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Authors

Miller, Mark
Hall, Randolph

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TravInfo Field Operational Test Traveler Information Center (TIC) Study (Technology Evaluation Element) Implementation Plan

Mark A. Miller
Randolph Hall

ABSTRACT

TravInfo is a Field Operational Test (FOT) sponsored by the Federal Highway Administration (FHWA) of the United States Department of Transportation. Over its three-year lifetime, TravInfo's goals are to implement a centralized traveler information center to collect, integrate, and broadly disseminate timely and accurate traveler information throughout the San Francisco Bay Area through a public/private partnership. California PATH at the University of California at Berkeley has been commissioned to perform a formal evaluation of this FOT.

The evaluation of TravInfo consists of four elements: institutional, traveler response, network performance, and technology. One element of the technology component will consists of an evaluation of the effectiveness of the Traveler Information Center (TIC), referred to as the "TIC study". The TIC is TravInfo's hub for data collection, processing, and dissemination. Thus the TIC study will focus on TravInfo's overall goal of implementing a system of collecting, integrating, and broadly disseminating timely and accurate traveler information throughout the Bay Area.

The TIC study will consist of four components: system reliability, operator interface, communications interface, and response time. System reliability will examine system failures, including their initial symptoms, causes, and duration, especially during times of stress on the system. Operator interface will investigate the human element by considering the full extent of the role of the operator in the flow of information through the TIC, the operators' tasks and responsibilities required to perform these tasks, and the operators' physical working environment. The communications interface will examine the constraints on the flow of information between the TIC and the outside world. The response time element will investigate response times of information through the TIC, especially during times of system stress.

EXECUTIVE SUMMARY

TravInfo is a Field Operational Test (FOT) sponsored by the Federal Highway Administration (FHWA) of the United States Department of Transportation. Over its three-year lifetime, TravInfo's goals are to implement a centralized traveler information center to collect, integrate, and broadly disseminate timely and accurate traveler information throughout the San Francisco Bay Area through a public/private partnership. California PATH at the University of California at Berkeley has been commissioned to perform a formal evaluation of this FOT.

The evaluation of TravInfo consists of four elements: institutional, traveler response, network performance, and technology. One element of the technology component will consists of an evaluation of the effectiveness of the Traveler Information Center (TIC), referred to as the "TIC study". The TIC is TravInfo's hub for data collection, processing, and dissemination. Thus the TIC study will focus on TravInfo's overall goal of implementing a system of collecting, integrating, and broadly disseminating timely and accurate traveler information throughout the Bay Area.

The TIC study will consist of four components: system reliability, operator interface, communications interface, and response time. System reliability will examine system failures, including their initial symptoms, causes, and duration, especially during times of stress on the system. Operator interface will investigate the human element by considering the full extent of the role of the operator in the flow of information through the TIC, the operators' tasks and responsibilities required to perform these tasks, and the operators' physical working environment. The communications interface will examine the constraints on the flow of information between the TIC and the outside world. The response time element will investigate response times of information through the TIC, especially during times of system stress.

Each of the four elements are discussed relative to three characteristics: relationship to TIC acceptance testing, data collection, and data analysis. TIC system requirements have been developed by TRW/ASG and include (1) subsystem functional requirements for data acquisition, data processing, and data dissemination, (2) data storage requirements, and (3) input parameter requirements for each data source. Acceptance testing will be conducted by MTC to determine whether all such requirements are satisfied. The TIC study will not duplicate or substitute for MTC's task, but, rather, to assess the effectiveness of the TIC. During the course of the TIC study, it will be possible to determine if, in actual operation, some system requirements are not satisfied. Even if compliance with all system requirements is met, the TIC's performance may still not be problem-free, effective especially under stressful conditions, or provide satisfactory service to customers. *An* important distinction between the TIC study and acceptance testing is that the former is more of an on-going examination of the performance of the TIC throughout the FOT, while the latter is a test that could be completed before the TIC goes on-line. Furthermore, the examination of the TIC will occur at a higher level than that for acceptance testing.

Data will be collected by numerous means including through (1) the TIC with the assistance of the TIC operations' staff, (2) a review of all relevant TIC documentation produced by TRW/ASG, (3) discussions and interviews conducted with TRW/ASG and TIC operations' staff including

questionnaires, and (4) observations of TIC operations. The data collected from within the TIC will be through either manual or computer-assisted means. The TIC evaluator team at PATH will have access to the TIC electronically in order to facilitate the electronic retrieval of files containing electronically-generated logs.

Data analysis will be performed for all four components of the TIC study. In the case of system reliability, the objective of the analysis is to understand the relationship between the number and frequency of failures and the duration of failures relative to other failure attributes, as well as changes exhibited over the course of the FOT. For the operator interface component, the objective of the analysis is to (1) determine the operator's role in the flow of information in the TIC and the identification of potential operator bottlenecks in the TIC information flow, (2) identify those operator job responsibilities and tasks that could directly affect the flow of information, and (3) identify the extent to which the operator workstations, that is, the TIC and operator interfaces, and the working environment support the operator in performing his/her job. Investigating this level of support will assist in understanding the overall TIC performance and effectiveness and enable recommendations to be made to make improvements in overall TIC performance where needed. For the communications interface component of the TIC study, the objective of the analysis is to understand the relationship between the volume of calls into the TIC and other factors including traffic conditions, time-of-day, and day-of-week over the course of the FOT. For the response time element of the TIC study, the objective is to understand the relationship between incident response times and other factors including incident type, time-of-day, and day-of-week. Output of the analysis will be presented in both tabular and graphical form.

