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Trav Info Evaluation (Technology Element) Traveler Information Center (TIC) Study: System Reliability and Communications Interface

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TravInfo Evaluation (Technology Element) Traveler Information Center (TIC) Study:

System Reliability and Communications Interface (9/96-12/97)

Mark Miller, Dimitri Loukakos

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System Reliability & Communications Interface
(September 1996 - December 1997)

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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 December 31 1997 with respect to the system reliability and communications interface elements. Particular emphasis is placed on the period between July and December 1997 and the BART strike during September 1997. System reliability examines system failures. The communications interface examines TIC data access on the part of both the public and private sectors.

With respect to system reliability, during July to December 1997, a total of thirty-eight internal and non-recurring TIC problems occurred. Eighty-four percent of all problems were either critical or major in severity. Approximately three-fourths of all problems were located in the Processing subsystem. Sixty percent of all problems were associated with TransView, the primary TIC software program.

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 December 1997, with the exception of the Bay Area Rapid Transit (BART) strike (September 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. The BART strike had a significant effect on overall call volume only during September 1997. Overall, however, the BART strike did not have any lasting effect on overall TATS call volume. The overall call volume went from 57,730 in August to 196,606 during September and then decreased to the "normal" level of 56,589 in October.

Private sector access of data, via the Landline Data System, has also been quite limited. From November 1996 to December 1997, only three ISPs downloaded data on a continuous basis, one of which downloaded approximately 90% of all data during this reporting period.

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 severity, and location. 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 December 31, 1997 with respect to system reliability and communications interface with particular emphasis placed on the time period from July through December 1997. This report is the second TIC evaluation report that documents system reliability and communications interface elements. The first document's citation is as follows:

> M. A. Miller and D. Loukakos, "TravInfo Evaluation (Technology Element) Traveler Information Center (TIC) Study (September 1996 - June 1997)", California PATH Working Paper, UCB-ITS-PWP-98-7, California PATH, University of California Berkeley, (1998).

During the period between July and December 1997, there were thirty-eight new or non-recurring internal problems experienced at the TIC. The problems experienced were quite different than those experienced during the reporting period of January through June 1997. During this reporting period (July - December 1997), only non-recurring problems were documented at the TIC and made available to the evaluation team. Because of the unavailability of documented TIC Problem Reports for recurring problems from July to December 1997, system reliability cannot be analyzed in a complete and consistent fashion throughout the FOT period and, in particular, precludes a valid comparison of the results of this section with the results for the January - June 1997 time period. For the July - December 1997 time period, however, the number of problems located within the acquisition, processing, and dissemination subsystems are 21%, 73.7%, 5.3%,

respectively. Of these problems, the number of problems classified as critical, major, and minor are 39.5%, 44.7%, 15.8%, respectively.
With the exception of the month of September 1997 during the Bay Area Rapid Transit (BART) strike, and an initial surge in call volume at the start-up of TravInfo, from September 1996 through December 1997 call volume to the Traveler Advisory Telephone System (TATS) has remained fairly constant at between 50,000 and 60,000 calls per month. The region with the highest call volume was Oakland (monthly average from September 1996 to December 1997: 46,159) followed by San Francisco (monthly average: 6,236), San Jose (2,799) and Santa Rosa (570). The advertising campaign from January to March 1997 had only minor effects on overall call volume. It should also 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.

The BART strike which occurred in September 1997, had a significant effect on overall call volume during that month. Overall, however, the BART strike did not have any lasting effect on overall TATS call volume. The overall call volume went from 57,730 in August to 196,606 during September and then returned to its "normal" level of 56,589 in October. The BART strike mostly had an effect on Transit call volume data. Most of the increase in transit calls was attributable to calls for the AC Transit system, which uses the TravInfo hotline as its main telephone line for customers.

The strike had only a fairly minor effect on traffic call volume. Typically, traffic call volume is on the order of 1,500 to 2,000 calls per week for the whole TATS system. When the strike was in full swing, traffic call volume doubled to 3,915. By the following week, traffic call volume was back to normal at 1,765. Part of the reason the BART strike had so much effect on transit and little effect on traffic is that during the strike most media outlets (primarily television stations) mentioned the TravInfo telephone number but described it as a transit hotline.

TATS system capacity use, assessed by measuring access to the publicly available voice ports, is very low. On average, for the Oakland region which is the busiest regional system, from September 1996 through December 1997, with the exception of the period during and immediately after the BART strike in September 1997, approximately 3% of the TATS system capacity was utilized. System capacity use was significantly lower for the other three regional systems. Port utilization did reach a maximum of approximately 25% and 75% in the Oakland region during the AM and PM peak periods of the first two days of the strike, respectively.

Private sector access of the data, via the Landline Data System, has also been quite limited. From November 1996 to December 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 during the period of November 1996 through December 1997, one of which downloaded approximately 90% of all data during the reporting period. Four ISPs downloaded data continuously during the shorter period of July through December 1997.

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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) through December 31, 1997 with particular emphasis on the period between July 1997 and December 1997 and additional focus on the Bay Area Rapid Transit (BART) strike during September 1997. The reader is referred to (1) for a detailed report on the evaluation of the TIC during the period of September 1996 through June 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, is currently under investigation and will be reported in a separate report. A complete description of the evaluation plan for the TIC may be found in (2) which provides additional detail on each of the four TIC evaluation components.

2. DATA: SOURCES AND COLLECTION METHODOLOGIES

The sources of data and the means of collecting them for subsequent analysis used in this second interim TIC evaluation report are consistent with that used in the first interim TIC evaluation report. The reader is referred to reference (1) to review all such information.

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 July to December 1997. TATS activity and port use results are presented from September 1996 to December 1997. Finally, LDS activity covers the period from November 1996 to December 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

- Thirty-eight non-recurring internal problems arose during the reporting period of July to December 1997
- Approximately three-fourths of the problems were located in the Processing subsystem

- Eighty-four percent of all problems were either critical or major in severity
- Sixty percent of all problems were associated with TransView, the primary TIC software program

3.1.2 TATS Activity

Weekly and Monthly Call Volume (excluding September 1997)

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

Daily Call Volume By Time-Of-Day (excluding September 1997)

- 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) (excluding September 1997)

- 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 (excluding quarter during BART strike: July - September 1997)

- AC Transit, BART and SAMTRANS-CALTRAIN account for 85%, 6% and 1-3% 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
- The remaining 1-3% of transit calls are placed in the “no selection” category.

Transit Service Providers (Quarter during BART strike: July - September 1997)

- AC Transit, BART and SAMTRANS-CALTRAIN account for 78%, 4% and 3% of all transit inquiries, respectively
- Other Transit Service Providers account for approximately 10% of all transit inquiries. This includes Alameda-Oakland Ferry, CCCTA, Golden Gate and MUNI
- The remaining 5% of transit calls are placed in the "no selection" category.

Selected Routes

- Four (880, 80, 580, 680) out of the top five and five out of the top ten selected routes are in the East Bay
- South Bay, the Peninsula and San Francisco account for 19.3%, 14.1% and 9.0% of all selected routes, respectively
- Bay Bridge is most popular bridge route and seventh 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

BART Strike Period of September 1997

- Overall call volume for the month of September was approximately 196,000 compared to the "normal" range of 50,000-60,000 calls
- The biggest impact was on transit calls which doubled in volume during the week immediately prior to the strike (August 31 - September 6) and increased to approximately nine times transit's "normal" call volume during the week of the strike (September 7 - 13)
- During following week, September 14 - 20 (BART service resumed September 15), transit call volume reverted to "normal" levels
- The increase in transit calls mostly attributable to increase in calls for AC Transit to find alternative means of transport to replace BART
- The effect on traffic calls was minor
- There was a major impact on call volume for carpooling TATS menu selection

3.1.3 TATS Port Use

- All four TATS regions were examined based on data throughout the reporting period of September 1996 - December 1997
- Except for the period during and immediately after the BART strike, port utilization remained unchanged

- Overall port utilization for the Oakland region[1], excluding September 1997, 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)
- First two days of the strike produced the peaks in port utilization

