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Travinfo Evaluation (technology Element) Traveler Information Center (tic) Study (september 1996 - June 1997)

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**TravInfo Evaluation (Technology Element)  
Traveler Information Center (TIC) Study  
(September 1996 - June 1997)**

**Mark A. Miller  
Dimitri Loukakos**

**California PATH Working Paper  
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Traveler Information Center (TIC) Study  
(September 1996 - June 1997)**

**Mark A. Miller  
Dimitri Loukakos**

**February 17, 1998**

## ABSTRACT

TravInfo is a Field Operational Test of advanced traveler information systems for the San Francisco Bay Area, sponsored by the Federal Highway Administration (FHWA). The project involves a public/private partnership which seeks to compile, integrate and broadly disseminate timely and accurate multi-modal traveler information through commercial products and services. The public sector component centers on the Traveler Information Center (TIC), which collects and integrates both static and dynamic traveler information. The TIC began operations in September 1996 and will operate as an FOT through September of 1998. Private sector participation includes Information Service Providers (ISPs), who refine the information and disseminate it to end users. This report documents the evaluation of the TIC performed from September 1, 1996 (date at which TravInfo went on-line) through June 30, 1997 with respect to the system reliability, communications interface and operator interface elements of the evaluation of the TIC. System reliability examines system failures, including their initial symptoms, causes and duration. The communications interface examines TIC data access on the part of both the public and private sectors. Operator interface investigates the human element by considering the role of the operator in the flow of information through the TIC, the operators' tasks and responsibilities and the operators' physical working environment.

With respect to system reliability, during the period of investigation (January-June 1997), a total of seventy-three problems originated within the TIC, eighty-nine percent of which originated within the primary TIC program, TransView. The publicly available traveler information phone service, Traveler Advisory Telephone System (TATS), recorded a fairly constant monthly call volume of between 50,000 and 60,000 calls during the reporting period of September 1996 through June 1997. AC Transit alone contributed approximately 55% of the overall call volume throughout the reporting period. On average, for Oakland, the busiest regional system, approximately 3% of the TATS system capacity was utilized. Private sector access of data, via the Landline Data System, has also been quite limited. From November 1996 to June 1997, only three ISPs downloaded data on a continuous basis, one of which downloaded 95% of all data during this reporting period. The operator's role in the flow of information through the TIC has been crucial both in terms of data entry and data interpretation and prioritization. The two most time-consuming data sources are the California Highway Patrol's Computer Aided Dispatch (CAD) system and Metro Network's airborne reports that respectively utilize approximately 57% and 26% of all operator time.

Key Words: TravInfo, traveler information center, evaluation, traveler information, information service providers, advanced traveler information systems

## **EXECUTIVE SUMMARY**

TravInfo is a Field Operational Test (FOT) of advanced traveler information systems (ATIS) for the San Francisco Bay Area, sponsored by the Federal Highway Administration (FHWA). The project involves a public/private partnership which seeks to compile, integrate and broadly disseminate timely and accurate multi-modal traveler information through commercial products and services. The public sector component centers on the Traveler Information Center (TIC), which collects and integrates both static and dynamic traveler information. The TIC began operations in September 1996 and will operate as an FOT through September 1998. Private sector participation includes Information Service Providers (ISPs), who refine the information and disseminate it to end users.

The evaluation of TravInfo consists of four major elements: (1) institutional, (2) technology, (3) traveler response and (4) network performance. The TIC study is part of the technology evaluation and consists of four primary elements: system reliability, communications interface, operator interface and response time analysis. System reliability examines system failures, including their initial symptoms, causes and duration. The communications interface examines TIC data access on the part of both the public and private sectors. Operator interface investigates the human element by considering the role of the operator in the flow of information through the TIC, the operators' tasks and responsibilities and the operators' physical working environment. Response time measures the operations' processing time of incidents from the time the raw data enters the TIC to the time it is distributed to the public and ISPs. This report documents the evaluation of the TIC performed from September 1, 1996, (date at which TravInfo went on-line) to June 30, 1997 with respect to system reliability, communications interface and operator interface. The response time component will be conducted at later stage of the evaluation.

During the period of investigation (January-June 1997), eighty-nine percent of the problems encountered at the TIC occurred in the main data processing software (TransView). Approximately one-third of non-LDS TransView problems occurred within the Traffic Incident Manager. Problems were primarily either major or critical in severity, not minor. Although independent of the functioning of the TIC, it should also be mentioned that there have been repeated problems in data acquisition, namely with the California Highway Patrol Computer Aided Dispatch (CAD) system functioning properly and more serious problems with the quality of the TOS freeway loop data.

From September 1996 to June 1997, call volume to the Traveler Advisory Telephone System (TATS) has remained fairly constant at between 50,000 and 60,000 calls per month (aside for September and October when it was slightly higher). The region with the highest call volume was Oakland (monthly average from September to June: 47,450) followed by San Francisco (monthly average: 5,836), San Jose (2,518) and Santa Rosa (581). Adjusting for the influence of regional populations, the Oakland area still had seven times more per capita calls than San Francisco, the region with the second highest call volume. The advertising campaign from January to March 1997 had only minor effects on overall call volume. Finally, it should be noted that the overall

call volume is “anomalously” skewed upwards because one of the major transit service providers of the San Francisco Bay Area, AC Transit (Oakland area), uses the TATS number as its only number for customers. AC Transit alone contributes on the order of 55% of the overall call volume throughout the reporting period.

TATS system capacity use, assessed by measuring access to the ports available to the public, is very low. On average, from September 1996 to June 1997, for Oakland, the busiest regional system, approximately 3% of the TATS system capacity was utilized. System capacity use was significantly lower for the other three regional systems.

Private sector access of the data, via the Landline Data System, has also been quite limited. From November 1996 to June 1997, 25 of the 40 registered participants (62%) downloaded data at one point or another, mostly in small amounts. Only three ISPs downloaded data on a continuous basis, one of which downloaded 95% of all data during the reporting period.

The operator’s role in the flow of information through the TIC is crucial both in terms of data entry and data interpretation and prioritization. All the data sources, aside from the Freeway Service Patrol (FSP) and in part the loop sensors, are manual thus reinforcing the importance of the operator in the flow of information through the TIC. The two most time-consuming data sources are the CAD and the airborne reports which respectively take up approximately 57% and 26% of all operator time. System and design problems have slowed down the speed of operator response to events to some extent. The greatest potential processing-time choke-point in the flow of information through the TIC is the CAD.

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## **1. BACKGROUND AND MOTIVATION**

This report documents the evaluation of the Traveler Information Center (TIC) performed from September 1, 1996, (date from which TravInfo went on-line) to June 30, 1997. The TIC study consists of four primary elements, namely system reliability, operator interface, communications interface and response time analysis. System reliability examines TIC system failures, including their initial symptoms, causes and duration. Operator interface investigates 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 examines TIC data access on the part of both the public and private sectors. The response time element will investigate response times for processing information within the TIC, especially during times of system stress. This last component, response time analysis, has not been conducted yet and will not be reported in this document. A complete description of the evaluation plan for the TIC may be found in (1) which provides additional detail on each of the four TIC evaluation components.

### **1.1 System Reliability**

The primary objective of this evaluation component is to gain an understanding of TIC reliability over the course of the entire Field Operational Test (FOT). System reliability examines system failures during TIC operations. An analysis of system and subsystem problems will allow detection and explanation of failure patterns over time. Core questions to be answered include the following:

- What is the nature of TIC problems?
- What patterns are there, if any, in the problems that occur over time, such as repeated occurrences of problems in the same functional subsystem of the TIC and repeated occurrences of problems of a particular severity?
- How has the nature of problems changed over time relative to measures such as duration?

A copy of the most current version of the TIC Problem Report may be found in Appendix A.

### **1.2 Communications Interface**

The TIC consists of three primary functional components: data acquisition, data processing and data dissemination. Within the data acquisition subsystem, the TIC receives data from numerous sources such as the California Highway Patrol Computer-Aided-Dispatch (CHP CAD), Freeway Service Patrol (FSP), Metro's Airborne fleet and Caltrans' mini-TOS. Within the data dissemination functional subsystem, the TIC transmits processed information to the public via the Traveler Advisory Telephone System (TATS) and to those members of the private sector who have signed up as TravInfo Registered Participants (RP) via the Landline Data System (LDS). The objective of this evaluation component is to examine the linkages between the TIC and the outside world via TATS and LDS. Core questions to be answered from an analysis of both TATS and LDS usage include the following:

- What is the nature of TATS calls with respect to their:
  - area of origin
  - duration
  - time period (month-of-year, day-of-week, time-of-day)
  - type (especially traffic and transit)
- How do TATS call volumes change over time with respect to callers' choices?
- What are the primary traffic corridors as measured by those routes that receive the greatest traffic inquiries by the public?
- Are there times during which all incoming publicly accessible ports for TATS use are simultaneously busy especially during peak period commute times?
- What data are the RPs principally interested in?
- What is the frequency and volume of data downloads by the RPs

### **1.3 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 TIC performance. The primary objective of this evaluation component is to understand this human element by focusing on an analysis of the role of operators in the flow of information throughout the TIC, an analysis of operator tasks and an analysis of the operator working environment and associated interfaces between the operator and the TIC. Core questions to be answered include the following:

- Where does the operator fit in the flow of information through the TIC; i.e. what is his/her role?
- Given the TIC operator's role, what are his/her tasks and job responsibilities?
- 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?

A copy of the first operator interview survey may be found in Appendix B.

## **2. DATA: SOURCES AND COLLECTION METHODOLOGIES**

This section describes the sources of data and the means of collecting them for subsequent analysis of each of the three primary components of the TIC evaluation documented in this report.

### **2.1 System Reliability**

The source of system reliability data consists of the TIC Problem Report (Appendix A) which when completely filled out contains the following types of information about each TIC problem:

- date and time detected
- date and time resolved
- description of problem
- severity
- location
  - functional
  - hardware
  - software
- cause
- priority
- action plan

With this type of information, the core questions (Section 1.1) as well as others may be answered. The current TIC Problem Report form is the second form in use and has been used since January 1, 1997. Originally, there were two forms in use. One was created by TRW, the developer of the TravInfo systems software, for their resolution of TIC problems. The other was developed by the evaluators. These two forms contained similarities and differences and overlapped especially in the problem resolution area of the form. To make the whole process of documenting TIC problems as efficient and streamlined as possible, a single and revised TIC Problem Report was developed by Metro and the evaluators that incorporated all the essential components of the two original reports and was signed-off by the Metropolitan Transportation Commission (MTC) and TRW. This revised form was put into use on January 1, 1997. Thus because of these issues associated with having two reports, January 1997 was designated as the date for the start of system reliability analysis. Furthermore, until January 1997, system acceptance testing was still on-going.

Portions of the revised TIC Problem Report especially having to do with problem resolution are meant to be filled out by TRW maintenance staff. Since the TRW maintenance contract was finalized and signed in November 1997, the Problem Reports were only partially completed during the reporting period. As a result, this will be reflected in this report and all the core questions, especially those concerning problem duration, cannot be answered.

## **2.2 Communications Interface**

Each of the two components of the communications interface element, TATS and LDS, has a single data source.

### **2.2.1 TATS**

TATS-related data consists of activity and port use data. Each call into TATS is recorded within databases corresponding to each of the four regions as defined by the four Bay Area area codes

(510, 415, 408 and 707). In August 1997, the 415 area code split into 415 and 650 codes and a six month grace period exists until February 1998 whereupon all calls originating from the 650 area will continue to be recorded as 415 calls for another three months. This will maintain the regional integrity of all incoming TATS calls. The time period documented in this report covers September 1, 1996 through June 30, 1997, during which there were four area codes.

### **2.2.1.1 Activity Data**

The complete profile of each call's contents, as defined by the caller's telephone keypad-generated menu selections, are included in this database. Weekly downloads of this data are performed for each of the four regions and entered into the Evaluation TATS Activity Database. Weekly data downloads are done via modem connections and the use of a communications software package (ProComm Plus) between the evaluators' computers and each of the four TATS sites. Octel Corporation, the developer of the TATS voice processing system for TravInfo, developed the necessary scripts running within ProComm Plus and the entire data file transfer process that occurs during each TATS Activity download. The evaluators are using Microsoft Access as the database platform for all its TATS Activity database analysis. The import of TATS activity data into the Evaluation TATS Activity Database includes additional minor format modifications.

### **2.2.1.2 Port Use Data**

For each of the four TATS voice processing systems (one for each of the four area code regions) multiple telephone lines or ports are available for callers to access TATS. Currently there are 53, 45, 37 and 22 publicly available voice ports for the 510, 415, 408 and 707 TATS systems, respectively. From the time TravInfo went on-line through the conclusion of the primary advertisement campaign (March 31, 1997), downloads of port use data were performed twice each weekday to capture port use from 7 AM to 9 AM and from 4 PM to 6 PM. These time periods were selected to coincide with the morning and afternoon commute peak periods. At the conclusion of the three-month advertisement campaign, port use data downloads were scheduled to occur on a sampling basis during one week each month for the remainder of the FOT, unless special requests were made. For purposes of the data analysis performed for this report, one week's worth of data per month was examined from September 1996 to June 1997, with the only exception that data was unavailable for the month of December 1996.

### **2.2.2 LDS**

Registered Participants have access via modem hook-up on either a shared or dedicated phone line to all outgoing TIC-processed TravInfo data via the LDS. Each access into the LDS is recorded within the LDS database. The complete profile of each such access' contents as defined by the RP's keypad-generated menu selections are included in this database as well as the size of each LDS database access. Monthly downloads of this data are performed by transferring files via the File Transfer Protocol (FTP) and entered into the Evaluation LDS Activity Database.



The evaluators are using Microsoft Access as the database platform for all its LDS Activity database analysis. The import of LDS activity data into the Evaluation LDS Activity Database includes additional minor format modifications. RP access downloads were performed in their entirety until March, 1997 when, due to the evaluators' resource limitations, data downloads by one RP who accesses very large quantities of data was discontinued. Since this RP accesses the entire TIC database, there is really no need to keep track of its data access, unless, of course, its data access behavior changes.

## **2.3 Operator Interface**

The primary sources of data for the Operator Interface component consist of documentation prepared by TRW over the course of their design, development and testing of the TIC as well the results of the first operator survey. The objective is to collect information that will assist in answering the core questions listed in Section 1.3. The focus of the first operator interview survey was on the flow of information both into and out of the TIC and the relationship of the TIC with the Caltrans Transportation Management Center (TMC). The objective was to ascertain all major data/information flows to and from the TIC; for each such flow, determine all points of operator interface; for each such point of operator interface, determine the level of attention required by the operator to detect the arrival of information and more generally to perform his/her job responsibilities. The text of the first operator survey may be found in Appendix B.

## **3. ANALYSIS AND INTERPRETATION OF RESULTS**

### **3.1 Summary of Key Findings**

Before delving into the detailed discussion of the results for each of the TIC evaluation components, a summary of key findings for each of these components is provided in this section to provide an overview of the results. System reliability results are provided from January to June 1997. Results are not provided from September to December 1996 as the problem report forms were filled out incompletely and acceptance testing was still on-going. TATS activity and port use results are presented from September 1996 to June 1997. Finally, LDS activity covers the period from November 1996 to June 1997. Data were not available to download by the evaluation team prior to November 1996 and, in any event, downloading of data by ISPs was minimal in September and October 1996 due to the continuation of acceptance testing.

#### **3.1.1 System Reliability**

- Primary TIC program, TransView, accounts for 89% of all problems
- LDS Update Formatter TransView problems account for 25% of all problems
- Non-LDS TransView problems account for 64% of all problems

- One-third of non-LDS TransView problems occurred within the Traffic Incident Manager
- Surges in problems observed in March and May relative to other months
- By location, Processing subsystem problems far outweigh problems in Acquisition and Distribution functional subsystems
- Problems were primarily either major and critical in severity, not minor
- 85% of all problems over 6 month period were either Processing/major or Processing/critical

### 3.1.2 TATS Activity

#### Monthly Call Volume

- Range of total call volume: 50 thousand - 60 thousand
- AC Transit calls represent 55% of overall calls and 85% of transit calls
- OAKLAND region (510) is consistently the major contributor to total call volume. Call volume in San Francisco (SF), San Jose (SJ) and Santa Rosa (SR) regions are very small relative to OAKLAND region
- Minor peaks in call volume are attributed to start of (1) TravInfo (official ribbon-cutting) in September 1996 and (2) weather conditions and advertisement campaign in January 1997
- Transit calls are major contributor to total call volume
- Overall call volume was influenced primarily by traffic calls only during the first month of operations

#### Average Hourly Call Volume (time-of-day)

- Morning and afternoon peaks during weekdays
- Transit calls show morning peak to be later than peak for traffic calls
- Afternoon peak periods approximately the same for transit and traffic calls
- Morning peak is, as expected, later on weekends than on weekdays

#### Call Duration Measures (average, standard deviation)

- For SF, SJ and SR regions, call duration measures for all calls are relatively close together.
- For OAKLAND region, call duration measures for all calls are considerably less than for other regions
- For traffic calls, all regions show similar call duration measures
- For transit calls, call duration measures are significantly less than for traffic calls region by region with OAKLAND considerably less than for other regions

#### Transit Service Providers

- AC Transit, BART and SAMTRANS-CALTRAIN account for 85%, 6% and 1-2% of all transit inquiries, respectively
- Other Transit Service Providers account for approximately 5% of all transit inquiries. This includes Alameda-Oakland Ferry, CCCTA, Golden Gate and MUNI

### Selected Routes

- Four out of the top five (880, 80, 580, 680) and five out of the top ten selected routes are in the East Bay
- South Bay, the Peninsula and San Francisco account for at least 18%, 11.3% and 8.1% of all selected routes, respectively
- Bay Bridge is most popular bridge route and sixth most popular route overall
- Approximately one-half of routes selected from OAKLAND and SJ TATS are East Bay and South Bay routes, respectively
- East Bay routes are selected from one-quarter of SF TATS and about one-third of SR TATS

### 3.1.3 TATS Port Use

- Focus placed on OAKLAND TATS
- Overall port utilization is very low and ranges from 1.6-3.5% during the AM peak (7 AM-9 AM) and from 1.3-5.2% during the PM peak (4 PM – 6 PM)
- Maximum number of incoming calls on a single port (busiest) during morning (7 AM-9 AM) and afternoon (4 PM – 6 PM) peak period ranges from 90-105 and 95-120 calls, respectively
- Number of ports in simultaneous use for morning and afternoon peak periods ranges from 4-9 and 5-10 respectively
- Port utilization for busiest port in morning and afternoon peak periods quite stable within 44-55% range

### 3.1.4 LDS Activity

- Overall during the reporting period, the number of registered participants was 40, give or take 2 or 3 depending on changes in participation
- Twenty five of the registered participants accessed data at one point or another of which 3 were regular users (accessing data continuously throughout the reporting period)
- Etak accounts for 95% of all bytes accessed over entire time period and nearly all data downloaded each week
- Maxwell and Daimler-Benz each account for 2-3% of all bytes accessed
- Third tier of data downloads arises from ISPs including Clarion, Contra Costa Times, KCBS on the order of 100 kilobytes per week though on an irregular basis
- Fourth (bottom) tier of data downloads arise from ISPs including Fastline, KPIX, KTVU on the order 10 kilobytes per week though on an irregular basis
- Speed & Congestion and Traffic Incidents account respectively for 85% and 14% of ISP data selection from main categories

### 3.1.5 Operator Interface

- The operator's role in the flow of information through the TIC is crucial both in terms of data entry and data interpretation and prioritization

- All the data sources, aside from the FSP and in part the loop sensors, are manual thus reinforcing the importance of the operator in the flow of information through the TIC
- The two most time-consuming data sources are the CAD and the airborne reports which respectively take up approximately 57% and 26% of all operator time
- System and design problems have slowed down the speed of operator response to events to some extent
- The third most time-consuming data source is the Instatrack taking up 5-6% of all operator time
- The greatest potential processing-time choke-point in the flow of information through the TIC is the CAD

### **3.2 System Reliability**

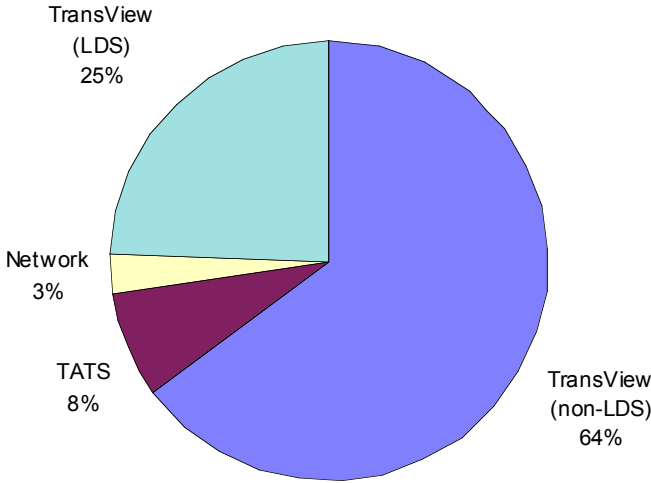
This section describes the problems experienced at the TIC between January and June 1997 relative to time measures such as per month and per week and relative to descriptive measures such as problem location and severity. No analysis of problems between the start-up of the FOT in September 1996 through December 1996 was performed (See Section 2.1). It needs to be noted that during the reporting period the maintenance contract with TRW had not yet been signed and in effect. Thus no TIC maintenance was being performed by TRW. Certain system maintenance responsibilities, however, such as file administration and archiving, are official TIC operations' work assignments and were performed. Also of importance is the fact that since only six months worth of data was collected and analyzed for this report, not enough time had really elapsed to identify any seasonal or yearly patterns in the occurrence of problems, if such patterns exist. Such trend analyses of the problems will be more readily performed in subsequent TIC evaluation reports which will cover longer time periods.

Problems encountered at the TIC that affected its performance may be divided into problems that are internal and external to the TIC. While these two types problems are discussed in this section, primary focus is placed on internal TIC problems since the TIC would have far less control over problems that originated outside its environment. The primary questions to answer are the following: What are the definitions of internal and external TIC problems, that is, what are the internal/external boundaries of the TIC? Problems that originate within the TIC are defined as internal TIC problems. Examples include problems 1) in TransView, the software suite custom-developed for the TravInfo FOT, 2) at an operator, database, or LDS workstation, or 3) within the TATS at the TIC. Problems originating at input sources to or at locations outside the TIC are defined as external TIC problems. Examples of external problems include problems originating at the CHP CAD, the mini-TOS (loop sensor data), Metro Network's Instatrack and Octel.

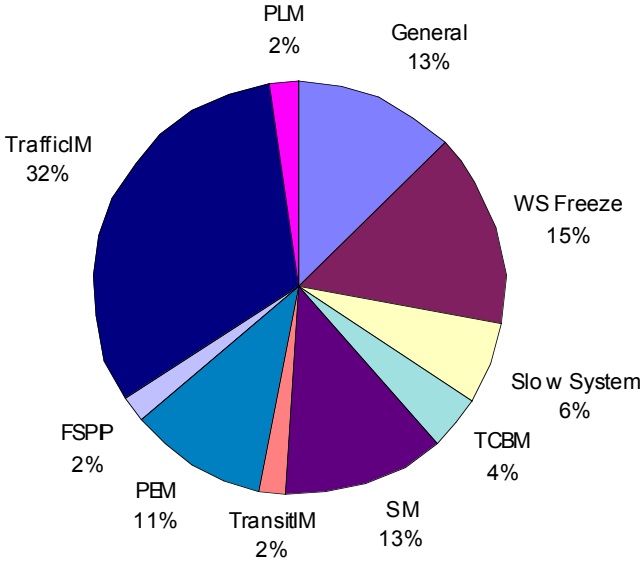
#### **3.2.1 Internal TIC Problems**

The first two figures focus on the nature of internal TIC problems that arose during the reporting period. During the reporting period, there were a total of seventy-three internal TIC problems. Figure 1a depicts the distribution of the type of problems. During the reporting period, approximately eighty-nine percent of problems have been identified as originating from the main TIC program, namely, TransView in which LDS-related TransView problems account for 24.7% of all problems and all other TransView problems account for 64% of all problems. The LDS-related problems are primarily LDS Update Formatter problems. The “Network” labeled problems were communication problems either within (workstation to dataserer), or leaving (sending reports to Registered Participants) the TIC. The other problem category is TATS. Figure 1b focuses and expands on the non-LDS TransView problems since they account for 64% of all internal TIC problems and are a significant portion of all internal TIC problems. One-third of all such TransView problems occurred within the Traffic Incident Manager window. The next two greatest number of TransView problems are attributable to workstation freezes and problems within the Sensor Manager. Two other problem types accounting for double-digit percentage contribution to non-LDS TransView problems are in the Planned Event Manager and general

**Figure 1a: Distribution of TIC Problems by Type:  
January - June 1997**



**Figure 1b: Distribution of TIC Non-LDS TransView Problems:  
January - June 1997**



WS Freeze = Workstation Freeze  
 TCBM = Traffic Congestion Backup Manager  
 SM = Sensor Manager  
 TransitIM = Transit Incident Manager  
 PEM = Planned Events Manager  
 FSP IP = FSP Input Processor  
 TrafficIM = Traffic Incident Manager  
 PLM = Parking Lot Manager

type problems. These five types of problems account for 82.9% of all non-LDS TransView-related problems.

The next set of figures focus on monthly problem occurrences.

Figure 2a displays the total monthly number of internal TIC problems. With a description of TIC problems at this high level, the primary observation that can be made is the surge in problems in both March and May. For March, problem contributors are TransView (LDS) and TransView (non-LDS) which account for 18.8% and 81.2% of the problems, respectively. For May, problem contributors are TransView (LDS), TATS and TransView (non-LDS) which account for 25%, 15% and 60% of the problems, respectively.