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1. INTRODUCTION

TravInfo is a Field Operational Test (FOT) in the San Francisco Bay Area. TravInfo will implement a comprehensive regionwide system that integrates and processes transportation information from multiple sources and disseminates the information through both public and private channels. TravInfo's primary goals are to:

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

(2)   Stimulate and support the deployment of a wide variety of Advanced Traveler Information System (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 improved travel information, changes in individual travel behavior, and the impact on overall transportation system performance.

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

The evaluation of TravInfo consists of four elements: (1) Institutional, **(2)** Traveler Response, (3) Network Performance', and (4) Technology *(1,2)*. This document provides the implementation plan for one part of the technology element -- the "TIC (Traveler Information Center) study" -- and discusses how the TIC study will be coordinated with other evaluation elements.

The TIC is TravInfo's hub for data collection, processing and dissemination. Hence, the focus of the TIC study is on TravInfo goal (1). The study will consist of four components:

System Reliability will examine system failures, including their initial symptoms, causes, and duration, especially during times of stress on the system (e.g. major incidents).

Operator Interface will investigate this human element by considering the full extent of the role of the operator in the flow of information through the TIC, the operators' tasks and responsibilities required to perform these tasks, and the operators' physical working environment.

Communications Interface will examine the constraints on the flow of information between the TIC and the outside world.

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[1] This element of the evaluation is currently under discussion. If it is canceled, then less data will be required to be collected within the Response Time element (See Section 5.2.2).

Response Time will investigate response times of information through the TIC, especially during times of system stress.

The components have strong linkages to each other, since (1) TIC response times depend on system reliability; (2) TIC response times depend on the level of support provided to the operator by TIC/operator interfaces as well as the efficiency with which operators carry out their job responsibilities; (3) Operator performance may influence or remedy system or subsystem failures; (4) Communications interface problems affect response times; and (5) Operators have a substantial role in preparing outgoing messages for dissemination through the communications interface.

The TIC study also has linkages to other evaluation elements and studies:

Target Study[2] (Traveler Response Element) When target surveys are conducted on the U.S. 101 corridor, detailed TIC logs related to that incident will be used to reconstruct the event and better interpret the target survey responses.

TATS Study (Traveler Response Element) The TATS survey will measure user response to TATS services and determine the profile of individuals who access, acquire, and use information available through TATS. Information from these surveys will be combined with data collected within the TIC study on call volume and caller waits.

Network Performance Element[3] Detailed logs collected for the target study (including location, duration and severity of incidents) will be used to model highway delays during and after case-study incidents on U.S. 101.

VAR Study (Technology Element) The VAR (Value Added Reseller) study will measure the effectiveness of TravInfo with regard to development and distribution of new ATIS (Advanced Travel Information Systems) products and services. The VAR study will also assess VARs' satisfaction with the TIC.

The TIC study is also related to acceptance testing that will be conducted by MTC. TIC system requirements have been developed by TRW/ASG and are documented in *(3)*. They include the following:

- subsystem functional requirements for data acquisition, data processing, and data dissemination

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[2] This element of the evaluation is currently under discussion. If it is canceled, then less data will be required to be collected within the Response Time element (See Section *5.2.2*).
[3] This element of the evaluation is currently under discussion. If it is canceled, then less data will be required to be collected within the Response Time element (See Section 5.2.2).

- data storage requirements

- input parameter requirements for each data source (e.g. event operators, Caltrans' mini-TOS, and regional transit operators);

The purpose of the acceptance testing is to determine whether all such requirements are satisfied. The TIC study performed by PATH is not intended to duplicate, or substitute for, MTC's acceptance testing, but, rather, to assess the effectiveness of the TIC. During the course of the TIC study implementation, however, it will be possible to determine if, in actual operation, some system requirements are not satisfied. Even if compliance with all system requirements is met, this does not imply that the TIC's performance will be (1) problem-free, *(2)* effective, especially under stressful conditions, such as a major accident, and (3) provide satisfactory service to the customers (e.g. travelers and VARs). Furthermore, an important distinction between the TIC study and acceptance testing is that the former is more of an on-going examination of the performance of the TIC throughout the FOT, while the latter is a test that conceivably will[4] be completed before the TIC goes on-line. Moreover, the examination of the TIC will occur at a higher level than that for acceptance testing.

The remainder of this document describes the four study components in detail. A *summary* of these components is provided in Table 1, indicating timing and responsibilities for PATH, the TIC Operator and TRW/ASG. Under the column "OPERATOR INTERFACE", references to "Phase I", "Phase 11", and "Phase 11l" refer to the elements of the Operator Interface component. All three elements are described in Sections 3.3.1-3.3.3.

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[4]The exact nature of the acceptance testing regimen is not yet completely determined.