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 nearly 90% of all bytes accessed over the entire time period and nearly all data downloaded each week
- Daimler-Benz accounts for approximately 8% of all bytes accessed
- Maxwell accounts for approximately 2% of all bytes accessed
- Contra-Costa Times accounts for approximately 1% of all bytes accessed
- Third tier of data downloads arises from ISPs including Clarion, KCBS, and Metro Networks 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 and discontinued downloading data after June 1997.
- Speed & Congestion and Traffic Incidents account respectively for approximately 85% and 14% of ISP data selection from main categories during the January through June 1997 period
- Speed & Congestion and Traffic Incidents account respectively for approximately 60 % and 40% of ISP data selection from main categories during the July through December 1997 period

3.2 System Reliability

This section briefly describes new or non-recurring internal problems experienced at the TIC between July and December 1997. The problems experienced were quite different than those experienced during the reporting period of January through June 1997 which is documented in (1). The System Reliability section of reference (1), encompasses all problems, recurring as well as non-recurring. During the reporting period for this section (July - December 1997), only non-recurring problems were documented at the TIC and made available to the evaluation team. Because of the unavailability of documented TIC Problem Reports for recurring problems from July to December 1997, system reliability cannot be analyzed in a complete and consistent fashion throughout the FOT period and, in particular, precludes a valid comparison of the results

[1]Oakland is the most heavily used of the four regions in terms of call volume as well as port utilization which accounts for the decrease in number of available ports

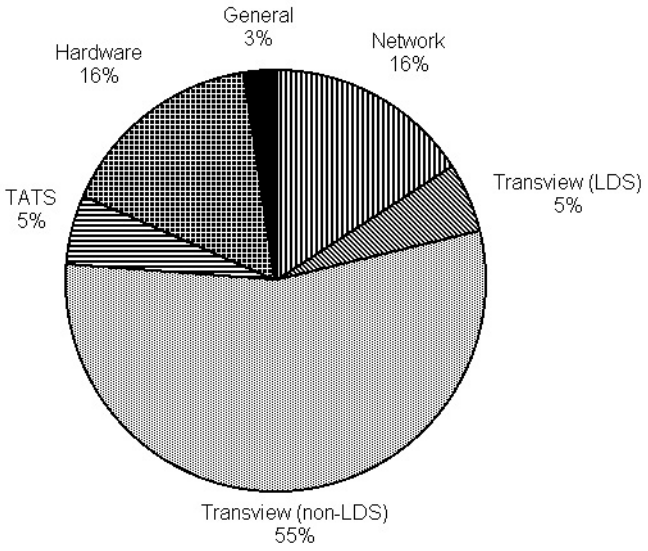
of this section with the results in (1). Thus this section is brief and focuses only the July to December 1997 time period.

During the reporting period for this report, there were a total of thirty-eight non-recurring problems. The percentage of problems located within the acquisition, processing, and dissemination subsystems is 21.0%, 73.7%, and 5.3%, respectively. Of these problems, the percentage classified as critical, major, and minor[2] is 39.5%, 44.7%, and 15.8 %, respectively. Table 1 focuses on the relationship between problem location and severity. The percentage breakdown in the types of problems is displayed in Figure 1 with a further partitioning of the types of problems by location and severity shown in Table 2.

Table 1: Non-Recurring TIC Problems: Location by Severity

	ACQUISITION	PROCESSING	DISSEMINATION	TOTAL
MINOR	1	5	0	6
MAJOR	2	13	2	17
CRITICAL	5	10	0	15
TOTAL	8	28	2	38

Figure 1: Distribution of Non-Recurring TIC Problems by Type



[2] Problem severity is defined as follows (1) : 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.

Table 2: Partition of Non-Recurring TIC Problems by Location and Severity

TYPE	NUMBER	LOCATION			SEVERITY		
		Acquisition	Processing	Dissemination	Critical	Major	Minor
Network	6	4	2	0	3	3	0
Transview (LDS)	2	0	1	1	1	1	0
Transview (non-LDS)	21	3	18	0	8	9	4
TATS	2	0	1	1	1	1	0
Hardware	6	1	5	0	2	2	2
General	1	0	1	0	0	1	0
Total	38	8	28	2	15	17	6

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 December 1997, call volume to the TATS system has remained fairly constant at between 50,000 and 65,000 calls per month (aside for September 1997 during which there was a strike at BART, the Bay Area's rail transit system). 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, no more than 2.7% capacity is being used for the Oakland TATS system, by far the busiest system of the four. During the BART strike, however, Oakland port use reached a maximum of 75% of capacity during one afternoon peak period.

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 from the LDS at one point or another, mostly infrequently and in small amounts. Only three ISPs downloaded LDS data on a continuous basis; one of which downloaded 95% of all data during the reporting period. From July to December 1997, private sector access actually decreased. During that period, 10 out of 40 registered participants (25%) accessed data at one point or another. Of those, four ISPs accessed data regularly, one of which accessed 87% of all data.

3.3.1 TATS Activity

This section describes TATS activity from July 1 to December 31, 1997, relative to several time measures, such as monthly, weekly, time-of-day, day-of-week and weekday and weekend split.

While most graphs include data from September 1, 1996 to June 30, 1997, this section will focus on the period July 1 to December 31, 1997. For precise reporting for the period September 1996 through June 1997, see the first TIC study (1). 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 as well as TIC supervisors placing calls to perform spot checking[3]. The large peak in call volume in September 1997 is due to a strike at BART. 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 contributed on the order of 55% to the overall call volume from September 1996 to December 1997 (excluding September 1997 data).

3.3.1.1 Monthly Call Volume

The first set of figures (Figures 2a - 2f) focus on monthly activity. Figure 2a depicts monthly call volume activity for the Bay Area as a whole as well as regionally for each of the four area code regions. In August 1997, the 415 area code split into 415 and 650 and a six month grace period existed through February 1998 during which dialing the TravInfo phone number, 817-1717, without the 650 area code would still connect to TravInfo. Between February and May 1998, accessing TravInfo from the 650 area code required initially dialing the former area code, 415, then the TravInfo phone number. From May through the end of the FOT, only dialing the 7-digit TravInfo phone number (no area code) is necessary since the call will be forwarded to the 415 TATS node. These procedures have and will continue to maintain the regional integrity for the analysis of all incoming TATS calls. Figures 2b and 2c 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 from July 1 to December 31, 1997 with the exception of the significant increase in September 1997 due to the BART strike . For details about trends from September 1996 to June 1997, refer to (1). Figure 2a 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 2d, regional and overall call volumes are depicted factoring out AC Transit. The trends are quite similar to those of Figure 2a aside from a decrease in overall call volume from July to August and a stable trend from October to December (as opposed to a slight decrease when AC Transit data is included). Figure 2e shows regional and overall call volumes factoring out the month of September 1997 and Figure 2f displays the same totals factoring out

[3] The reader is referred to (1) (Section 3.3.1) for information on the percentage of operator calls specifically for the purpose of call checking during the period of June 1996 to September 1997. After September 1997, the call checking procedure changed for both the operators and supervisors and thus it is difficult to say with certainty what the percentage would be for the October to December 1997 period. Differences exist in the level of call checking among the operators and supervisors. Supervisors' call checks are primarily due to necessary though irregular menu changes that have been implemented. Moreover, the level of intensity of such calls varies by supervisor.

both the month of September 1997 and AC Transit data. This last figure shows that monthly call volume has generally oscillated between 20,000 and 30,000 calls per month throughout TravInfo's history. Since February 1997, call volume has remained at between 21,000 and 26,000 calls per month, with the exception of July 1997 when call volume was at its highest at 31,000, again without AC Transit and September 1997.

