational System

With TravInfo, there will be an improvement in incident management in the Bay Area. Traffic control systems and ramp metering protocols will be improved. Transit usage will increase due to the improvement in accessing and using the Bay Area's multi-operator public transportation system.

## 4.5 Experimental Design

In response to the public sector's provision of open access to the transportation database, the private sector is expected to market a wide range of ATIS devices and services. Information dissemination is available through a variety of communication channels, including the cellular telephone system, FM subcarrier, TV Second Audio Program (SAP) channels and the public telephone network. These systems will be able to provide information on all modes of travel.

In assessing user friendliness and viability **of** ATIS products and services under TravInfo, a combination of "pre-and-post test" and "time series" methods will be used through surveys of Bay Area travelers. Questionnaires regarding product evaluation of TravInfo systems will be included in the traveler response surveys. The "pre-and-post test" method will allow the study team to compare before and after effects of TravInfo services in terms **of** product liability, operability, and functionality. The "time series" method will allow the team to monitor development of and consumer response to technologies over time.

In assessing the performance of the elements of the TIC, the "maturation effect," i.e., improvement in service over time due to the experience gained by system operators and working problems out of the system, must be taken into account, so a time series approach will be used to collect information on the performance of all TIC components.

A time series approach to evaluating the private sector devices and products will be utilized.

### 4.6 Data Collection

Data will be gathered from four sources: 1) vendors, **2)** users of devices and subscribers to information services by way of vendors or service providers, **3)** MTC's ADI consultants for evaluation of TIC component performance, and **4)** large-scale and panel surveys of travelers. Questions concerning market response to the TravInfo products and services will be included in the large-scale surveys mentioned previously in the Traveler Response and Institutional Arrangement sections.

Industries needing special access to TravInfo will be encouraged to file a description of their products and a quarterly report. The second source of information will be data obtained from the consumers with the assistance of the vendors. Mail-back survey questionnaires will be distributed to the users of products or the subscribers to services directly by vendors or service providers, *so* that confidentiality of consumers can be protected. These data along with the traveler response information will be used to determine which classes of technologies are most likely to improve travel on a personal level. The third source will be data from within the TIC which will include interviews or surveys of system operators, as well as performance statistics collected automatically by the system itself. The fourth source of data will be from the large-scale survey of Bay Area travelers.

#### 4.6.1 Value Added Resaler Survey Work

One aspect of the Technology Assessment component of the TravInfo evaluation is the determination of the market response to new products and services made available by Value Added Resalers (VARs) in response to their access to different types of information (traffic conditions, etc.). This will be accomplished by means of surveying the consumers of individual VAR products.

a) Survey administration: Agreement on survey distribution methods will be made through discussions with the VARs. Since the results of the surveys would be of great benefit to the VARs and at no cost to them, we assume that the vendors would be open to these surveys being conducted. The VARs could mail the surveys to their customer base keeping names and addresses secret to assure confidentiality and privacy. Survey responses would be returned to the evaluation team through the VARs. Alternatively, the

evaluation team could communicate directly with the VARs customer base if the VARs were agreeable to it.

b) Instrument Design: The vendor survey focus is to discover the market response to new products and services under TravInfo. The principal portion of the survey will be to inquire as to the use and usefulness **of** individual products and services. Questions could include queries on topics such as the specific product purchased, length of ownership, reasons for purchase, previous ownership of similar products or services, and extent of use and usefulness (if no longer in use, reasons why; frequency of use; what is done with information obtained; value of information). Other survey sections could include questions in other categories such as (1) socioeconomic attributes and personality and **(2)** normal driving patterns. The surveys should be distributed three times to capture changes in customers' responses about the products and services over time, though not necessarily the same set of customers. In particular, if the first vendor survey is distributed too soon after TravInfo becomes fully operational, conducting only a single survey would be biased against the products and/or the TravInfo system since there are bound to be problems to work out and a need for the system to reach maturity and some sort of steady state level.

c) Sampling method: Assume information is disseminated through three generic types of technologies from a simple to a sophisticated devices: three types are (1) a one-way communication devices such as radio and television, **(2)** two-way communication device such as cellular phones, and **(3)** a sophisticated two-way communication device such as computerized in-vehicle monitors.

Each survey will distribute questionnaires to customers over three technology categories for 500 responses per category or for 1,500 total returns per survey.

### 4.6.2 Statistical Method

The cross-tabulation statistical method will be used to measure associations between individual products and market consumption and between demand for services and service categories.