Table 1

TIC Study Data Collection: Timing and Responsibilities

	SYSTEM RELIABILITY	OPERATOR INTERFACE	COMMUNICATIONS INTERFACE	RESPONSE TIME
TRWIASG	1. Assign to PATH an account number for TIC electronic files of computer/operator generated failure (maintenance) logs 2. Design logs for electronic transfer and format manual log sheets before TIC startup	1. Be available for discussions with PATH (Phase I & II)	1. Ensure TIC installs call reporting software and captures call-related data 2. Design electronic logs **of** call-related data for electronic transfer to PATH before TIC startup	**1.** Design TIC so that electronic response time logs are generated and prepared for electronic transfer to PATH 2. Design TIC so that all incident time logs are saved for at least **48** hours throughout FOT
TIC OPERATOR	1. Fill out paper and computer-assisted failure logs for all failures (See Table 2) 2. Send to PATH paper failure logs monthly 3. Place electronic logs in PATH files for monthly retrieval	1. Fill out PATH-prepared questionnaire (Phase I & II) 2. Available for follow-up interview w/ PATH, as necessary **3.** Discussions w/ PATH (Phase III) as necessary	1. Place electronic logs in PATH files for monthly retrieval	1. Place electronic logs in PATH files for retrieval every **6** months
PATH	1. Retrieve files of computer-aided logs electronically on monthly basis **2.** Import files (electronic & paper) into PATH database	1. Prepares questions for operators (Phase **I & 11)** 2. Review TRWIASG TIC documentation 3. TIC site visits **4.** Conduct discussions with operators	1. Retrieve files electronically on monthly basis **2.** Import files into PATH database **3.** Interview VARs, Vendor Server (DBS link) and data input sources	1. Retrieve files electronically every six months 2. Import files into PATH database
TIMING	CONTINUOUS	Phase **I & 1l:** WITHIN **6** MONTHS OF STARTUP Phase III: EVERY **6** MONTHS	CONTINUOUS VAR INTERVIEWS: (1 OR 2 WAVES)	TWO WEEK PERIOD EVERY **6** MONTHS

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2. SYSTEM RELIABILITY

This section provides the details to evaluate system reliability, including measures of effectiveness (MOE), data collection, and data reduction and analysis. The goal of this component of the evaluation is to gain an understanding of TIC reliability and thereby also its availability and maintainability.

2.1   Relationship To TIC Acceptance Testing

The TIC system requirements are listed in (3), of which the following four requirements are applicable to the system reliability component of the TIC study:

- TravInfo/TIC system shall be capable of demonstrating a mean time between failure (MTBF) of at least 600 hours when operated in an air conditioned environment
- Average response time for critical hardware/software failures shall be 30 minutes and restoration of system operation shall average 60 minutes
- Response time for all failures shall average no longer than four hours
- Mean time to repair (MTTR) for all failures shall not exceed four hours from the time the maintenance personnel and spare parts are on site

These requirements relate to the frequency and duration of failures. While the evaluation of system reliability also deals with these two parameters, more than just failure frequency and duration data will be collected and analyzed. The resulting investigation of failure frequency and duration will be more detailed than a basic verification of compliance with an MTBF or failure duration requirement as there will be an on-going data collection effort over the entire FOT period as well as an analysis of failure frequency and duration with respect to other failure-related data (See Section **2.3 Data Analysis** below).

2.2   Data Collection

This section presents both the types of data that need to be collected and the schedule for collection during the FOT.

2.2.1   Data Types

The reliability component will study the occurrence of failures, where a failure is defined as the inability of a TIC subsystem or component to perform its intended function. Table 2 below lists the data requirements for each failure.

Table 2

Failure Attributes and Values

Failure Attributes	Attribute Values
TIC functional subsystem	Acquisition, Processing, Dissemination
TIC hardware component	Voice Grade Line I/O in Acquisition subsystem Frame Relay I/O Data Base Workstation Operator Workstation LDS Workstation Voice Grade Line I/O in Dissemination subsystem TATS
TIC software subsystem	DataIn Admin Data View DataOut TranSys TransEvnt
Symptoms	text describing signs of failure
Cause	text describing reasons for failure
Impact	text describing status of TIC during failure
Action	text describing actions taken to repair failure
Date	day, month, and year
Time-Of-Day (T-O-D)	hour and minute for both failure detection and correction based on 24-hour clock

The first three attributes address the issue of where in the TIC the failure occurred: functionally, physically, and logically. The next three attributes enable a complete failure profile to be developed, and the last two characteristics enable the duration of the failure to be calculated.

These data are important to completely understand the causes of system failures. Without such data, recurring failure patterns could go unexplored and unexplained, for example, similar failure occurrences over time in the same location within the TIC (functional, physical or logical) during especially stressful conditions. These data are also valuable in the case of a failure in which there is no negative impact downstream, i.e. it goes unnoticed by travelers or VARs. Nevertheless, it still may be important to determine what actions were taken to insure that there was no delay in disseminating the integrated information to the customer. Having the necessary information allows the linkage with the operator interface component of the evaluation to be better understood, that is, to learn whether or not the operators on duty took extraordinary actions to insure no downstream delay and hence no customer dissatisfaction.

Primary MOEs are the following:

1. number of failures
2. frequency of failures
3. duration of failures (failure duration is defined as the time between its detection and correction)
4. change in 1. through **3.** over time.

Raw failure data from the TIC will be in the form of manual or computer-aided logs (See Section 2.2.2 Data Collection Schedule below). **A** database of failures will be developed at PATH for analysis. **A** description of the database's record of failures with the data attributes (Table 2) is provided in Table 3, providing a hard-copy template version of the electronic database presented in a single form. Table 4 contains the values that would be entered into the data fields described in Table 3. It is, however, recommended that failure logs (manual or computer-aided) be generated at the TIC in a two-step process. The first step is a log for the detection of failures, containing:

1. date
2. time-of-day detected
3. initial symptoms of failure

The second step is a log for the correction of the failure, containing:

1. date
2. time-of-day corrected
3. functional subsystem
4. hardware component
5. software subsystem
6. cause
7. impact
8. action

Since these logs are generated at different times and possibly multiple operators provide input for the same failure, correction logs must be matched with detection logs to form a single record of the failure.