Figure 2a: Regional and Bay Area Total Monthly Call Volume

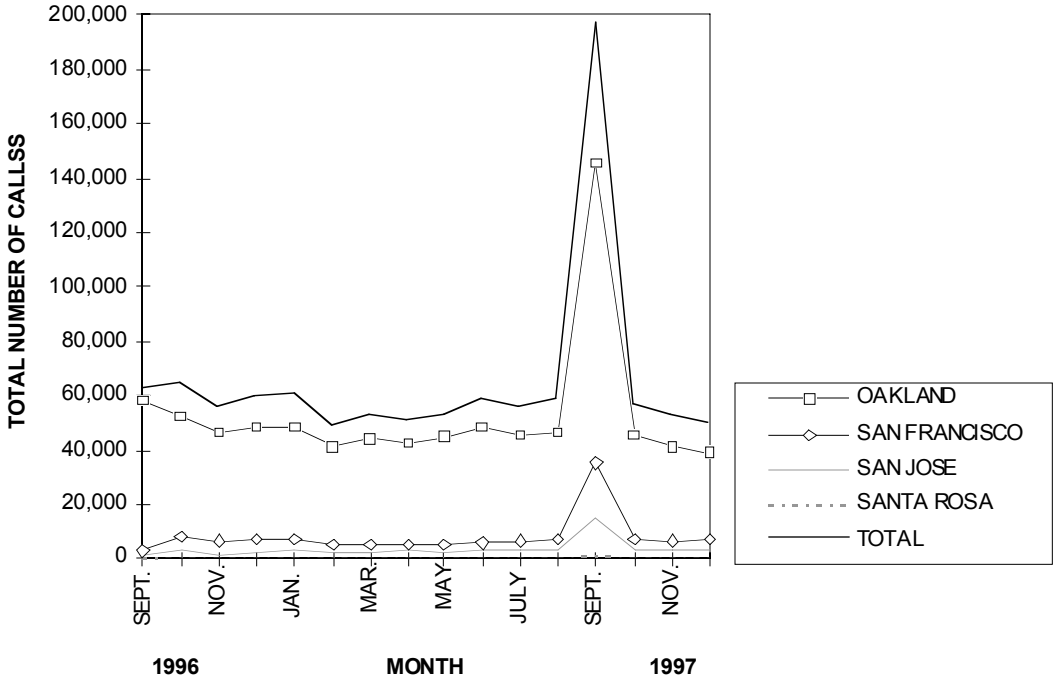


Figure 2b: Oakland, San Francisco and Bay Area Total Monthly Call Volume

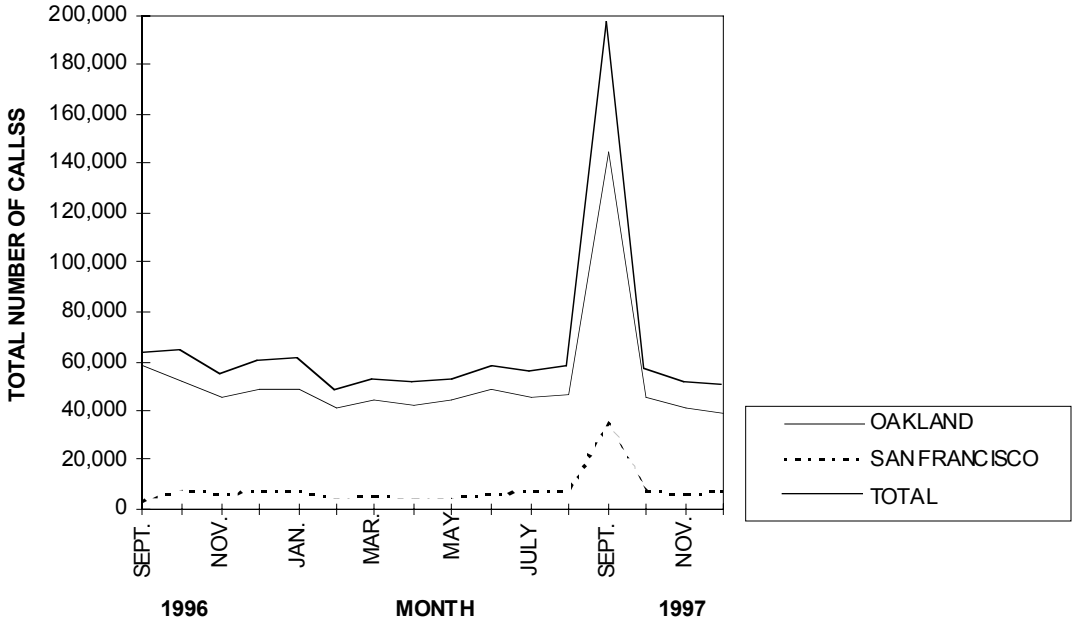


Figure 2c: San Jose and Santa Rosa Regional Monthly Call Volume

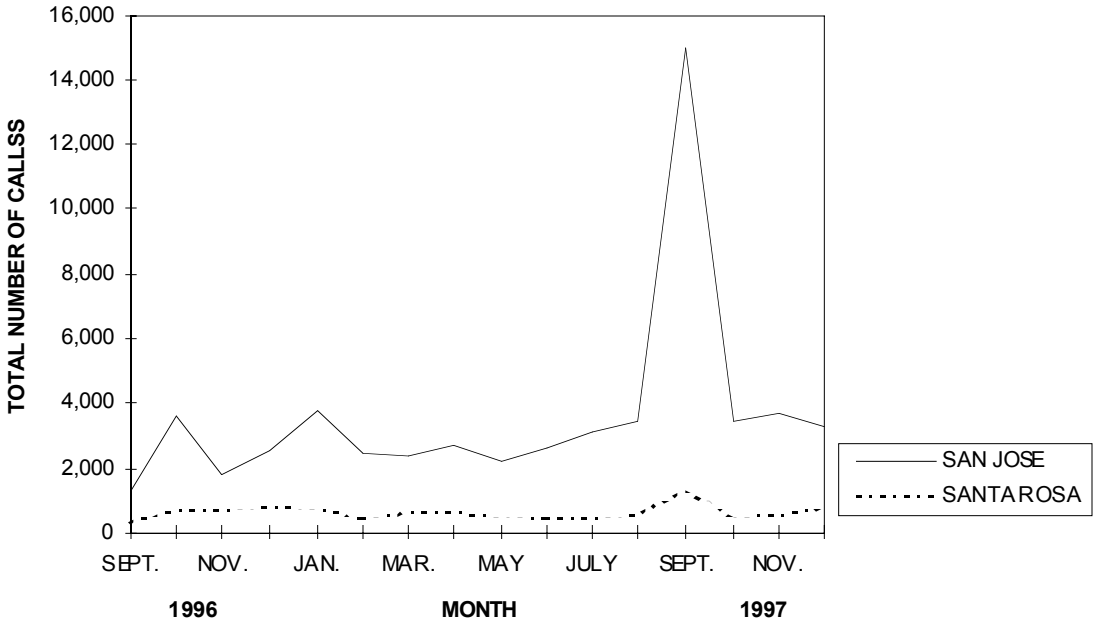


Figure 2d: Regional and Bay Area Total Monthly Call Volume Factoring Out AC Transit

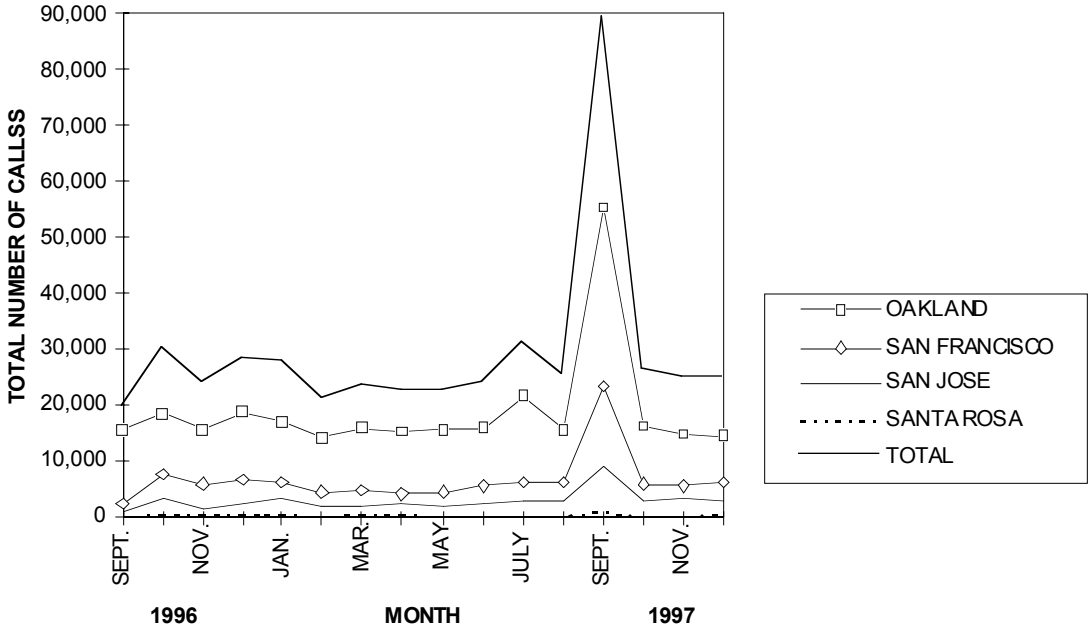


Figure 2e: Regional and Bay Area Total Monthly Call Volume Factoring Out Month of September 1997 (BART Strike)