Other statistical methods used will likely include formulating t-statistics and F-statistics to test the difference of means, as well as goodness-of-fit measures, such as the R-squared statistic.

## 4.7 Data Reduction and Analysis

Vendor product data will be analyzed with respect to the taxonomy presented in Figure 4.1, to determine which classes of technologies are most successful in the marketplace. The analysis will entail: a) determination of promising technologies in terms of performance and the price of the product, b) assessment of the technology impact on travel conditions, and c) identification of R&D needs to improve ATIS products under TravInfo.

TIC performance analysis and hypothesis testing will be conducted based on raw data automatically collected by the system as well as obtained by mail surveys or interviews with system operators. Univariate statistical techniques (frequency analysis, cross tabulations) will be used.

Traveler response to the use of vendor products will be analyzed based on traveler survey data. Simple univariate statistical techniques such as frequency analysis and cross tabulations will be used for analysis and hypothesis testing.

## 4.8 Evaluation Tasks and Test Schedule

The test will begin in March 1994 and end in March 1996. (Figure 4.2)

### 4.8.1 Evaluation Pretest Activities

The pretest activities include development and revision of the TravInfo Evaluation Plan which will outline the necessary tasks to perform the test activities.

### 4.8.2 Evaluation Test Activities

The evaluation test activities are presented in two groups: evaluation of TravInfo performances including the interim and final systems, and evaluation of technologies for ATIS devices.

**A. TravInfo system evaluation**

a) Review ESL's design plan.

b) Develop detailed criteria for evaluation of TravInfo system performance (March 1994—September 1994).

TECHNOLOGY : _____

MANUFACTURER/SPONSOR: _____

| INFORMATION TYPE / CHOICES | STATIC | | DYNAMIC | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | HISTORICAL | | REAL TIME | | PREDICTIVE | |
| | QLT | QNT | QLT | QNT | QLT | QNT | QLT | QNT |
| DESTINATION | | | | | | | | |
| MODE | | | | | | | | |
| DEPARTURE TIME | | | | | | | | |
| PRE-TRIP ROUTE | | | | | | | | |
| EN-ROUTE DIVERSION AND/OR RETURN | | | | | | | | |
| PARKING | | | | | | | | |
| TRIP CHAINING | | | | | | | | |