**Figure 2a: Total Monthly TIC Problems**

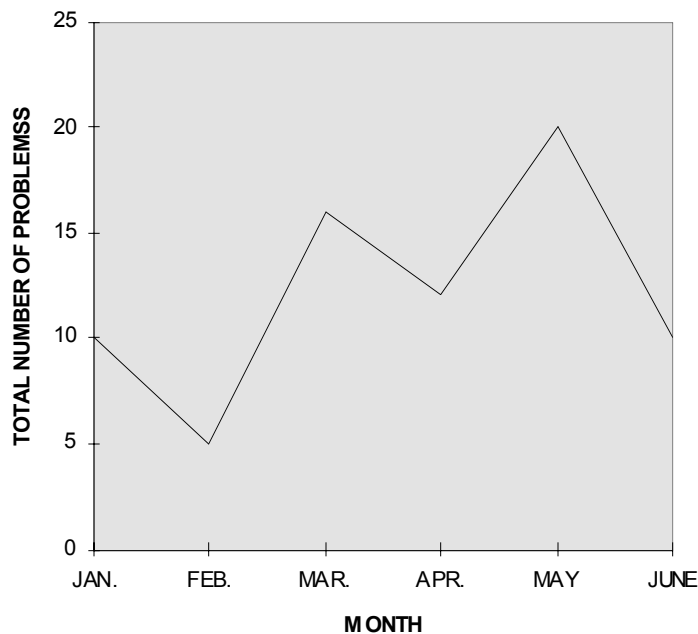


Figure 2b disaggregates the total number of TIC problems by their location according to functional subsystem: acquisition, processing and distribution. For each month, processing

**Figure 2b: Total Monthly TIC Problems by Functional Subsystem**

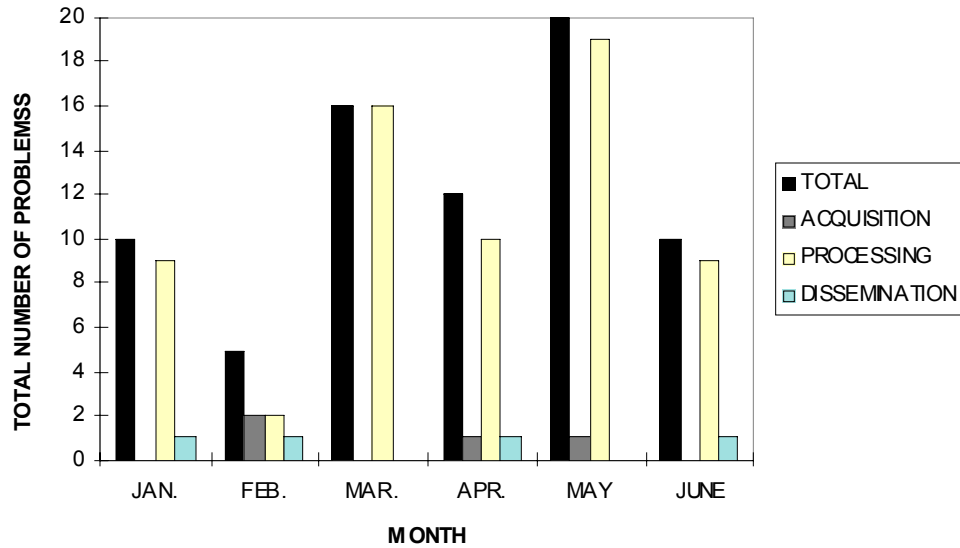
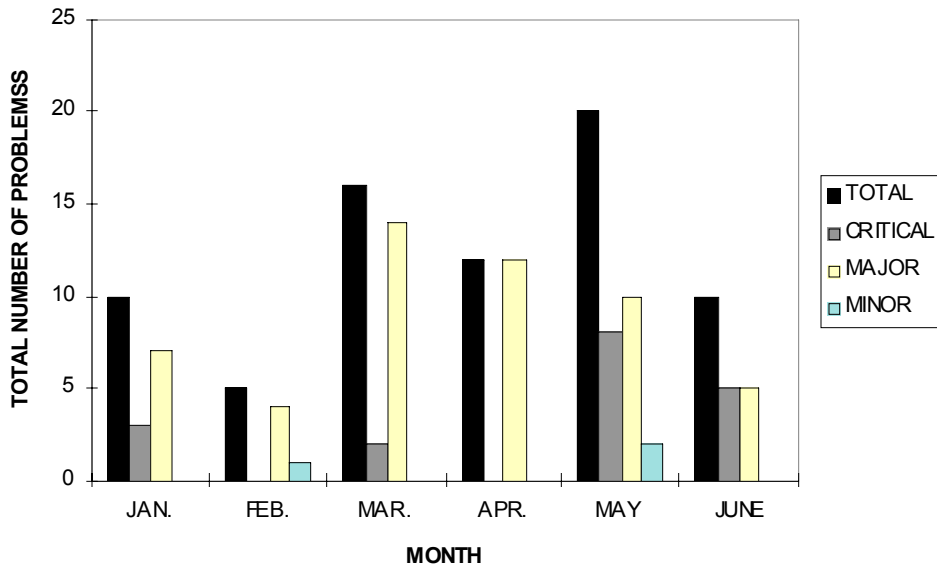


Figure 2c examines the problems by severity with three levels of severity considered: minor, major and critical.

**Figure 2c: Total Monthly TIC Problems by Severity**



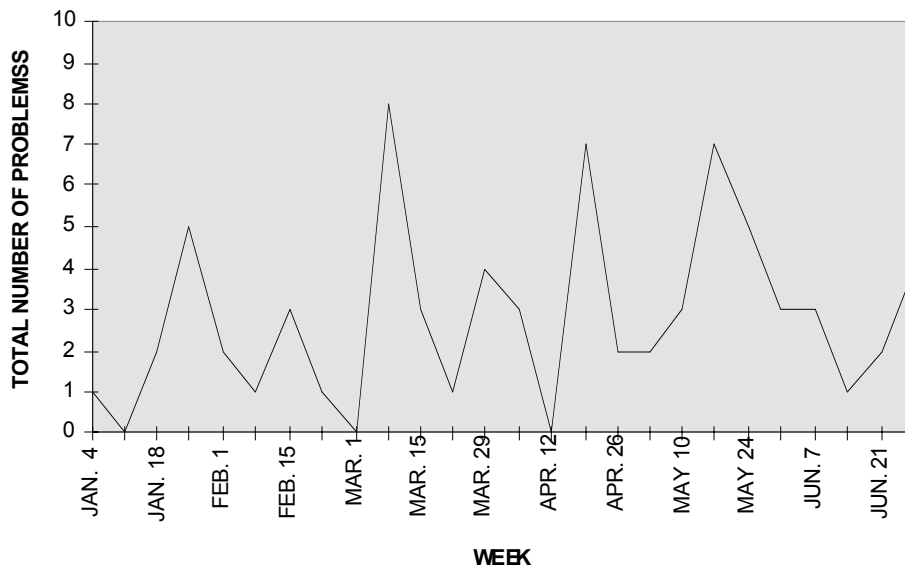


subsystem problems far outweigh any problems in either of the other two functional subsystems. There is never more than a single dissemination subsystem problem per month. Monthly acquisition problems are also very few in number.

Minor problems are defined as those problems that have little, if any, impacts on TIC operations. Major problems are defined as those affecting at least one TIC subsystem or component, though system operation can continue. Critical problems are defined as those in which at least one component or subsystem cannot function properly or successfully. Since TIC operations’ staff fill out the problem reports, TIC problem severity is based on the judgment of TIC operations’ staff. The definition of problem severity was based on discussions between the evaluators and TIC operations. Problems experienced over the six month period were primarily major or critical in severity with major problems outnumbering critical problems each month except during June.

The next figure (Figure 3) focuses on weekly problem occurrences. The problem volume increases for March and May can be observed in more detail.

**Figure 3: Total Weekly TIC Problems**



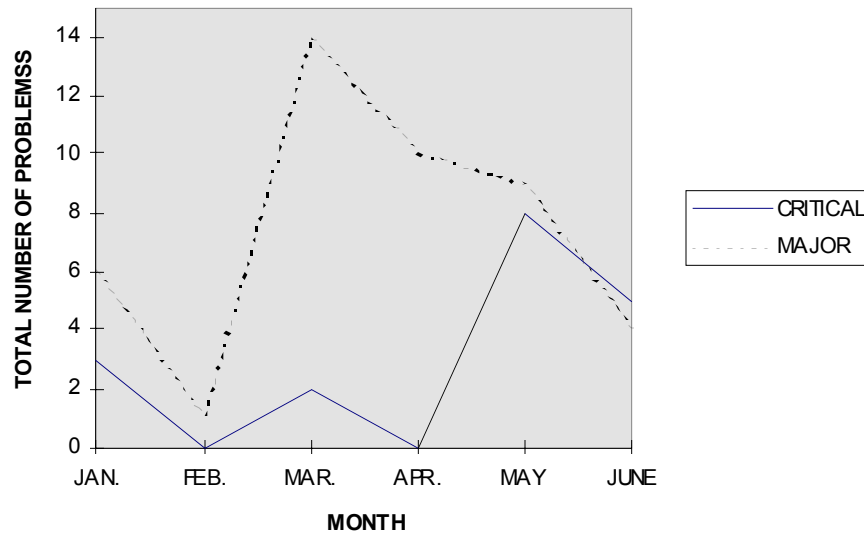
The following table (Table 1) and subsequent figure (Figure 4) focus on the relationship between problem location and severity over time and then further concentrate on those TIC problems in the processing subsystem with a “major” or “critical” severity rating. Such problems comprise approximately 85% of all problems that occurred during the January to June time period.

**Table 1: January-June TIC Problems: Location by Severity**

	ACQUISITION	PROCESSING	DISSEMINATION	TOTAL
MINOR	0	3	0	3
MAJOR	3	44	4	51
CRITICAL	1	18	0	19
TOTAL	4	65	4	73

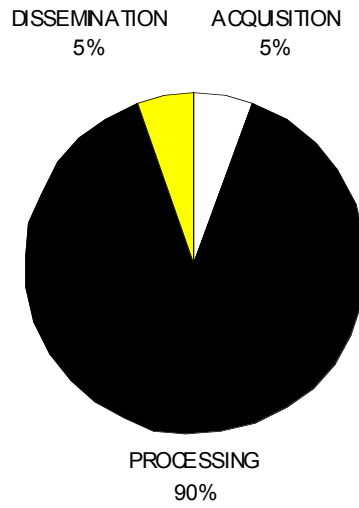
Figure 4 partitions processing/major and processing/critical problems by month.

**Figure 4: Processing Subsystem TIC Problems**

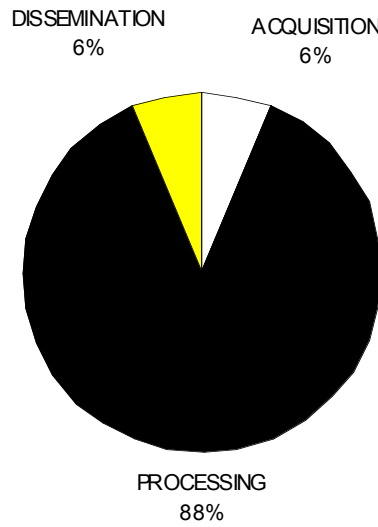


The following set of figures (Figures 5a-5f) concentrate on the quarterly distribution of TIC problems to provide a slightly longer view, in terms of the time period, of problems with respect to location and severity. Processing problems account for approximately 90% of all problems. Major problems account for between approximately two-thirds to four-fifths of all problems, whereas, critical problems account for approximately one-sixth to approximately one-third of all problems.

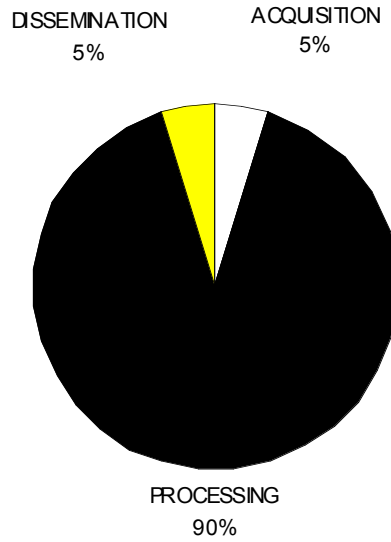
**Figure 5a: Distribution of Problems by Functional Subsystem:  
January - June**



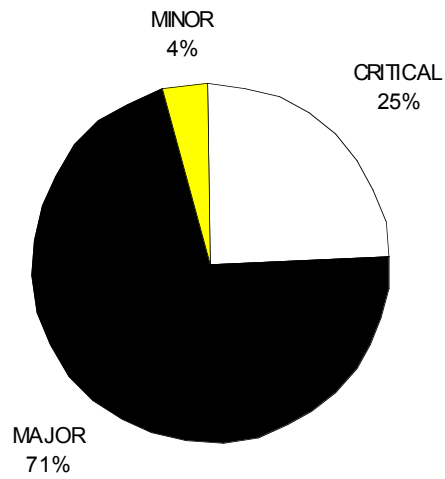
**Figure 5b: Quarterly Distribution of Problems by Functional Subsystem:  
January - March**



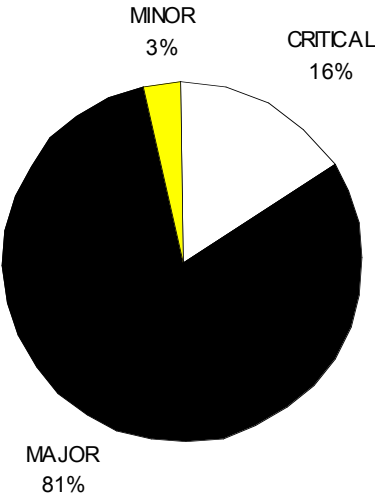
**Figure 5c: Quarterly Distribution of Problems by Functional Subsystem:  
April - June**



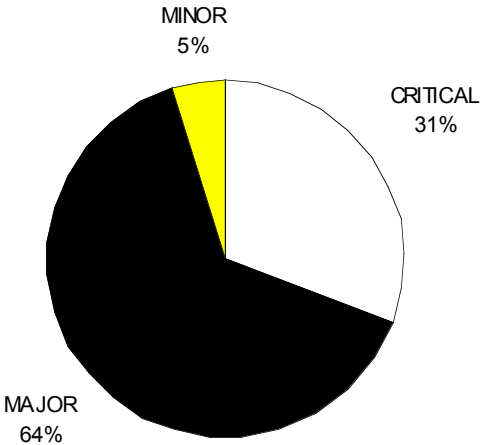
**Figure 5d: Distribution of Problems by Severity:  
January - June**



**Figure 5e: Quarterly Distribution of Problems by Severity:  
January - March**



**Figure 5f: Quarterly Distribution of Problems by Severity:  
April - June**



### **3.2.2 External TIC Problems**

External TIC problems have an influence on the effectiveness of TIC operations by impacting the content and quality of information that is entered into the TIC and the time it takes for the complete acquisition-processing-dissemination cycle to run its course. The primary sources of problems external to the TIC are the TOS, CAD and to a lesser extent the FSP. Other sources include Metro Network's Instatrack, and Octel.

While the TIC Problem Reports identify and document some of the external TIC problems, the Data Source Monitoring Reports (DSMR) are the primary information source for external TIC problems. These reports are produced weekly by TIC operations. During the reporting period (January through June 1997), there was one TATS-related problem that originated in the Octel system off-site, one Metro Network's Instatrack problem and one network communications problem. In addition, the TOS, FSP and CAD experienced an abundance of problems. The degree to which such problems are quantified depends on the source.

The DSMR documents approximately 15 to 20 TOS-related problems in which the TOS either went down for varying amounts of time or supplied information that was inaccurate. The TOS includes a network of sensors (a total of 168 as of September 1997) embedded in Bay Area freeways, mostly along highways 17, 24 and 101. Speed and congestion data is collected at Caltrans' Traffic Management Center and then routed to the TravInfo TIC. The loop data is one of the TIC's two fully automated data sources (the other is the FSP). Loop sensor data is used almost exclusively by operators at the slowdown position (see section 3.4). The quality of the loop data, however, has been problematic since the beginning of the project. Indeed, as of September 1997, TravInfo staff has impeded approximately 75% of all sensors from feeding data into the TIC because of serious data quality concerns.

The DSMR documents that the FSP incurred problems (went down, lost or otherwise unavailable data) approximately 15 to 20 times during the reporting period. These problems were clustered in twelve out of the twenty-six week period.

The DSMR documents repeated CAD problems, i.e. the CAD "went down", throughout the six month reporting period. In fact, there was not one week in which the CAD did not fail and have to be rebooted. This rebooting process is performed by the operators and requires 2-4 minutes until the CAD is performing normally. Such CAD-related failures and the additional time necessary for rebooting adds time to total operator response in acquiring, processing and disseminating traveler information. An analysis of response times is a component of the TIC evaluation and will be performed in the winter and summer of 1998.

### **3.3 Communications Interface**

The communications interface section assesses public call volume to the TATS system, TATS system capacity use and data access via the LDS on the part of registered participants. From

September 1996 to June 1997, call volume to the TATS system has remained fairly constant at between 50,000 and 60,000 calls per month (aside for September and October when it was slightly higher). The advertising campaign from January to March 1997 had only minor effects on overall call volume. TATS system capacity use, assessed by measuring access to the ports available to the public, is very low. On average, from September 1996 to June 1997, for Oakland, the busiest regional system, approximately 3% of the TATS system capacity was utilized. Private sector access of the data has also been quite limited. From November 1996 to June 1997, 25 of the 40 registered participants (62% ) downloaded data at one point or another, mostly in small amounts. Only three ISPs downloaded data on a continuous basis, one of which downloaded 95% of all data during the reporting period.

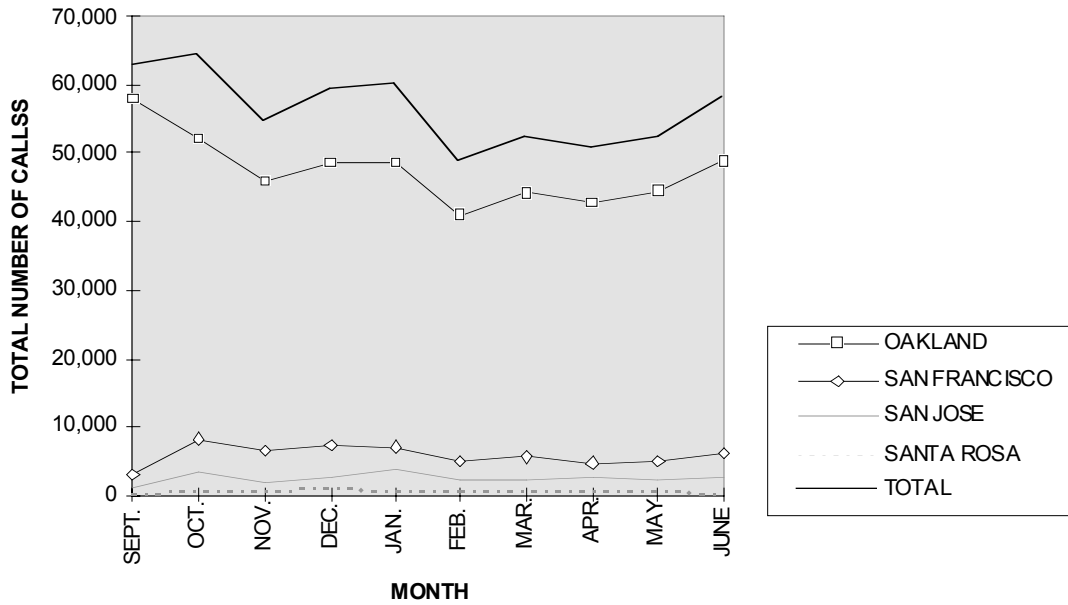
### **3.3.1 TATS Activity**

This section describes TATS activity between September 1, 1996 and June 30, 1997 relative to several time measures, such as monthly, weekly, time-of-day, day-of-week and weekday and weekend split. TATS activity is also discussed by individual region as well as for the Bay Area as a whole. TATS activity is also examined with respect to the top and lower levels of TATS menu selections, with a focus on traffic and transit. Part of the call volume is due to TIC operators calling at the beginning and the end of their shifts to check that information is properly placed within the TATS system. From June 1996 to September 1997, operator calls are responsible respectively for approximately 31%, 7%, 3% and 0.4% of calls in the SR, SJ, SF and OAKLAND systems. Finally, it should be noted that the overall call volume is “anomalously” skewed upwards because one of the major transit service providers of the San Francisco Bay Area, AC Transit, uses the TATS number as its only number for customers. AC Transit alone contributes on the order of 55% of the overall call volume throughout the reporting period.

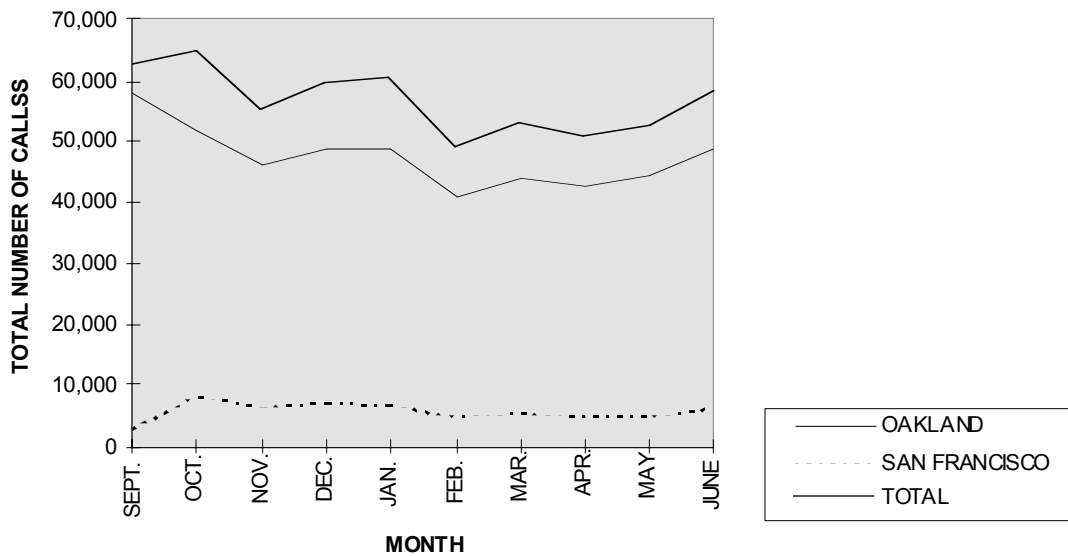
#### **3.3.1.1 Monthly Call Volume**

The first set of figures (Figures 6a - 6d) focus on monthly activity. Figure 6a depicts monthly call volume activity for the Bay Area as a whole as well as regionally for each of the four area code regions. Figures 6b and 6c separate monthly call volumes by area code to display more prominently regional activity, especially for the SR and SJ regions which display the smallest activity. The overall monthly call volume has remained fairly consistent over the ten month reporting period. There was a slight increase in total call volume immediately following the official ribbon-cutting at the end of September, 1996, as well as a minor upswing that correlates with the start of the TravInfo advertisement campaign and a period of bad weather during the month of January, 1997. The dip in total call volumes in February is due more to the fewer number of days in February relative to other months than to any external “event.” Figure 6a also dramatically points out the importance of OAKLAND call volume relative to the other three regions and how much total monthly call volume behavior mirrors that of OAKLAND. In Figure 6d, regional and overall call volumes are depicted factoring out AC Transit. The trends are quite similar to those of figure 6a aside from a more pronounced increase in overall call volume from September to October and a slight decrease from December to January.

**Figure 6a: Regional and Bay Area Total Monthly Call Volume**

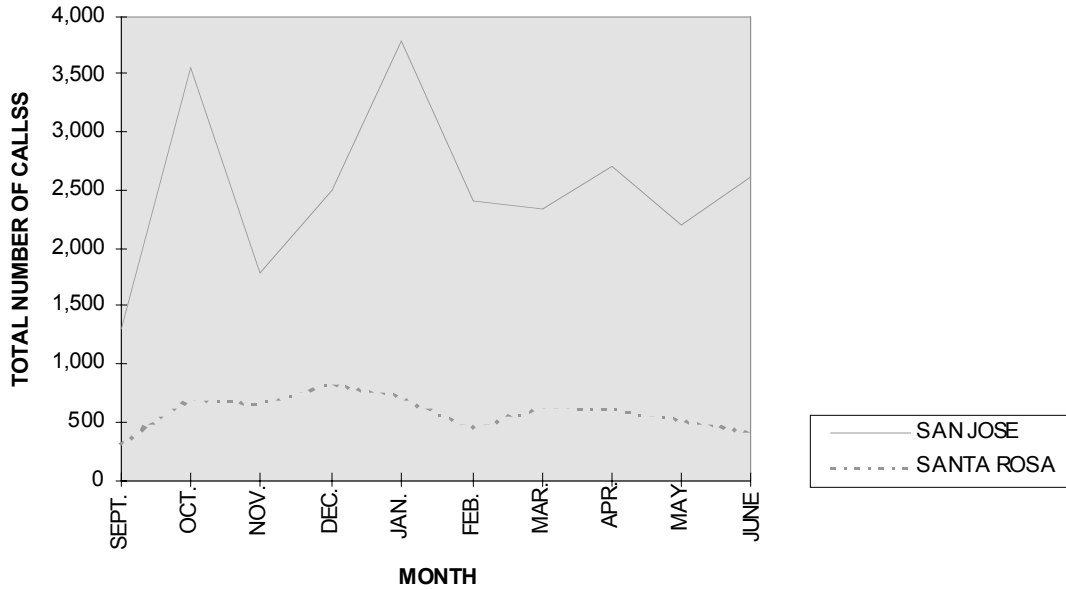


**Figure 6b: Oakland, San Francisco and Bay Area Total Monthly Call Volume**

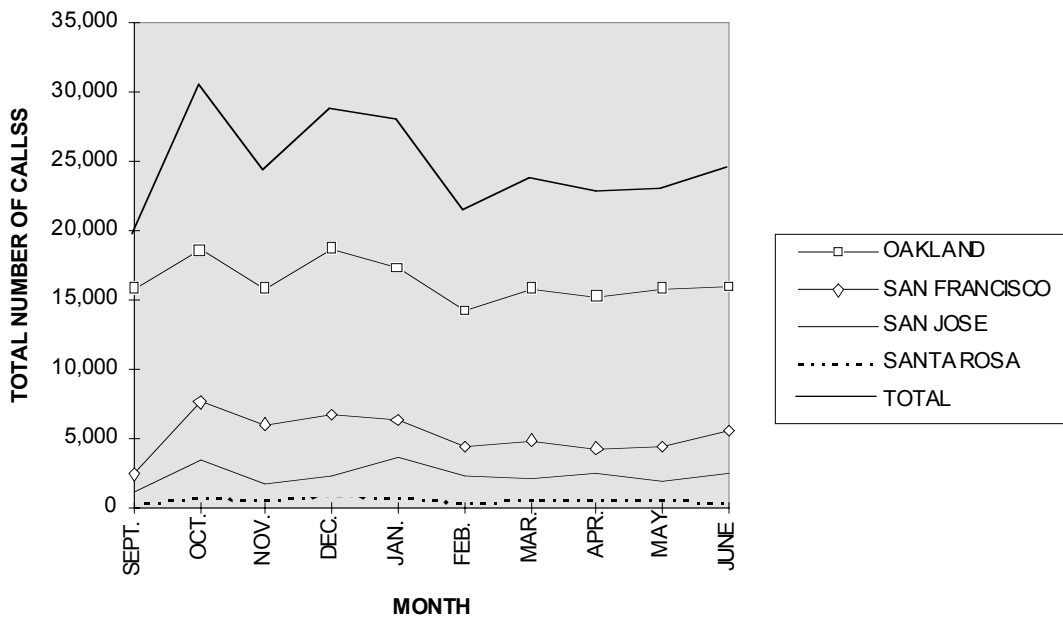




**Figure 6c: San Jose and Santa Rosa Regional Monthly Call Volume**

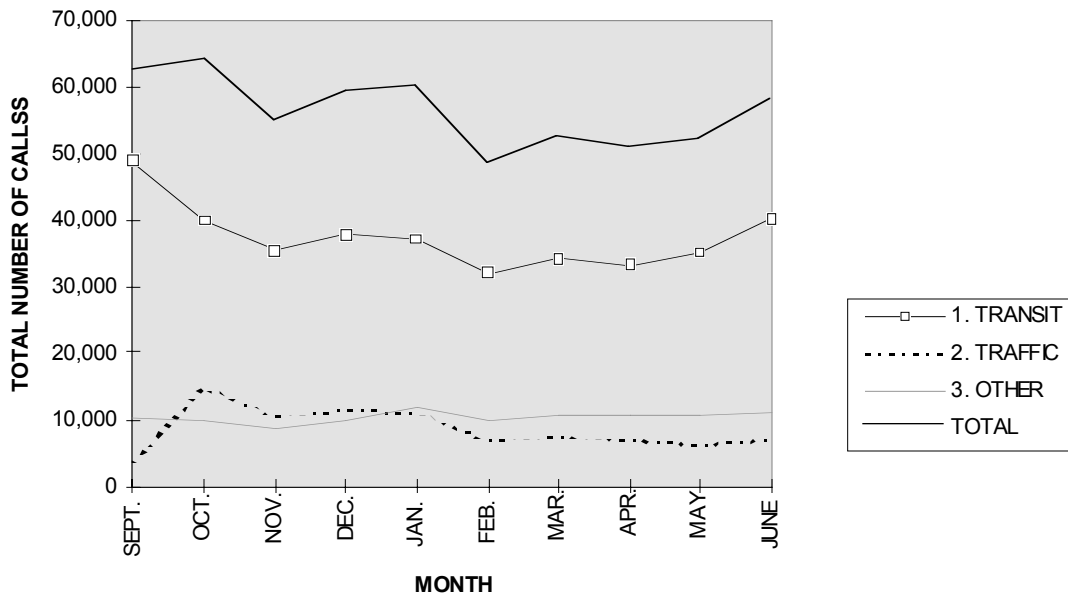


**Figure 6d: Regional and Bay Area Total Monthly Call Volume Factoring Out AC Transit**

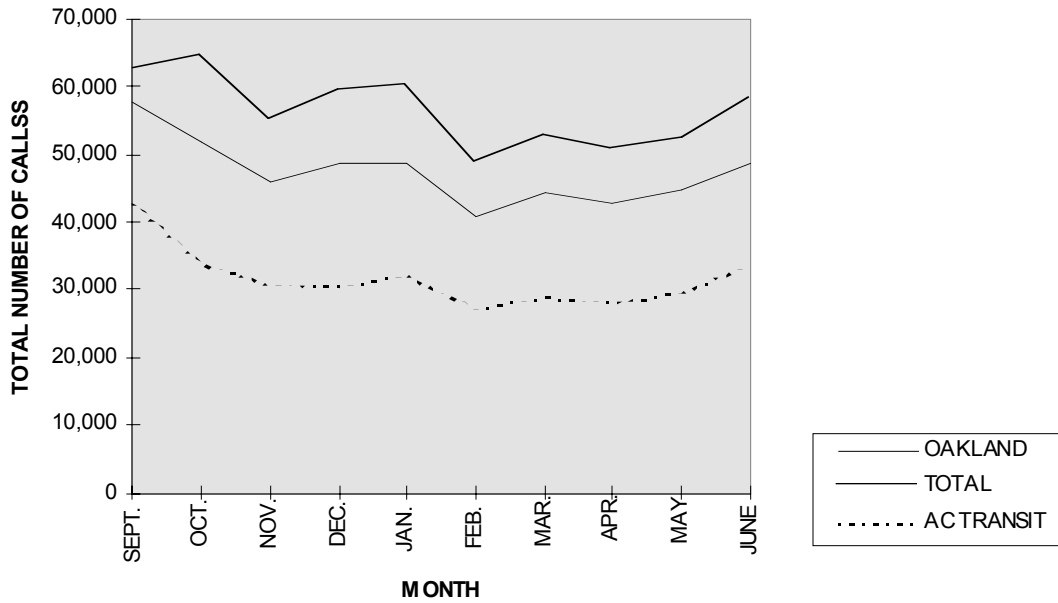


The next group of figures (Figures 7a and 7b) depict monthly call volumes by type of call. Figures 7a and 7b show monthly call volume disaggregated by the two main call types, transit and traffic. Figure 7a includes AC Transit, overall transit, traffic and total calls. Figure 7b shows AC Transit activity relative to total calls in OAKLAND and the Bay Area overall. The primary observations in Figure 7a are that AC Transit (which is 85% of overall transit) determines the total call volume activity very closely (except for September 1996 when traffic had more of an influence on total call volume than transit) and that traffic inquiries remain fairly stable through the reporting period. Figure 7b shows how closely OAKLAND call activity mirrors that of AC Transit. In Figure 7c, AC Transit data was factored out. Aside from September and October (and to a small extent May), traffic and transit calls display similar trends, with the latter having more of an influence on the evolution of overall volume. Starting in March, call volume remained fairly constant with a minor upswing in June.