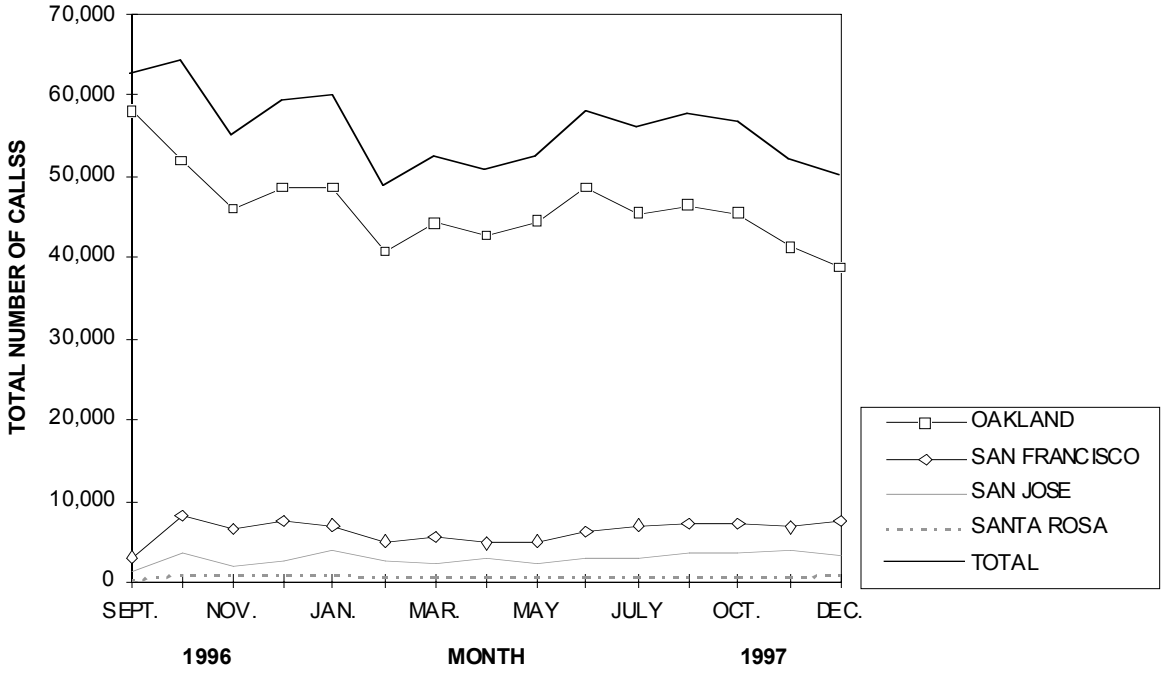
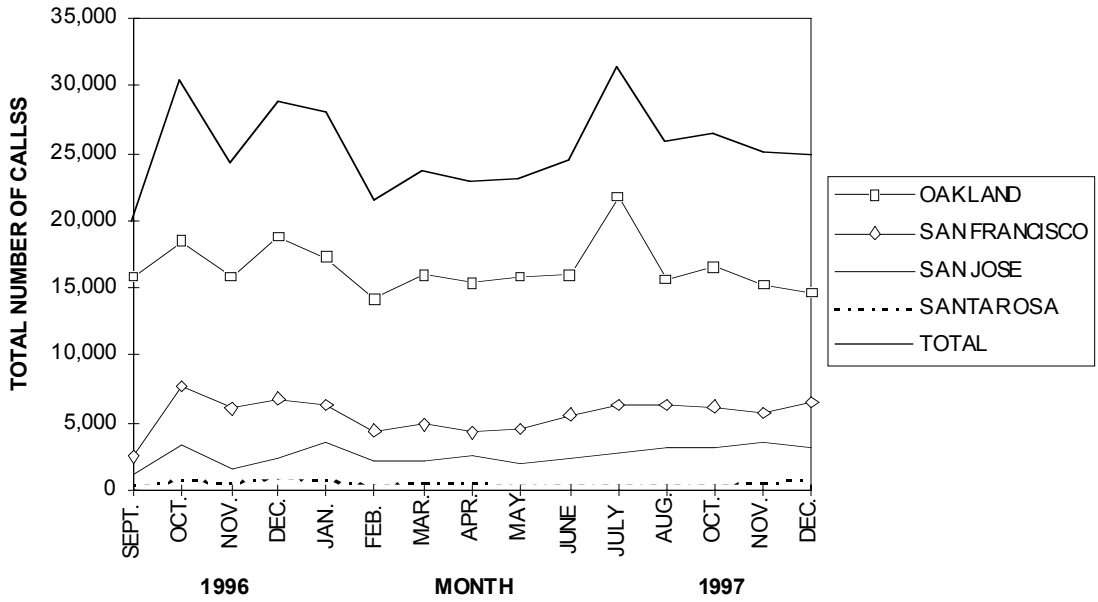


Figure 2f: Regional and Bay Area Total Monthly Call Volume Factoring Out AC Transit and Month of September 1997 (BART Strike)



The next group of figures (Figures 3a-3e) depict monthly call volumes by type of call. Figures 3a and 3b show monthly call volume disaggregated by the two main call types, transit and traffic. Figure 3a includes AC Transit, overall transit, traffic and total calls. Figure 3b shows AC Transit activity relative to total calls in OAKLAND and the Bay Area overall. The primary observations in Figure 3a are that AC Transit (which is approximately 85% of overall transit from September 1996 to December 1997) 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). Similarly, traffic inquiries remain fairly stable through the reporting period even during the BART strike in September 1997. Figure 3b shows how closely OAKLAND call activity mirrors that of AC Transit. In Figure 3c, AC Transit data was factored out. Figure 3d shows call volumes factoring out the month of September 1997. Figure 3e displays the same totals factoring out both the month of September 1997 and AC Transit data. Aside from September/October 1996 and July to November 1997 (and to a more limited extent during March-May 1997) traffic and transit calls display similar trends, with the latter having more of an influence on the progression of overall volume.

