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

TravInfo Evaluation Plan

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UCB-ITS-PWP-93-16

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FOREWORD

This is an evaluation plan for the TravInfo project, a field operational test of a centralized database in the San Francisco Bay Area. The TravInfo Evaluation Plan is prepared in accordance with the Mitre guidelines adopted by the Federal Highway Administration (FHWA) for IVHS Operational Test Evaluation Plans. The content of the TravInfo Evaluation Plan is presented in the order specified in the "Individual Evaluation Test Plan Template" of the Mitre guidelines.

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1 INTRODUCTION

TravInfo is a public/private partnership formed to provide widespread 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 (FOT) of a centralized database providing easy access to real-time travel information on all modes of transportation in the San Francisco 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:

- 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.

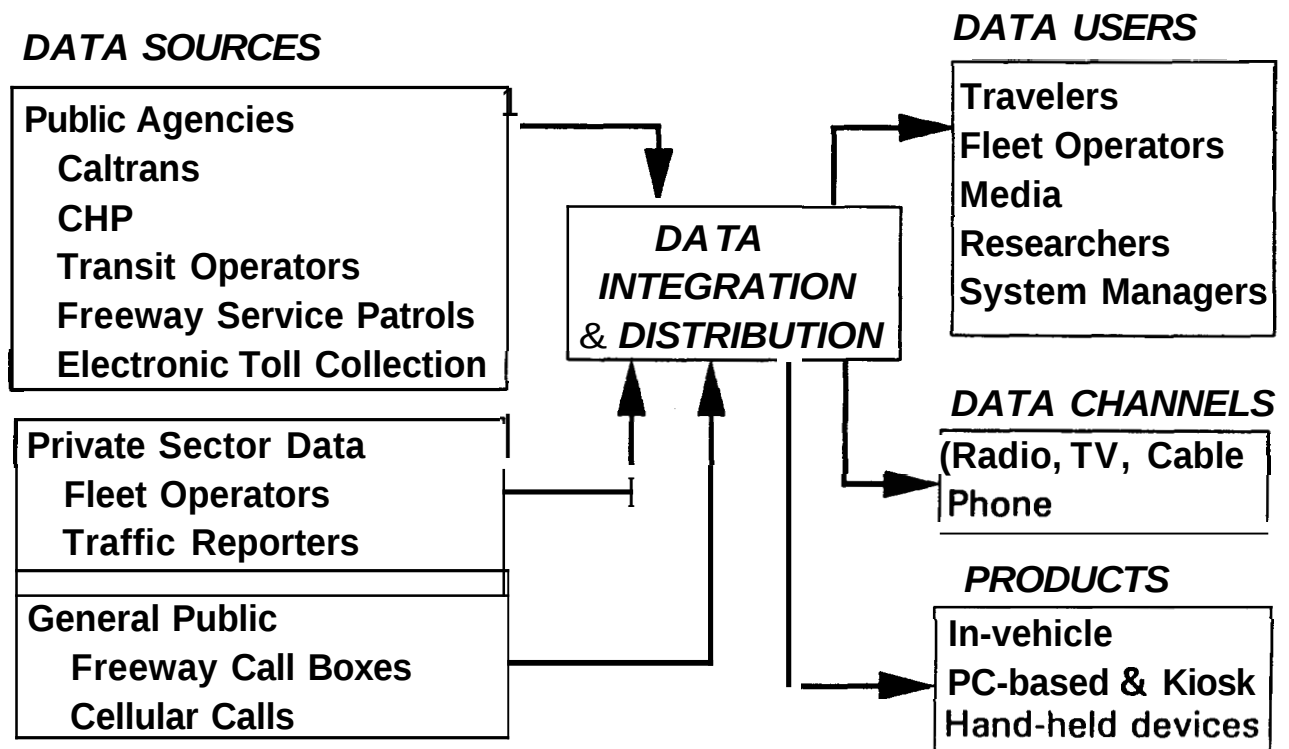
When complete, TravInfo will incorporate:

- 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 en** route stages.

The overall project structure is illustrated in Figure 1.

Figure 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.

12 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.

Y.B. Yim of PATH will serve as overall manager for the evaluation project. Dr. Yim will report to Randolph Hall, who will be responsible for coordination with PATH's overall research and testing program in Advanced Traveler Information Systems (ATIS). Asad Khattak will be responsible for the traveler response component of the study. Mark Miller will be responsible for technology assessment and Hong Lo 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.