Table 3

TIC Failure History Profile Database

REC NUM	FUNC. SUBSYS.	HARDWARE	SOFTWARE	SYMP-TOMS	CAUSE	IMPACT	ACTIONS	T-O-D (detected)	T-O-D (corrected)	DATE
1										
2										
3										
4										
5										
...										
...										
...										
N-1										
N										

Table 4

Data Field Entries

Field Name	Data Entry	Data Type
RECORD NUMBER	Sequential numbering of records	Numeric
FUNCTIONAL **SUBSYSTEM**	A (Acquisition), P (Processing), or D (Dissemination)	Alphabetic
HARDWARE COMPONENT[a]	V_A (Voice Grade Line I/O in Acquisition subsystem) F (Frame Relay I/O) D (Data Base Workstation) O (Operator Workstation) L (LDS Workstation) V_D (Voice Grade Line I/O in Dissemination subsystem) T (TATS) — (No failure)	Alphanumeric

[a] Source: Top Level System Design Deliverable 4.1.12-Revision 1 by TRW/ASG

Field Name	Data Entry	Data Type
SOFTWARE **SUBSYSTEM**[b]	I (DataIn) A (Admin) V (DataView) O (DataOut) T (TranSys) E (TransEvnt); — (No failure)	Alphabetic

[b] Source: Top Level System Design Deliverable 4.1.12-Revision 1 by TRW/ASG

Field Name	Data Entry	Data Type
SYMPTOMS	Text briefly describing first signs of failure	Alphanumeric
CAUSE	Text briefly describing reasons for failure	Alphanumeric
IMPACT	Text briefly describing status of system during failure	Alphanumeric
ACTIONS	Text briefly describing actions taken to repair failure	Alphanumeric
TIME-OF-DAY	hh:mm (24-hour clock) for failure detection and correction	Numeric
DATE	mm/dd/yy	Numeric

2.2.2 Data Collection Schedule

The major issues relative to the schedule for collecting the required data are the (1) form of the raw data and (2) transfer of the data to PATH.

It has not yet been decided whether TIC operators will record data manually (pen and paper) or electronically. It is unlikely that the TIC computer will automatically generate records[5]. The exact nature of the setup of maintenance logs is essential to help determine how data get transferred from the TIC to PATH and to accurately assess the level of effort required at PATH to prepare the data for analysis.

Hardcopy generated logs should be transferred to PATH monthly for input into the database, and for verification purposes. Sending the logs to PATH would be the responsibility of the TIC operations staff. Such evaluation-related responsibilities by the TIC operations staff must be explicitly stated in the TIC operator's contract. TRW/ASG will set up an account for PATH in which files generated with computer assistance required for the system reliability evaluation, that is, the failure data that is documented electronically, will be deposited by the TIC operations' staff for subsequent electronic retrieval by PATH (monthly). Electronic logs will be located at the TIC and operator maintained. It must be checked whether the same failure data is collected by multiple sources, for example, both manually and by computer. If such data collections occur, then these data must be examined to identify and resolve all discrepancies.

2.3   Data Analysis

Failure attributes, including (1) causes, (2) impacts, and (**3**) repair actions, will initially be aggregated into appropriate categories for each of these three failure attributes to help make further failure data analysis and presentation of results more tractable and understandable. For example, there could be three categories of impacts consisting of (a) none, (b) minor, and (c) major.

Subsequent data analysis will be performed employing appropriate statistical methods. The objective is to understand the relationship between the number and frequency of failures and the duration of failures relative to other failure attributes, as well as changes exhibited over the course of the FOT. Output will be presented in both tabular and graphical form. The number and duration of failures may vary by the failure attributes listed in Table 2. A sample of the graphical analyses to be performed are listed as follows:

- plot of number of failures by week

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[5] Based on discussions with **TRWIASG.**

- o   plots of number of failures by week for each functional subsystem, hardware component, and software subsystem
- o   plot of average failure duration by week
- o   plots of average failure duration by week for each functional subsystem, hardware component, and software subsystem
- o   distribution of impact of failures (e.g. none, minor, major) illustrated by pie chart
- o   distribution of causes of failures illustrated by pie chart
- o   distribution of repair actions taken illustrated by pie chart

3.   OPERATOR INTERFACE

The human operator is integral to the functioning of the TIC. Thus, an evaluation of this human element and the extent to which the TIC supports human tasks is essential to obtain a complete picture of the performance of the TIC.

3.1   Relationship To TIC Acceptance Testing

The TIC system requirements are listed in (*3*), of which the following four requirements are related to the operator interface component of the TIC study:

- TATS[6] database shall allow a human operator to view and update all information on the system
- TATS shall provide a human-computer interface for the human operator that is menu-driven and operator friendly
- TATS shall provide a screen for data entry by a human operator, including pull-down menus and automatically filling in of text fields, that minimize keystrokes and screen clutter
- Operator personnel shall be experienced in the "hands on" operation of computer based, console operated, communication and information processing systems.

These requirements relate to very basic and elementary human-computer interface functions.   The evaluation of the operator interface component of the TIC study will examine the entire relationship between the human operator and the TIC.   The evaluation will have the following three principal components:

- Information Flow Analysis
- Task Analysis
- Interfaces and Working Environment

The primary objectives of these three areas of investigation are listed in Table 5 and are phrased in terms of answering core questions.

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[6]TATS = Traveler Advisory Telephone System, will be examined in Section **4:** Communications Interface.

Table 5

Objectives of TIC Operator Interface Analysis

Area of Investigation	Core questions to be Answered
Information Flow Analysis	Where does the operator fit in the flow of information in the TIC; i.e. what is his/her role?
Task Analysis	Given the TIC operator's role, what are his/her tasks and job responsibilities?
Interfaces and Working Environment	How does the operator relate to his/her working environment? How do the interface and working environment support the operator in performing his/her job? What recommendations can be made for improvement?

3.2 Data Collection

This section presents the evaluation of the TIC/operator interface will involve observation, discussions, and interviews with both the TIC operators and their supervisors.