Figure 3a: Bay Area Monthly Call Volumes by Call Type

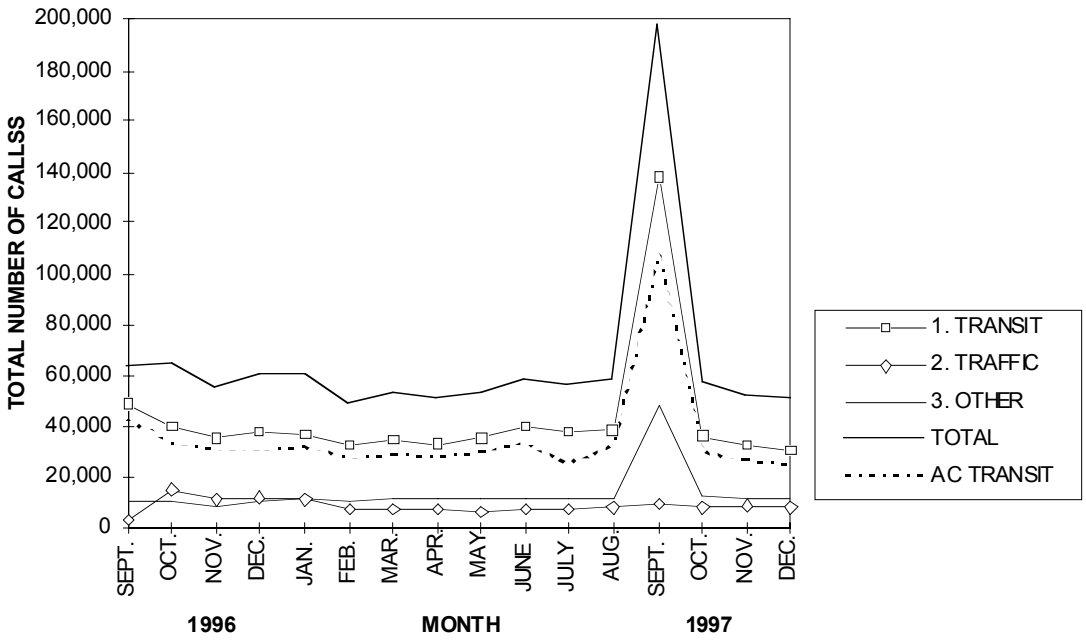


Figure 3b: AC Transit Call Volume Relative to Oakland Region and Bay Area

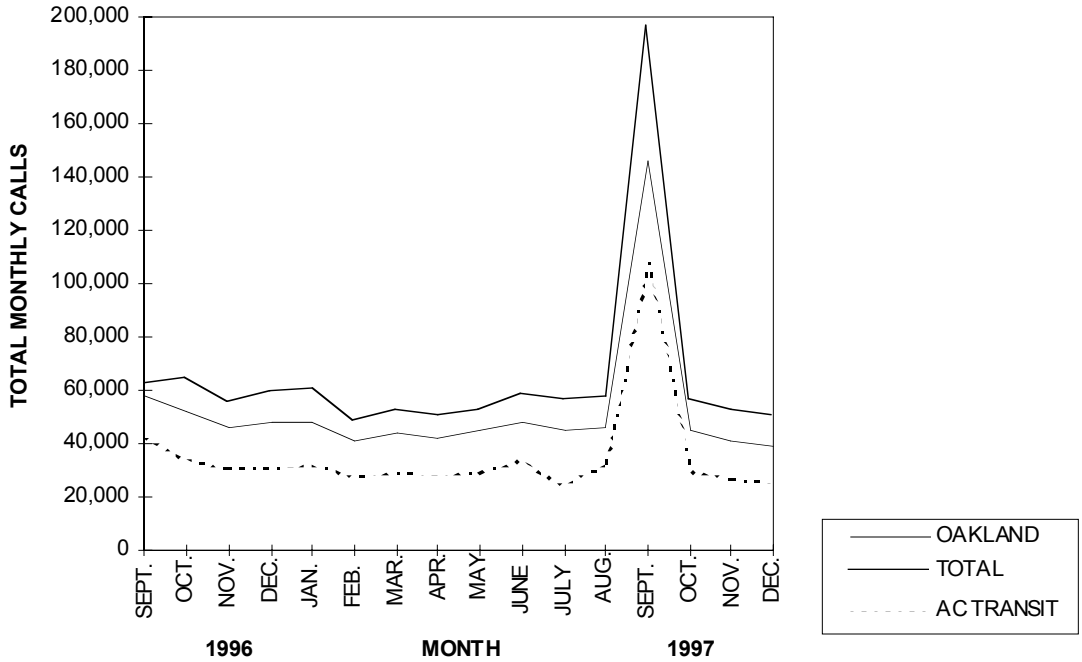


Figure 3c: Bay Area Monthly Call Volumes by Call Type Factoring Out AC Transit

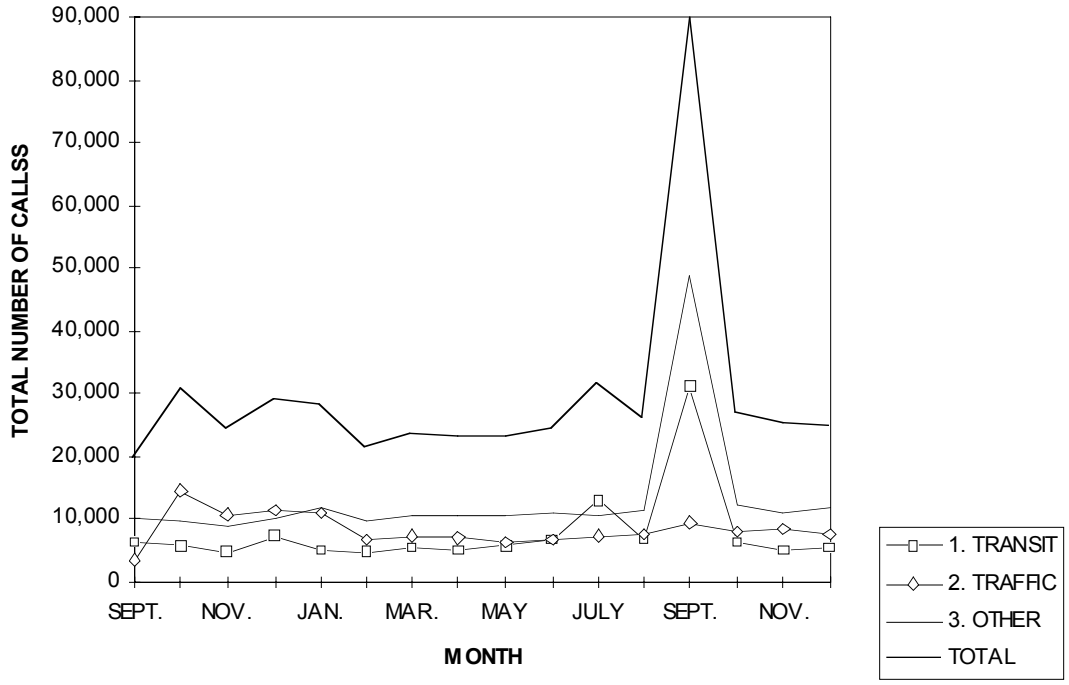


Figure 3d: Bay Area Monthly Call Volumes by Call Type Factoring Out Month of September 1997 (BART Strike)

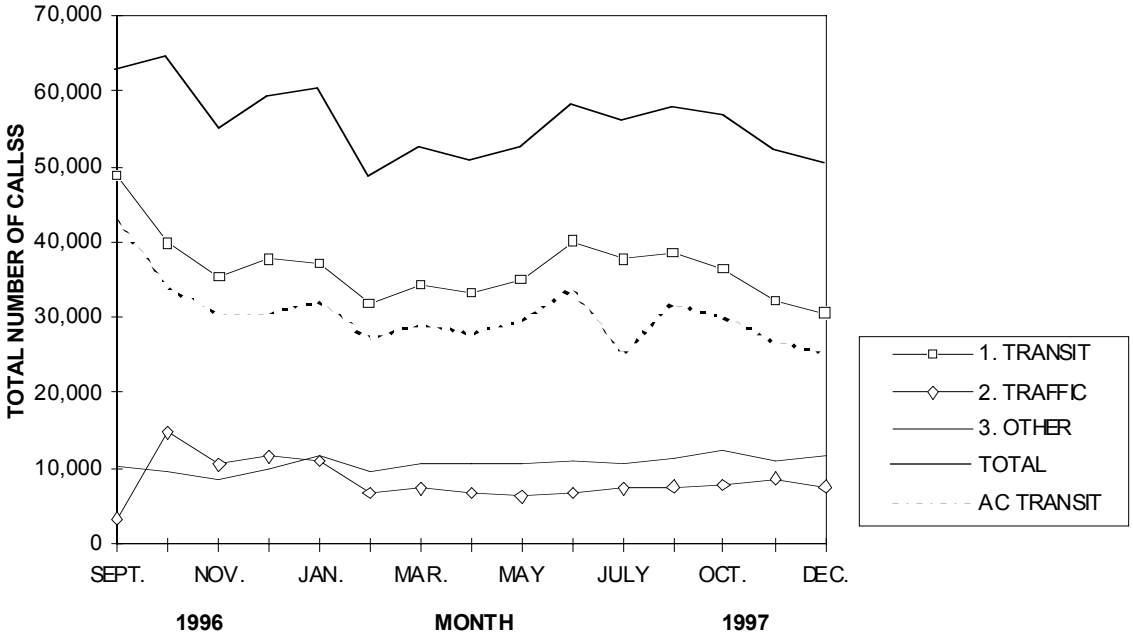
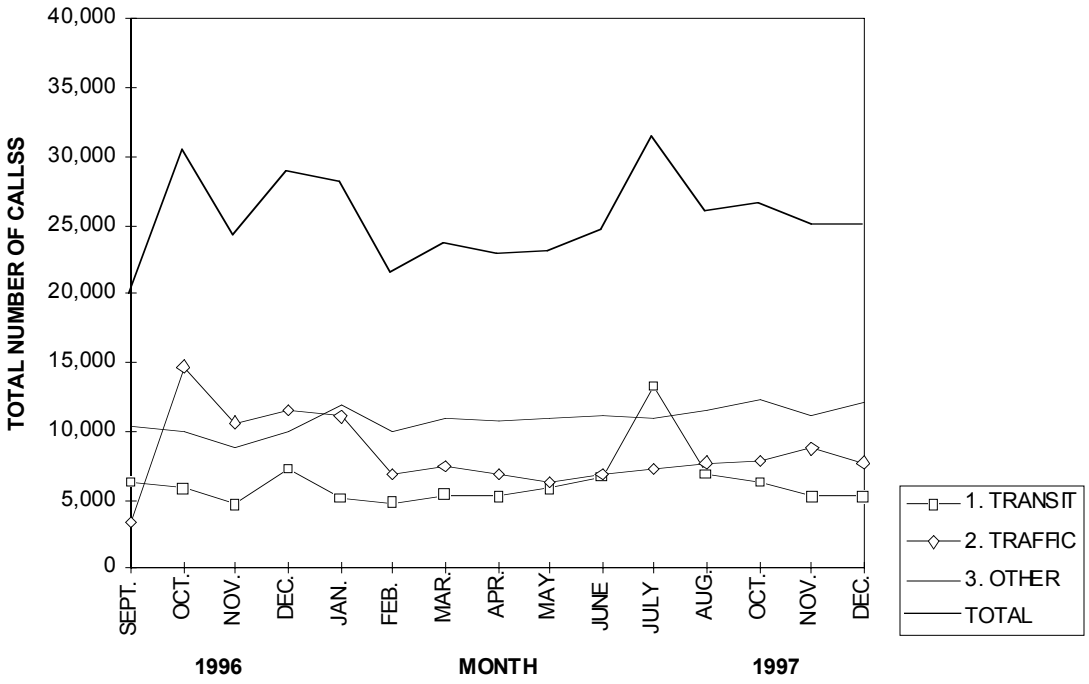