13 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 TravInfo would become operational on January 1, 1995, an interim version of TravInfo would be operational on January 1, 1994, and that specific tasks outlined in this plan are subject to modification as the TravInfo project evolves over time.

1.4. Organization of report

This report consists of five major sections, including the introduction as Section 1. Section 2 describes the traveler response component of the evaluation plan. The institutional component of the evaluation is presented in Section 3. The technology assessment is given in Section 4. The system evaluation is described in Section 5.

2. TRAVELER RESPONSE

2.1. Purpose of the test

The purpose of the test is to measure changes in individual travel patterns that result from TravInfo, and traveler acceptance of and preference for TravInfo technologies.

The purpose of the test is directly related to **Goals** 1, 2, and 3.

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

To evaluate the effectiveness of ATIS technologies, it is necessary to understand the factors influencing traveler behavior, particularly the effect of information on route choice, departure time, trip chaining and mode choice. There is also a need to understand how travelers will respond to various technology attributes and how ATIS will influence pre-trip and en route decisions.

Traveler decisions may **be** strongly influenced by the technology through which they receive the information in addition to the content, format, type, attributes **of** TravInfo information they receive, as well as attributes of the alternatives, individual and trip characteristics, environmental conditions, and situational factors.

Key elements of the evaluation of TravInfo are to investigate general traveler behavior **as** well as the traveler response to ATIS devices and services. Potential market response to technologies will **be** assessed from interviews with test groups and through survey research.

2.3.1. Description of test

Bay Area travelers will be tested in terms **of**: a) their willingness to utilize TravInfo services, b) their awareness, preference, and acceptance of the advanced traveler information devices under TravInfo, and c) 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 behavioral impacts of the TravInfo project, a longitudinal panel of travelers will be used. By following individuals' behavior over the long-term, the impact of information technologies on strategic decisions such as mode choice, route choice, and departure time can be understood. A traveler panel will also provide an overall assessment of the study in the long-run.

2.3.2 Hypotheses

The hypotheses are directly related to Goals 1, 2, and 3.

1. Usage of TravInfo services

- a) 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.
- b) The extent to which travelers will use TravInfo depends on the quality of information and the method by which the information is disseminated.

2. 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.

3. 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, type of services, needs of customers, and format and availability of information.

4. Travel behavior

Bay Area travelers will respond to improved information by altering mode, route, departure time, and foregoing discretionary trips.

5. Benefits of TravInfo

- a) Bay Area motorists will benefit from TravInfo in terms of reduced travel time and reduced travel costs. Benefits will result from changes in travel **patterns** and mode under congested conditions and from a decrease in excess travel time to unfamiliar destinations.
- b) Travelers will have increased knowledge of travel options and be able to revise trip schedules, change routes, alter trip chaining, and choose travel mode.
- c) Even if travelers do not change their travel decisions, information services will reduce anxiety. A TravInfo type system will require a critical level of market penetration and system use to affect network efficiency.

233. Experimental design

The survey research method will be used to assess traveler response to, and perception of, the TravInfo project, and various information devices made available to the public. The large-scale survey will enable comparisons of before and after TravInfo. The panel survey will enable a study **of** individual behavior over time, and the impact of TravInfo information on strategic decisions, such as mode choice, auto ownership and relocation.

Two survey techniques will be employed: 1) a large-sample survey, administered annually (3 times total), and 2) a small sample panel survey, administered quarterly to a common group of 300-500 individuals. The large-sample survey will be conducted in a mail-out/mail-back format, while the panel survey will be administered by telephone interview (Figure 2). Ten thousand questionnaires will be distributed to randomly selected 10,000 Bay Area travelers.

The panel survey will include a one-day "information" diary that focuses on what information the individual motorist received and when he or she received it from what sources. Questions about route, departure time, trip purpose, and trip origin and destination will be asked in the panel questionnaire to **assess** the impact before and during

trips. Moreover, questions about information on congestion and alternative routes and modes will be included in the questionnaire.