3.2.1 Data Types

In order to answer the core questions listed above with respect to this section of the TIC evaluation, the following information will be required:

- Flow of information through the TIC
- Points of operator interface in the flow of TIC information
- Operator tasks, responsibilities to perform these tasks

3.2.2 Data Collection Schedule

Data will be collected within the first six months after the startup of the FOT for the Information Flow Analysis and Task Analysis components. Information will be collected at six month intervals to conduct the Interfaces and Working Environment component (See Sections 3.3.1-3.3.3).

3.3   Data Analysis

The analysis portion of the Operator Interface element of the TIC study is discussed in terms of the three principal components outlined above.

3.3.1   Phase I: Information Flow Analysis

The first stage in the TIC/operator interface evaluation will consist of an information flow analysis. The objective is to determine the operator's role in the flow of information in the TIC. The investigation of the operator's role is described in the subsequent section on Task Analysis.

The operator's role will be ascertained in the following three steps:

Step 1:   Determine all possible data/information flows into and out of the TIC.
Step 2:   For each data/information flow, determine all points of operator interface.
Step 3:   For each point of operator interface, determine the level of attention required by the operator to detect arrival of data/information, and in general to perform his/her job responsibilities in handling such data and information.

The level of attention required by the operator will be aggregated into a few discrete categories, e.g. (1) no operator attention required, with automatic and continuous data transfer, (2) predictable timetable for data arrival requiring minimal operator attention until the anticipated time of arrival, and *(3)* intermittent and uncertain timetable for data arrival, thus requiring the operator to monitor and detect the arrival of new data to enter it into the system or otherwise process it.

This three-step procedure will assist in identifying the operator role in the overall functioning of the TIC and in locating potential operator chokepoints in the flow of information within the TIC. The information required for this analysis will be obtained through (1) discussions with TRW/ASG and a review of TIC system documentation, and (2) TIC operator responses to an evaluator prepared short list of questions based on steps **1-3** above, with follow-up interviews with operators conducted when necessary[7].

A complete understanding of the flow of information through the TIC, i.e. the results of this analysis, will include all significant information flow parameters such as data sources, communication method used for data transfer, all operator interface points, and data transfer controls at all such points (See Table 6 for an example of such significant information flow analysis parameters).

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[7]Operator involvement in collection of information for evaluation must be incorporated into operator contract.

Table 6

Information Flow Analysis Parameters

DATA SOURCE	DATA NAME	COMMUNICATION METHOD	TRANSFER CONTROLS	INITIAL RECEIVER	FLOW PATH	FINAL DESTINATION
SOURCE 1						
SOURCE 2						

...						
SOURCEN						

3.3.2 Phase 1l: Task Analysis

The second phase in the TIC/operator interface evaluation will consist of an assessment of operator tasks and job responsibilities. This phase builds upon the results of Phase I and will gain insight into the operator's role by determining how the operator interacts with the system and the data flow within the system. Whereas Phase I will have identified potential operator bottlenecks in the TIC information flow, the objective of Phase II is to identify those operator job responsibilities and tasks that could directly affect the flow of information. There is an expected strong link between the operator's responsibilities and information flow within the TIC and hence overall TIC performance and effectiveness.

This work will be achieved in the following two steps:

Step 1:   Identify which operator tasks are significant to maintaining the flow of information through the TIC.

Step 2:   For each identified operator task, determine the exact nature of the operator responsibilities to perform that task. The following list of questions will assist in determining operator job responsibilities:

- What are the cues that signal the operator that data or information requiring some operator action is about to appear?
- What subtask(s) need to be performed?
- What, if any, decision support tools assist the operator in completing the task?
- What difficulties are there in performing the task?
- What is the frequency of performing this task?
- What are the consequences of not performing or completing the task?
- What are the performance indicators used by the operator to conclude whether or not the task was done correctly and successfully completed?

The information required will be obtained through discussions with TRW/ASG and TIC operator responses to an evaluator prepared short list of questions based on steps 1 and 2 with follow-up interviews with operators conducted when necessary, and will commence after Phase I is complete[8].

'Operator involvement in information collection for evaluation must be incorporated into operator contract.

3.3.3   Phase 1ll: Interfaces and Working Environment

The third phase will consist of an analysis of the TIC/operator interfaces and the operator working environment and how they support the operator in performing his/her tasks. This phase builds upon the **task** analysis activity **as** it (Phase II) will have provided the background information required to perform Phase III work and assists in identifying factors that affect TIC information flow. The objective of Phase III is to identify the extent to which the interfaces and the working environment support the operator in performing hisiher job. Investigating this level of support will assist in understanding the overall TIC performance and effectiveness and enable recommendations to be made to make improvements in overall TIC performance where needed.

The TIC/operator interfaces are the operator workstations which link the operator to the TIC computers and databases. This work will be achieved in the following three steps:

Step 1:   Develop criteria, including design objectives and interface features, against which the operator workstations, i.e. the interfaces, will be evaluated vis-a-vis their level of operator support. Source material to help perform this task may be found in (*4*, *5*, *6*) as well as site visits to the TIC.

Step 2:   Develop analogous criteria against which the operator's working environment, outside the workstation boundary, will be evaluated as in Step 1. Again, source material to help perform this task may be found in (*4*, *5*, 6) and site visits to the TIC.

Step **3:**   Perform evaluation of both interface and working environment by assessing the degree that the above criteria are satisfied.

The evaluations will be assessed through on-site observations and inspections by the evaluator team and discussions with individual operators. The operator interviews will enable the evaluator to probe deep into the operators' appraisals of the interface and surrounding working environment. This work will be performed at six-month intervals throughout the FOT, enabling observations to include the time period once the operators have become proficient with their job responsibilities, that is, under "steady-state" conditions.