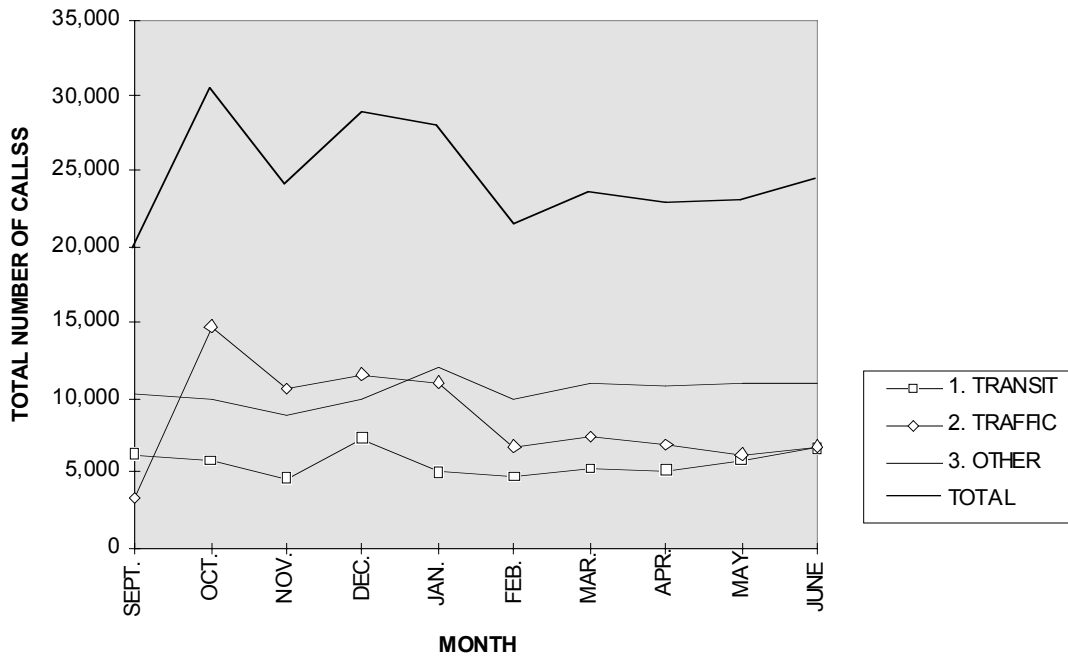
**Figure 7a: Bay Area Monthly Call Volumes by Call Type**



**Figure 7b: AC Transit Call Volume Relative to Oakland Region and Bay Area**

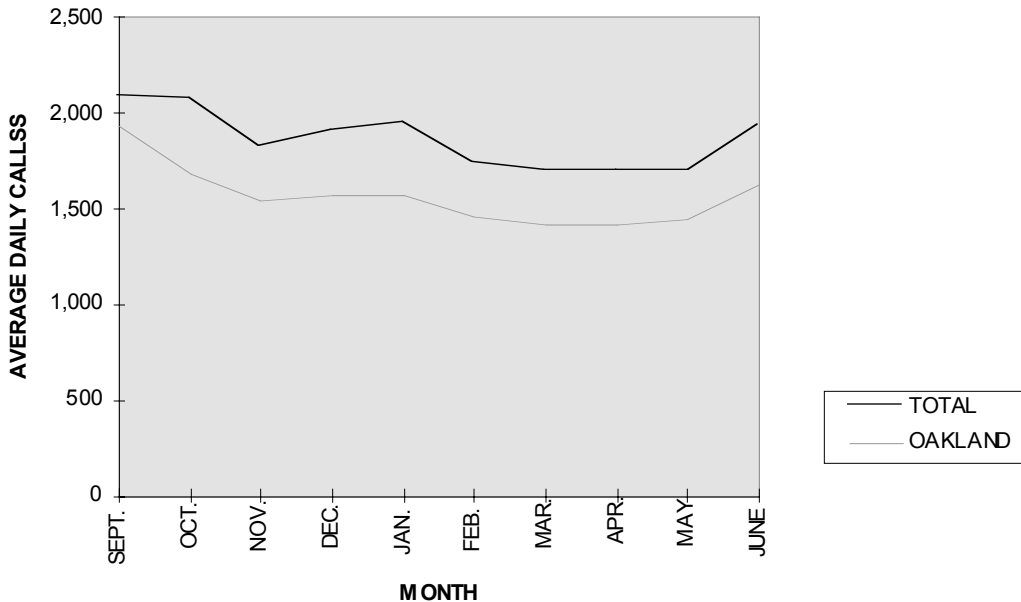


**Figure 7c: Bay Area Monthly Call Volumes by Call Type Factoring Out AC Transit**

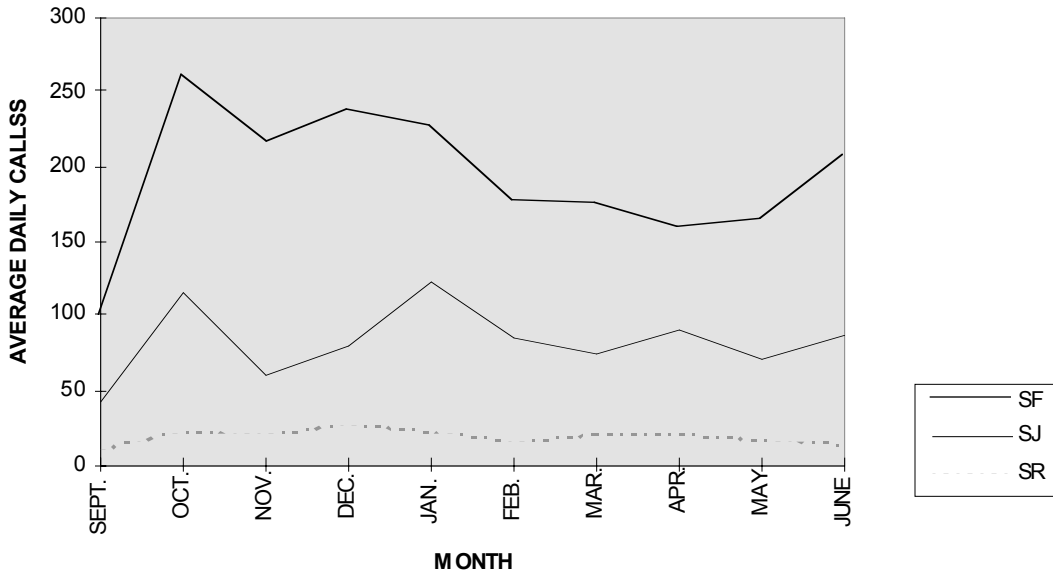


The next group of figures (Figures 8a - 8c) depict average daily call volumes per month by region. Figure 8a shows the average daily call volume per month for the Bay Area as a whole and for the OAKLAND region. This figure factors out the monthly differences evident in previous figures, that is, call volume differences due to the number of days per month. Maxima in call volumes may be seen in the September-October 1996 time-frame (beginning of TravInfo) and in January 1997 (combination of bad weather and advertising campaign). Figure 8a also shows how closely total call volume mirrors that of OAKLAND. Figure 8b shows the three other regions. Note the different vertical axis scales in Figure 8a relative to 8b. In conclusion, when analyzing the data in terms of average daily calls per month, it is clear that usage of the TATS system overall has remained constant or fluctuated only very slightly. In figure 8c, average daily call volume per month is calculated subtracting AC Transit numbers. Two differences appear compared to figure 8a: 1. there is a one-third increase from September to October excluding AC Transit numbers as compared to a stable trend in figure 8a and 2. the minor increase of figure 8a from December to January becomes a minor decrease when subtracting the AC Transit numbers.

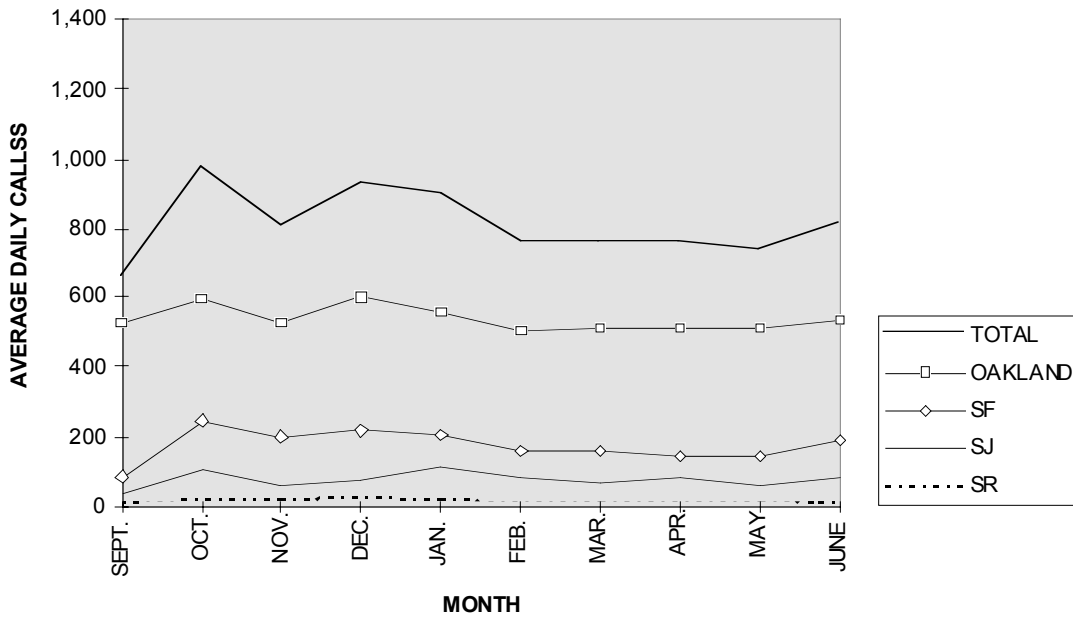
**Figure 8a: Average Daily Call Volume: Bay Area Total vs. Oakland**



**Figure 8b: Average Daily Call Volume: San Francisco, San Jose and Santa Rosa**



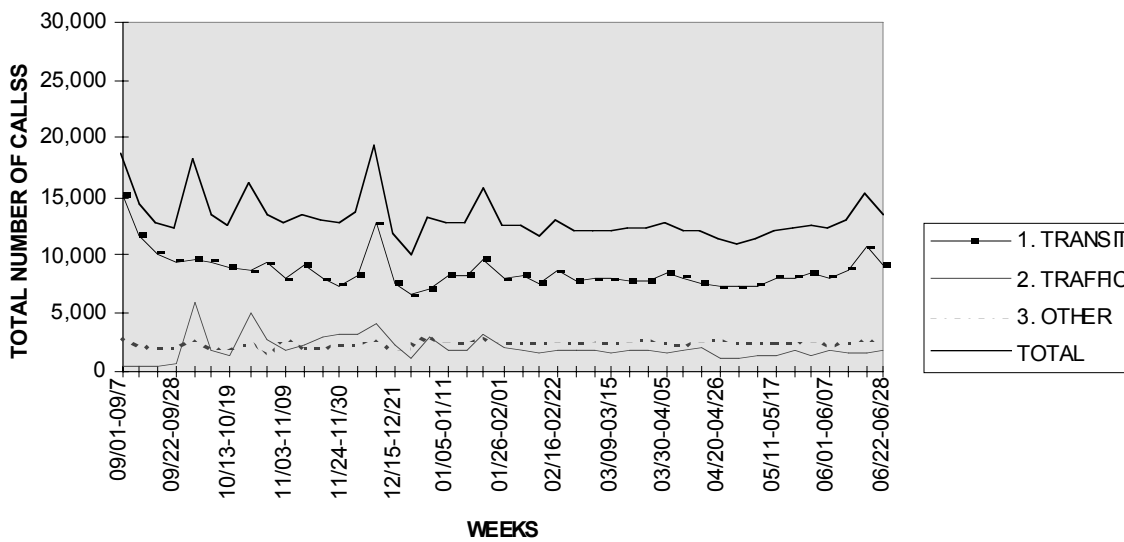
**Figure 8c: Average Daily Call Volume Factoring Out AC Transit: Bay Area and Regions**



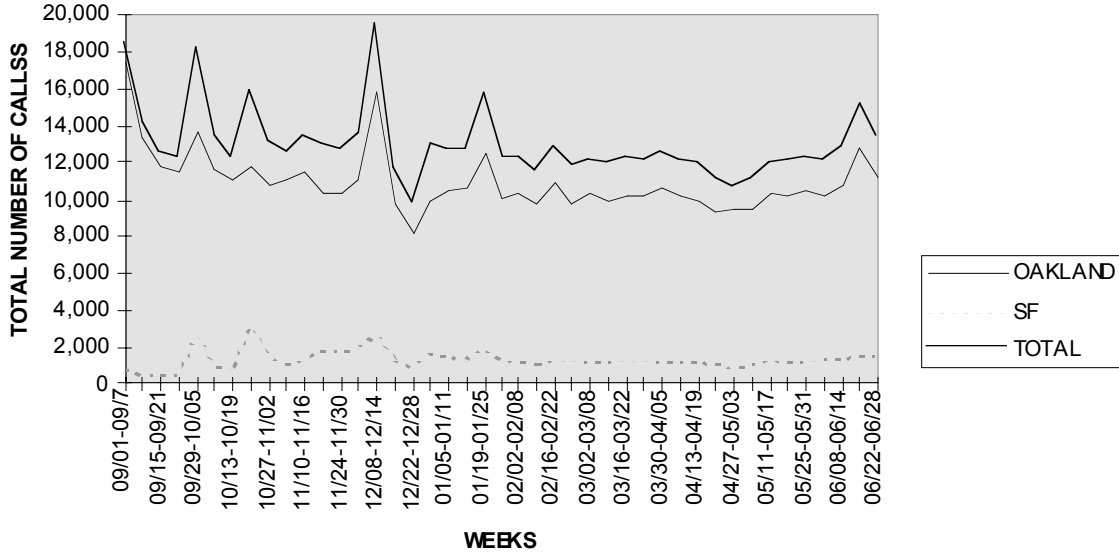
### 3.3.1.2 Weekly Call Volume

The next group of figures (Figures 9a - 9c) focus on weekly call volume activity. Figure 9a shows weekly call volumes for all calls as well as for transit, traffic and all other call types. Again, it is clear that with the exception of the first month of TravInfo in which traffic dominates the overall total call volume behavior, transit has the most influence over total call volumes. The first two peaks in call volume for traffic likely result from the ribbon-cutting ceremony, initial excitement over the start of TravInfo and residual media coverage. The largest peak in total call volumes results from a similar spike in transit, i.e. AC Transit, call volume combined with a minor increase in traffic calls. This activity occurred approximately the second week of December 1996. While AC Transit instituted no fare changes within the past year, there have been quarterly schedule changes (August 31, December 31, March 31 and June 30). This large increase in AC Transit volume during the second week of December is likely attributable to the December AC Transit schedule changes, coupled with the approaching holiday season and an anticipation factor, that is, an anticipation of these events. Given the slight increase in traffic calls during the same period it is likely that weather (which was rainy during that week) and the approaching holiday season also had some effect. While similar increases in March did not occur, a surge in transit calls in June may also have resulted from AC Transit schedule changes coupled with the oncoming Summer season and the end of the school season. The peak occurring around week 21 (January 19-25, 1997) can be attributed to the advertisement campaign and the presence of bad weather (rainy six out of the seven days of that week). The slight dip in activity between week 33 (April 13-19, 1997) and week 35 (April 27-May 3, 1997) is due to the intercepts of TATS calls in preparation for the follow-up TATS survey. Figure 9b shows, again, how closely total call volume activity is driven by call volume activity in the OAKLAND region.

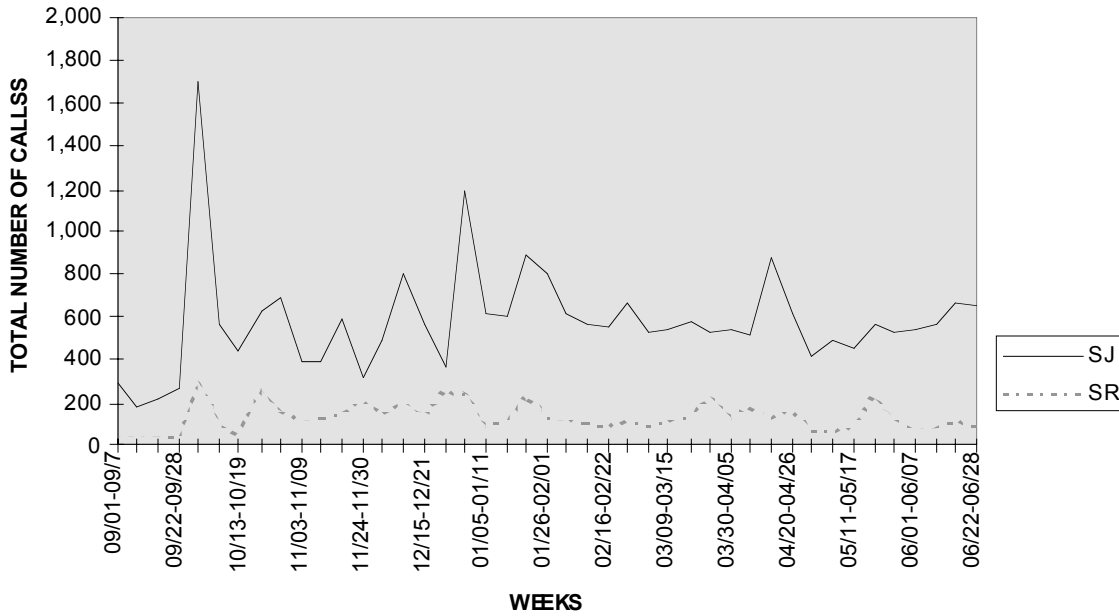
**Figure 9a: Weekly Total Call Volume for Bay Area by Call Type**



**Figure 9b: Weekly Total Call Volume for Bay Area, Oakland and San Francisco Regions**



**Figure 9c: Weekly Total Call Volume for San Jose and Santa Rosa Regions**



### 3.3.1.3 Daily Call Volume

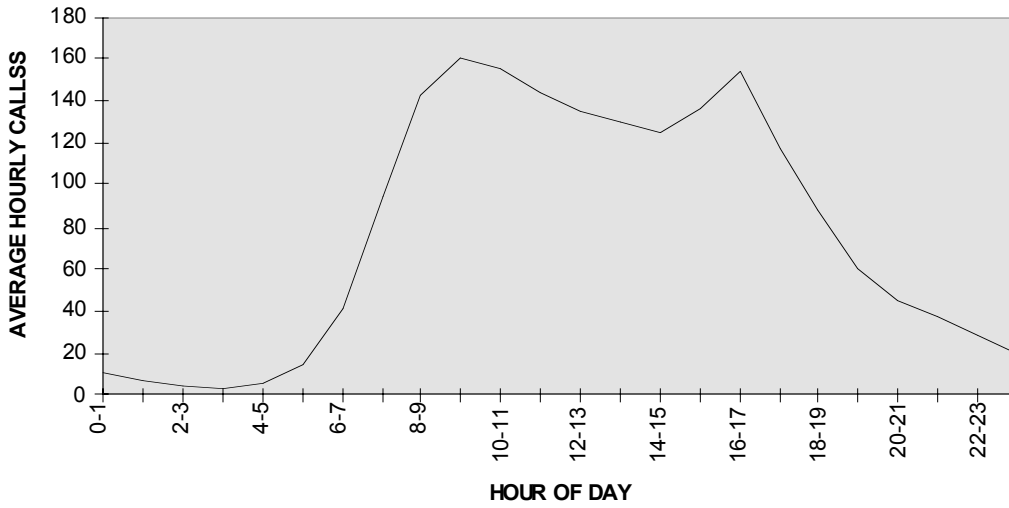
The next set of figures (Figures 10a-10f) concentrates on time-of-day call volume activity for the time period September 1996 to June 1997. Figure 10a depicts the overall hourly average call volume for all call types over the entire Bay Area. It displays the expected double-peak calling pattern corresponding to morning and afternoon travel to and from work. The afternoon call volume maximum occurs during the 4 PM to 5 PM hour and the morning call volume maximum occurs during the 9 AM to 10 AM hour, which is later than intuitively expected. Figure 10b splits the hourly average call volume into weekday and weekend time periods. The weekday behavior explains the peaks in overall hourly average call volume relative to when peaks occur. Weekend calling behavior displays has a single peak occurring in the late morning reflecting the fact that people tend to sleep later on the weekends and call in to TATS prior to a weekend outing.

Figure 10c depicts the hourly average call volume for traffic calls. The maximum calling activities in the morning and afternoon occur between 8 AM and 9 AM and 5 PM and 6 PM respectively. Similarly, it can be observed in Figure 10d, which splits hourly average traffic calls into weekday and weekend, that overall calling activity reflects the weekday hourly average calling behavior with two peaks in the 8 AM to 9 AM and 5 PM to 6 PM periods. The weekend traffic calling behavior is naturally muted relative to weekday behavior, yet the peak occurs as expected in the late morning and late afternoon.

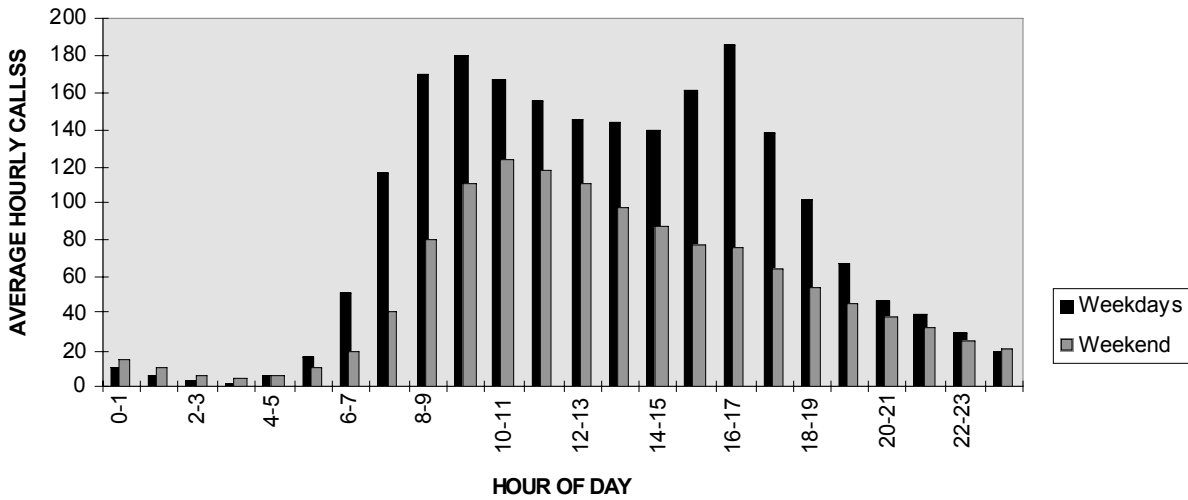
Figures 10e and 10f display transit hourly average calling behavior. Comparing the figures in pairs, i.e. 10a and 10b, 10c and 10d, and 10e and 10f, it is clear that transit calling behavior (Figures 10e and 10f) governs the overall calling behavior. This transit dominance explains the later than expected weekday maximum call volume activity (9 AM to 10 AM). Calling activity is fundamentally different for traffic than for transit. Transit callers generally pre-plan, whereas traffic callers call just prior to leaving or while in traffic.