**FEATURES :**

☐ PORTABLE ☐ NON-PORTABLE

☐ IN-VEHICLE ☐ OUT-OF-VEHICLE

☐ AIJDIO ☐ VISUAL

☐ SINGLE MODE INFORMATION ☐ MULTI-MODE INFORMATION

☐ EMERGENCY COMMUNICATION ☐ NO EMERGENCY COMMUNICATION

☐ ONE-WAY ☐ TWO-WAY COMMUNICATION

RESERVATION OF ☐ DESTINATION ☐ MODE ☐ PARKING

ROUTE OPTIMIZATION BY ☐ CENTRAL COMPUTER ☐ IN-VEHICLE COMPUTER ☐ NONE

CENTRAL CONTROL OF TRAVEL CHOICE ☐ YES ☐ NO

VEHICLE LOCATION ☐ KNOWN ☐ UNKNOWN

**TECHNOLOGY STATUS:** ☐ IN MARKET ☐ FIELD TESTED ☐ DEVELOPED ☐ PROPOSED

IF FIELD TESTED, NUMBER OF VEHICLES USED IN THE FIELD TEST: _____

**Figure 4.1. Taxonomy of ATIS Technologies.**

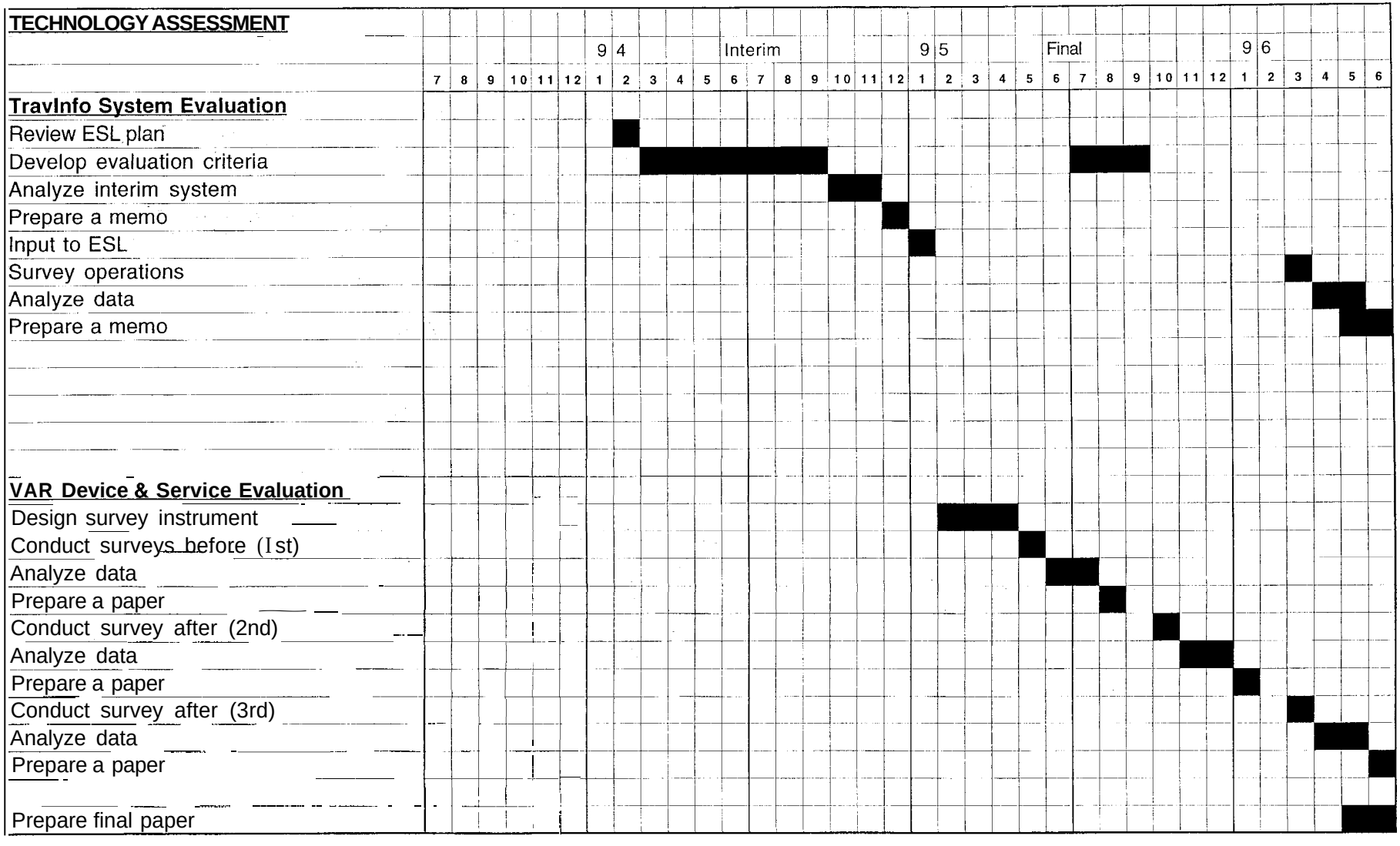



**Figure 4.2. Technology Assessment Evaluation Schedule.**

c) Gather data for evaluation of the interim system from ESL and operators of the interim system (July 1994—September 1994).

d) Analyze data for evaluation of the interim system (October 1994—November 1994).

e) Prepare a memorandum describing the findings of the test (December 1994).

f) Survey TravInfo operators for performance evaluation of the final system (November 1995—December 1995).

g) Analyze performance of TravInfo final system software and hardware (January—February 1996).

h) Prepare a memoranda reporting on the findings of the study (March—April 1996).

**B. VAR device and service evaluation**

a) Explore with the TravInfo Management Board and Advisory Committee the policy for vendor participation and access to TravInfo (June 1995).

b) In cooperation with the ADI consultant, develop procedures for on-line recording of system performance to facilitate technology evaluation (January—September 1994). Document the data collection plan in a working paper.

c) Sign an agreement with vendors and service providers for the distribution of survey questionnaires (February 1995).

d) Establish information technology testing procedures, including relevant parts of the panel survey design, technology classification procedure, and methodology for evaluating marketing information (April—June 1994).

e) Design the survey instruments (January—April 1995).

f) Conduct the initial wave of the customer survey through vendors prior to the final system's being operationalized (May 1996).

g) Analyze the initial survey data and document the survey results (June—July 1996).

h) Analyze the panel survey results with respect to technology performance (November 1995—February 1996).

i) Analyze data from protocol statements to track technology trends (September—December 1995).

j) Conduct the first wave of the customer survey through vendors after the final system is in place (October 1995).

k) Analyze the first wave of survey data and document the survey results (November—December 1995).

l) Conduct the second wave of the customer survey through vendors after the final system is in operation (April 1996).