4. COMMUNICATIONS INTERFACE

The TIC consists of three primary functional components, namely, data acquisition, data processing, and data dissemination. Within the data acquisition subsystem, the TIC will receive data from numerous sources such as Caltrans' mini-TOS, event operators, transit agencies, local jurisdictions, weather agencies, and possibly others. Within the data dissemination functional subsystem, the TIC transmits information that has been processed for eventual public consumption. The following schematic diagram displays the general communication linkages into and out of the TIC:

Figure 1

TIC Communication Linkages

INCOMING DATA   **OUTGOING DATA**

| Caltrans mini-TOS | Hi-speed Phone Line (leased) → | **T I C** | TATS | Phone Lines (dial-up) ↔ | Travelers |

(figure)
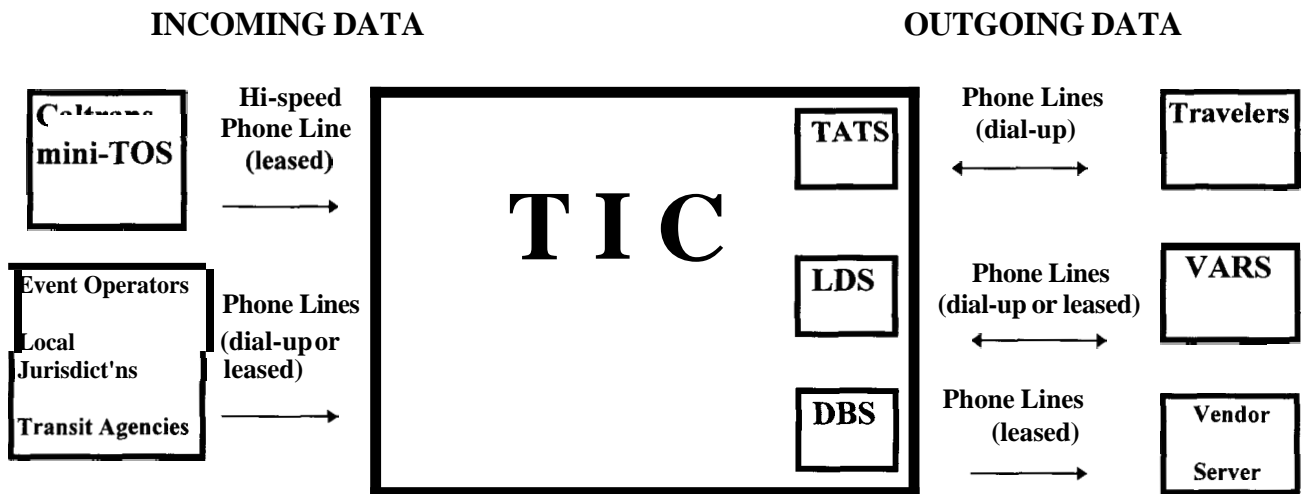
The objective of the evaluation is to examine the level of service the TIC provides to the outside world (input data sources and output information recipients), and hence how satisfied the outside world is with this service. The primary communications interface is through telephone lines, either through dial-up (shared) lines or leased (dedicated) lines (Figure 1). Other communication media, however, will be used. In fact, the final linkages between event operators, local jurisdictions, and transit agencies and the TIC are likely to be primarily faxes, mail, phone (voice), and hardcopy.

The evaluation will focus on the following remaining linkages because these connections will have dial-up phone lines which require incoming calls to share the line and may result in communication delays. The TATS–Travelers' connection is exclusively dial-up telephone lines, whereas the LDS–VARs linkage may be through dial-up or leased lines:

- TATS–Travelers
- LDS–VAR

4.1 Relationship to Acceptance Testing

The TIC system requirements are listed in (*3*), of which the following requirements are related to the communications interface component of the TIC study:

The TATS system shall

- Provide access through a phone number accessible throughout the Bay Area
- Ensure that service requests shall be completed within an average of three minutes
- Be designed to accommodate a peak call usage of 1,000 calls/hour with **24** calls at one time that allows for increased call volumes during significant traffic occurrences
- *o* Have the capacity to handle any percentage of calls accessing any configuration of the various route reports, including all calls accessing the same report at one time
- Be modularly expandable in number of ports and voice storage capacity to accommodate growth when needed
- Be available to callers while the route conditions/reports are being updated

The LDS system shall

- Provide 10 modem ports, accessed through a standard telephone system
- Accommodate 20 leased lines
- *o* Be capable of supporting outputs of traveler information at a combined maximum rate of 20,000 bytes per second over the dedicated land lines
- Be capable of supporting outputs of traveler information at a combined maximum rate of 10,000 bytes per second over the dial-up land lines

These requirements relate to several aspects of incoming calls to both TATS and LDS, including the volume and length of calls accessing TATS, and the size of calls accessing LDS. While the evaluation of the communications interface also deals with some of these parameters, more than just volume of calls will be collected and analyzed. The planned investigation of call volumes into both TATS and LDS will be more detailed than a basic verification of compliance with a peak call usage accommodation requirement or average service time requirements. There will be an on-going data collection effort over the entire FOT period as well as an analysis of call volume data

with respect to other factors (See Section 4.3 Data Analysis). Furthermore, the satisfaction of these requirements does not ensure that customers will be satisfied with either the TATS or LDS service. In addition to the communications-related data that will be collected, the level of customer satisfaction with both TATS and LDS, in which the customers are individual travelers and VARs, respectively, will be assessed separately through surveys and interviews (I).

4.2 Data Collection

This section presents both the types of data that need to be collected and the schedule for collection of this communications-related data during the FOT.