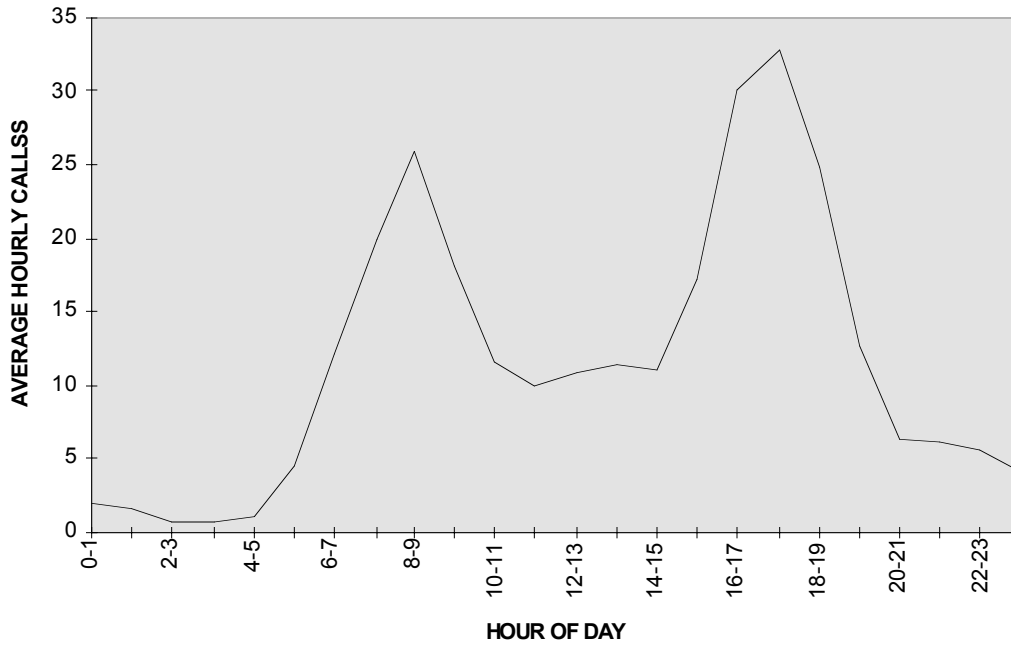
**Figure 10a: Bay Area Average Hourly Call Volume**



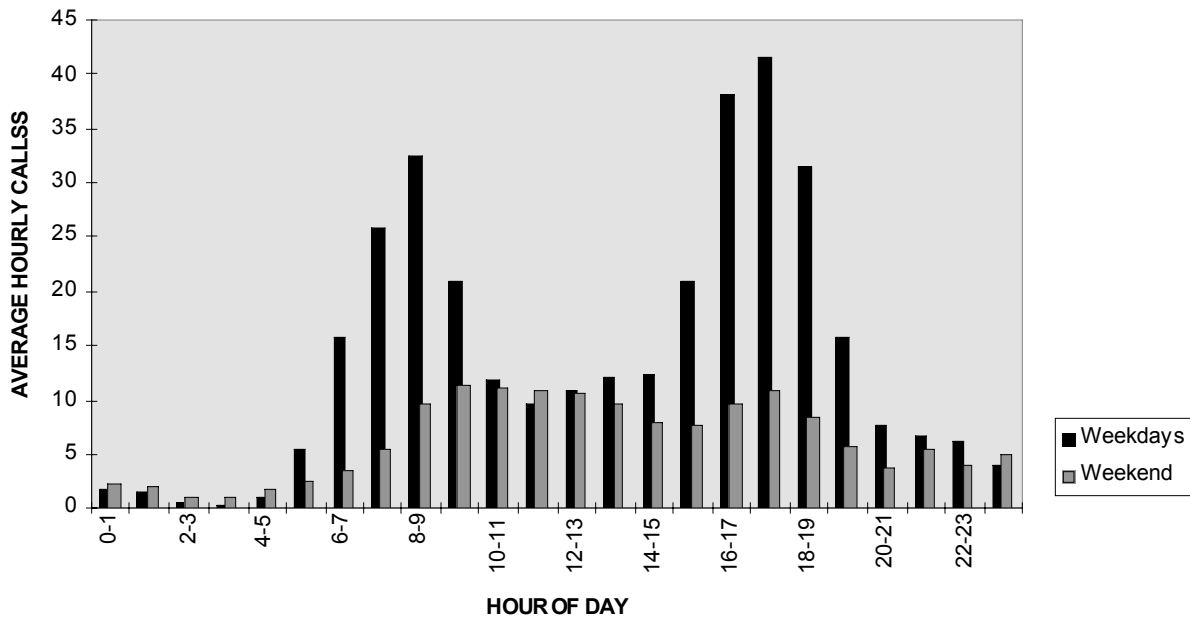
**Figure 10b: Bay Area Average Hourly Call Volume: Weekday vs. Weekend**



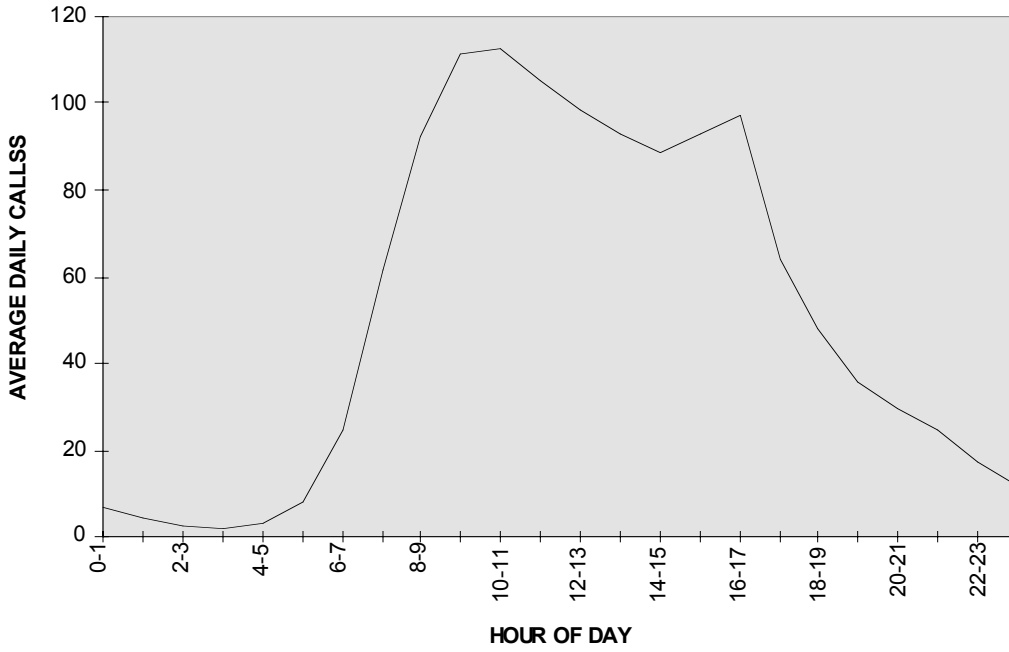
**Figure 10c: Bay Area Average Hourly Traffic Call Volume**



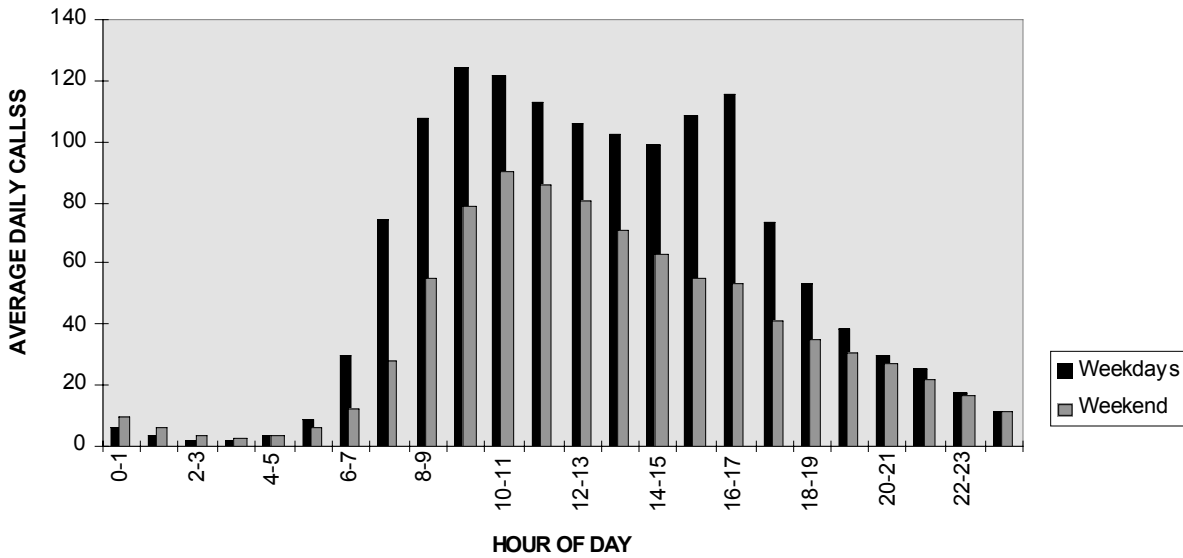
**Figure 10d: Bay Area Average Hourly Traffic Call Volume: Weekday vs. Weekend**



**Figure 10e: Bay Area Average Hourly Transit Call Volume**

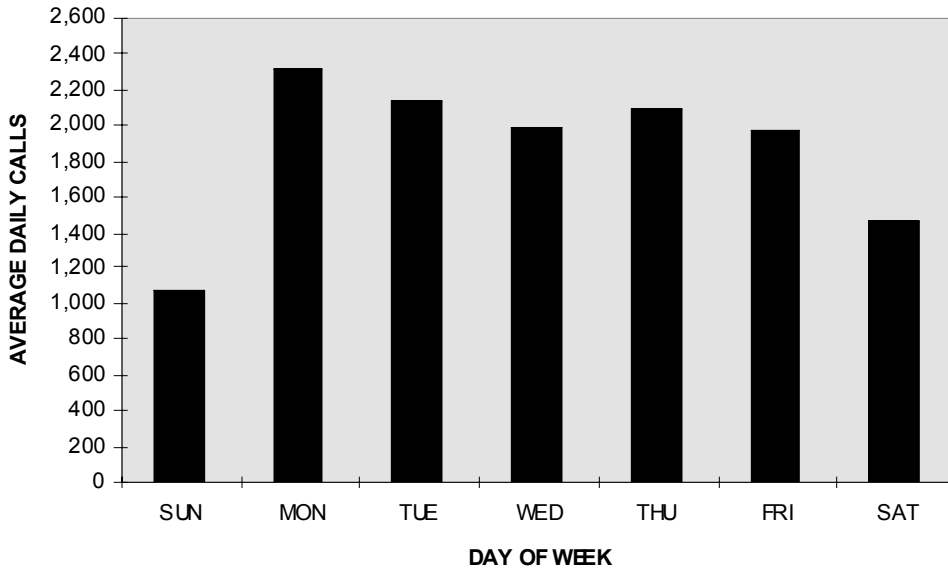


**Figure 10f: Bay Area Average Hourly Transit Call Volume: Weekday vs. Weekend**



The next figure (Figure 11) focuses on day-of-week call volume activity for the Bay Area and the results are expected with weekday call volume greater than weekend call volume.

**Figure 11: Average Day-of-Week Call Volume Bay Area-Wide**



### 3.3.1.4 Regional Per Capita Call Volume

There are significant call volume differences among the four TATS regions. One important difference is due to calls for AC Transit which contribute approximately two-thirds of incoming OAKLAND system calls, yet significantly smaller portions for the SF, SJ and SR systems - 9%, 6% and 1%, respectively (Also see Figures 6a, 6d and 7b). An additional contributing factor for such low call volumes in the SR region is that the TravInfo advertisement campaign in January through March of 1997 was not implemented in the SR region (707). A final contributing factor is due to the differences in population for each of the four regions. The question to be answered is: How much of the call volume is due to population? Per capita estimates were derived to factor out population as a contributing source of call volume differences.

The population for each of the four TATS regions is given in Table 2a. The first step in developing population estimates for each of the four TATS regions was to determine the counties corresponding to each of them. While the 707 and 408 area code boundaries include counties beyond the nine county Bay Area, (e.g. Mendocino and Santa Cruz counties are part of 707 and 408 areas, respectively) only those counties within each area code and within the Bay Area were used to estimate regional populations since TravInfo focused on the Bay Area and the primary advertising campaign did not go beyond the Bay Area. An exact match between area code and county boundaries exists for 707 (Napa, Sonoma, Solano) and 510 (Alameda and Contra Costa). The situation is not as precisely determined for 415 and 408. First, note that what follows is

based on the situation that existed prior to the 415 area code split. The 415 area code consists of San Francisco, Marin, San Mateo and part of Santa Clara counties. The remaining portion of Santa Clara county not in 415 is in 408. The part of Santa Clara county in the 415 area code includes primarily the cities of Los Altos, Los Altos Hills, Palo Alto and Mountain View. County and city populations were based on information contained in references (2) and (3). Cellular calls do not pose any problem since if a cellular call is made to TravInfo, the call gets logged to the TATS system corresponding to the “home” area code for the cellular phone number, not the TATS system corresponding to the area code from where the caller is placing the call.

**Table 2a: Regional Population for 1996**

REGION	1996 POPULATION
Oakland (510)	2,209,629
San Francisco (415)	1,820,354
San Jose (408)	1,434,704
Santa Rosa (707)	902,920

Per capita estimates of the number of calls were derived for three different categories of call volumes (See Table 2b): all calls, all calls with AC Transit-related calls factored out and for traffic calls only. As discussed in Section 3.3.1, some incoming calls to each of the four TATS are made by operators. The volume of such operator calls have already been factored out of Table 2b. In order to show estimates relative to the same units of time and population across all

**Table 2b: Total Regional Call Volumes (September 1996-June 1997)**

REGION	ALL CALLS	ALL CALLS WITH AC TRANSIT FACTORED OUT	TRAFFIC CALLS ONLY
Oakland (510)	472,606	162,854	38,560
San Francisco (415)	56,607	51,665	28,453
San Jose (408)	23,415	21,923	13,553
Santa Rosa (707)	4,010	3,954	1,869

**Table 2c: Per Capita Regional Call Volumes (Monthly Average/10 Thousand People)**

REGION	ALL CALLS	ALL CALLS WITH AC TRANSIT FACTORED OUT	TRAFFIC CALLS ONLY
Oakland (510)	213.9	73.7	17.5
San Francisco (415)	31.1	28.4	15.6
San Jose (408)	16.3	15.3	9.4
Santa Rosa (707)	4.4	4.4	2.1

three call volumes and all four regions, per capita estimates were derived on a monthly basis for every 10 thousand people of the population. Results are shown in Table 2c.

A comparison of results in Table 2c and Table 2b indicates the relative contribution of each regional population towards regional call volume. Even with AC Transit calls factored out, however, there are nevertheless sizable differences in per capita call volumes among all four regions though smaller than indicated in Table 2b. For traffic calls only, OAKLAND and SF regional per capita totals are almost within ten percent of each other whereas the SF call volume is less than three-quarters of OAKLAND call volume (Table 2b).

### **3.3.1.5 Call Durations**

TATS usage and resource utilization in general can also be assessed by measuring call duration. The following tables (Tables 3a-c) focus on call duration. Table 3 shows the average duration and standard deviation for all call types on a regional basis. It can be observed that for all regions, other than OAKLAND, the average call durations are relatively close together in value with a range of 71.2 sec. (minimum) to 81.2 sec. (maximum). The average call duration for the OAKLAND area (33.5 sec.) is less than half that for SJ (71.2 sec.) which has the smallest of the other three average duration values. The very low average duration relative to the other three regions results from the larger percentage of transit calls coming into the OAKLAND area intended for AC Transit (See Table 3). Callers are transferred to the transit service provider (TSP) instead of remaining within TATS to obtain information, such as for traffic (See Table 3). Thus, transit calls are much shorter than traffic calls.

In Table 3b, the average call durations are relatively close in value with a range of 67.6 sec (minimum) to 83.8 (maximum) again reflecting the fact that all such calls are traffic and the caller remains in the TravInfo TATS to receive all such traffic-related information.

In Table 3a, the standard deviation for OAKLAND is significantly less than for the other three regions, again reflecting the influence that transit calls play in OAKLAND compared to the other three regions. Less variability in call duration for transit versus traffic calls results from transit calls being shunted to the TSP once that specific selection has been made. Furthermore, the transfer to the TSP occurs approximately at the same time for each call, especially considering the magnitude of AC Transit's contribution to OAKLAND calls.

In Table 3b (traffic call durations), the standard deviations for each region are relatively close in value, with a range from 61.1 sec. (minimum) to 78.3 sec. (maximum). Traffic calls inquiries are made for any number of routes which results in a high degree of variability in traffic call duration.

In Table 3c (transit call durations), the standard deviation values are significantly smaller than for traffic calls and range from 16.7 sec. (minimum) to 36.5 sec. (maximum). For the transit calls, there is nevertheless a significant difference between the standard deviation for OAKLAND compared to the standard deviation for the other three regions. This difference is due to the

placement of individual TSPs within the transit menu structure for each of the four TATS. The TSPs are split into multiple tiers within the transit menu structure for each TATS. For OAKLAND, AC Transit is not only in the first group or tier called out, it is the first TSP within the first tier and it accounts for the great majority of OAKLAND transit calls. Thus, AC Transit calls are shunted out rapidly resulting in little variability in transit call duration. Moreover, little variability is also due to the overwhelming weight of AC Transit to the transit category. For the other three regions, calls to certain TSPs that appear in at least the second and even the third tier of TSPs, contribute a sizable portion of all transit calls in that region, resulting in higher duration averages as well as standard deviations.

**Table 3a: Overall Call Duration Measures**

<u>REGION</u>	<u>AVERAGE</u> (sec)	<u>STANDARD DEVIATION</u> (sec)	<u>NUMBER OF CALLS</u>
OAKLAND	33.5	39.6	474,504
S.F.	72.3	68.6	58,358
SAN JOSE	71.2	65.5	25,177
SANTA ROSA	81.2	83.7	5,812

**Table 3b: Call Duration Measures (Traffic Calls)**

<u>REGION</u>	<u>AVERAGE</u> (sec)	<u>STANDARD DEVIATION</u> (sec)	<u>NUMBER OF CALLS</u>
OAKLAND	75.8	72.0	38,718
S.F.	74.1	63.8	29,341
SAN JOSE	67.6	61.1	14,805
SANTA ROSA	83.8	78.3	2,764

**Table 3c: Call Duration Measures (Transit Calls)**

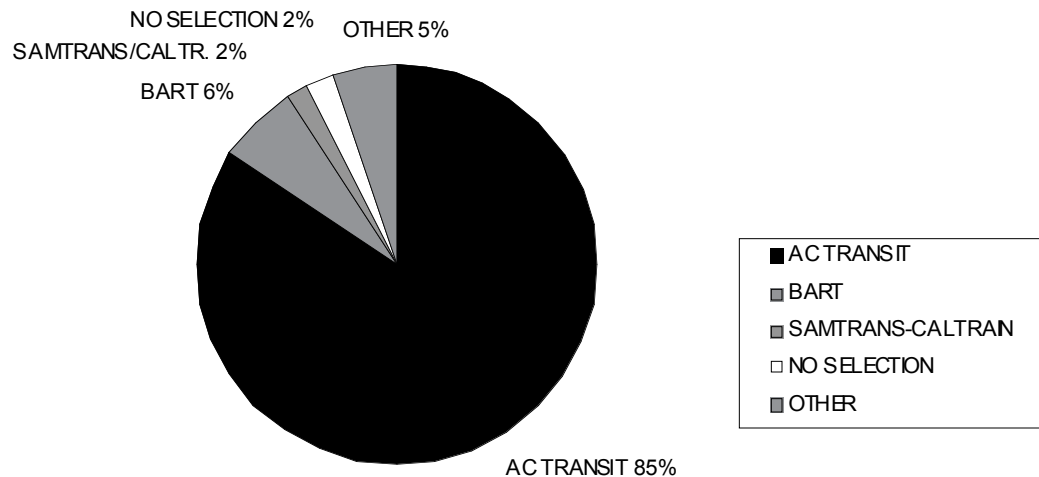
<u>REGION</u>	<u>AVERAGE</u> (sec)	<u>STANDARD DEVIATION</u> (sec)	<u>NUMBER OF CALLS</u>
OAKLAND	22.6	16.7	349,849
S.F.	35.4	27.1	17,383
SAN JOSE	32.3	26.7	6,179
SANTA ROSA	44.0	36.5	1,051

### 3.3.1.6 Transit Calls

The next set of figures (Figures 12a - 12h) show the overall quarterly distribution of selected transit service providers. Figures 12a and 12b show such a distribution for the three full quarters during the reporting period (October 1996 through June 1997). Figure 12a depicts all TSPs with a call volume share of 2% or more of the overall transit call volume (referred to as TSPs with “high” call volume) and groups all TSPs below the 2% level into a single grouping called “other.” (Figure 12b). A similar method of presentation is used for each of the individual quarters (October 1996 - December 1996; January - March 1997; April - June 1997).

Figures 12a, 12c, 12e and 12g consistently show that AC Transit<sup>1</sup>, BART and SAMTRANS-CALTRAIN account for 85%, 6% and 1-2% of all transit inquiries, respectively. All “other” TSPs collectively account for 4% to 6% of all transit inquiries. Among “other” TSPs, Alameda-Oakland Ferry, CCCTA, Golden Gate and MUNI consistently account for 8%-10%, 14-18%, 11%-14% and 25%-27% of 5% (“other” TSPs) of transit inquiries, that is, approximately 0.5%, 0.8%, 0.6%, and 1.3% of all transit inquiries, respectively. For SCVTA, there is steady growth in the amount of inquiries to this TSP, from 0.5% to 1.2%.

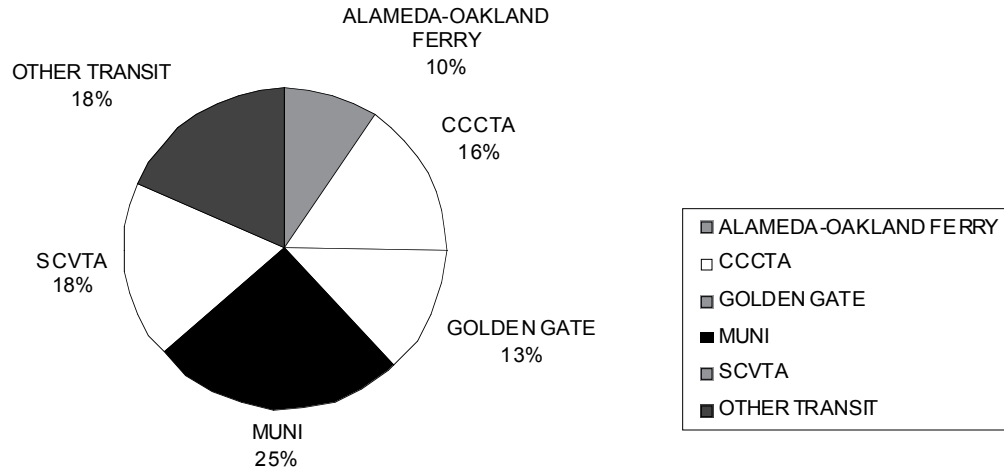
**Figure 12a: Distribution of Transit Calls for Transit Service Providers with “High” Call Volume: October 96 - June 97**



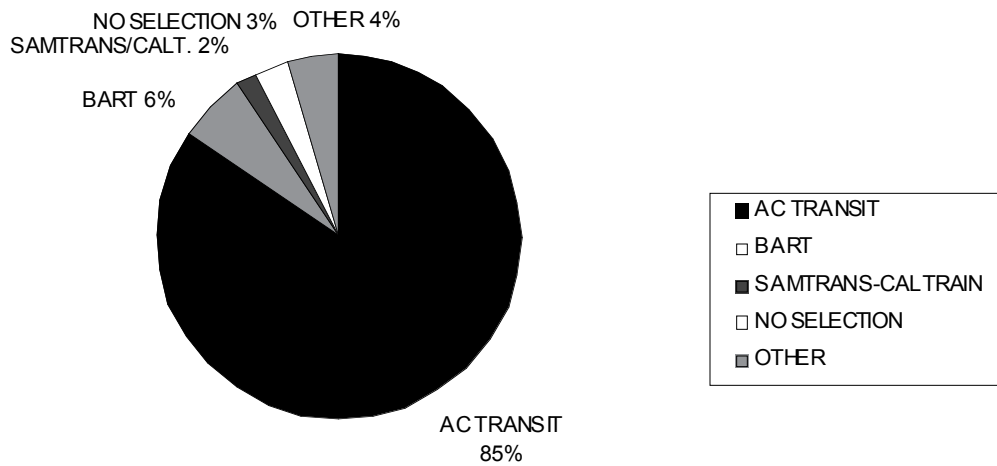
<sup>1</sup> AC Transit’s call volume is overwhelmingly larger than that of any other TSP because beginning in December 1995 it began using the TravInfo number as its sole number for customers. The average monthly AC Transit call volume for the 9-month period prior to switching to the TravInfo number was 40,226; from December 1995 to August 1996 (just prior to the start of operations) it was 33,061 and for the first nine months of TravInfo operations it was 35,308. The drop in call volume was likely due to the fact that AC Transit switched from a toll-free number to the TravInfo number (which costs the price of a local call) so that there was a drop in “frivolous” calls.