Figure 3e: Bay Area Monthly Call Volumes by Call Type Factoring Out Month of September 1997 (BART Strike) and AC Transit



The next group of figures (Figures 4a - 4d) depict average daily call volumes per month by region. Figure 4a 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. The peak in September 1997 shows the overwhelming effect of the BART strike on average daily calls. Figure 4a also shows how closely total call volume mirrors that of OAKLAND. Figure 4b shows the three other regions. Note the different vertical axis scales in Figure 4a relative to 4b. 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 virtually constant, aside from September 1997. In figure 4c, average daily call volume per month is calculated subtracting AC Transit numbers. A few differences appear compared to Figure 4a: 1. there is a one-third increase from September to October 1996 excluding AC Transit numbers as compared to a relatively flat trend in Figure 4a; 2. the minor increase of Figure 4a from December 1996 to January 1997 becomes a minor decrease when subtracting the AC Transit numbers and 3. the minor upswing in July/August 1997 becomes a decrease. Figure 4d displays the average daily call volume overall and for OAKLAND excluding the month of September 1997.

Figure 4a: Average Daily Call Volume: Bay Area Total vs. Oakland

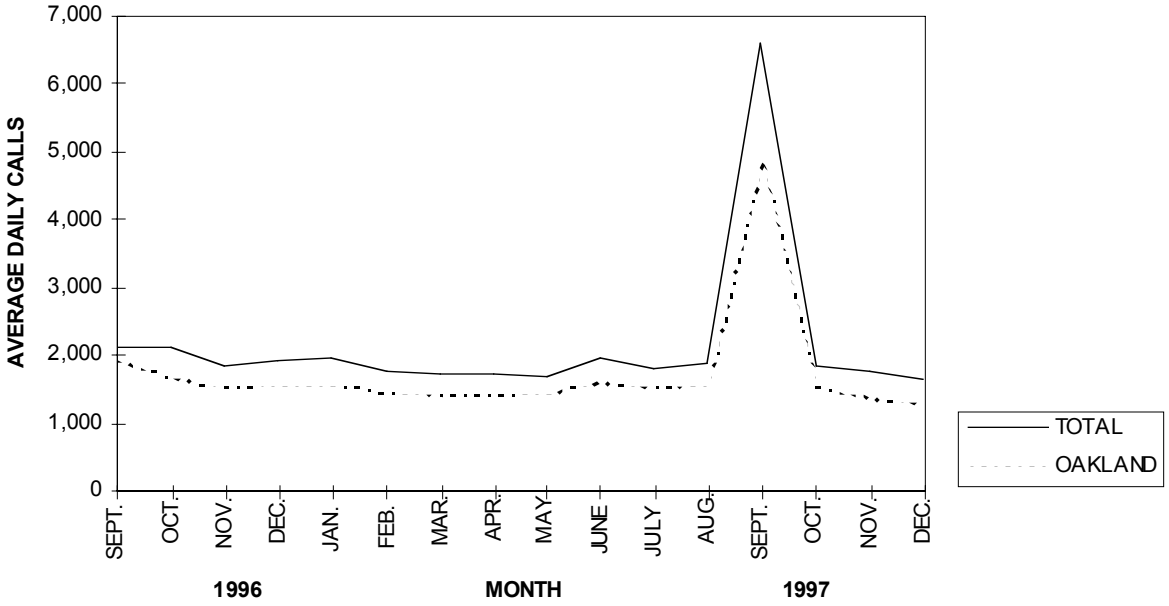


Figure 4b: Average Daily Call Volume: San Francisco, San Jose and Santa Rosa

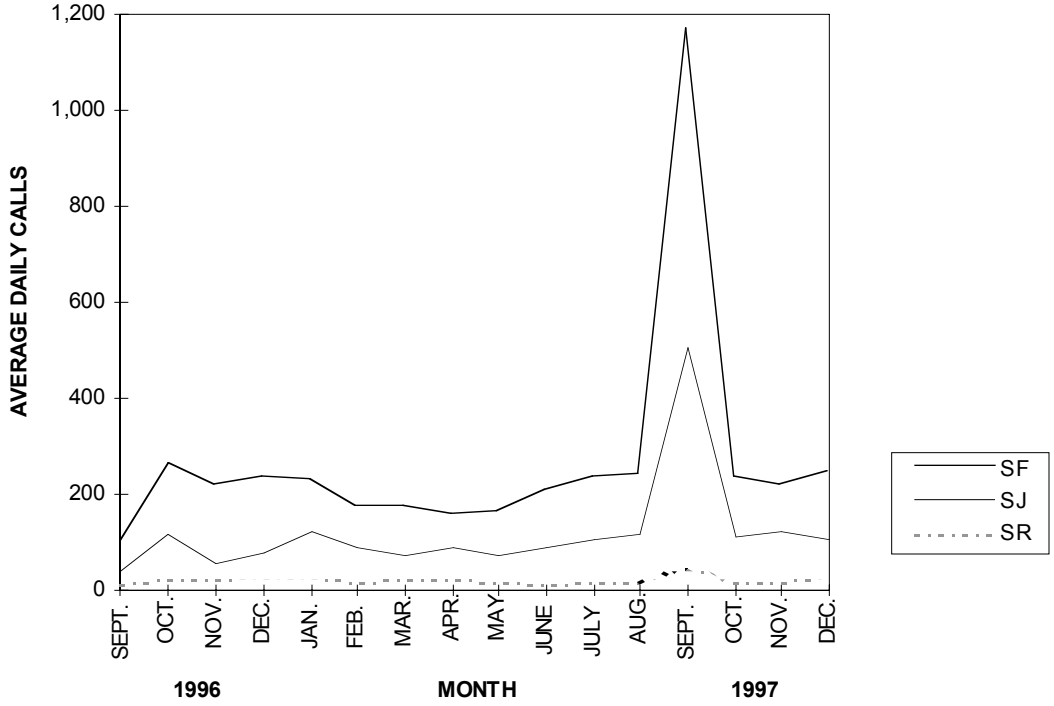


Figure 4c: Average Daily Call Volume Factoring Out AC Transit: Bay Area and Regions