4.2.1 Data Types

4.2.1.1 TATS—Traveler Linkage

As part of the traveler response element, a survey of travelers accessing TATS will be conducted at six-month intervals throughout the TravInfo FOT. This survey will seek to quantify the level of satisfaction with the TATS information service, including (1) product satisfaction, (2) consumer profile comparative analysis, (3) product usage, and (4) degree of willingness to pay for TATS services. Survey participants will be a subset of all TATS callers who had previously volunteered to participate in a follow-up call when their initial TATS call was intercepted[9]. In addition to TATS survey data, the following telephone communication-related data will be collected. Disaggregate data for each incoming TATS call:

- length of call
- date
- time of day
- area code
- choice(s) of menu selection path(s), i.e. complete set of numbers corresponding to the entered telephone keypad push buttons and roadway route numbers in the order the caller made the selections.

Additional disaggregate data required:

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[9] Details for the intercept process are presently being worked out between PATH and Octel, the contractor developing the TATS Voice Processing System.

[10] The first draft of the TATS survey instrument **is** presently under review.

- proportion of time each day during which callers would encounter a busy signal (i.e. proportion of time when all incoming lines" are unavailable [separately for each of the 4 area codes]).

Aggregate data:

In addition to this disaggregate data, the number of calls will be aggregated by hour of the day and number of calls per area code aggregated by hour of the day.

These data should be collected through the TIC's acquisition of standard call reporting software[12]. The electronic logs of this communications-related data should be deposited in the PATH account set up by TRW/ASG for monthly retrieval by PATH. Electronic logs will be located at the TIC and operator maintained.

4.2.1.2 LDS—VAR Linkage

VARs may initiate communication with LDS to receive information on a continuous update basis. For dial-up phone line LDS—VAR connections, delays could occur and such wait-related information would be significant to obtain for evaluation purposes. The following data are required for each incoming call:

- length of connection
- information that is accessed
- date
- time-of-day

Additional disaggregate data required:

- time period during which each line is engaged

Queue-slots will not be used in the LDS—VAR communications system, resulting in a busy signal to incoming VAR calls when all lines are in use. As with TATS, these data should be collected continuously throughout the FOT, and reported by hour by day.
Statistics collected on the LDS-VAR communication system will be compared to the responses to the VAR interviews, which will include questions pertaining to the VARs' level of satisfaction with their link with the TIC through the LDS. Two sets of interviews with the Vendor Server (linked to DBS) and with event operators, local jurisdictions, and transit agencies will be scheduled to assess the degree to which these entities are satisfied with TIC service. The

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[11]There is a one-to-one correspondence between telephone lines and ports, the access points or gateways to the TATS computer database. Thus this data is equivalent to the proportion of time each day when all ports are unavailable.
[12]PATH is currently working with Octel to finalize the specifics of this data.

electronic logs of this communications-related data should be deposited in the PATH account for monthly retrieval by PATH. Electronic logs will be located at the TIC and operator maintained.

4.2.2   Data Collection Schedule

The data will be collected continuously throughout the FOT. The account previously described set up for PATH by TRW/ASG will also be used by the TIC operations' staff to deposit the electronically-generated logs containing the call-related data for subsequent electronic retrieval by PATH (monthly). Electronic logs will be located at the TIC and operator maintained.

4.3   Data Analysis

4.3.1   TATS—Traveler Linkage

Data analysis will be performed using appropriate statistical methods. The objective is to understand the relationship between the volume of calls (all calls and all calls for each of the four area codes to be used [415, 510, 408, 7071) and certain factors. To achieve this objective, variations in the volume of calls will be investigated over the course of the FOT with respect to the following attributes:

- o Time-of-day variations with special focus placed on both the morning and afternoon peak travel periods.
- o Day-of-week changes with special focus placed on the differences between usual work days (Monday through Friday) and weekend days.
- • Seasonal changes
- o Differences relative to the type of day it is with respect to the number and severity of incidents

Analysis will also be conducted on the distribution of TATS menu items selected and the correlation between the items selected and the (1) length of the telephone call and (2) the type of day (incident free, severe incidents, etc.), as well as on the availability of telephone lines to access TATS and changes in line availability over time.

Output of the analysis will be presented in both graphical and tabular form.

4.3.2   LDS—VAR Linkage

Data analysis will be performed using appropriate statistical methods. The objective is to understand the relationship between the volume of calls into LDS and certain factors over the length of the FOT. Variations in the volume of calls will be investigated with respect to the same attributes listed above with respect to TATS.

The linkage between the LDS-VAR communication system and the responses to the VAR interviews will also be investigated. Recall that the VAR interviews will include questions pertaining to the VARs' level of satisfaction with their link with the TIC through the LDS.

Output of the analysis will be presented in both graphical and tabular form.

5. RESPONSE TIME

This section provides the details to evaluate system response times. The goal of this component of the TIC study is to gain an understanding of TIC response times. As previously described in the discussion on the TIC operator interface, the operator is a potential chokepoint in the flow of information through the TIC. The information flow analysis previously discussed will provide a valuable foundation for the understanding of TIC performance relative to response times.

5.1 Relationship To TIC Acceptance Testing

The TIC's system requirements are listed in (*3*), of which one requirement is especially appropriate to the response time component of the TIC study and is listed below. Incoming data are divided into the following three types: static, periodic, and dynamic. These data types differ primarily in the degree of change they experience over time. Static data consists of definitions and locations, e.g. freeway segment definition and transit stop location. Periodic data consists of information related to planned events, weather, and transit (routes, schedule, and fare). Dynamic data is subject to unplanned variability at any time, e.g. roadway speeds, level of congestion, and incidents.