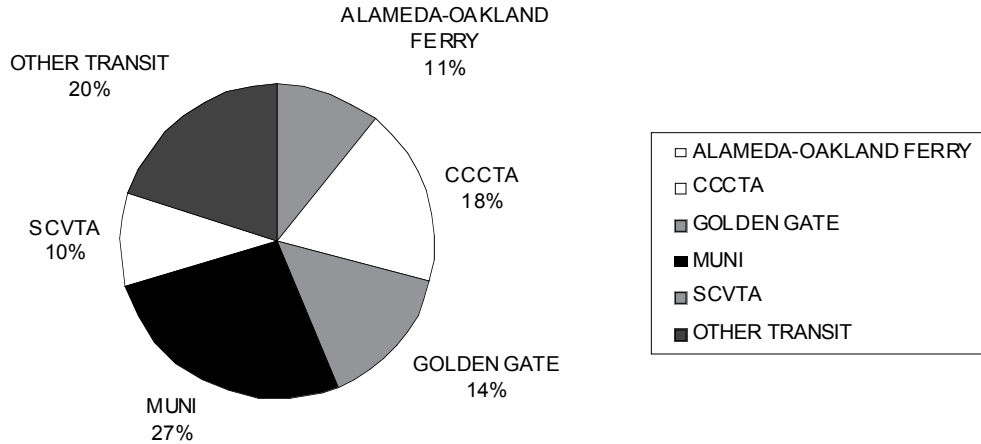
**Figure 12b: Distribution of Transit Calls for “Other” Transit Service Providers:  
October 96 - June 97**



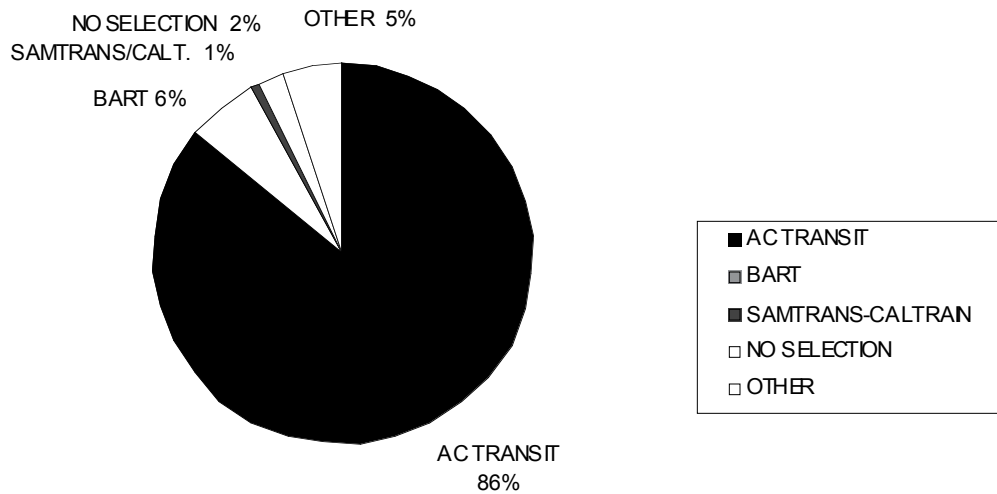
**Figure 12c: Distribution of Transit Calls for Transit Service Providers with “High”  
Call Volume: October 96 - December 96**



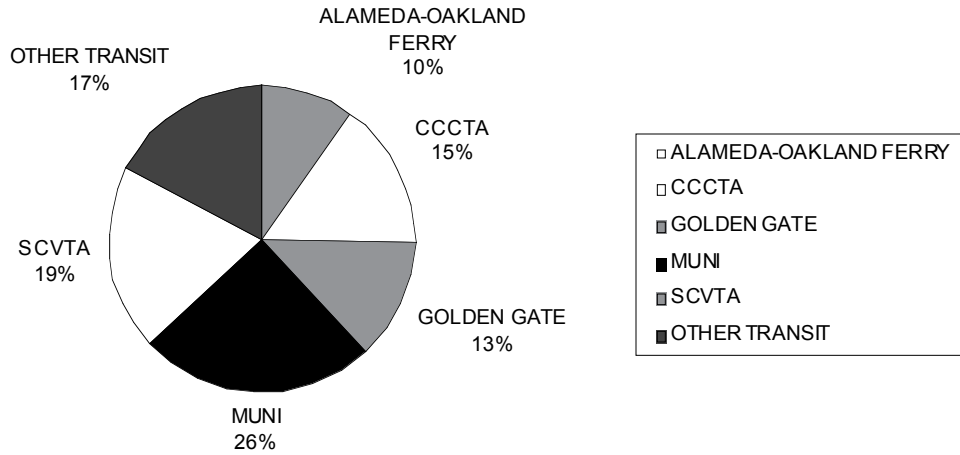
**Figure 12d: Quarterly Distribution of Transit Calls for “Other” Transit Service Providers: October 96 - December 96**



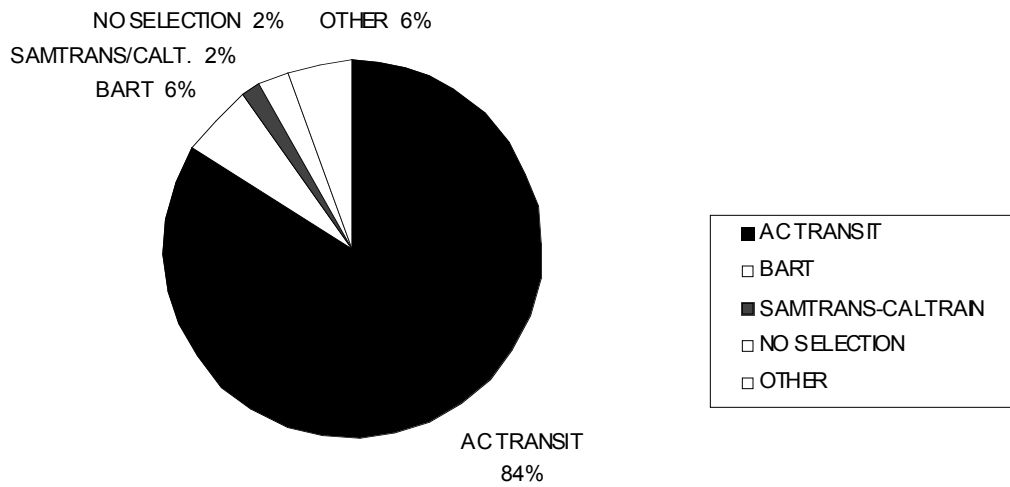
**Figure 12e: Distribution of Transit Calls for Transit Service Providers with “High” Call Volume: January 97 - March 97**



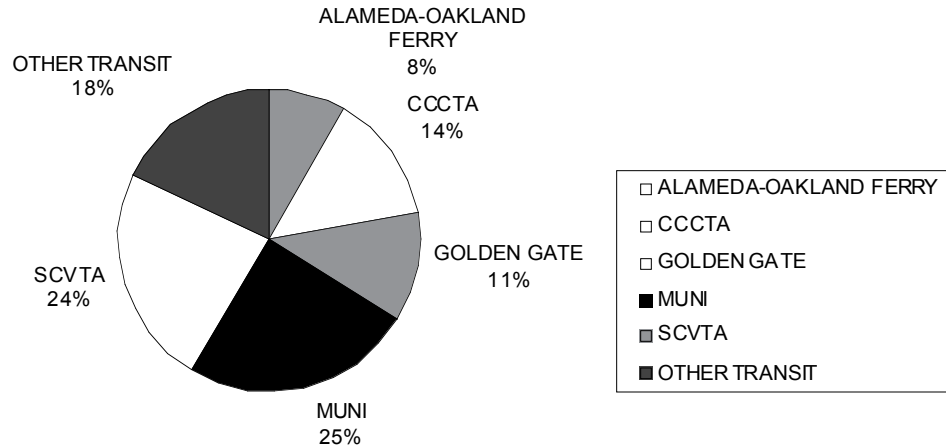
**Figure 12f: Quarterly Distribution of Transit Calls for “Other” Transit Service Providers: January 97 - March 97**



**Figure 12g: Distribution of Transit Calls for Transit Service Providers with “High” Call Volume: April 97 - June 97**



**Figure 12h: Quarterly Distribution of Transit Calls for “Other” Transit Service Providers: April 97 - June 97**



### 3.3.1.7 Top Level Menu Selections

Table 4 below depicts the quarterly distribution of top level menu selections as well as the total for the entire three quarter period (October 1996 through June 1997). Overall there is very little overlap in menu selections during individual phone calls. From September 1996 to June 1997, only from 0.25 to 0.75% of all calls were calls with multiple menu selections. For traffic selections, the sizable decrease from the first quarter to the second quarter may be attributed to reduced media exposure after the start-up of TravInfo. For the “central freeway/highway construction update” selection, callers heard information on the Central Freeway demolition through the first two quarters and the selection was changed at the beginning of the third quarter to more general highway construction update information. The bulk of the work on the Central Freeway was completed by the end of the first quarter resulting in considerably fewer calls during the second quarter. For the “other” selection category, there is a significant drop in volume from the 2nd to the 3rd quarter. This decrease was due to a change in what information callers initially heard about this category. During the first two quarters, callers would have to select this category and then they would hear what the category contained. During the third quarter, this was modified and callers would hear the full range of subcategories before having to make the selection. This change resulted in a significant drop in inquiries as callers knew before having to select this category what information it contained. There is a small problem in the query analysis of TATS data for the “no selection” category. The correct number of selections for this category has not been obtained from the query analysis for the first quarter and part of the second quarter (indicated by an “\*” in the table). On-going research into this problem will be performed until it is resolved.

**Table 4: Quarterly Upper Level Menu Selections**

	<b>1st Q</b>	<b>2d Q</b>	<b>3d Q</b>	<b>TOTAL</b>
<b>1. TRANSIT</b>	113,110	103,484	108,694	325,288
AC TRANSIT	95,419	88,415	91,133	274,967
<b>2. TRAFFIC</b>	36,832	25,196	19,962	81,990
<b>3. CARPOOLING</b>	898	1,184	1,208	3,290
<b>4. CENTRAL FREEWAY/ HIGHWAY CONSTRUCTION UPDATE</b>	1,644	594	1,236	3,474
<b>5. OTHER</b>	6,910	5,238	1,859	14,007
<b>6. SYSTEM INFORMATION</b>	3,895	1,700	1,765	7,360
<b>7. BAY BRIDGE COMMENT</b>	-	-	1,155	1,155
<b>NO SELECTION</b>	*	*	9,742	*
<b>ROTARY DIAL OUT</b>	12,662	15,669	17,297	45,628
<b>TOTAL</b>	<b>178,601</b>	<b>161,371</b>	<b>161,272</b>	<b>501,244</b>

### 3.3.1.8 Traffic Route Selections

The next group of tables (Tables 5a-5b) and figures (Figures 13a-13d) focus on the route selections made within the traffic menu category.

Table 5a shows which routes are selected most frequently within the traffic menu. A total of sixty-one routes are available for selection. All routes with at least a 1% selection rate (with the selection rate corresponding to the number of selections for one specific route as a percentage of all routes selected) have been listed in Table 5a and this group accounts for 89% of all routes selected. The routes shown are divided by region and by bridges. From September 1996 to June 1997, the average number of routes selected per traffic call was 2.7. Four out of the top five selected routes are in the East Bay (880, 80, 580 and 680), one-half of the top ten selected routes are in the East Bay and the East Bay accounts for at least 35.4% of all route selections. This is not necessarily due to a preference for East Bay routes but simply to the fact that call volume is much higher in San Francisco and the East Bay. The second, third and fourth most popular regions are the South Bay, the Peninsula and San Francisco accounting for at least 18%, 11.3% and 8.1% of all routes selected, respectively. As expected, the Bay Bridge is the most popular bridge route. Note also that the only North Bay routes in this list are 101 and 80.

**Table 5a: Route Selection Rankings**

<b>REGION/BRIDGE</b>	<b>ROUTE</b>	<b>TIMES SELECTED</b>	<b>PERCENTAGE</b>	<b>RANK</b>
EAST BAY	880	16,022	7.0	1
EAST BAY	80	15,988	7.0	1
PENINSULA	101	13,231	5.8	2
EAST BAY	580	11,165	4.9	3
EAST BAY	680	11,007	4.8	4
BRIDGE	BAY	9,818	4.3	5
SOUTH BAY	17	9,343	4.1	6
SOUTH BAY	101	8,517	3.7	7
EAST BAY	24	7,382	3.2	8
SAN FRANCISCO	101	7,344	3.2	8
PENINSULA	280	6,227	2.7	9
SAN FRANCISCO	80	5,517	2.4	10
BRIDGE	SAN MATEO	5,331	2.3	11
SOUTH BAY	280	5,208	2.3	11
NORTH BAY	101	4,670	2.0	12
SOUTH BAY	680	4,640	2.0	12
SOUTH BAY	85	4,498	2.0	12
SOUTH BAY	237	4,150	1.8	13
PENINSULA	92	4,074	1.8	13
EAST BAY	92	3,847	1.7	14
EAST BAY	4	3,543	1.5	15
SAN FRANCISCO	280	3,317	1.4	16
BRIDGE	DUMBARTON	3,209	1.4	16
EAST BAY	980	3,158	1.4	16
EAST BAY	238	3,146	1.4	16
EAST BAY	84	3,102	1.4	16
NORTH BAY	80	3,024	1.3	17
EAST BAY	2*	2,924	1.3	17
BRIDGE	GOLDEN GATE	2,762	1.2	18
EAST BAY	13	2,578	1.1	19
SAN FRANCISCO	2*	2,516	1.1	19
SOUTH BAY	2*	2,435	1.1	19
SOUTH BAY	87	2,406	1.0	20
NORTH BAY	2*	2,327	1.0	20
PENINSULA	2*	2,197	1.0	20
EAST BAY	242	2,182	1.0	20
TOTAL		202,805	88.6	

\*= Callers press “2” for city streets and other roadways not listed in the Traffic submenus

Table 5b displays the top ten route selections for each TATS region. The percentage associated with each route for each region is the percentage of all route selections made from that region. For example, 9.0% of all routes selected from the OAKLAND TATS are E880. The top ten routes per region account for between approximately 40% and 60% of all route selections per region. Several of these route selections correspond to the worst congestion locations in the San Francisco Bay Area. Appendix C displays the ten worst congestion locations in the Bay Area in 1996. Keeping in mind that analysis of the TATS data covers the last 4 months of 1996 and the first half of 1997, that congestion measurement techniques vary and that congestion has likely increased in 1997, the data in Appendix C provides a basis for “informal” comparison between the top ten routes selected per region and the ten most congested routes.

Calls made into the SF and SJ regions show a strong preference for a single route over all others, that is, P101 and S17, respectively. The routes chosen in calls coming into the OAKLAND and SR TATS do not display this significant preference for one route over all others. This table also indicates general travel corridor patterns. Calls coming into the OAKLAND TATS, i.e. from the East Bay, inquire principally about East Bay routes (six out of the top ten are East Bay routes) and for calls coming into the SJ TATS, six out of the top ten routes selected are South Bay routes. North Bay routes are not selected by callers into the OAKLAND, SF and SJ TATS. Routes E880, BAY BRIDGE, E680 and P101 are selected by callers in three of the four TATS regions and E80 is the most popular or second most popular route.

**Table 5b: Top Ten Routes Selected From Each TATS Region**

<b>OAKLAND (510) ROUTE (%)</b>		<b>SF (415) ROUTE (%)</b>		<b>SJ (408) ROUTE (%)</b>		<b>SR (707) ROUTE (%)</b>	
<b>E880</b>	<b>(9.0)</b>	<b>P101</b>	<b>(13.6)</b>	<b>S17*</b>	<b>(13.1)</b>	<b>E80</b>	<b>(9.6)</b>
<b>E80</b>	<b>(8.5)</b>	<b>E80</b>	<b>(7.1)</b>	<b>S101</b>	<b>(9.0)</b>	<b>N101</b>	<b>(6.6)</b>
<b>E580</b>	<b>(6.9)</b>	<b>BAY BRIDGE</b>	<b>(6.6)</b>	<b>S280</b>	<b>(5.7)</b>	<b>N80</b>	<b>(4.4)</b>
<b>E680</b>	<b>(6.3)</b>	<b>SF101</b>	<b>(6.5)</b>	<b>E880</b>	<b>(5.6)</b>	<b>E680</b>	<b>(3.8)</b>
<b>E24</b>	<b>(4.7)</b>	<b>P280</b>	<b>(5.8)</b>	<b>S85</b>	<b>(5.2)</b>	<b>BAY BRIDGE</b>	<b>(3.2)</b>
<b>BAY BRIDGE</b>	<b>(4.2)</b>	<b>E880</b>	<b>(4.8)</b>	<b>P101</b>	<b>(4.9)</b>	<b>N2**</b>	<b>(3.1)</b>
<b>S17</b>	<b>(2.4)</b>	<b>SF80</b>	<b>(4.1)</b>	<b>E680</b>	<b>(4.6)</b>	<b>N37</b>	<b>(2.8)</b>
<b>E4</b>	<b>(2.2)</b>	<b>S101</b>	<b>(4.1)</b>	<b>S680</b>	<b>(4.0)</b>	<b>E24</b>	<b>(2.6)</b>
<b>P101</b>	<b>(2.1)</b>	<b>SAN MATEO</b>	<b>(3.8)</b>	<b>S237</b>	<b>(3.5)</b>	<b>GOLDEN GATE</b>	<b>(2.4)</b>
<b>SF80</b>	<b>(2.0)</b>	<b>E580</b>	<b>(3.4)</b>	<b>P280</b>	<b>(2.5)</b>	<b>SF101</b>	<b>(2.4)</b>
<b>TOTAL</b>	<b>(48.3)</b>	<b>TOTAL</b>	<b>(59.8)</b>	<b>TOTAL</b>	<b>(58.1)</b>	<b>TOTAL</b>	<b>(40.9)</b>

NB:

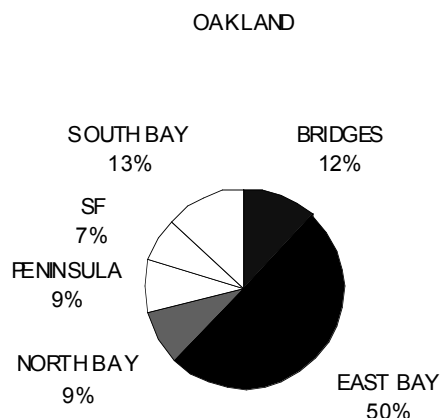
\*= Route 880 is located in both the East and South Bays, where immediately south of Interstate 280, route 880 becomes SR17. Until June 1997, callers received information about both 880 and 17 upon selecting routes 880 or 17. Thus, selections for route 17 in the South Bay (S17) likely include selections for the portion of 880 that is in the South Bay, since the volume of selections for 880 in this region were very small. This is likely due to the fact that the portion of 880 in the South Bay was originally called “17” leading to a tendency to associate “880” with the East Bay, not the South Bay.

\*\*= Callers press “2” for major roadways not listed

E, N, P, S, SF stand respectively for East Bay, North Bay, Peninsula, South Bay and San Francisco.

Figures 13a-13d show the regional distribution of routes selected from calls received in each of the four TATS regions. Different information is provided than from Table 5b in that the percentage split for all routes per TATS region is shown, yet no specific route is listed as in Table 5b. As indicated in the discussion of Table 5b, OAKLAND TATS calls are mainly interested in East Bay routes (50% from Figure 12a) and SJ TATS calls are mainly interested in South Bay routes (46% from Figure 12c). Twenty to thirty percent of routes selected from calls received outside the OAKLAND TATS are East Bay routes. Thirteen percent of the routes selected from calls received outside the SJ TATS are South Bay routes. The SR TATS is the only TATS in which “local” routes do not constitute a majority of selected routes within that region, that is, North Bay routes constitute 24% of route selections from the SR TATS, whereas East Bay routes constitute 31% of route selections from this same TATS.

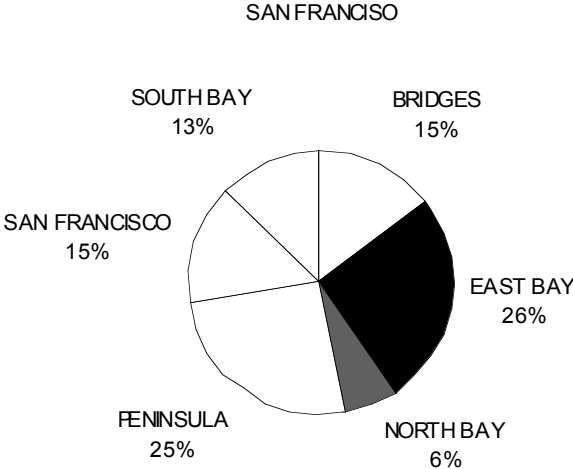
**Figure 13a: Regional Distribution of Route Selections Originating in Oakland**



NB: Total route selections originating in Oakland: 116,706 of which: Bridges = 14,352; East Bay = 57,807; North Bay = 10,542; Peninsula = 10,107; San Francisco = 8,446; South Bay = 15,452.

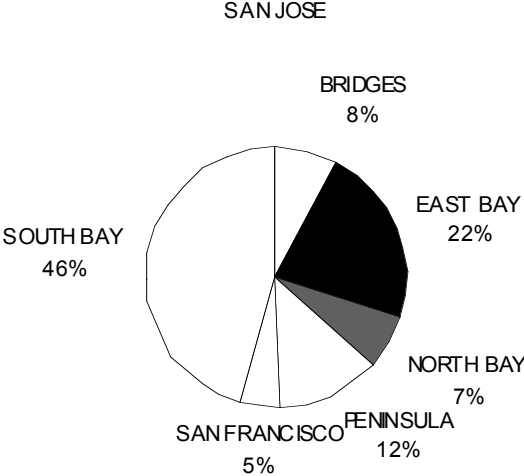


**Figure 13b: Regional Distribution of Route Selections Originating in San Francisco**



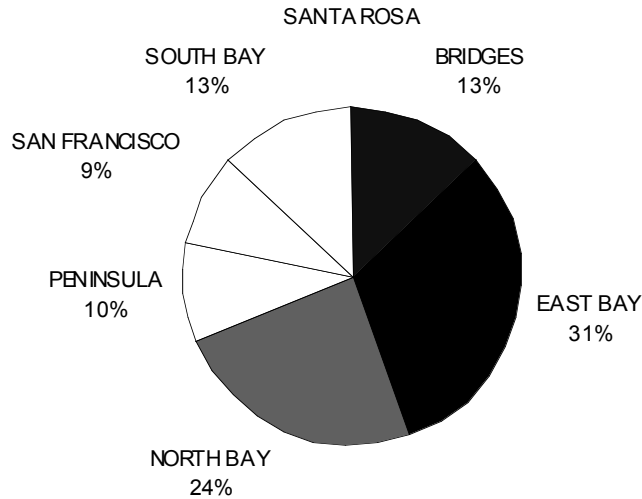
NB: Total route selections originating in San Francisco: 62,562 of which: Bridges = 9,236; East Bay =16,200; North Bay = 4,014; Peninsula = 15,657; San Francisco = 9,385; South Bay = 8,070.

**Figure 13c: Regional Distribution of Route Selections Originating in San Jose**



NB: Total route selections originating in San Jose: 40,456 of which: Bridges = 3,135; East Bay =8,956; North Bay = 2,825; Peninsula = 4,996; San Francisco = 2,084; South Bay = 18,460.

**Figure 13d: Regional Distribution of Route Selections Originating in Santa Rosa**



NB: Total route selections originating in Santa Rosa: 9,933 of which: Bridges = 1,332; East Bay = 3,081; North Bay = 2,380; Peninsula = 969; San Francisco = 870; South Bay = 1,301.

### 3.3.2 TATS Port Use

This section describes TATS port use between September 1, 1996 and June 30, 1997 relative to several measures. Focus was placed on investigating port use only for the 510 region as it experienced the largest call volume by an order of magnitude over the second place region each month (415 region) since TravInfo went on-line. The primary measures of performance are as follows:

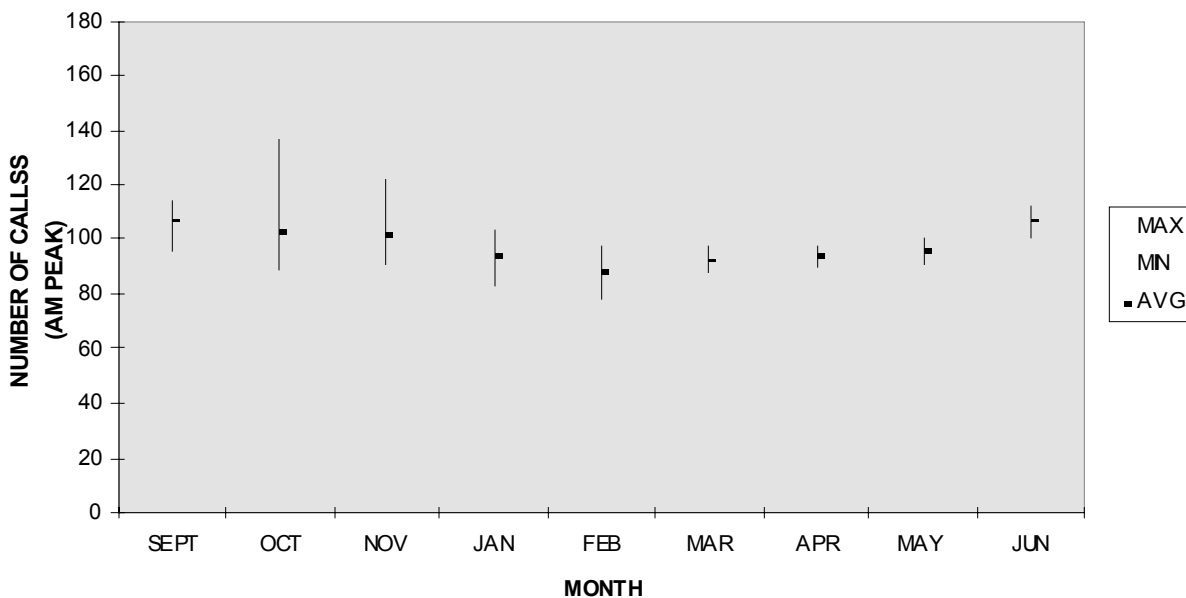
- port utilization (percentage of time) of all ports during AM and PM peak periods
- maximum number of incoming calls on an individual port during AM and PM peak periods
- port utilization (percentage of time) on the busiest port during AM and PM peak periods
- number of ports simultaneously in use during AM and PM peak periods
- percentage of all ports simultaneously in use during AM and PM peak periods

Overall utilization for all ports provides an informative measure of performance for the OAKLAND TATS as a whole. For the ten month time period of September 1996 through June 1997, port utilization<sup>2</sup> over all ports in the OAKLAND TATS during the AM and PM peak periods ranged between 1.6% and 3.5% with an average value of 2.3% and between 1.3% and 5.2% with an average value of 2.7%, respectively.

<sup>2</sup> Port utilization is defined as the total number of seconds during which the 53 publicly available voice ports in the OAKLAND region were in use divided by the sum over all such ports of the total number of seconds during the period under investigation.

The first set of figures (Figures 14a & 14b) focus on number of incoming calls. Figures 14a and 14b show the number and range (minimum, maximum and average) of incoming calls into the busiest port, almost exclusively port number 1, for the OAKLAND TATS during the morning (7 AM-9 AM) and afternoon (4 PM-6 PM) peak periods. For the morning peak period during the early months of TravInfo, there was more variability in the number of incoming calls than during later months. The afternoon peak period shows some variability throughout the ten month reporting period. Focusing on the average number of morning and afternoon incoming calls during each month, both figures indicate stable incoming call volume behavior, of approximately 90 to 105 incoming calls during the morning peak period and 95 to 120 incoming calls during the afternoon peak period. Based on the average duration for all calls for the OAKLAND region (Table 3a), 33.5 seconds, an approximate upper bound on the number of incoming calls, i.e. incoming call capacity, that each port can accommodate may be estimated<sup>3</sup>. Over the two hour morning and afternoon peak periods, this upper bound is approximately 215 incoming calls. The utilization<sup>4</sup> for port 1 for the morning and afternoon peak periods range between 41.9% and 48.8% and between 44.2% and 55.8%, respectively.

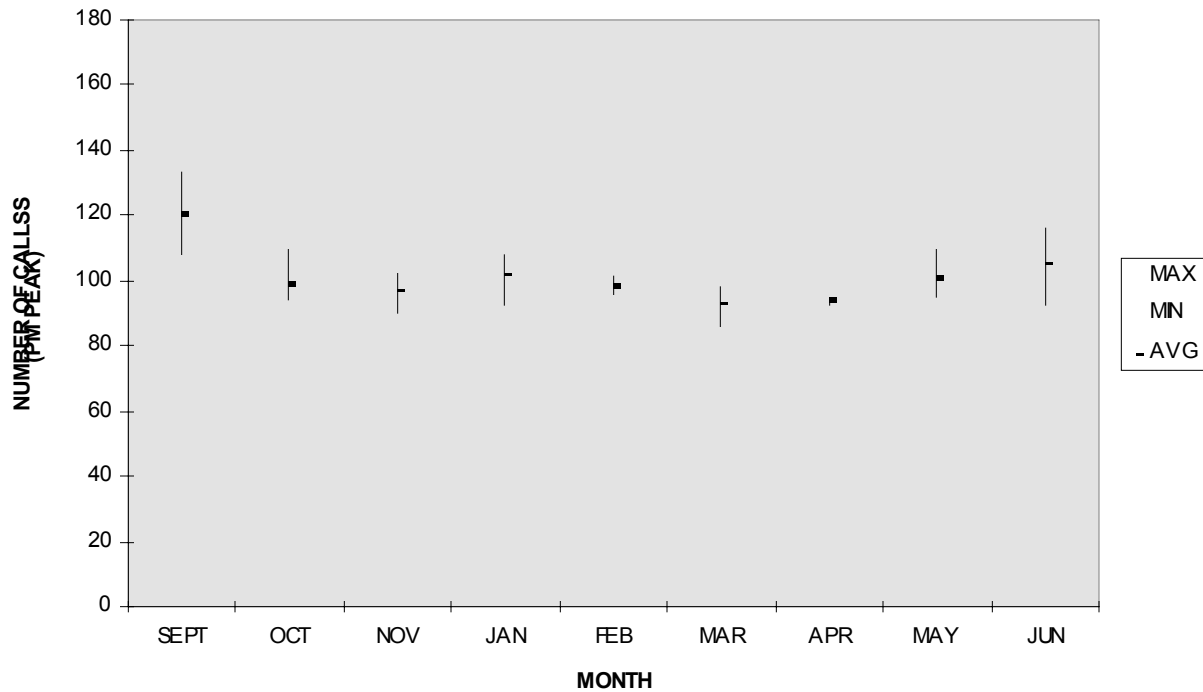
**Figure 14a: Maximum Number of Incoming Calls On A Single Port (AM peak period)**



<sup>3</sup> Divide the total number of seconds in the time period under investigation by the number of seconds required for call duration. In this case, 7200 seconds /33.5 seconds per call ~ 215 calls.

<sup>4</sup> Utilization is calculated as the ratio of the number of incoming calls to the incoming call capacity, i.e. 215.