2.3.4. Statistical method

The large survey sample will be taken from Bay Area motorists. The panel survey sample will be taken from a pool of the large sample survey respondents. Sample sizes for the large sample survey will be determined based on the required sample size for the panel surveys since the panel survey participants will be a subset of the large-sample surveys. From sampling theory, the basic question that needs to be answered is: How large must the sample size, "n", be to guarantee with a probability of $1-\alpha$ or level of confidence that the answer to a particular survey question differs from the views of the population at large by no more than a certain tolerance level, d? Since costs are an important factor in the analysis, the smallest possible "n" is desired to satisfy the above requirements. Commonly used values for both parameters are, $\alpha = 5\%$ and $d = 5\%$. The larger the confidence level or the smaller the tolerance level, the larger "n" must be. The value of "n" may be estimated by the following formula:

$$n = (z_{\alpha/2}/2d)^2$$
, where $z_{\alpha/2}$ is the value for the standard normal random variable, Z, such that the probability is $1 - \alpha$ that Z lies between $-z_{\alpha/2}$ and $z_{\alpha/2}$. Using this formula to estimate the panel sample size for a 95% confidence level, the sample size would be approximately 384, which is rounded up to 400 panel participants.

Some percent of the large survey participants will participate in the panel survey and there will be the loss of panel participants due to dropouts. Based on previous studies, a 30% attrition rate is estimated for the first panel, 25% for the second panel, and 20% for the third and final panel. To maintain a sample size of 400, it will be necessary to have an initial pool of approximately 800 willing participants.

To answer behavioral and policy questions, multivariate statistical techniques such as discrete choice modelling will be used. Multivariate techniques are superior to examination of variables independently because they compensate for interdependencies among explanatory variables.