Response Time Requirement:

- Average latency of dynamic data will be at most one minute, where latency of dynamic data is the time delay between the receipt of dynamic information to the time the TIC outputs results

The satisfaction of functional requirements does not guarantee that customers will be satisfied; there could still be locations of operator chokepoints resulting in ultimate customer dissatisfaction with "TIC service", even though the average response time requirement was satisfied. Although the average response time may be satisfactory, a more detailed examination of response time disaggregated by components within the TIC information flows could reveal problems and bottlenecks within particular areas of the TIC, and thus would provide a substantially more complete picture of the TIC's performance.

5.2 Data Collection

This section presents both the types of data that need to be collected and the schedule for collection during the FOT.

5.2.1   Data Types

The TravInfo System Requirements document *(3)* states that the evaluator will be provided with the following data:

o   Time it takes from report/receipt of a traffic incident to dissemination of data to the output source (TATS, DBS, etc.)
•   Time it takes for data to get from an input source to the output/dissemination source

Calculation of these values requires processing of incident records, including the time (or times) that incidents are reported and the time (or times) that messages are disseminated. There are four major time periods between the time a message enters and exits the TIC relative to an incident, as follows:

   1.   Incoming message enters system and is placed into queue awaiting operator action
   2.   Message leaves queue and operator processing of message begins
   3.   Message processing ends and outgoing message enters dissemination system
   4.   Outgoing message is ready for travelers (via TATS) and VARs to access information

These four response times correspond to the following three events:

   Event between times 1. and **2.:**   message waits in queue
   Event between times 2. and 3.:   operator processes message
   Event between times 3. and 4.:   operator prepares outgoing message for TATS (LDS case is done automatically)

As previously mentioned, it would be valuable to know the response times for each of these four time segments so as to reveal problems and bottlenecks within particular areas of the TIC. Based on discussions with TRW/ASG, only the following data will be automatically collected within the TIC:

•   Exact message received
•   Time/date when each message is received, i.e. enters Data Acquisition subsystem and is put into queue awaiting operator (corresponds to 1. above)
o   Time/date when message processing ends and outgoing message enters Data Dissemination subsystem (corresponds to 3. above)
•   Exact message disseminated to output sources, i.e. to TATS, LDS, and DBS
•   Incident type

Thus, the aggregate response time for time in queue plus message processing will automatically be collected. Manual attempts will be made to determine the individual component response times by on-site TIC observations and through operator interviews. **A** description of the database's record of response times with the data types is provided in Table 7, providing a hard-copy template version of the electronic database.

Table 7

TIC Message Response Time Log

REC NUM	INCIDENT ID	INCIDENT TYPE	INCIDENT LOCATION	MESSAGE: INCOMING (I) OUTGOING (O)	MESSAGE TEXT	DATE	TIME MESSAGE ENTERS ACQUISITION SUBSYSTEM	TIME MESSAGE ENTERS DISSEMINATION SUBSYSTEM
3								
N-1								
N								

The means through which messages received (incoming) are associated with messages disseminated (outgoing), i.e. the correspondence between them, is also important to fully understand and assist in reconstructing the details of incidents. The correspondence between incoming and outgoing messages correlated with the same incident cannot be captured automatically within the TIC, however, manual attempts will be made to obtain this information.

The content of incident messages, in particular the TIC's outgoing messages, will not contain certain information that is important for evaluation purposes. In particular, speed and other congestion-related data on the links where an incident occurs is part of this omitted data. It is, however, important to obtain as complete a data set of incident-related information as possible for purposes of the evaluation to learn how the facts of the incident correlate with each other. A separate log of such omitted data may be obtained, however, in that case, the correlation with the response time logs will have to be manually performed by the evaluator team.

5.2.2 Data Collection Schedule

Due to the enormous amount of information entering the TIC, response time data should be collected on a time-sampled basis, covering approximately two-week periods at six-month intervals. During these periods, the TIC Operator would deposit a complete incident response time log (as specified above), as well as its summarized response time calculations, to PATH. The collection periods would coincide with the collection periods for the TATS survey and the operator interface component (Phase 111). Response time data will also need to be collected after major case-study incidents, as specified in the Target Study[13]. These data will only cover the days of the incidents and may not coincide with the regular data collection schedule described here, i.e. at six-month intervals. Only the data for the 101 corridor is required. However, if simpler for the TIC operator, a complete log for the incident day would be sufficient.

The response time data will be collected automatically within the TIC's computer system. A database of response times will be developed at PATH for analysis purposes. The account for PATH set up by TRW/ASG to collect system reliability logs will also be used to collect the electronic response time logs. The TIC operations' staff will be responsible for depositing these electronic logs of response time-related data in the PATH account for electronic retrieval every six months by PATH. Electronic logs will be located at the TIC and operator maintained.

5.3 Data Analysis

Data will be analyzed with appropriate statistical methods. The objective is to understand the relationship between the incident response times and other changes exhibited over time. Output

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[13] This element of the evaluation is currently under discussion. If it is canceled, then this data will not be required to be collected.

will be presented in both tabular and graphical form. Response times may vary by the variables previously listed. Examples of the graphical analyses to be performed are listed **as** follows:

- plot of average response time per incident for each sampling period
- plot of average response time per incident for each incident type by sampling period
- plots of average response times per incident by sampling period for functional subsystems and output sources for which data is available

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(*5*)   Mayhew, D.J., *Principles & Guidelines in Software User Interface Design,* Englewood Cliffs/Prentice-Hall, 1992.

(*6*)   Byerly and Bernard, *Computer, Communications, and Usability: Design Issues, Research, and Methods for Integrated Services,* North Holland Series in Telecommunications, 1993.