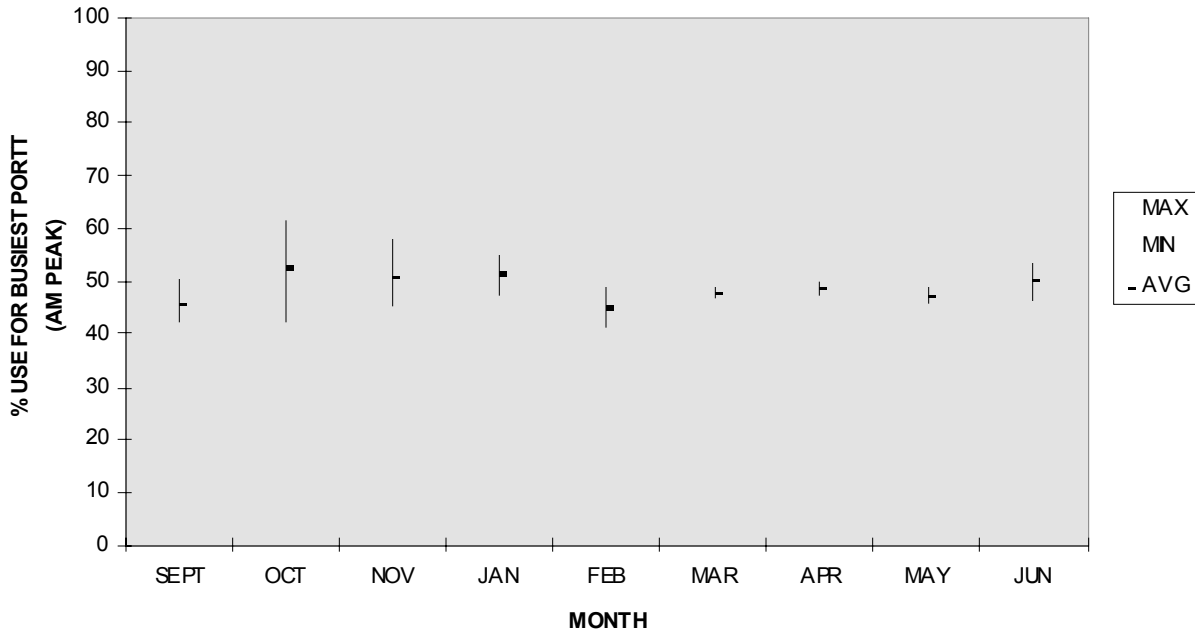
**Figure 14b: Maximum Number of incoming Calls On A Single Port (PM peak period)**



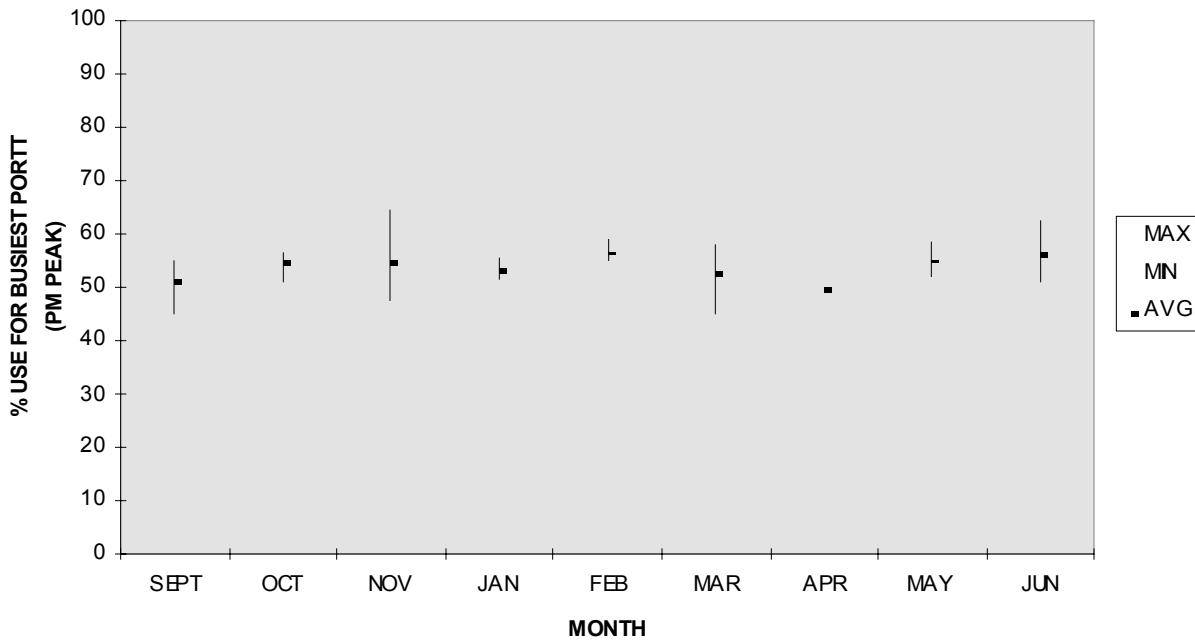
The next set of figures (Figures 15a & 15b) focus on port utilization. Figures 15a and 15b show the port utilization on the busiest port during the morning and afternoon peak periods. The busiest port was almost exclusively port 1. Port utilization is defined as the total number of seconds during which Port 1 was in use divided by the total number of seconds during the period under investigation, in this case approximately<sup>5</sup> 7200 seconds for each of the morning and afternoon peak periods. Port utilization remains stable and clustered approximately within the 45 to 55 percent range, though naturally experiences some variability over the ten month reporting period. Utilization for Port 1 calculated this way is consistent with the utilization previously derived based on the estimate for the approximate upper limit for the number of incoming calls possible on Port 1 and the number of actual incoming calls. Differences are due to the fact that the single average value for call duration over all calls was used to derive the upper limit on the number of incoming calls and there was considerable variability in this value (Table 3a). Thus, in essence, the OAKLAND TATS and thus all other TATS, are not experiencing stress on port usage.

<sup>5</sup> Actual morning and afternoon time periods for port use data downloads were not always exactly 7200 seconds in length. Occasional variability on the order of a few minutes was present due to scheduling difficulties, data download failures requiring retries, etc. Such deviation from the 7200 second figure was accounted for in all calculations where necessary.

**Figure 15a: Port Utilization for Busiest Port (AM peak period)**

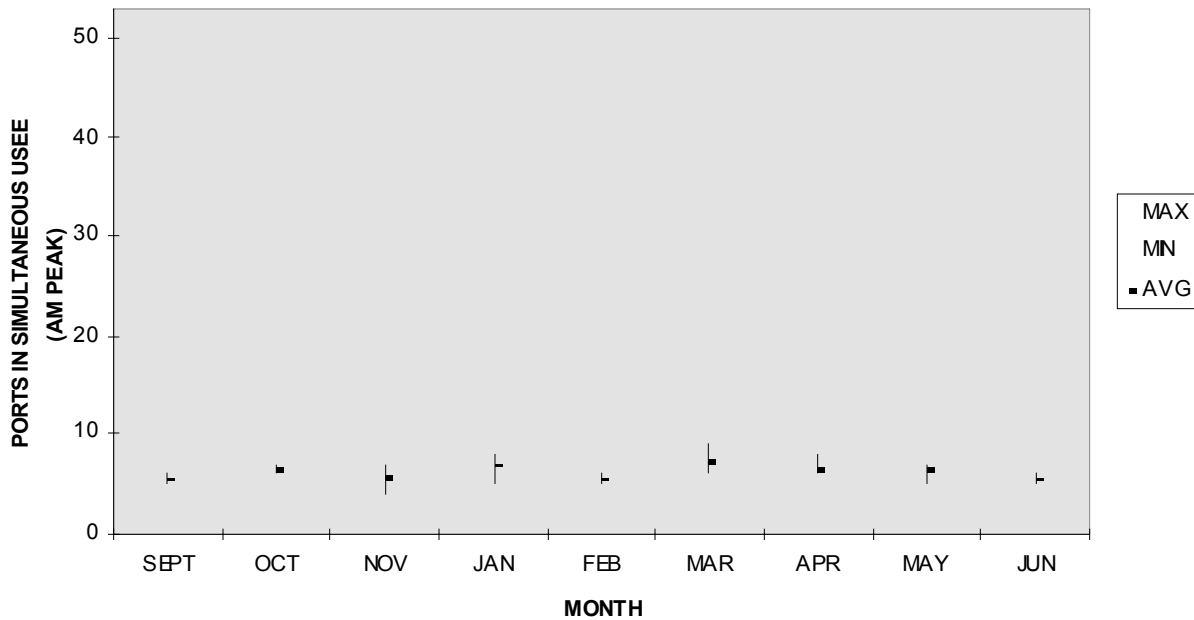


**Figure 15b: Port Utilization for Busiest Port (PM peak period)**

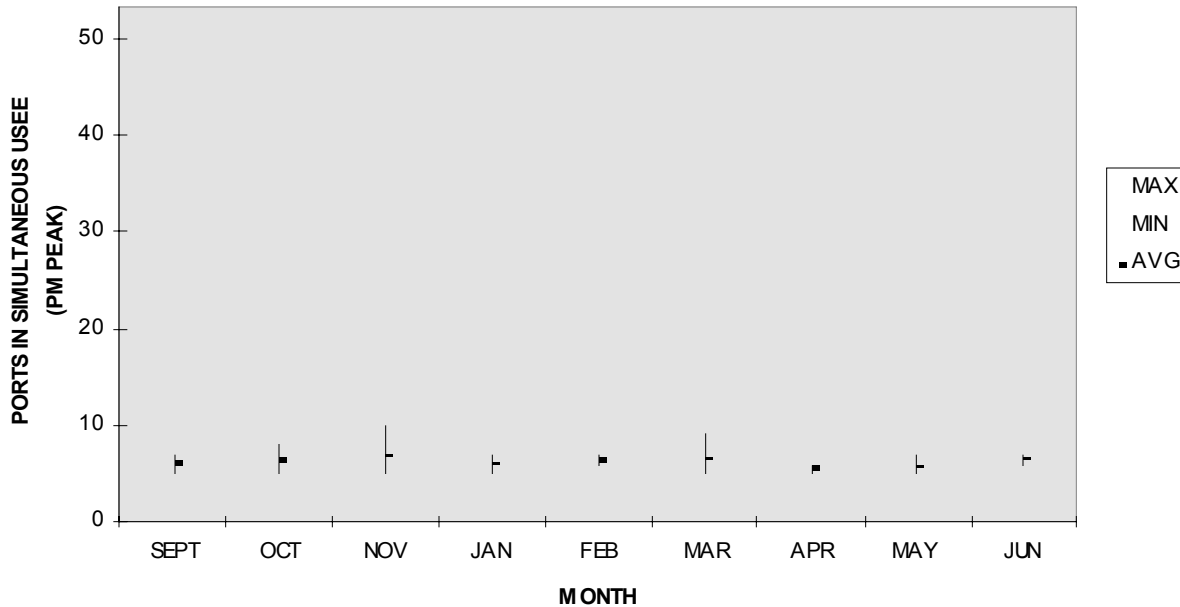


The final group of figures (Figures 16a & 16b) focus on the number of ports in simultaneous use. Figures 16a and 16b show the range (minimum, maximum and average) in number of ports in simultaneous use during the morning and afternoon peak periods. There are currently 53 publicly available voice ports for use in the OAKLAND (510) TATS region. The largest maximum number of ports in simultaneous use over the ten month reporting period was 10, which occurred only once, in November 1996, during an afternoon peak period. For each of the peak periods, there is, of course, variation in the number of ports in simultaneous use over time, but this variation is within a narrow band. These figures indicate that the OAKLAND TATS and hence all the other three TATS, are taxed very little for port use capacity. The scale of the vertical axis used in Figures 16a and 16b has an upper limit of 53, the maximum number of publicly available voice ports in the OAKLAND region. By exhibiting the results in this way, the range in the number of ports in simultaneous use relative to the total number of ports available may be observed. The maximum number of ports in simultaneous use during the AM and PM peak periods was 9 and 10 occurring in March 1997 and November 1996 respectively. Such maximum values translate into 17% and 19% respectively for the percentage of all ports simultaneously in use during the AM and PM peak periods.

**Figure 16a: Number of Ports in Simultaneous Use (AM peak period)**



**Figure 16b: Number of Ports in Simultaneous Use (PM peak period)**



### 3.3.3 LDS Activity

This section describes LDS usage between November 1, 1996 and June 30, 1997 relative to several measures. TIC Acceptance Testing continued into September and October and it was felt that including LDS usage during this period would not be entirely appropriate. The measures of analysis that were used consist of the total number of LDS accesses by each ISP, the total volume of data that each ISP downloads and the distribution of data by menu selection.

Overall during the reporting period, the number of registered participants was 40, give or take 2 or 3 depending on changes in participation. Twenty five of the registered participants accessed data at one point or another of which 3 were regular users (accessing data continuously throughout the reporting period). Two registered participants began downloading small amounts of data (less than 150KB per week) on a fairly regular basis starting in early May, 1997.

Table 6 presents the total number of logons per ISP. This information is valuable to get a sense of the total number of logons each ISP performs. This information should not, however, be considered in isolation. While Etak tends to download 95% of all data, it performs few logons relative to Maxwell or Daimler-Benz. Etak performs approximately 3% of the number of logons that Maxwell performs, the ISP with the greatest number of logons. Several of the ISPs rarely logon and when they do logon, only a small amount of data are transferred. Maxwell and Daimler-Benz logon the most often and download a considerable amount of data, yet still significantly less than Etak.

**Table 6: Total Number of Logons by ISP: November 1996 - June 1997**

<b>ISP</b>	<b>TOTAL</b>
<b>Clarion</b>	<b>23</b>
<b>Contra-Costa Times</b>	<b>252</b>
<b>Daimler-Benz</b>	<b>21,840</b>
<b>Etak</b>	<b>1,358</b>
<b>Fastline</b>	<b>1</b>
<b>Feldman</b>	<b>10</b>
<b>KCBS</b>	<b>11</b>
<b>KPIX</b>	<b>1</b>
<b>KTVU</b>	<b>1</b>
<b>Maxwell</b>	<b>46,272</b>
<b>Metro Dynamics</b>	<b>16</b>
<b>Metro Networks</b>	<b>52</b>
<b>Microsoft</b>	<b>33</b>
<b>Navigation Tech.</b>	<b>1</b>
<b>RIDES</b>	<b>5</b>
<b>Shadow</b>	<b>1</b>
<b>Small Business Connection</b>	<b>1</b>
<b>SmartRoute</b>	<b>2</b>
<b>SmartInfo</b>	<b>1</b>
<b>Subcarrier Systems</b>	<b>2</b>
<b>Telcontar</b>	<b>3</b>
<b>Toyota</b>	<b>4</b>
<b>TranSmart</b>	<b>1</b>
<b>TravRoute</b>	<b>31</b>
<b>TOTAL</b>	<b>69,922</b>

Table 7 presents in more detail the size of each ISP's data transfers during the reporting period. Etak downloads 95% of all data that are transferred from the LDS, with Maxwell and Daimler-Benz each downloading approximately 2-3% of all data. The remaining 21 ISPs downloaded 0.1% of all data from November 1996 through June 1997.



**Table 7: Total Bytes Accessed by Each ISP: November 1996-June 1997**

	<b>BYTES</b>	<b>% OF TOTAL</b>	<b>% OF TOTAL*</b>
<b>Clarion</b>	169,184	0.01%	0.23%
<b>Contra-Costa Times</b>	294,503	0.02%	0.40%
<b>Daimler-Benz</b>	31,689,676	<b>2.19%</b>	<b>43.09%</b>
<b>Etak</b>	1,371,400,596	<b>94.91%</b>	
<b>Fastline</b>	21,884	0.00%	0.03%
<b>Feldman</b>	15,199	0.00%	0.02%
<b>KCBS</b>	212,677	0.01%	0.29%
<b>KPIX</b>	52	0.00%	0.00%
<b>KTVU</b>	6,593	0.00%	0.01%
<b>Maxwell</b>	40,484,182	<b>2.80%</b>	<b>55.04%</b>
<b>Metro Dynamics</b>	18,326	0.00%	0.02%
<b>Metro Networks</b>	154,592	0.01%	0.21%
<b>Microsoft</b>	24,428	0.00%	0.03%
<b>Navigation Tech.</b>	2,280	0.00%	0.00%
<b>RIDES</b>	1,677	0.00%	0.00%
<b>Shadow</b>	609	0.00%	0.00%
<b>Small Business Connection</b>	731	0.00%	0.00%
<b>SmartRoute</b>	992	0.00%	0.00%
<b>SmartInfo</b>	52	0.00%	0.00%
<b>Subcarrier Systems</b>	2,130	0.00%	0.00%
<b>Telcontar</b>	1,098	0.00%	0.00%
<b>Toyota</b>	3,201	0.00%	0.00%
<b>TranSmart</b>	3,010	0.00%	0.00%
<b>TravRoute</b>	442,371	0.03%	0.60%
<b>TOTAL</b>	1,444,950,043	100%	

\* The third column are percentages of total excluding Etak. The bytes include both lines of input (to obtain data) and lines of output (data selected).

The following group of figures (Figures 17a-17d) present the total weekly access for each ISP. Figure 17a presents in more detail the amount of Etak's data transfer on a weekly basis relative to the total amount of data that are downloaded. This figure shows quite dramatically that the total amount downloaded is almost all due to Etak. The drop in late April and early May is due to the LDS Update Formatter problems that were documented in the TIC Problem Reports and discussed in Section 3.2.

**Figure 17a: Weekly Volume of Data Accessed: Total and Etak**

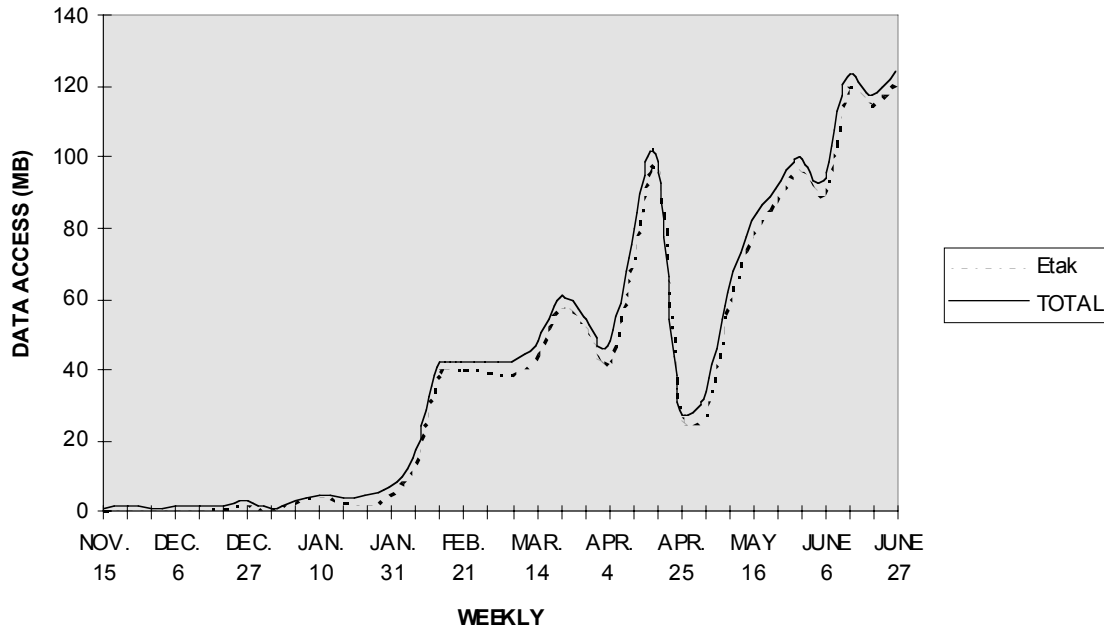
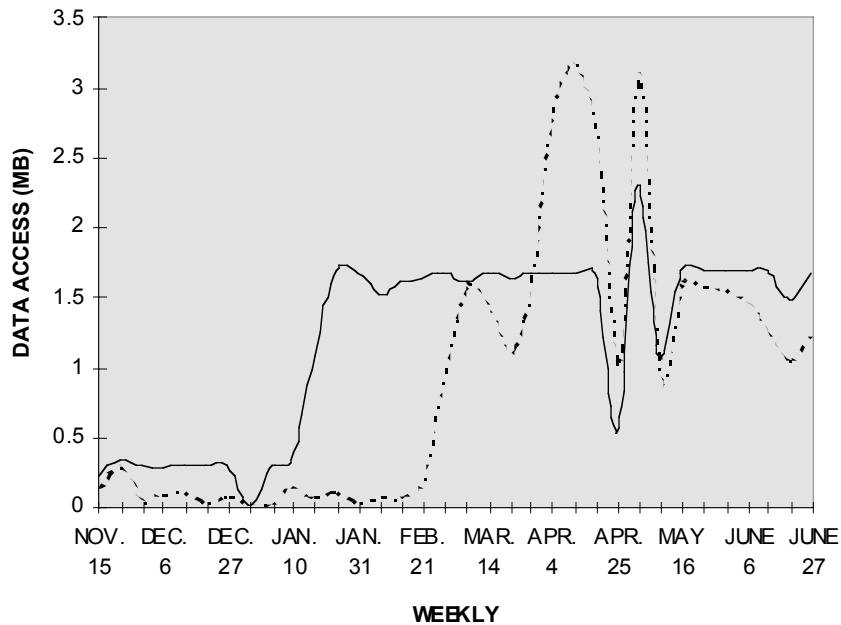


Figure 17b presents the next tier of ISP data downloads, which in this case is Maxwell and Daimler-Benz. Maxwell began downloading data, on the order of 1.5MB per week, approximately one month before Daimler-Benz did. Daimler-Benz’s downloading of data was more irregular in terms of quantity. Again, note the drop in late April due to LDS Update Formatter problems. Also, note the different scale on the vertical axis compared to that on Figure 17a.

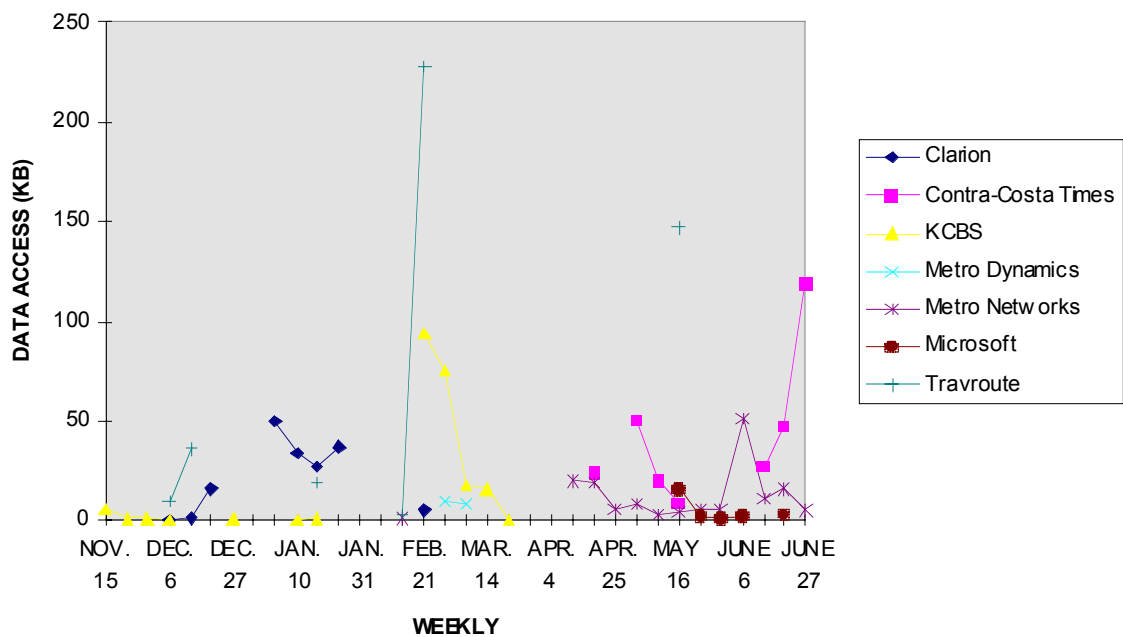
Figure 17c presents the third tier of ISP data downloads in units of kilobytes. A break in the line for a given ISP indicates that for that given week(s) no data was downloaded. Note again the change in the scale for the vertical axis. This third tier of ISPs (not all ISPs, but some) are downloading data on the order of approximately 100 kilobytes compared to the first two tiers of downloading on the order of 100 megabytes (Figure 17a) and 10 megabytes (Figure 17b), respectively. It should be noted however that only two ISPs appear to be downloading data regularly (Metro and Contra Costa Times) and most ISPs downloaded data briefly then stopped.

The downloads for the fourth and final tier of ISPs is shown in Figure 17d and shows how infrequently and how little data is downloaded by these ISPs. The vertical scale here is on the order of approximately 10 kilobytes.

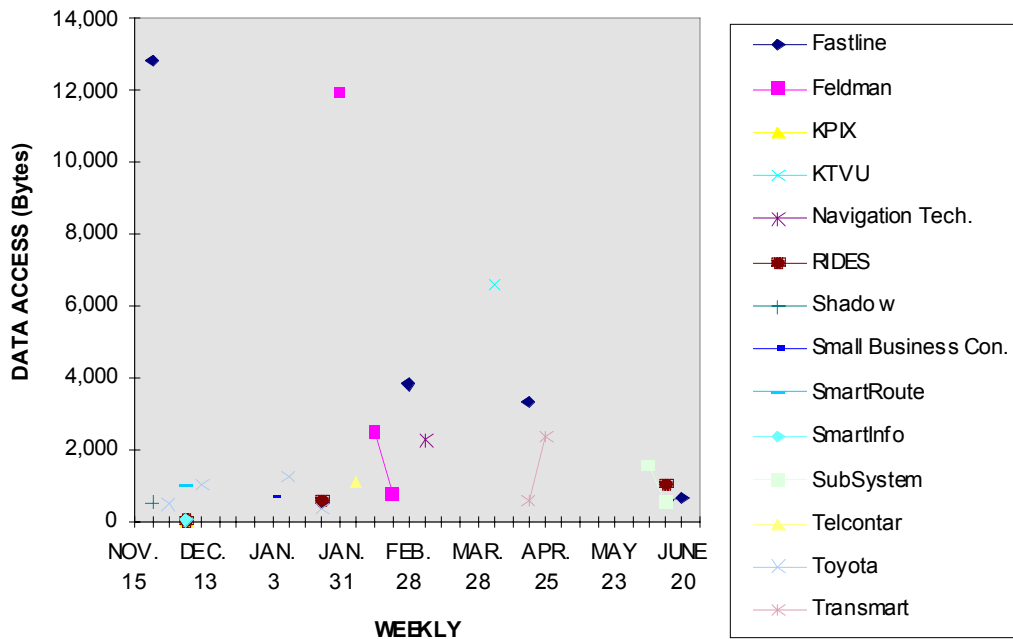
**Figure 17b: Weekly Volume of Data Accessed: Maxwell and Daimler-Benz**



**Figure 17c: Weekly Volume of Data Accessed: Third Tier ISPs**



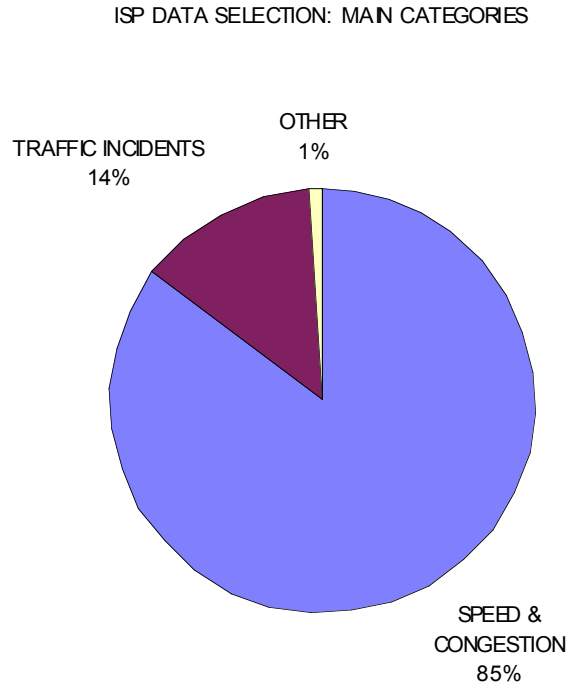
**Figure 17d: Weekly Volume of Data Accessed: Fourth Tier of ISPs**



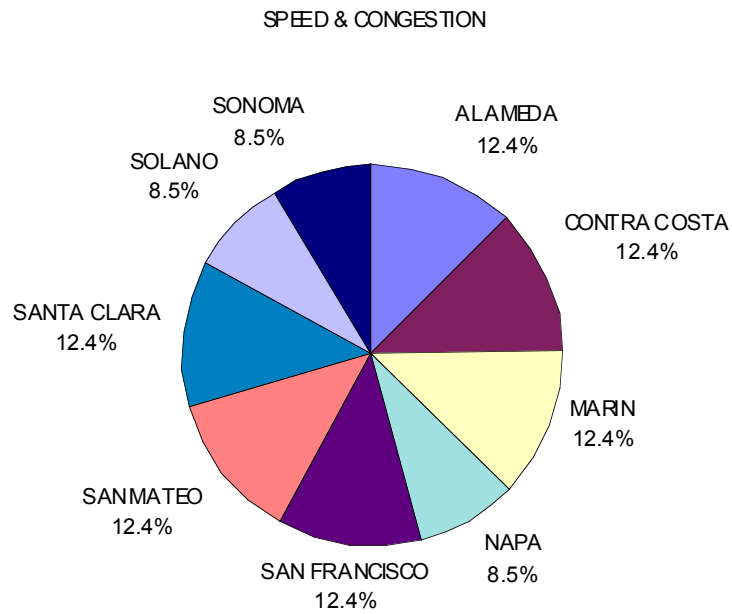
The final three figures (Figures 18a-18c) depict the distribution of ISP data selections for all ISPs except Etak, i.e. primarily Maxwell and Daimler-Benz. PATH data downloads for Etak were suspended in March 1997 because Etak was downloading 95% of all data as can be seen in Figure 17a. It was thus felt that the following figures would be valuable to understand what selection non-Etak ISPs were making. Speed & Congestion account for 85% of the selections made and Traffic Incidents for approximately 15% of the selections (an individual selection corresponds to a line of output). Figures 18b and 18c show the distribution for each of these selections by county.