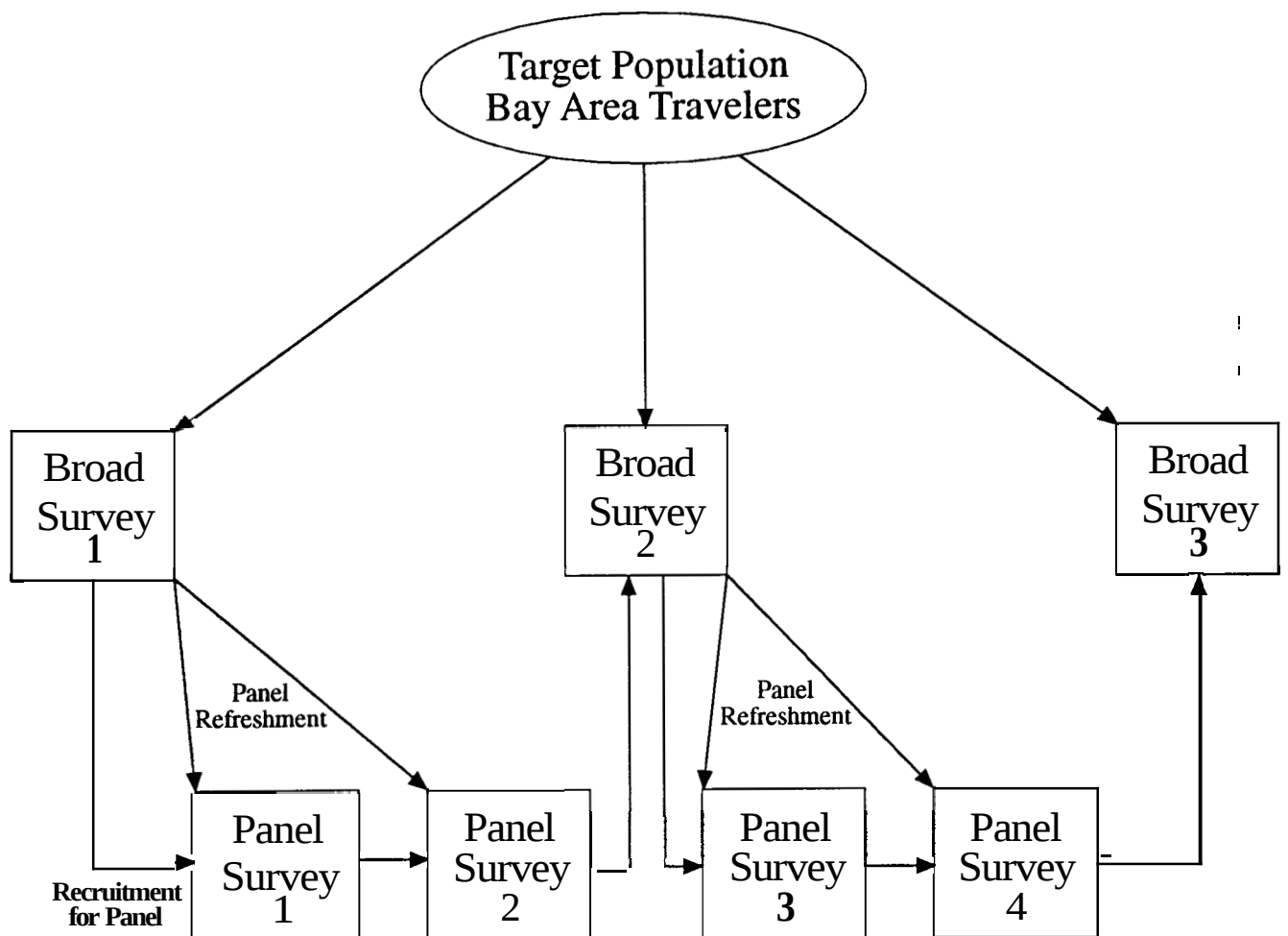


Figure 2. Design of Traveler Response Survey

2.3.5. Data collection method

The mail-out survey sample (large sample survey) will be taken from Bay Area residents according to zip code. Stratified sampling will be used to take samples for geographic coverage. The door-to-door survey method will be used for three large-scale mail surveys. Questionnaires will be distributed at randomly selected addresses for representative neighborhoods. The second and third large-scale mail surveys will be conducted among those who responded to the first survey. A panel survey sample will also be taken from a pool of mail survey respondents.

Assuming a typical response rate of **20%** among Bay Area motorists to the mail survey and an estimated 50% of respondents to the initial mail survey agreeing to participate in the panel survey (Yim, 1991; Yim, et al., 1992), the total number of surveys that need to be sent out is estimated to be 8,000. Based on this number of mail-out surveys, a conservative estimate of 10,000 broad surveys is made.

2.3.6. Test location and duration

The test will be conducted in the San Francisco Bay Area over a three year period. The Bay Area consists of nine counties; Alameda, Contra Costa, Marin, Napa, San Francisco, San Mateo, Santa Clara, Solano, and Sonoma.

2.3.7. Key conditions

The Bay Area transportation system is constrained by its geography. The narrow band of flat land between the San Francisco Bay and adjacent hills resulted in older urban growth. This urban core is served by a limited number of north-south freeways and rail lines. Major east-west facilities are concentrated in the passes through the hills in the East Bay and Peninsula. As a result, alternate freeway routes are limited.

2.3.8. Key assumptions

- a) A large number of vendors will participate in the experimental design of the TravInfo system.
- b) The survey participants will provide adequate information about their travel behavior.

2.3.9. Key constraints

The key constraints are: 1) 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) obtaining a sufficient number of respondents from surveys who have purchased ATIS products or devices.

2.3.10. Security considerations

Security considerations will be associated with information about vendors' marketing strategies and their customers.

2.3.11. Safety considerations

Safety considerations will be associated with the interface between the traveler and the information system. Information can be disseminated either visually or audibly or **both** visually and audibly. In-vehicle information displays may affect safety; accidents may result from distractions caused by ATIS displays. Accidents may be reduced through avoidance of hazardous conditions and reduced usage of paper maps.

2.3.12. Privacy considerations

Information on vehicle location and vehicle identification may need to be protected for the privacy of motorists. Survey questions or panel participation could be potentially invasive. Private firms may view this survey as interfering with their own market surveys.

2.3.13. Potential impacts on the operational system

The future operation of the TravInfo system will be improved because of the expanded knowledge of traveler behavior and market potential **as** well as the traveler being able to take advantage of excess capacity in the transportation system.

2.4. Test schedule

The test will begin in October 1993 and end in March 1996. The first large-scale mail survey will be conducted in October 1993, the second survey will be in October 1994, and the third survey will be in October 1995.

2.5. References

- a) Khattak, Asad, Haitham Al-Deek, Youngbin Yim, Randolph Hall, "Bay Area ATIS Testbed Plan," PATH Research Report, UCB-ITS-PRR-91.
- b) Bay Area Ad Hoc IVHS Committee, "TravInfo, Bay Area Intermodal Traveler Information System," October 16, 1992.
- c) Yim, Youngbin, "Electronic Toll Collection Study, San Francisco Bay Area," PATH Research Report UCB-ITS-PRR-90.
- d) Yim, Youngbin, Adib Kanafani, and Jean-Luc Ygnace, "Expanding Usage of Cellular Phones, Transportation and Economic Issues," PATH Research Report UCB-ITS-PRR-91.