### 4.8.3 Post-Test Activities

Prepare a report on the technology performance of TravInfo and ATIS devices using TravInfo (May—June 1996).

## 4.9 Deliverables

Working papers will summarize the analysis **of** data. The findings of the study will be reported in the final report.

## 4.10 References

1. Bay Area Ad Hoc IVHS Committee, "TravInfo, Bay Area Intermodal Traveler Information System," October 16, 1992.

2. Khattak, A., H. Al-Deek, Y. Yim, R.W. Hall, "Bay Area ATIS Testbed Plan," PATH Research Report, UCB-ITS-PR-92-1, Institute of Transportation Studies, University **of** California, Berkeley, 1992.

# *5.* SYSTEM PERFORMANCE

## 5.1 Evaluation Goals and Objectives

The goal of the system component of the TravInfo evaluation project is to assess the effects of TravInfo on the operational efficiency of the Bay Area freeway network and on the environmental quality. The objectives of the test are: 1) to measure changes in system level performance in the areas of network traffic, **2)** to quantify the changes in link flow, and **3)** to evaluate the impact of TravInfo on the environmental quality.

## 5.2 Overall Test Responsibility

The PATH research team, led by Stein Weissenberger, will be responsible for evaluating the system performance component of the study. Caltrans will be responsible for furnishing traffic data before and after the final TravInfo system is operationalized.

## 5.3 Overview

The TravInfo system will consist of three basic components: data collection, data fusion/integration, and data dissemination. Within this basic framework, the overall system architecture and functional relationships will be defined: what the system will do and how it will do it. The evaluation study will consider the existing architecture of the Caltrans Traffic Management Center (TMC) and the Regional Transit Telephone Information System (RTTIS). The TravInfo system architecture will be incrementally expandable, upgradable, and reconfigurable since the exact nature of future ATIS needs and functions is difficult to predict. The system specifications will consist of hardware, software and database modules, including input, output, and data processing related elements.

TravInfo will provide real-time traffic information and travel options to Bay Area travelers through commercial vendors and service providers. The quality of the Bay Area transportation services will be influenced by TravInfo by: 1) providing a range of travel options with real-time information for current and predicted travel conditions, **2)** allowing effective pre-trip planning, **3)** providing real-time route selection opportunities, and **4)** increasing overall trip safety. The conjecture is that the advanced information services under TravInfo should encourage more efficient use of the transportation network.

## 5.4 Description of the Test

A combination of traffic simulation modeling and direct measurement will be used to assess changes in system level performance. The survey results of Bay Area motorists will be incorporated in the development of simulation models. These models will explicitly represent information type, content, and format, and will be used to estimate Measures of Effectiveness **(MOEs),** such as traffic throughput (volume of vehicles per unit time), average **speed,** average travel time, variability of average travel time, traffic delay, and on-road mobile-source vehicle emissions (carbon monoxide, hydrocarbon, and oxides of nitrogen).

The TravInfo system performance will be evaluated according to the expected benefits of the project on the following elements:

**Benefit 1.** Increased capacity and operational efficiency.

The TravInfo project will reduce congestion (delay and travel time reduction and increases in **speed)** through improved information about the location and nature of incidents, and by lowering the information barriers for transit use. The benefits of TravInfo are expected to be on the systemwide network traffic flow. The direct benefits of TravInfo on the throughput of the network will be difficult to measure because of other trip reduction programs underway in the Bay Area. However, the approximated benefits of TravInfo can be estimated if information about the effects on on-going trip reduction programs is available.

The effectiveness of TravInfo will be measured based on: (1) the increased throughput of the corridors where reliable traffic data are available, **(2)** increased travel **speeds, (3)** reduced travel time and delay, **(4)** reduced incident detection time, (5) reduced incident removal time, (6) reduced delay caused by incidents, (6) increased vehicle occupancy, (7) increased use of public transit, and **(8)** increased predictability of travel times as measured by standard deviation of travel time.