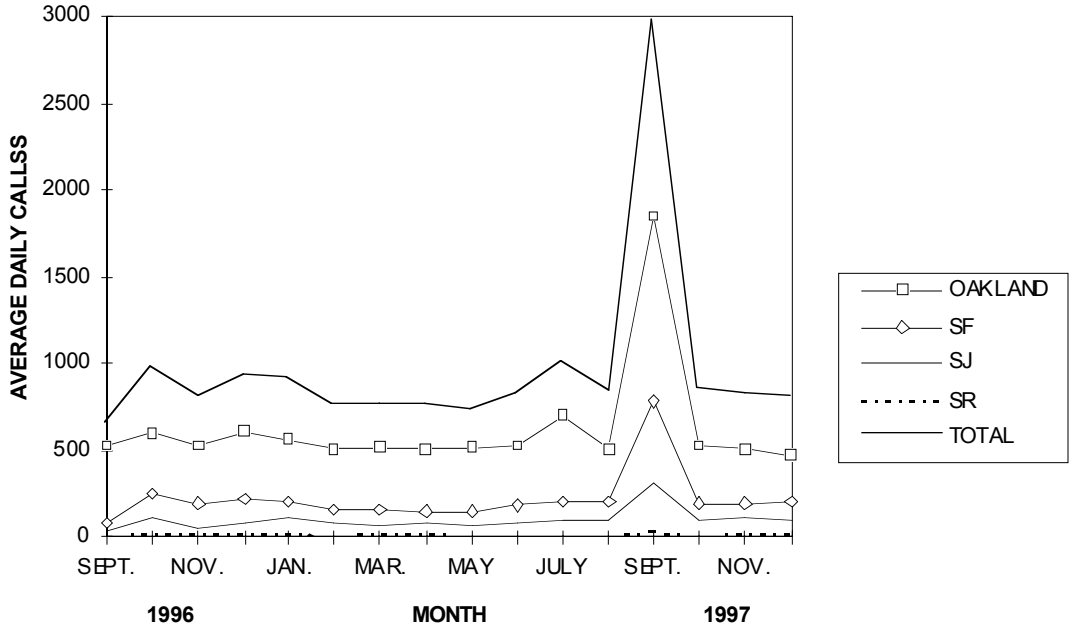
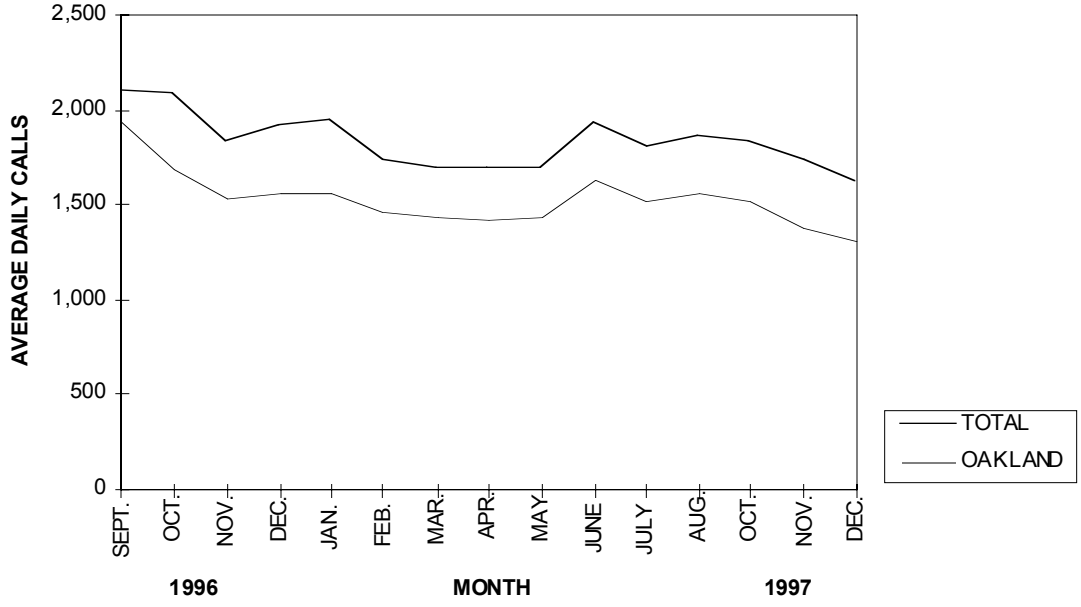


Figure 4d: Average Daily Call Volume: Bay Area Total vs. Oakland Factoring Out Month of September 1997 (BART Strike)



3.3.1.2 Weekly Call Volume

The next group of figures (Figures 5a - 5d) focuses on weekly call volume activity. Figure 5a shows weekly call volumes for all calls as well as for transit, traffic and all other call types. The largest peak in total call volume again results from the BART strike of September 1997. Figure 5b shows, again, how closely total call volume activity is driven by call volume activity in the OAKLAND region. Figure 5c displays weekly call volume for the San Jose and Santa Rosa regions. Figure 5d shows weekly call volume by type excluding September 1997 data. From July 1997 on (again excluding September 1997), transit call volume declined, although in irregular fashion, from 10,500 the first week of July to close to 7,000 towards the end of December. Traffic call volume during that period mostly remained fairly stable at between 1,500 and 2,000 calls per week

Figure 5a: Weekly Total Call Volume for Bay Area by Call Type

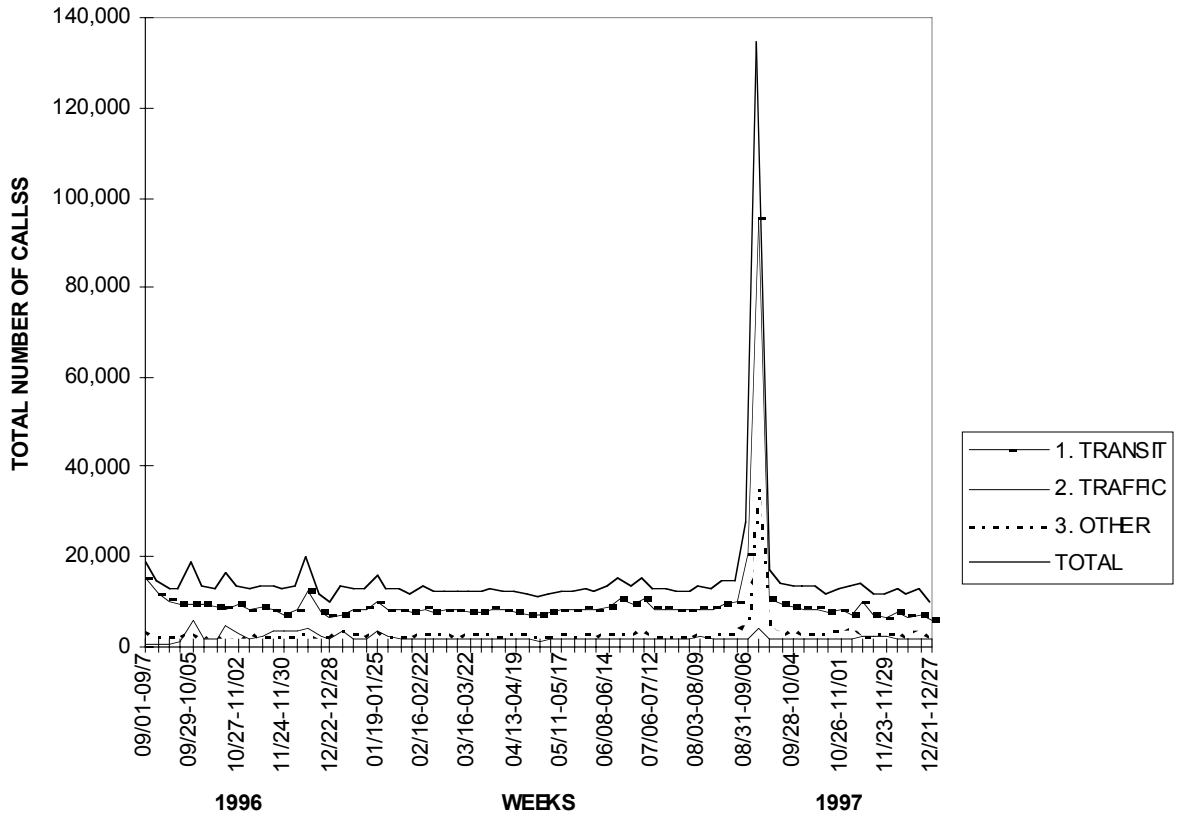


Figure 5b: Weekly Total Call Volume for Bay Area, Oakland and San Francisco Regions