2.6. Pre-test activities

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

2.7. Evaluation test activities

- a) Execute initial large-sample survey (October 1993).
- b) Analyze initial survey results and document in working paper (November 1993 - March 1994).
- c) Execute panel survey (quarterly, beginning October 1994, continuing to January 1995).
- d) Analyze panel survey results (ongoing, November 1994 - February 1995).
- e) Execute second large-sample survey (October 1994).
- f) Analyze second large-sample survey and compare results to initial large sample survey (November 1994 - February 1995).
- g) Execute third large-sample survey (October 1995).
- h) Analyze third large-sample survey and compare results to initial large sample survey (November 1995 - January 1996).

2.8. Post-test activities

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

2.9. Data reduction and analysis

The survey data will be analyzed in a **SPSSPC** environment. **SPSSPC** is statistical software which *can* be applied to frequency analysis and cross tabulation. The **data** analysis will include examination of: 1) similarities and differences in stated and revealed preferences relative to TravInfo, 2) motorist travel behavior in terms of route choice, mode shift, and departure time because of TravInfo, and 3) consumer attitude toward and market demand for TravInfo services.

2.10. Reporting requirements

Survey instruments for large-scale and panel surveys will be submitted to **FHWA** for approval prior to conducting surveys. The findings of the evaluation plan will be documented in the draft and final reports and submitted to transportation conferences and professional journals. Working papers will be prepared to document the survey results.

3. INSTITUTIONAL ISSUES

3.1. Purpose of the test

The purpose of the test is to examine the group dynamics and institutional effectiveness of the TravInfo organizations. The purpose of the test is directly related to Goals 1, 2, 3, and 4.

The hypotheses are directly related to Goals 1, 2, 3, and 4.

3.2. Overall test responsibility

The PATH research team will be responsible for evaluating the institutional aspect of the TravInfo project.

3.3. Overview

The success of the TravInfo project depends on the active participation of public, private, and academic partners. The TravInfo Field Operational Test will be implemented through a public/private partnership based on a flexible institutional arrangement. 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 supervising bodies of the TravInfo project are the Management Board, a three member board composed of representatives from key public agencies, the Advisory Committee, with membership open to any firm or agency that wishes to participate, and the Advisory Committee's Steering Committee, which is composed of thirteen individuals nominated by the Advisory Committee and selected by the Management Board. The purpose of creating these bodies is to capture a wide range of knowledge from the broader ATIS community, thus enabling more effective deployment of ATIS technology.

The TravInfo project and field operations test will be directed by the Management Board (MB) composed of Metropolitan Transportation Commission, Caltrans District 4 and the California Highway Patrol. Caltrans Headquarters New Technology Division, Federal

Highway Administration, Federal Transit Administration, PATH, and Chair of the Steering Committee will serve as ex-officio members of the Management Board. The MB is the policy setting body for all testbed activities, responsible for reviewing and approving procedures for the conduct of tests, and setting access restrictions to databases. The MB will have the ultimate authority for approval of TravInfo expenditures and the Advisory and Steering Committees will have no direct authority for setting testbed policy and procedures but will advise the MB on all issues. The TravInfo management plan exploits the unique experience and knowledge of both the private and public sectors, while giving primary managerial responsibility to the public sector.

3.3.1. Description of test

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. Public and private participants will be individually interviewed to elicit their perceptions regarding organizationaleffectiveness, identifying both the strengths and 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, to include liability and intellectual property issues. Based on this information, the evaluation team will suggest changes in institutional arrangements and management approach.

3.3.2. Hypotheses

The hypotheses are directly related to Goals 1, 2, 3, and 4.

1. Institutional aspects

- a) The availability of timely and accurate information about the Bay Area multi-modal transportation systems will stimulate the development and deployment of a variety of ATIS products and services.
- b) There will be a large number of ATIS vendors willing to both participate in the TravInfo Advisory Committee and to compete in the Bay Area ATIS market. The ATIS products under TravInfo will migrate to other regions and the TravInfo project will create new jobs in California, especially in the service sector.

- c) TravInfo will establish a common framework within which **ATIS** products *can* be developed and industries will adopt TravInfo standards for their products and services.