From the previous figures and tables it is thus clear that, overall, there only has been limited regular use of the data on the part of the ISPs from November 1996 to June 1997. Sixty two percent of the ISPs downloaded data at one point or another, mostly in small amounts (88% of the ISPs downloaded less than 250KB per week for any given week). Of the ISPs downloading data, 12% downloaded data on a continuous basis. After April 1997, this number went up to 20%. As a consequence of this limited downloading of data, so far very few products and services have been brought to the market. Experimentation and product development on the part of ISPs, however, does not require regular data downloading.

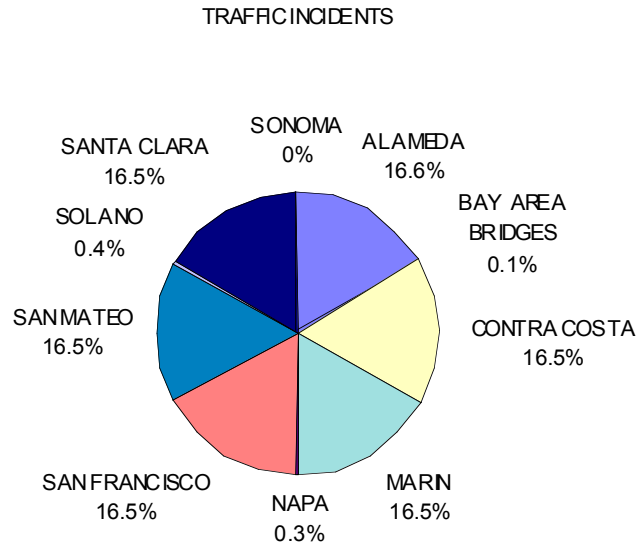
**Figure 18a: Distribution of ISP Selections by Main Category**



**Figure 18b: Distribution of ISP County Selections for Speed & Congestion**



**Figure 18c: Distribution of ISP County Selections for Traffic Incidents**



NB: Figures 18a-18c do not include data for Etak. Also, figures 18a-18c reflect query or menu selections not necessarily actual data downloaded, although there is clearly a strong correspondence between the two. In figure 18b, county selections for speed and congestion in Napa, Sonoma and Solano reflect ISP query selections rather than actual content downloaded. Indeed, there are no sensors in these three counties.

### 3.4 Operator Interface Analysis

This segment of the report provides results from interviews conducted with TIC personnel. It is the first component of the Operator Interface, a part of the TIC evaluation that assesses the role of human operation at the TIC. The study will seek to determine all information flows into and out of the TIC and assess the level of operator interface and attention required for each data flow. The purpose of this evaluation component is to determine the role of the operator in the overall functioning of the TIC and in locating potential operator choke-points in the flow of information through the TIC.

This evaluation component begins by briefly discussing the methodology for data collection and analysis. Interview results are then discussed which clarify the role of the operator in the flow of information for each TIC data source. Finally, conclusions are presented that are based on the synthesis of information from the interviews and on observations made during evaluation visits at the TIC.

### **3.4.1 Study Design**

Interviews were conducted with twelve operators and two supervisors covering all TIC staff directly involved in the handling of information. Most of the interviews were conducted during the month of May 1997. The interview was divided into three sections of pre-selected, mostly open-ended, questions, covering: 1) Data flowing into the TIC; 2) Data flowing out of the TIC and 3) Relationship of the TIC to the Traffic Management Center (See Appendix C for a list questions). Interviews typically lasted 60-90 minutes.

The interview data were analyzed by collating answers into simple percentages and by summarizing open-ended responses.

### **3.4.2 Interview Results**

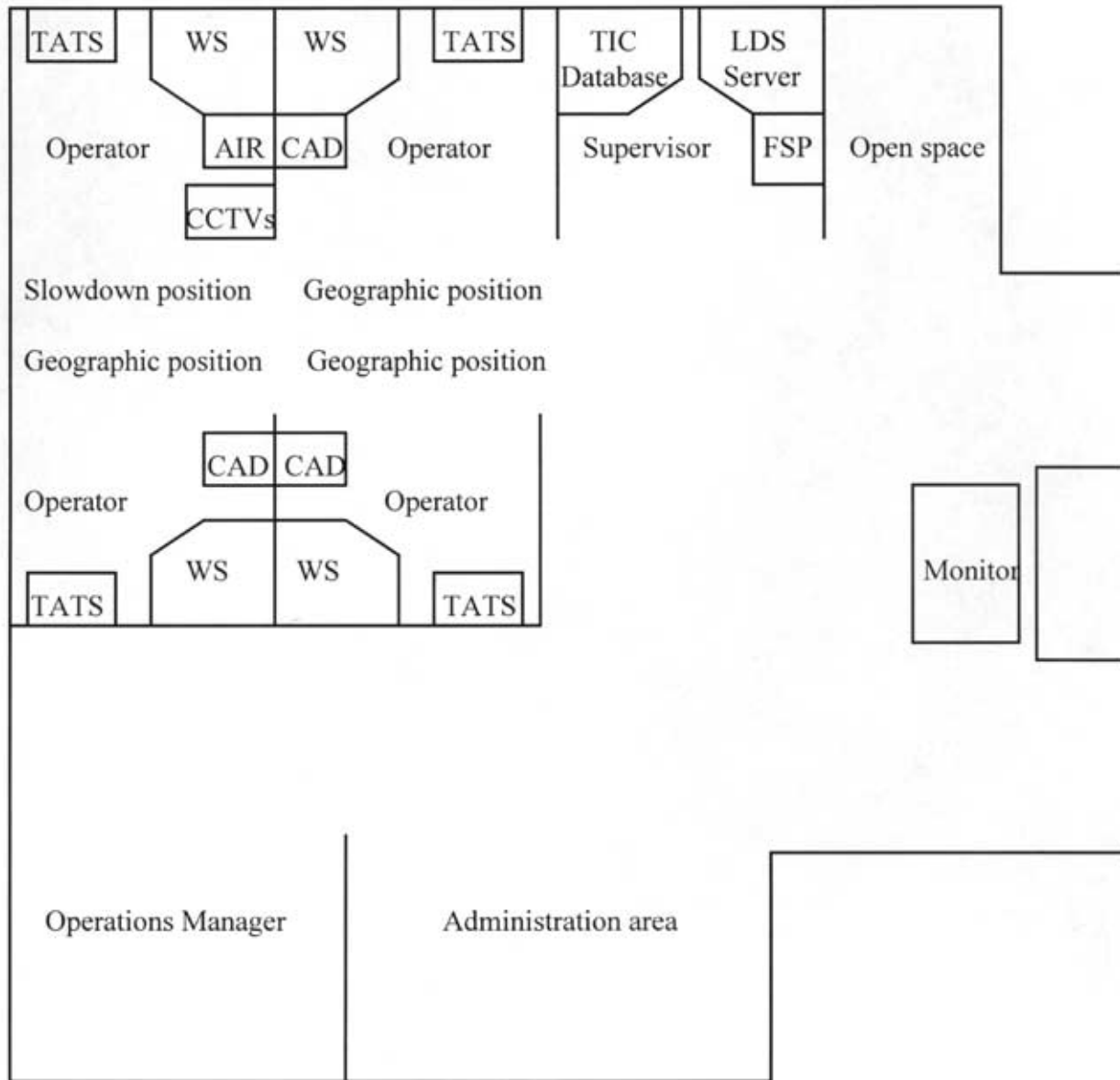
This section begins by providing an overview of TIC operations and a description of the basic role of a TIC operator. Each subsequent section discusses the role of the operator in handling each one of the main data sources of the TIC. In the following sections, the word “operators” is used to describe both the operators and the two supervisors who perform operator duties since there were only minor differences in responses between these two groups.

#### **3.4.2.1 Operations Overview**

The TIC system operates 24 hours a day, 7 days a week. During weekdays, there are three main shifts (5 AM-1 PM, 1 PM-9 PM and 9 PM-5 AM). The morning and afternoon shifts are staffed by 4 operators and 1 supervisor. The overnight shift is staffed by one operator. The TIC is located at the Caltrans Traffic Management Center in Oakland, California. Figure 19 illustrates the floor plan for the TIC operations room. During the weekends, there are rotating shifts with generally two operators on duty during the day and one during the overnight.

Operators process information coming into the TIC from a variety of sources (See Table 8 for a list of data sources). TravInfo receives some of its data, mainly loop sensor and FSP (Freeway Service Patrol) data, in the form of an automated feed into the TIC system. The majority of the data sources, however, require human interpretation and processing such as for the CAD and airborne reports. The operators interpret dynamic traveler information and input the data into the TIC and TATS systems for dissemination to end users. Once an event or incident is created on an operator workstation, it is recorded on the TIC master database and then routed to the LDS (Landline Data System) server for dissemination to registered ISPs via a combination of leased (dedicated) and dial-up lines. The same event or incident is also made available to the public at large when the operator records it onto the TATS (a TATS recording system is located adjacent to each workstation). Generally, operators will first create the event or incident by inputting it into the TIC and will then record it onto the TATS. The operators can implement changes on existing incidents or events as updates are received from data sources. Once the changes are executed, the new data are automatically recorded by the TIC master database and routed to the LDS server.

**Figure 19: TIC Operations Floor Plan - June 1997**



AIR = Metro Networks Airborne Reports  
 CAD = Computer Aided Dispatch  
 CCTV = Closed Circuit Television  
 FSP = Freeway Service Patrol  
 WS = Workstation



During the two main shifts (5 AM-1 PM and 1-9 PM), each of three operators works on a workstation covering a geographic region (East Bay, San Francisco & Marin and Peninsula). These three operators enter incidents or events onto the TIC and then record them onto the TATS. The fourth operator works on a workstation covering exclusively traffic slowdowns and roadwork for the whole Bay Area (slowdown information is covered mainly during rush-hours while mostly roadwork data is input the rest of the time). The duties and data sources used are different depending on whether the operator works a geographic region or the slowdown position. During the overnight shift, the operator covers mainly incidents and inputs roadwork data. During weekends, operators have similar duties to weekday operators aside from the fact that there is no slowdown position.

**Table 8: TravInfo Information Sources**

Source	Data Type	Communication	Automation level
CHP CAD	Incidents	T-1 line	Manual
Metro Air	Incidents, congestion	2-way radio, phone	Manual
Metro Instatrack	Incidents, congestion	Modem/ISDN (web)	Semi-automated
Caltrans	Roadwork	Hardcopy	Manual
CCTV	Congestion	Video display	Manual
Cell calls	Congestion, incidents	Phone	Manual
Local agencies	Events, parking, lane closures, congestion	Phone, mail, FAX	Manual
FSP	Speed, location	Direct feed	Automated
Internet	Weather	Modem/ISDN (web)	Manual
Police agencies	Incidents, events	Phone, FAX	Manual
TOS	Speed, congestion	Frame relay router	Automated
Transit agencies	Routes, schedules, stops	Phone, FAX	Manual

### 3.4.2.2 California Highway Patrol Computer Aided Dispatch

The CHP Computer Aided Dispatch is indisputably the number one data source used by operators at the TIC in terms of time spent on processing. The CAD is used mainly while the operator is at one of the geographic workstations. It is generally not used by the operator at the slowdown position. The CAD is used overwhelmingly as a source of new information.

#### 3.4.2.2.1 Duties

The operators begin by interpreting incidents on the CAD terminal located next to each geographic workstation to determine whether they are relevant to the geographic area they are presently covering and whether incident severity justifies inclusion into the TIC database.

Once the operator determines that an incident is relevant, she or he will enter the incident identification code on the CAD to check the incident in more detail. If the operator decides to include the incident in the TIC system, she or he will then turn to the TIC workstation adjacent to the CAD (see figure 19), fill out the geographic location information and write up a brief description of the incident in the Traffic Incident Manager (TIM) window of the TIC system (filling out the geographic information can involve opening one or two other windows, such as the location map, to determine where exactly the incident occurred). The operator will then record the incident information on the TATS phone system for dissemination to the public and mark the mailbox just used on the TATS mailbox tracker plastic sheet. Finally, the operator will fill out a form to record the CAD incident identification number, the TATS mailbox number, the traffic incident number and the time of creation. Periodically, the operator will check the incident number on the CAD again to see whether there have been any updates. If there are relevant updates, the operator will go back to the TIM window and modify the existing incident.

#### **3.4.2.2.2 Time**

Eighty-six percent (12 out of 14) of the operators stated they spent 75% or more of their time processing CAD data (the average for this group being 79%). The other 14% (two operators) stated they spent 50-60% of their time on CAD data. The operators monitor the CAD continually. On average, two thirds of the operators state they spend two to three minutes processing a typical CAD incident (this time period corresponds to the time that elapses between noticing an incident on the CAD and finishing the input of information into the TIC system). One third state they spend 1-2 minutes processing a CAD incident. This response time can be longer if the operator is confronted with a difficult incident and/or if (s)he has a substantial backlog of incidents to process (such as during bad weather conditions). Conversely, if the incident is relatively simple and/or well documented the process might take less than the average 2-3 minutes. Once the incident is input in the TIC, it takes an extra 30 seconds to one minute for the operator to input the incident on the TATS system.

#### **3.4.2.2.3 Usefulness and Improvements**

All the operators ranked the CAD as the number one TIC data source and stated it was “very useful,” if not critical, to the functioning of the TIC. While the operators stated that CAD was essential to the TIC, they all suggested improvements relating to the CAD that would positively affect the flow of information. Among suggested ameliorations were:

- Access to full CAD: TravInfo presently has “media” access to the CAD. In essence, this means that some incidents, for example those involving medical emergencies or law enforcement action, are not included in the CAD data that TravInfo receives. Several of the operators thought this was detrimental to the project because of the potential of emergencies, medical or otherwise, to impact traffic conditions unbeknownst to TravInfo.

- Automation of CAD data into TIC: since a considerable portion of the response time is affected by having to manually input incident data into the TIC, several operators mentioned CAD data automation into the TIC as a major potential improvement in the flow of information.
- Geographic filter: CAD items are not organized by region or county and since each operator is responsible for one of the three defined regions (East Bay, San Francisco & Marin and Peninsula), the operator needs to scrutinize items for the whole Bay Area to find those relevant to his or her area. A filter would obviously speed the process of selecting relevant CAD items.
- 1126s: every item on the CAD is identified by an incident type code. For example, 1182 always refers to an accident. One of the incident types is 1126 which refers to a stalled vehicle not blocking the roadway. 1126s generally don't affect traffic and are ignored by TravInfo. Operators state that there can be many 1126s on any given day and that this results in a mixing of important and useless items on the CAD screen. Time is lost in having to screen out the 1126s but also because their presence creates several screens of data and when the CAD is slow it takes more time to switch from screen to screen and collect all the important items. Apparently, the CHP has removed the 1126s from their system several times but during interviews operators mentioned these were back on the system now for several months.

### **3.4.2.3 Metro Networks Airborne Reports**

The Metro airborne reports are also a crucial source of information at the TIC. From operators' responses, it appears the airborne reports are the second most important data source after the CAD. Metro airborne reports are used by operators working both the geographic and slowdown workstations, although more intensively for the latter. The airborne reports are used as much as a source of new information as for verification of existing items. Airborne reports occur from 6 AM to 9 AM and from 4 PM to 7 PM, Monday through Friday.

#### **3.4.2.3.1 Duties**

Duties in this case are relatively straightforward: the operator will overhear an incident or congestion report relevant to his position (geographic or slowdown), will write down the information (the reports are tape recorded in case the operator is busy on another task) and input the data into the TIC and TATS systems (whether it is an update on an existing item or a creation of an item). Finally, the operator will mark the TATS tracker sheet and fill out the incident form.

#### **3.4.2.3.2 Time**

On average, when covering a geographic position, operators state they spend about 10% of their overall time on airborne reports, processing an item every five to ten minutes. The creation of a new item in the TIC system takes operators 2-3 minutes, an update of an existing item one minute or less.

While at the slowdown position, operators state they spend about 80% of their time (during rush hours) on this data source. The processing frequency of airborne reports is higher than when they are at the geographic positions: operators state an item is processed every 1-5 minutes. The length of the duties per airborne item is the same at both the slowdown and geographic positions.

### **3.4.2.3.3 Usefulness and Improvements**

All the operators describe the airborne reports as “very useful.” While at the geographic positions, 55% of the operators rank airborne reports as the second most important data source in terms of amount of operator time (6 out of 11, 3 of the 14 operators are weekend staff and hence don’t get airborne reports). For the slowdown position, the importance of the airborne reports is even more pronounced: 91% (10 out of 11) of the operators rank the airborne reports as the number one data source. The airborne reports is the data source operators seemed most satisfied with at the TIC. About 60% of the operators had improvements to suggest regarding the reports, however, these were minor and consisted mainly in:

- Pilots using less short-hand language in describing traffic conditions.
- More planes covering the Bay Area freeway network.

### **3.4.2.4 Metro Networks Instatrack**

The Instatrack is a webpage, available to Metro partners only, that contains incident and congestion information. Generally, operators use the Instatrack to verify an incident or congestion report (73% of the operators state that 80% or more of the Instatrack data is for verification rather than for creation of a new item). The Instatrack is maintained 24 hours a day seven days a week, generally by one operator at Metro Networks in San Francisco. The Instatrack is used mostly by operators working the geographic workstations (only three operators mentioned using the Instatrack for the slowdown position).

#### **3.4.2.4.1 Duties**

Periodically, operators will check the Instatrack webpage to get an update on an existing TIC incident or to find new information. Once an item of interest is found, the operator will input that data into the TIC system, generally in the TIM window and then will record it on the TATS system (and mark the TATS tracker sheet and fill out the form).

#### **3.4.2.4.2 Time**

On average operators state they spend about 5-10% of their time on the Instatrack. The frequency of use varied among operators, but two thirds of the operators stated they used the Instatrack as least every 15 minutes. The creation of a new item in the TIC system takes operators 2-3 minutes, an update of an existing item one minute or less.

#### **3.4.2.4.3 Usefulness and Improvements**

Fifty-eight percent of the operators describe the Instatrack as “very useful” and 25% as “useful” to TIC operations. While at the geographic positions, 36% of the operators rank the Instatrack as the second most important data source and 14% rank it as the third most important data source. The operators seemed fairly satisfied with the quality of the Instatrack. About half the operators did suggest improvements:

- A newer version of Netscape.
- A function to automatically reload the Instatrack web page: if the Instatrack web page is not reloaded regularly the information becomes outdated.
- More up-to-date information.

#### **3.4.2.5 Closed Circuit Television**

CCTVs are a useful data source to operators particularly for verification of congestion or incidents. As of February 1997, there were 34 CCTVs in operation located primarily along Highway 101 (16 CCTVs) stretching from San Francisco to Highway 92 and along Highways 24 (6), 680 (4) and along the 80/580 juncture. CCTVs are used by operators at both the geographic and slowdown positions.

##### **3.4.2.5.1 Duties**

Generally, operators will use a CCTV to verify an incident or congestion report (80% of the operators state that 90% or more of the CCTV data results is for verification rather than creation of a new incident). If an operator wishes to verify an incident or congestion report, he or she will go to the CCTVs at the slowdown position and select the appropriate camera (if it is not being used by the TMC next door which has priority over the cameras). If the data from the camera requires an update of an existing TIC item, the operator will go back to his station and change the item in the TIM and record the information on the TATS (mark the TATS tracker sheet and fill out the form).

##### **3.4.2.5.2 Time**

Ninety percent of the operators at geographic positions state they spend 1-5% of their time on this data source. At the slowdown position, operators spend slightly more time on this data source: 80% of the operators state they spend 2-5% of their time on it and 20% state they spend 10-15% on it. The frequency of use seems to be divided into two general groups: half the operators state they use the CCTVs every 5-30 minutes, the other half uses them once an hour or less.

### **3.4.2.5.3 Usefulness and Improvements**

For the geographic positions, half the operators described the CCTVs as “very useful”, another 20% describe them as “useful.” For the slowdown position, half the operators describe them as “useful” and 30% as “very useful.” 93% of the operators made suggestions for the improvement of the CCTVs as a TIC data source. The two main desired changes were:

- Installation of more cameras.
- Capability to control the movement of the cameras: the operators state that they are not allowed to turn the cameras to other directions and zoom in or out because Caltrans’ TMC has exclusive control of the cameras. This inability to control the cameras (aside from the top two cameras which operators have control over) can at times preclude them from obtaining traffic information.

### **3.4.2.6 Cellular Callers**

At the time of the interviews, TravInfo had given out 35 cellular phones to volunteers to ensure coverage of interstate or state highways 17, 80, 84, 101 (from San Francisco to 17), 237, 280 (from 380 to 17), 580 (from 205 to 101), 680 (from 580 to 237 ), 880 (from 980 to 17). Cellular call data is used by operators at both the geographic and slowdown positions both as a source of new information and for verification of existing data. On average operators report about half the volunteers actually call TravInfo and most of the calls occur during the rush-hours (the two TravInfo supervisors report that the operators’ observation regarding the call rate is a close approximation of the true call rate).

#### **3.4.2.6.1 Duties**

Operators receive a cellular call, fill out a paper form specifically designed to track cell calls (name of person who called, time of departure from home or work, time of arrival, traffic conditions and whether TravInfo has verified the report). If the information is new or is an update on an existing item, the operator will input the data into the TIC and TATS systems (or will forward the data to the operator covering the area the call refers to).

#### **3.4.2.6.2 Time**

For the geographic positions, 90% of the operators state they spend between 1% and 5% of their time processing cellular call information. At the slowdown position, operators spend slightly more time on this source: 70% of the operators say they spend 2-5% of their time and 30% state they spend 10-15% of their time on it. During rush-hours, 78% of the operators report they receive calls every 6-12 minutes and 22% of the operators state they receive a call every 30 minutes. The time they spend processing cellular data does not differ from the general average of 2-3 minutes for a new item and 1 minute or less for an update.

### **3.4.2.6.3 Usefulness and Improvements**

For the operators at both geographic and slowdown positions, the breakdown in usefulness is approximately the following: 30% describe this data source as “very useful,” 20% as “useful,” 40% as “somewhat useful” and 10% as “not useful.” Many of the operators did not seem very satisfied with the quality of this data source and in fact all the operators but one suggested improvements. The recommendations voiced most often were:

- Cellular callers should not phone in before leaving and when arriving: many operators expressed this concern and stated that this practice should be replaced with that of having the callers phone when they are in traffic
- Better information: several operators thought the routes and times covered were not always good and that some of the callers needed some training in traffic reporting.
- Elimination of the Cellular Calls form.
- A higher call rate: operators state approximately half the volunteers do not phone TravInfo.

### **3.4.2.7 Caltrans TOS Loop Sensor Data**

The TOS includes a network of sensors (a total of 168 as of September 1997) embedded in Bay Area freeways, mostly along highways 24 and 101, as well as Interstates 680 and 880. Speed and congestion data is collected at Caltrans' TMC and then routed to the TravInfo TIC. The loop data is a one of the TIC's two fully automated data sources (the other is the FSP). Loop sensor data is used almost exclusively by operators at the slowdown position. The quality of the loop data, however, has been problematic since the beginning of the project. Indeed as of September 1997, TravInfo staff has impeded approximately 75% of all sensors from feeding data into the TIC because of serious data quality concerns .

#### **3.4.2.7.1 Duties**

Operators use the loop sensor data to obtain congestion level reports. The operator opens the Traffic Backups window, checks the list of backups, selects backups that are not in the system, creates an item in the Traffic Incident Manager window for each backup, records them on the TATS and fills out the incident form.

An additional duty to be performed by the operator at the East Bay position is to monitor the status of the loops and FSPs on an hourly basis to verify that these data sources are feeding information into the TIC in a timely fashion.

### **3.4.2.7.2 Time**

Of the seven operators who use sensor data (36%, or 4 out of 11 operators report not using the sensor data or only rarely), five spend 5-10% of their time on loop data, one states 25% and another 70%. Five of the seven operators using the loop data state they use it on a continual basis, one states every 15 minutes and another every 3-5 minutes. The length of the duties does not vary much from that for other data sources.

### **3.4.2.7.3 Usefulness and Improvements**

The operators are generally fairly critical of the quality of the loop data: 9% of the operators describe it as “very useful,” 45.5% as “somewhat useful,” and 45.5% as “not useful.” In fact, all the operators aside from one state that improvements are needed. Chief among them are:

- Greater data accuracy and reliability.
- Elimination of duplicate sensor readings in the Traffic Backups window.
- Creation of a process button to automatically transfer Traffic Backups window event to the TIM window.
- Installation of more sensors.

### **3.4.2.8 Caltrans Roadwork Data**

The Caltrans Roadwork data is obtained from the TMC radio room and is used almost exclusively by the operator at the slowdown position. Caltrans roadwork data is input mostly after the rush-hours at around 9:30 AM and 9:00 PM by the morning and overnight crews.

#### **3.4.2.8.1 Duties**

The morning operator at the slowdown position obtains a complete hard-copy list of roadwork items from the radio room at the TMC at 9 AM. Approximately 45 minutes later, the operator goes to the radio room, checks the folder with roadwork items and determines which items are still current and adds new roadwork items to his or her list. During the morning shift, the operator at the slowdown position inputs all the roadwork items into the TATS while the operators at the geographic positions input the items relevant to their region in the TIC. When the slowdown operator comes back from the radio room, he or she thus makes the roadwork data available to the other operators so that each operator can select data relevant to his or her region for input into the TIC. The slowdown operator then verifies existing roadwork data in the TATS and takes out the items that are no longer ongoing and inputs the new data in the TATS as well as fills out the TATS tracker sheet and incident form.