**Benefit 2.** Improved safety.

The TravInfo project will improve safety and decrease freeway accidents by decreasing the number of vehicles on the freeway system and by diverting travelers away from incident sites. Congestion is the major cause of rear-end collision. When traffic is more evenly distributed for a steady flow, accidents *can* be reduced. Therefore, the effectiveness of TravInfo will be measured according to: (1) the reduction in the number of accidents including fatal and injury accidents, and the cost of accidents, **(2)** the reduction in secondary accidents associated with incidents, and **(3)** the reduction in incident response times.

**Benefit 3.** Improved environmental auality.

Bay Area air quality will be improved from decreased automobile trips and reduced congestion. Congestion is a major air quality problem because vehicles that are moving slowly and accelerating and decelerating in accordion fashion produce much higher emissions than vehicles moving steadily at **speeds** up to the posted limit. The effectiveness of TravInfo will be measured based on: (1) reduced vehicle emissions calculated according to the **speed** of travel on the selected corridors, and **(2)** reduced fuel consumption.

**Benefit 4.** Improved cooperation between transportation system operators.

TravInfo will allow traffic operators to cooperatively exchange and share information. The centralized traffic database will also help operators access information in a timely manner. The effectiveness of the system performance will be measured on the basis of (1) increased accessibility to incident/congestion information; **(2)** increased sharing of information; **(3)** reduced cost for information gathering; **(4)** increased knowledge of control strategies; (5) reduced resource requirements and stress on system operators because of the automation capability of TravInfo.

**Benefit 5.** Improved transportation forecasting and evaluation.

Because of the availability **of** timely information, transportation forecasting will be improved. Therefore, the effectiveness of the system will be measured based on: (1) the increased accuracy of transportation data, and **(2)** improved trip generation forecasting models with real-time traffic information.

### 5.4.1 Test Location and Duration

The test will be conducted in the **San** Francisco Bay Area over a three-year period. The Bay Area transportation system serves nine counties: Alameda, Contra Costa, Marin, Napa, San Francisco, San Mateo, Santa Clara, Solano, and Sonoma.

### 5.4.2 Key Conditions

Traffic data prior to TravInfo implementation need to be collected at selected links and the accuracy of the data needs to be determined, ***so*** that traffic data after implementation can be compared.

### 5.4.3 Key Assumptions

Caltrans, CHP and local agencies will collect traffic data at selected links. A network traffic simulation model will be used in the analysis and is required to adequately replicate pre-TravInfo travel patterns in the Bay Area.

### 5.4.4 Key Constraints

It will be difficult to develop a simulation model which can replicate Bay Area traffic conditions because the assumptions in the model can be unrealistic. Identifying the individual influence of TravInfo on the network opposed to the interference from other factors such as the local economy, legislation, or new technology development will be difficult.

### 5.4.5 Security Considerations

No security problems are anticipated in the conducting of this test because all data is of a type that is ordinarily available to the public.

### 5.4.6 Safety Considerations

No safety problems are envisioned in the conducting of this test because data collection methods are non-intrusive.

### 5.4.7 Privacy Considerations

No privacy problems are expected in the conducting of this test because all data is of a type that is ordinarily available to the public.

### 5.4.8 Potential Impacts on the Operational System

The impacts would include improved operational efficiency and traffic monitoring.

## 5.5 Experimental Design

Changes in delay will be measured on selected freeway links where severe congestion has occurred. Actual changes in delay will be measured in throughput and **speeds** on freeways and city arterials. To measure the effects of TravInfo, traffic data at diversion points will be compared with the traveler survey results. For evaluation of the overall network performance, the existing simulation models developed by FHWA, Caltrans, and by PATH will be used to measure changes in delay.

**To assess** the impacts of TravInfo on emissions levels, no direct measurements will be taken of pollutant levels, and thus an indirect approach will be used via analytical regression models, considering both linear and non-linear regression models. These models will likely be a function of some or all of the following explanatory variables: average vehicle **speed,** travel time, total time in queue, and total distance traveled. In addition, models developed by the Environmental Protection Agency and the California Air Resources **Board** will be investigated for use to assess emissions impacts. Statistical techniques to be employed are t-statistics, F-statistics, and $R^2$ values.

### 5.5.1 Statistical Method

The t-statistics will be used to test the statistical significance of regression equation coefficients. F-statistics will be **used** to test the statistical significance of the regression model as a whole. The value of $R^2$ will be used to qualitatively describe the proportion of the variance in the dependent variable 'of the regression equation which is attributable to the independent variables in the model.