2. Organizational effectiveness

- a) The TravInfo management plan will create an organizational structure that 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) The TravInfo management plan will ensure that the traveler information is formatted and summarized in ways useful to **ATIS** commercial vendors and to the general public.
- c) The TravInfo organizational structure will provide incentives to the private sector to participate in the process of designing and implementing TravInfo Traveler Information Center (TIC) and will allow the Management Board to adhere to the project schedule and budget.

3. Public relations

The TravInfo FOT will encourage participation by the **ATIS** community in all policy issues and all aspects of system architecture, design, and implementation. A public relations and advertisement campaign oriented at the general public will be undertaken prior to and during the operations of the FOT.

4. 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.

5. 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.

3.3.3. Experimental design

The success of the TravInfo project depends on the institutional organization and on cooperation between the private and public sectors. The effectiveness of inter-organizational arrangements and procedures will be evaluated in terms of: 1) broad acceptance of the TravInfo project by local government 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 provision of local and regional employment opportunities, 5) the degree to which TravInfo interfaces and databases are accepted in other regions of the country, 6) the ability of TravInfo to satisfy the requirements of private product and service providers.

The TravInfo organizational structure and inter-organizational coordination will be documented and analyzed on the basis of: 1) leadership of the Advisory Committee and Management Board, 2) cooperation between private organizations and public agencies, and 3) project management ability of the Management Committee.

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.

3.3.4. Statistical method

The cross-tabulation statistical method will be used to measure associations between product line and product region; between TravInfo standards and stimulated products; between database access protocols and the product type.

3.3.5. Data collection method

For the institutional study, the major sources of data will be from meeting notes and memoranda prepared by participating agencies. Additional data will be solicited from active participants through telephone surveys and in-person interviews for suggested

changes in institutional arrangements and management approaches. The interviews will address the perceived direction of the TravInfo project and the expected outcome of the project. Confidential views on successes and failures will be assessed from the interviews.

Another data source will be the protocols and reports voluntarily filed by vendors needing access to the TravInfo database. Vendors and service providers will be encouraged to file a statement with a detailed description of the technology and how the information will be used, along with a marketing plan and prototype device. In addition, providers will be encouraged to file a quarterly statement specifying the number of users and any deviations from the initial plan.

3.3.6. Test location and duration

The test site will be the San Francisco Bay Area over a three year ~~period~~. However, interviews will be conducted with public and private sector representatives from outside of the Bay Area.

3.3.7. Key conditions

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

3.3.8. Key assumptions

- a) There will be a significant number of entrepreneurs wishing to use the TravInfo database.
- b) TravInfo will establish a common framework within which ATIS products *can* be developed and industries will adopt TravInfo standards for their products and services in the Bay Area.

3.3.9. 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 would require a significant amount of time. It can potentially delay the project schedule.

3.3.10. Security considerations

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

3.3.11. 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.

3.3.12. Privacy considerations

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

3.3.13. Potential impacts on the operational system

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

3.4. Test schedule

The test will begin in June 1993 and end in June 1996.

3.5. References

- a) Khattak, Asad, Haitham Al-Deek, Youngbin Yim, Randolph Hall, "Bay Area ATIS Testbed Plan," PATH Research **Report**, UCB-ITS-PR-92-1.
- b) Bay Area Ad Hoc IVHS Committee, "TravInfo, Bay Area Intermodal Traveler Information System," October 16, 1992.

- c) Yim, Youngbin, "Electronic Toll Collection Study, San Francisco Bay Area," PATH Research Report UCB-ITS-PR-90.

3.6. Pre-test activities

Develop institutional evaluation plan, format for interviews, set up **an** interview schedule, list meetings to attend (April-May, 1993; delivered as **part** of detailed evaluation plan).

3.7. Evaluation ~~test~~ activities

- a) Attend board and advisory meetings **as** an observer. (April 1993 - June 1996).
- b) Conduct initial wave **of** interviews with project participants, and prospective TravInfo partners (September - October 1993).
- c) Document findings from initial observations in a working paper (October - December 1993).
- d) Conduct the second wave **of** interviews (September - October 1994).
- e) Document findings from the second wave in a working paper (October - December 1994).
- f) Conduct the final wave of interviews (September - October 1995).

3.8. Post-test activities

Document institutional evaluation in a research report (March - June 1996).

3.9. 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.