By the time the afternoon crew takes over, most if not all the roadwork items have been entered in the system. The main responsibility of the afternoon operator at the slowdown position is to



go to the radio room every half hour to see if there are updates on roadwork items. When there are, the operator will then either update or delete an existing item in both the TIC and TATS systems. The overnight operator will input roadwork data based on the list of items that is delivered at 5 PM by the radio room.

#### **3.4.2.8.2 Time**

After the morning rush-hour, operators state they spend over 90% of their time processing roadwork items. Depending on construction, traffic and weather conditions, operators report they process between 20-40 roadwork items from approximately 9:30 AM to 1 PM. Operators process a roadwork item every 5-10 minutes during the morning shift. On average it takes operators 2-3 minutes to create an item on the TIC (excluding time spent collecting data at the radio room). The overnight operators similarly process anywhere from 20 to 40 items depending on conditions. During the afternoon shift, operators process between 5 and 20 items (mostly deletions and updates). The frequency of data processing in the afternoon is approximately once every half hour.

#### **3.4.2.8.3 Usefulness and Improvements**

All the operators describe the Caltrans roadwork data as “very useful.” Nonetheless, all the operators had improvements to suggest:

- The most common point made by operators was: computerizing the tracking of roadwork items at the radio room instead of having paper records and subsequently establishing an electronic link between the radio room and the TIC.
- The present organization of the long-term roadwork items in the Service Interruption Manager window makes retrieval of individual items time-consuming.

#### **3.4.2.9 Other Data Sources: Beat calls, FSP and TMC**

The operators obtain other traveler-related information from a variety of sources. One of the sources of information is from “beat” calls to bridges, transit agencies, police stations and county offices of public information. Operators generally call once every half hour during rush-hours and once an hour during off-peak time. This takes on average a minute or less. Operators seemed to think this was a useful source of information. The main complaint operators had concerning this data source was a lack of cooperation on the part of many of the agencies they called (i.e. representatives of the agencies provide little or no valuable information). Several of the operators thought that the agencies should be phoning in themselves to provide information.

The FSP is one of two fully automated data sources into the TIC. Operators do not have any duties to perform relative to the FSP data aside from monitoring it once an hour to ensure timely reporting of information.

The operators also obtain some information from CHP officers at the TMC, located adjacent to the TIC. In addition to the CAD, loop sensor, CCTV and roadwork data which come to the TIC via the TMC, operators can obtain information on specific CAD incidents by asking CHP officers at the TMC. Three of the operators mentioned using TMC data while at the geographic position and ranked this data source third (two operators) and fourth (one operator). These three operators state they spend 5-10% of their time going to the TMC to obtain data and inputting it in the TIC system.

#### **3.4.2.10 System Problems Affecting Flow of Information**

During the interviews, when operators were asked about improvements to each data source that would accelerate the flow of information, all of them mentioned system problems and the need for system enhancements. From the interviews, it is clear that system problems and/or interface design issues negatively impact the working environment of operators and consequently slow down the flow of information. Among the system or interface problems mentioned most often were:

- Slowness of system overall: Many of the operators, as well as the supervisors, stated that the system was often very slow. In fact, evaluators have noticed this during their visits to the TIC. The system slowness occurs not just for graphics intensive windows such as the Area Map but also in the location selector of the TIM window, which is all text.
- Design problems in the TIM window: one example is that several of the fields such as Incident Type, Incident Subtype and Incident Advice contain useless items (such as radiation hazard or air raid) and lack important ones (such as stall or car fire) causing the operator to lose time while looking for the appropriate item.
- Design problems in the Location Selector within the TIM window: one among several problems is the fact that the Location Selector's county and city selections don't act as filters for highway selections. For example, if an operator selects the South Bay and then Highway 101, ideally the freeway exits should only contain ones for the South Bay, however, presently all exits for Highway 101 (including those in San Francisco) are listed forcing the operator to do the geographic filtering and consequently resulting in a loss of time.

Design and system issues, affecting the speed of operator response, were mentioned for several other windows in the TIC system including: the Area Map, the Traffic Congestion Backup Manager, the Planned Events, the Points of Interest, the Service Interruption Manager and the Transit Incident Manager.

#### **3.4.3 Study Conclusions**

Conclusions are divided into two sections. First, choke-points in the flow of information through the TIC are described. Secondly, the role of the operator in the flow of information through the TIC is discussed.

### 3.4.3.1 Choke-points in the flow of information

Based on the interview results, tables 8 and 9 were constructed to bring to light potential choke points in the flow of information. These tables rank the data sources relative to the amount of operator time spent on each one and relative to the level of operator use for each source (i.e. the percent of operators who state they use the data source). Table 8 clearly illustrates the overwhelming importance of the CAD, which represents the greatest potential choke-point in the flow of information through the TIC, particularly since it is a manual source of information. Indeed, 57% of all operator time is spent on the CAD. During visits to the TIC, several of the operators mentioned that during bad weather conditions or particularly busy days a backlog of incidents develops on the CAD forcing the operator to select only the more important incidents. Automation of the CAD along with the creation of a geographic filter, which several of the operators mentioned and the TravInfo team plans on implementing, would greatly speed up the flow of information through the TIC. The only other data source which could be automated to enhance the flow of information through the TIC would be the Instatrack (nothing can be done to accelerate the input of airborne, CCTV and cellular data aside from perhaps the elimination or shortening of data tracking forms).

**Table 9: Data Use at Three Geographic Positions**

Rank	Source	Operator Time	Operator Use	Frequency	Automation level
1	CAD	75%	100%	Continually	Manual
2	Airborne	10%	82%	5-10 min	Manual
3	Instatrack	5-10%	93%	15 min	Manual
4	CCTV	1-5%	71%	30-60 min	Manual
5	Cell calls	1-5%	71%	6-12 min	Manual

**Table 10: Data Use at Slowdown Position (Rush-Hours)**

Rank	Source	Operator Time	Operator Use	Frequency	Automation level
1	Airborne	80%	100%	Continually	Manual
2	CCTV	2-5%	90%	30-60 min	Manual
3	Cell calls	2-5%	90%	6-12 min	Manual
4	Loops	5-10%	64%	Continually	Semi-automated
5	Instatrack	5-10%	18%	5-10 min	Manual

NB: a. The numbers in Tables 8 and 9 are those indicated by most operators (i.e. by two thirds of the operators or more) rather than “firm” or exact numbers. For example, for the Airborne reports at the geographic positions (Table 8), 9 out of 11 operators reported using the airborne reports and two thirds of these stated they spent between 7.5% and 15% of their time on this data source (the most common number being 10%). We summarized this as 82% (9 out of 11) of the operators use the airbornes for approximately 10% of the time; b. Some of the aforementioned data sources are not available 7 days a week, 24 hours a day. Specifically: airborne reports are available only Monday through Friday, 6-9 AM and 4-7 PM; cellular calls come in mostly during rush hours, Monday through Friday.

### **3.4.3.2 Role of the operator**

The role of the operator in the flow of information through the TIC is critical in many ways. First, given that most of the data sources are manual, human processing is essential. Initially, in the original 1992 TravInfo proposal, data integration was envisioned to be highly automated: “To the greatest extent practical and feasible, data integration methods will be automated to lighten the enormous operator burden and resource requirements of such systems.” However, when operations began in August 1996, there were only two automated data sources, the TOS and the FSP. Automation of other data sources is not likely to occur throughout the period of the FOT, except perhaps for the CAD. Second, not only is the operator needed to input information in the TIC system but also more importantly to interpret data coming in from a variety of sources or from within a single data source. For example, operators are constantly prioritizing incidents within the CAD to decide what ultimately gets included in the TIC system.

Even if some data sources are eventually automated, many of the data sources such as the airborne reports, CCTVs and cellular calls cannot be automated and will always require human interpretation and processing. In fact, even with automation, such as for the CAD, human interpretation and decision-making might still be necessary in the last steps of data integration. Indeed, while automation of the CAD would likely filter the incidents geographically for each geographic workstation and purge useless items (such as 1126s), operator intervention would probably still be necessary to analyze which items should ultimately be included in the TIC system. Finally, the operator’s role is crucial in the execution of many functions essential to the timely and accurate flow of information through the TIC, such as general system maintenance, circumventing design shortcomings and data verification and tracking.

## **4. ONGOING AND NEW TIC EVALUATION WORK**

The evaluation of the TIC is a work-in-process relative to each of the components discussed in this report. For System Reliability, the TIC Problem Report may undergo additional modifications. Discussions with Metro and the TRW maintenance staff will be held to determine the extent of such changes. Moreover, with the TRW maintenance contract now signed and in

effect, the reports should now be more completely filled out and provide needed and valuable information in the area of problem resolution and duration. With respect to TATS activity and port use data collection and analysis as well as LDS data collection and analysis, an ongoing effort with regular data downloads and analysis continues throughout the FOT. For the Operator Interface element, a second survey instrument was developed and executed in the September 1997 - January 1998 time period. This second survey focused on (1) operator tasks and job responsibilities and (2) TIC/operator interfaces and the working environment (See (1)). A third survey is also being planned to specifically include TIC operations management. In addition to this ongoing work, the response time analysis portion of the evaluation will be performed in the winter and summer of 1998.

## **5. PRELIMINARY CONCLUSIONS**

This evaluation report documents the first nine months of TIC operations for the two year TravInfo FOT and focuses on three of the four primary TIC evaluation components: system reliability, communications interface, and operator interface. Based on the performance of the TIC during this time period, conclusions, though preliminary, may nevertheless be offered and are be valuable. Such conclusions should, however, be understood in this context. For example, the assessment of operations over time through observation and analysis of trends is part of the evaluation work. The reporting periods for this study, however, range from six to ten months depending on the evaluation element being investigated. Such time periods are not sufficiently long to perform trend analyses and this part of the evaluation work will not be performed until later on in the evaluation, and possibly not until the conclusion of the FOT in September 1998.

During the first nine months of operations, data access at the TIC has fallen well short of that envisioned in the general goals set out for the TravInfo Field Operational Test. The first two goals for the TravInfo FOT are: 1.a) Collect and integrate traveler information b) broadly disseminate information throughout the San Francisco Bay Area and c) provide timely and accurate traveler information and 2. Stimulate and support the deployment of a wide variety of ATIS products and systems creating a competitive market with products providing a range of prices and capabilities.

Thus far, TravInfo seems to have satisfactorily implemented goal 1.a , although there have been serious problems with the quality of the TOS loop detector data. However, TravInfo is still far from reaching goal 1.b of broadly disseminating information throughout the San Francisco Bay Area, particularly real-time data (goal 1.c). Call volume to the TATS telephone hotline has remained virtually constant during reporting period oscillating between 1,700 and 2,080 calls per day or between 50,000 and 60,000 a month (except for September and October when monthly call volumes were respectively 62,600 and 64,400). Assuming a quite conservative average estimate of 7 calls per month to TravInfo for each user and an upper bound of 60,000 calls per month, that would correspond to no more than approximately 8,500 users, far from broad

dissemination in a metropolitan area of over 6 million people.<sup>6</sup> Furthermore, during the September 1996 to June 1997 time period, approximately 74% of all calls were for transit information (85% of which was for AC Transit) and 16% were for traffic information. Thus, real-time data is being disseminated even less than other types of data hence frustrating part of goal 1.c.

Data access by the private sector has also been very limited. Access by the private sector participants, monitored from November 1996 to June 1997, is essentially limited to three ISPs, one of which downloads 95% of all data accessed. Although TravInfo has managed to involve some private sector participants in the FOT, it has so far not reached its second goal of stimulating and supporting the deployment of a wide variety of ATIS products and systems. Troubling for TravInfo is the fact that approximately 85% of data accessed by ISPs is speed and congestion data, which relies on loop sensors 75% of which have not been allowed to feed data into the TIC because of accuracy problems. This loop sensor data problem has likely led to limited data access on the part of ISPs. There are several other potential reasons for the limited data access on the part of the public and private sectors. These will be covered in the final TIC Evaluation Report, the second TATS survey report and the second ISP survey report to be published after the conclusion of the FOT in September 1998.

## 6. REFERENCES

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<sup>6</sup> The calculation of the number of TATS users is based on results from the first wave of surveys conducted with TATS users in April 1997. The sample population was 511. One of the survey questions asked how many times TATS users called into the system. While the sample population was not entirely representative of the actual population of TATS callers to correct for the anomalously high transit population (see (4) for details), this question, combined with results for the total number of calls, allows a general estimation of the total population of callers. The total population of TATS callers was estimated to be approximately 5,000 and, taking the upper bound of 60,000 calls per month and the minimum number of calls each person stated he or she made per month, the upper bound of TATS users was estimated at 8,500. It should also be kept in mind that the total Bay Area population obviously includes people who would never make calls, such as the very young and non-english speakers.

## **7. APPENDICES**

This section contains the following two appendices:

Appendix A TIC Problem Report

Appendix B Ten Worst Bay Area Congestion Locations in 1996

Appendix C Operator Interface Survey





## APPENDIX B OPERATOR INTERFACE SURVEY

(This survey will be executed by means of in-person one-on-one interviews)

### INFORMATION FLOW ANALYSIS COMPONENT

Date and time of interview: \_\_\_\_\_

Name of interviewee: \_\_\_\_\_

Position of interviewee:  Operator  Supervisor

Start of employment: \_\_\_\_\_

### SCRIPTED INTRODUCTION

The University of California at Berkeley is conducting interviews of TIC Personnel to assess the effectiveness of the TravInfo project and more particularly the Traveler Information Center. The objective of this particular survey is to gather data on the operator's role in the flow of information through the TIC. Information that you provide will be kept confidential.

#### A. DATA FLOWING INTO TIC

*Primary objectives: To determine all possible data/information flows into the TIC. To determine all points of operator interface for each data information flow. For each point of operator interface, determine the level of attention required by the operator to handle information.*

1. When you are covering traffic and incidents for one of the geographic regions (workstations 1, 2 or 3) which data sources require the most attention on your part for integration into the TIC (please rank by order of importance)? What percentage of your time do you dedicate to integration of these data sources into the TIC? Please specify the usefulness of the data source (not useful, somewhat useful, useful, very useful).

Data source	% of time allocated	Usefulness
CAD		
Airborne reports		
Instatrack		
Cell calls		
CCTV		
Loop sensors		

**Data source 1: CHP CAD**

a. What duties do you perform to integrate this data source into the TIC? Please specify all steps involved.

- Interpret incidents on CAD (is it relevant to my geographic area and is it an event of interest to TIC?)
- After selection of item, enter item code on CAD and check incident in more detail
- Fill out geographic location information in incident manager window
- Fill out form
- Check item number on CAD later and update if necessary
- Other:

b. How often do you perform these duties and for how long?

- How often :     Continuously  
                   Every 0-3 minutes  
                   Other:
- Length of duties:     2-3 minutes  
                           Other:

c. Do any of the system features need improvement? If yes, how could they be improved?

- CAD:

- T.I.M.:

- Location selector:

- Other:

d. Do you verify this data source against another? If yes, what data source is used for verification and what is the verification procedure?

- Yes     No

**Data source 2: Metro Airborne reports**

a. What duties do you perform to integrate this data source into the TIC? Please specify all steps involved.

- Data used for verification:           % of data
- Data as source of new info:           % of data

Duties:

- Update existing incident
- Integrate new data in TIM
- Other:

b. How often do you perform these duties and for how long?

- How often :
- Every 0-10 minutes
  - Every 10-20 minutes
  - Every 20-30 minutes
  - Other:

Length of duties:

For update of incident:

For creation of new incident:

c. Do any of the system features need improvement? If yes, how could they be improved?

**Data source 3: Metro Instatrack**

a. What duties do you perform to integrate this data source into the TIC? Please specify all steps involved.

- Data used for verification:           % of data
- Data as source of new info:           % of data

Duties:

- Update existing incident
- Integrate new data in TIM
- Other:

b. How often do you perform these duties and for how long?

- How often :
- Every 0-5 minutes
  - Every 5-10 minutes
  - Every 10-15 minutes
  - Other:

Length of duties:

For update of incident:

For creation of new incident:

c. Do any of the system features need improvement? If yes, how could they be improved?

d. Do you verify this data source against another? If yes, what data source is used for verification and what is the verification procedure?

- Yes
- No

#### **Data source 4: Cell Calls**

a. What duties do you perform to integrate this data source into the TIC? Please specify all steps involved.

- Data used for verification:        % of data

- Data as source of new info:           % of data
- Data not useful:                       % of data

Duties:

- Update existing incident
- Integrate new data in TIM
- Fill out form
- Other:

b. How often do you perform these duties and for how long?

How often (number of calls per hour during peak hours, of those number that are useful):

Length of duties:

For update of incident:

For creation of new incident:

c. Do any of the system features need improvement? If yes, how could they be improved?

d. Do you verify this data source against another? If yes, what data source is used for verification and what is the verification procedure?

- Yes     No

**Data source 5: Caltrans Roadwork Data**

a. What duties do you perform to integrate this data source into the TIC? Please specify all steps involved.

- Inspect roadwork sheets (for roadwork relevant to my geographic area)
- Update existing roadwork incident in “Service Interruption Manager” window
- Integrate new roadwork incident in “Service Interruption Manager” window
- Fill out form
- Other:

b. How often do you perform these duties and for how long?

How often (number of roadwork incidents per hour during peaktime):

Length of duties:

For update of incident:

For creation of new incident:

c. Do any of the system features need improvement? If yes, how could they be improved?

d. Do you verify this data source against another? If yes, what data source is used for verification and what is the verification procedure?

- Yes     No

**Data source 6: CCTVs**

a. What duties do you perform to integrate this data source into the TIC? Please specify all steps involved.

- Data used for verification:       % of data
- Data as source of new info:       % of data

Duties:

- Update existing incident
- Integrate new data in TIM
- Other:

b. How often do you perform these duties and for how long?

How often :

Length of duties:

For update of incident:

For creation of new incident:

c. Do any of the system features need improvement? If yes, how could they be improved?

d. Do you verify this data source against another? If yes, what data source is used for verification and what is the verification procedure?

- Yes     No

### **Data source 7: Loop Sensors**

a. What duties do you perform to integrate this data source into the TIC? Please specify all steps involved.

- Monitor status (to verify loop are reporting data in a timely fashion)
- Fill out status form
- Verify validity of TOS data
- Other:

b. How often do you perform these duties and for how long?

Monitor status:

Fill out form:

Verify validity of data:

Other:

c. Do any of the system features need improvement? If yes, how could they be improved?

d. Do you verify this data source against another? If yes, what data source is used for verification and what is the verification procedure?

- Yes     No

**Data source 8:** \_\_\_\_\_

a. What duties do you perform to integrate this data source into the TIC? Please specify all steps involved.



b. How often do you perform these duties and for how long?

How often :

Length of duties:

c. Do any of the system features need improvement? If yes, how could they be improved?

d. Do you verify this data source against another? If yes, what data source is used for verification and what is the verification procedure?

Yes     No

2. When you are covering slowdowns and roadwork (workstation 4) which data sources require the most attention on your part for integration into the TIC (please rank by order of importance)? What percentage of your time do you dedicate to integration of these data sources into the TIC? Please specify the usefulness of the data source (somewhat useful, useful, very useful).

FOR SLOWDOWNS (Peak hours)

Data source	% of time allocated	Usefulness
Airborne reports		
Loop detectors		
CCTV		
Cell calls		

FOR ROADWORK (mostly off-peak)

Data source	% of time allocated	Usefulness
Caltrans road work data		

**Data source 1: Metro Airborne reports**

a. When at the slowdown position, are the duties you perform to integrate airborne data into the TIC different than when you are at positions covering geographic areas?

- Yes *Ask about duties and proceed with questions on this page*
- No *Proceed to next data source*

b. How often do you perform these duties and for how long?

How often :

Length of duties:

c. Do any of the system features need improvement? If yes, how could they be improved?

d. Do you verify this data source against another? If yes, what data source is used for verification and what is the verification procedure?

### **Data source 2: CCTVs**

a. When at the slowdown position, are the duties you perform to integrate CCTV data into the TIC different than when you are at positions covering geographic areas?

- Yes *Ask about duties and proceed with questions on this page*
- No *Proceed to next data source*

b. How often do you perform these duties and for how long?

How often :

Length of duties:

c. Do any of the system features need improvement? If yes, how could they be improved?

### **Data source 3: TOS - Loop Sensors**

a. What duties do you perform to integrate this data source into the TIC? Please specify all steps involved.

- Set parameters in \_\_\_\_\_ window of Dataserver workstation (Ex: Heavy chocked etc. etc.)
- Go back to workstation, open “Congestion manager backup window”, check list of backups
- Select backup relevant to my area
- Fill out TIM
- Fill out form
- Verify validity of TOS data
- Other:

b. How often do you perform these duties and for how long?

- How often :
- Continuously
  - Every 0-3 minutes
  - Other:

- Length of duties:
- 2-3 minutes
  - Other:

c. Do any of the system features need improvement? If yes, how could they be improved?

d. Do you verify this data source against another? If yes, what data source is used for verification and what is the verification procedure?

- Yes     No

**Data source 4: Cell Calls**

a. When at the slowdown position, are the duties you perform to integrate cell call data into the TIC different than when you are at positions covering geographic areas?

- Yes    *Ask about duties and proceed with questions on this page*  
 No    *Proceed to next data source*

b. How often do you perform these duties and for how long?

How often :

Length of duties:

c. Do any of the system features need improvement? If yes, how could they be improved?

d. Do you verify this data source against another? If yes, what data source is used for verification and what is the verification procedure?

- Yes     No

**Data source 5: Caltrans road work data**

a. What duties do you perform to integrate this data source into the TIC? Please specify all steps involved.

- Verify roadwork data list from Caldecott Center against data at TMC radio room
- At Radio room check roadwork that is still current and add missing roadwork data
- Make data available to other operators so that each operator can select data relevant to his or her region for input into TIC.
- Verify existing roadwork data in TATS
- Input data into TATS
- Fill out form
- Other:

b. How often do you perform these duties and for how long?

How often (number of roadwork incidents completed per hour during peak time) :

Length of duties:

c. Do any of the system features need improvement? If yes, how could they be improved?

d. Do you verify this data source against another? If yes, what data source is used for verification and what is the verification procedure?

Yes     No

3. What other miscellaneous sources do you use on a daily or regular basis to collect transportation related information such as weather, bikeways etc.? Please specify the duties involved and the collection schedule for each of these data sources.

Data Source	Data Type	Duties involved	Collection schedule
	Weather		
	Public events		
	Bike information		
	Carpooling		

4. You did not mention the following data sources (**check data source list at end of questionnaire**):

Do you perform any duties do integrate those data sources into the TIC?

Yes *Proceed to rest of Q. 4*  
 No (*Ask person to confirm that no operator attention is required*). *Proceed to Part B*

**Omitted data source 1:** \_\_\_\_\_

a. What duties do you perform to integrate this data source into the TIC? Please specify all steps involved.

b. How often do you perform these duties and for how long?

How often :

Length of duties:



c. Do any of the system features need improvement? If yes, how could they be improved?

d. Do you verify this data source against another? If yes, what data source is used for verification and what is the verification procedure?

**Omitted data source 2:** \_\_\_\_\_

a. What duties do you perform to integrate this data source into the TIC? Please specify all steps involved.

b. How often do you perform these duties and for how long?

How often :

Length of duties:

c. Do any of the system features need improvement? If yes, how could they be improved?

d. Do you verify this data source against another? If yes, what data source is used for verification and what is the verification procedure?

**Omitted data source 3:** \_\_\_\_\_

a. What duties do you perform to integrate this data source into the TIC? Please specify all steps involved.

b. How often do you perform these duties and for how long?

How often :

Length of duties:

c. Do any of the system features need improvement? If yes, how could they be improved?

d. Do you verify this data source against another? If yes, what data source is used for verification and what is the verification procedure?

**Omitted data source 4:** \_\_\_\_\_

a. What duties do you perform to integrate this data source into the TIC? Please specify all steps involved.

b. How often do you perform these duties and for how long?

How often :

Length of duties:

c. Do any of the system features need improvement? If yes, how could they be improved?

d. Do you verify this data source against another? If yes, what data source is used for verification and what is the verification procedure?

## **B. DATA FLOWING OUT OF TIC**

*Primary objectives: To determine all possible data/information flows out of the TIC. To determine all points of operator interface for each data information flow. For each point of operator interface, determine the level of attention required by the operator to handle information.*

### **1. TATS**

a. What general duties do you perform to prepare dynamic data for final integration into the TATS system, in addition to those duties already performed to prepare data for the TIC?

Check status of mailboxes

- Press record option, record and then punch in mailbox number
- Mark mailbox on plastic sheet
- Fill out form
- Other:

b. What is the average time-lag between creation of an event/incident on the TIC and its recording on the TATS?

- One minute or less
- 1-2 minutes
- Other

c. Are incidents/data generally created in the TIC before they are recorded onto TATS?

- Yes
- No (*Inquire further. Ask: Why are data sometimes recorded onto the TATS first? How often does this occur?*)

d. Have you ever recorded static data onto the TATS as part of your operator duties?

- Yes *Proceed to Q. 1.e*
- No *Proceed to Q. 2*

e. How many times a month do you record static data onto the TATS as part of your operator duties?

On average, how much time do you spend on each TATS recording session for static data?

## 2. General

a. In the event of workstation failures or problems, what corrective actions do you take to maintain the flow of information through the TIC? Please give examples.

b. Is the integration of a data source sometimes interrupted by integration of another more important data source (i.e. do you prioritize among data sources)? If so, how often, when and why does this occur?

c. Through what other channels does data flow out of TravInfo (voice, fax etc.)? What type of data is this generally and who are the receiving parties?

### **C. RELATIONSHIP TO THE TMC**

*Primary objectives: To determine all possible data/information flows between the TIC and the TMC.*

1. What data does the TMC provide to the TIC and how are they provided?

- Data for verification purposes
- Current roadwork data
- Other:

2. Are there standard procedures for the exchange of information between the TMC and the TIC or is this done on an informal basis? Please explain what level of cooperation exists between the two agencies.

3. Are there any comments you would like to add regarding the role of the operator in the flow of information through the TIC?

## APPENDIX C

### TEN WORST BAY AREA CONGESTION LOCATIONS IN 1996\*

	County-route, direction, peak, limits of congestion	Delay (veh-hrs)	1995 rank
<b>1</b>	Ala/CC-80, westbound, A.M.; Appian Way to Ala/ SF Co. line	8,210	1
<b>2</b>	Ala-680. southbound, A.M.; Bernal to south of Rte 262	6,970	2
<b>3</b>	Ala-880, southbound, A.M.; Mowry Ave. to Dixon Landing Rd	4,380	17
<b>4</b>	SCI-237, eastbound, P.M.; North First St. to Rte 880	2,720	3
<b>5</b>	Mrn-101, southbound, A.M.; Rowland Blvd. to Mission Ave.	2,590	5
<b>6</b>	SM/Ala-92, eastbound, P.M.; Foster City Blvd. to Rte 880	2,300	16
<b>7</b>	CC-680, southbound, A.M.; Willow Pass Rd. to Rte. 24	2,140	9
<b>8</b>	SF-80, eastbound, P.M.; 80/101 interchange to Sterling St.	1,910	19
<b>9</b>	SM-101, northbound, P.M.; Whipple Ave. to Third Ave.	1,760	27
<b>10</b>	Mrn-101, northbound, P.M.; Rte 1 to San Pedro Rd.	1,560	12

\* These “rankings” are somewhat subjective in that congestion locations shown are for routes in which continuous stop & go conditions occur with few, if any, breaks in the queue. Thus, corridors which have equally severe delays but where congestion is broken into several segments may rank lower in this type of comparison. For example, the southbound P.M. commute on SCI-101 between Mountain View and southern San Jose would have ranked #5 if all of the individual locations of congestion were added up.

Source: Caltrans District 4, Office of Highway Operations; *Highway Congestion Monitoring Report, 1996*; May 1997.