## 5.6 Data Collection

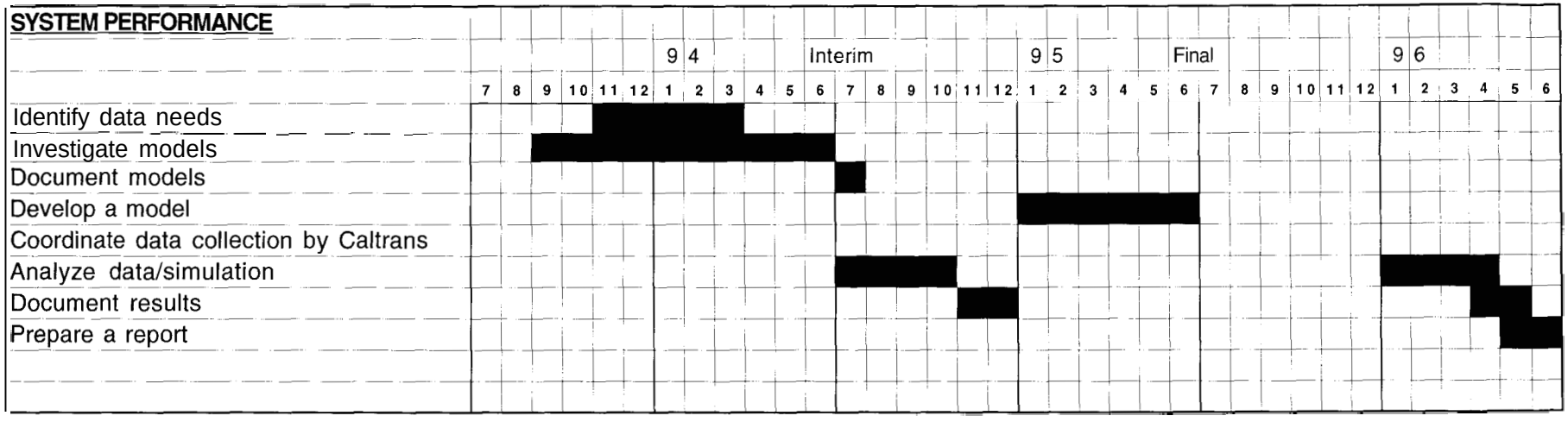
The data necessary to evaluate system performance include traffic information on congested links and overall network **speeds** and traffic levels before and after TravInfo implementation. Caltrans has been obtaining and updating traffic data every three years. Local agencies in the Bay Area have kept traffic records on arterial links. Traffic volume, percent occupancy, and signal control data will be gathered from Caltrans, CHP, and local agencies. Traffic data will be collected over a one month period before and after implementation of TravInfo.

## 5.7 Data Reduction and Analysis

For traffic data reduction, regression models will be used to identify the relationships between the data taken at various times and to eliminate outliers that do not follow traffic patterns. To measure the actual changes in delay, before and after statistical comparisons will be made using cross-tabulation in throughput and **speeds** on selected freeway links and city arterials. To measure the shifts in traffic volume, traffic data at diversion points will be analyzed using the statistical techniques including estimation of t-statistics and multivariate analysis. To assess the impacts of TravInfo on air quality, statistical techniques to be employed are t-statistics, F-statistics, and $R^2$ values.

## 5.8 Evaluation **Tasks** and Test Schedule

The test will begin in March 1994 and end in March 1996 (Figure 5.1).




S

**Figure 5.1. System Performance Evaluation Schedule.**

### 5.8.1 Pre-Test Activities

Develop a detailed plan for collecting data on freeway network performance (January—March 1994).

### 5.8.2 Evaluation Test Activities

1) Identify traffic data needs for the TravInfo evaluation study (October 1993—March 1994).

2) Coordinate with Caltrans for collecting freeway network performance data (January 1994—February 1996).

3) Investigate network models for simulation/evaluation of changes in network performance and document modeling approaches (September 1993—July 1994).

4) Develop a model specifically designed for the TravInfo evaluation project based on the existing models (January 1995—June 1995).

5) Perform simulations and evaluations, using survey results and network performance data as input (July 1994—October 1994, January 1996—April 1996).

### 5.8.3 Post-Test Activities

1) Document system Performance results (November—December 1994, April—May 1996).

2) Prepare the final report (May—June 1996).

## 5.9 Deliverables

There will be working papers summarizing the analysis of the data. The findings of the study will be reported in the final report.

## 5.10 References

1. Peat, Marwick, Mitchell & Co. and JHK & Associates. "IMIS Evaluation Plan — Volume 1: Technical Report," February 1980.