3.10. Reporting requirements

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

4. TECHNOLOGY ASSESSMENT

4.1. Purpose of the test

The purpose of the test is to assess the performance of TravInfo system elements, both devices and services. This includes estimating the use of the TravInfo database, determining those technologies that are promising for improving travel conditions in the Bay Area, and measuring the performance of the TravInfo Traveler Information Center (TIC) hardware and software, with respect to such factors as reliability, operability, maintainability, and functionality.

The hypotheses are directly related to Goals 2 and 3.

4.2. Overall test responsibility

PATH 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 that 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 creates 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 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.

4.3.1 Description of 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 potential for full deployment. The information from vendors will also provide additional insights to 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 of 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** access publicly available information. Traveler response to the products and services will be quantified in terms of their usefulness and effectiveness.

4.3.2. Hypotheses

The hypotheses are directly related to **Goals** 2 and 3.

- a) The TravInfo project will provide practical experience to private vendors that 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.

4.3.3. 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.

4.3.4. 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.

4.3.5. Data collection method

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 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 section.

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 subscribers of 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.

4.3.6. Test location and duration

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

4.3.7. Key conditions

Under other efforts, the 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.

4.3.8. Key assumptions

- a) 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.
- b) 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 overlap will occur among phases.
- c) There will be a large number of vendors willing to enter the Bay Area market with various products and services.

4.3.9. 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.

4.3.10. 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.

4.3.11. Safety considerations

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

4.3.12. 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.

4.3.13. 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.

4.4. Test schedule

The test will begin in March 1994 and end in March 1996.

4.5. References

- a) Khattak, Asad, Haitham Al-Deek, Youngbin Yim, Randolph Hall, "Bay Area ATIS Testbed Plan," PATH Research Report, UCB-ITS-PR-92-1.
- b) Bay Area Ad Hoc IVHS Committee, "TravInfo, Bay Area Intermodal Traveler Information System," October 16, 1992.

4.6. Pre-test activities

- a) Explore with the TravInfo Management Board and Advisory Committee the policy for vendor participation and access to TravInfo. (September - December 1993)
- 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.

4.7. Evaluation test activities

- a) 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).
- b) Analyze panel survey results with respect to technology performance (November 1995 -February 1996).
- c) Analyze performance of TravInfo software and hardware (November - December 1995).
- d) Analyze data from protocol statements to track technology trends (September - December 1995).

4.8. Post-test activities

Document technology performance (January - March 1996).

4.9. Data reduction and analysis

Vendor product data will be analyzed with respect to the taxonomy presented in Figure 3, 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.

4.10 Reporting requirements

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

5. SYSTEM PERFORMANCE

5.1. Purpose of the test

The purpose of the test is to measure changes in system level performance in the areas of network traffic and the environment. The purpose of the test is directly related to **Goal 3**.

The hypotheses are directly related to **Goal 3**.

5.2. Overall test responsibility

Caltrans will be responsible for furnishing traffic data before and after implementation of the TravInfo project. **PATH** will be responsible for conducting analysis of the data.

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 will consider 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.

5.3.1. Description of 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. The models employed 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, oxides of nitrogen).

5.3.2. Hypotheses

The hypotheses are directly related to Goal 3.

- a) 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.
- b) 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.
- c) The Bay Area air quality will be improved from decreased automobile **trips** and reduced congestion.

5.3.3. 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.

5.3.4. 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.

5.3.5. Data collection method

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. The 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.

5.3.6. ~~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.

5.3.7. Key conditions

Traffic data prior to TravInfo implementation needs 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.

5.3.8. 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 the pre-TravInfo travel patterns in the Bay Area.

5.3.9. 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 local economy, legislation, or new technology development will **be** difficult.

5.3.10. Security considerations

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

5.3.11. Safety considerations

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

5.3.12. Privacy considerations

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

5.3.13. Potential impacts on the operational system

The impacts would include improved operational efficiency and traffic monitoring.

5.4. ~~Test~~ schedule

The test will begin in March 1994 and end in March 1996.

5.5. References

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

5.6. Pre-test activities

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

5.7. Evaluation test activities

- 1) Collect freeway network performance data (April 1994 - September 1995).

- 2) Investigate network models for simulation/evaluation of changes in network performance (April **1994** - October **1994**).
- 3) Document modeling approach in **a** working paper (November - December **1994**).
- 4) Perform simulations and evaluations, using survey results and network performance data **as** input (October - December **1995**).

5.8. Post-test activities

Document system performance results (**January** - March 1996).

5.9. 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 comparison 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.

5.10. Reporting requirements

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