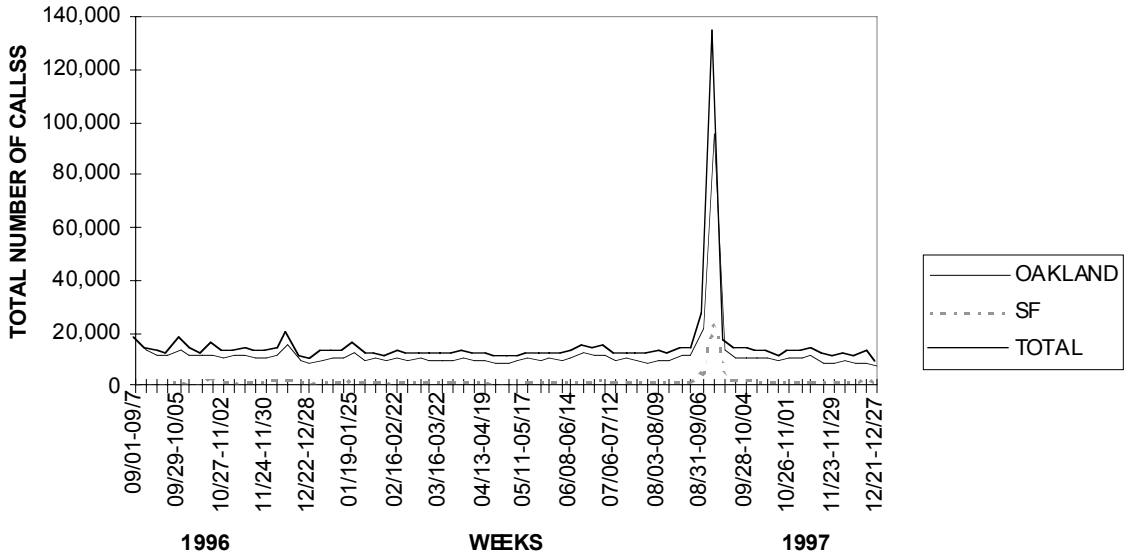


Figure 5c: Weekly Total Call Volume for San Jose and Santa Rosa Regions

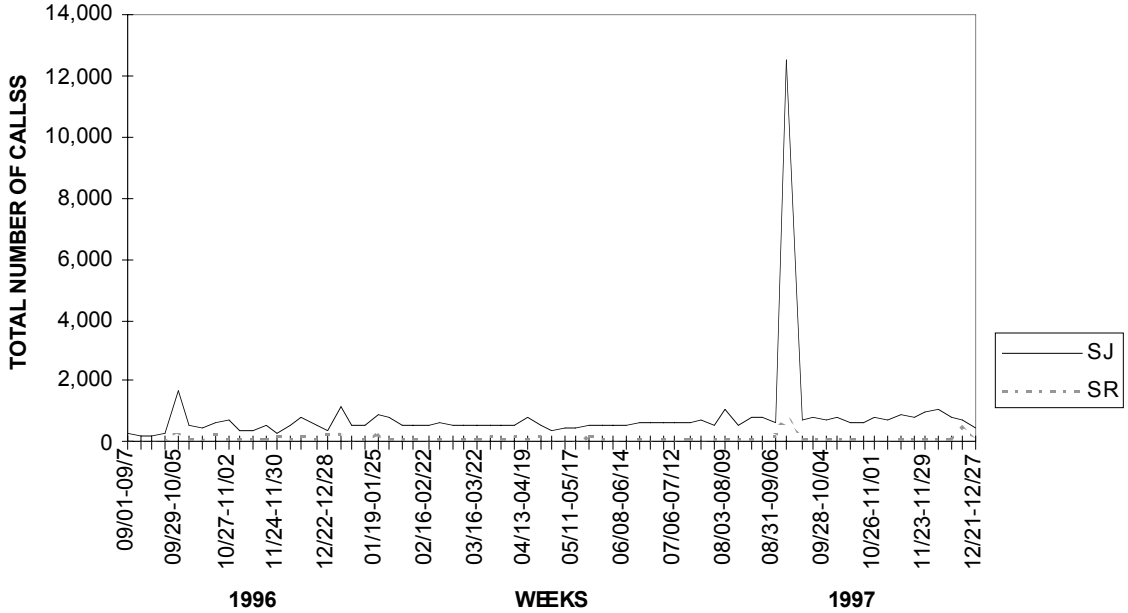
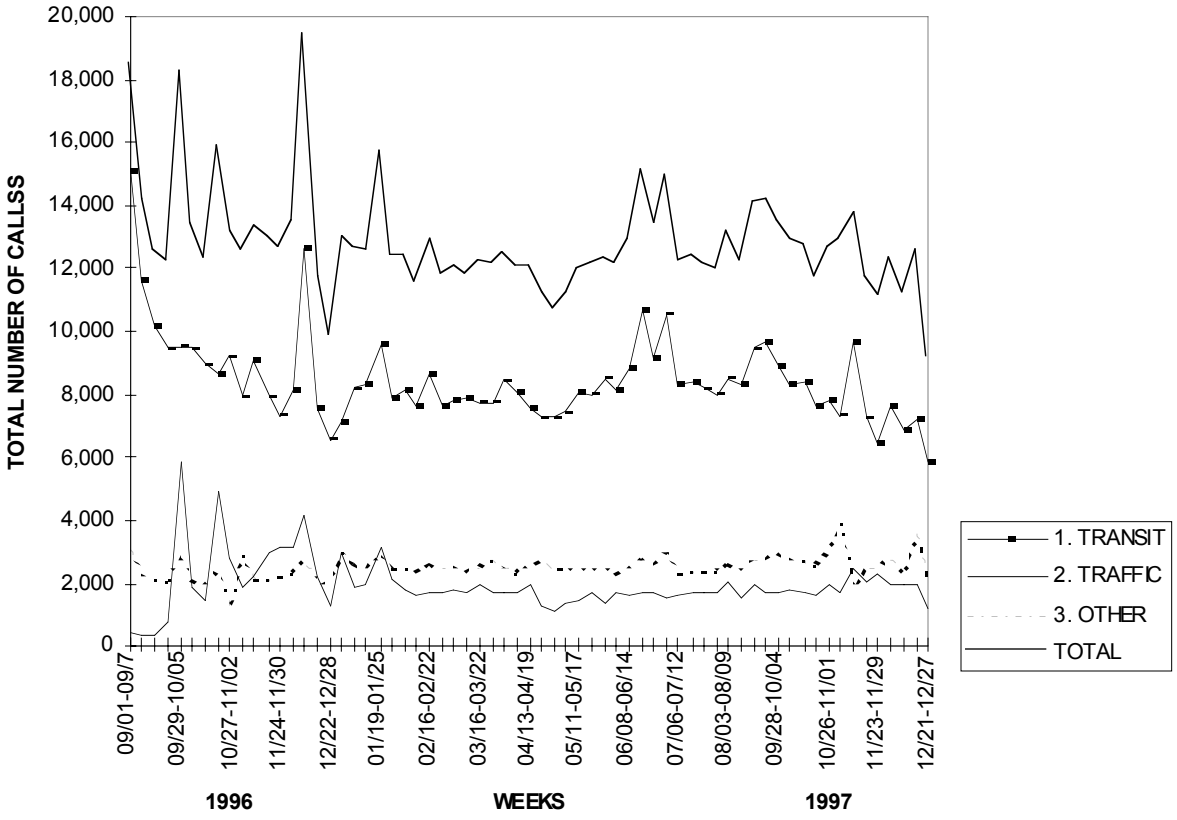


Figure 5d: Weekly Total Call Volume for Bay Area by Call Type Factoring Out Month of September 1997 (BART Strike)



3.3.1.3 Daily Call Volume

The next set of figures (Figures 6a-6f) concentrates on time-of-day call volume activity for the time period September 1996 to December 1997, excluding the month of September 1997.[4] Figure 6a 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 6b splits the hourly average call volume into weekday and weekend time periods. The weekday behavior determines the peaks in overall hourly average call

[4] This reporting period was chosen because it was felt that the BART strike would change results due to the high volume of transit calls that occurred during that event. In the TATS system, peaks in transit calls occur slightly later than peaks in traffic calls and there would thus be a shift in the time-of-day call volume pattern for the Bay Area as a whole toward that exhibited by the transit pattern.

volume. Weekend call volume displays a single peak occurring in the late morning. This likely reflects the fact that people tend to sleep later on the weekends and call in to TATS prior to a weekend outing.

Figure 6c depicts the hourly average call volume for traffic calls. Peaks in call volume occur from 8 to 9 AM and from 5 to 6 PM. Similarly, Figure 6d, which splits hourly average traffic calls into weekday and weekend, shows how the weekday calling behavior determines overall calling activity. 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 6e and 6f display transit hourly average calling behavior. Comparing the figures in pairs, i.e. 6a and 6b, 6c and 6d, and 6e and 6f, it is clear that transit calling behavior (Figures 6e and 6f) governs the overall calling behavior. This transit dominance explains the later than expected weekday maximum call volume activity (9 AM to 10 AM) observed in Figures 6a and 6b. 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 6a: Bay Area Average Hourly Call Volume

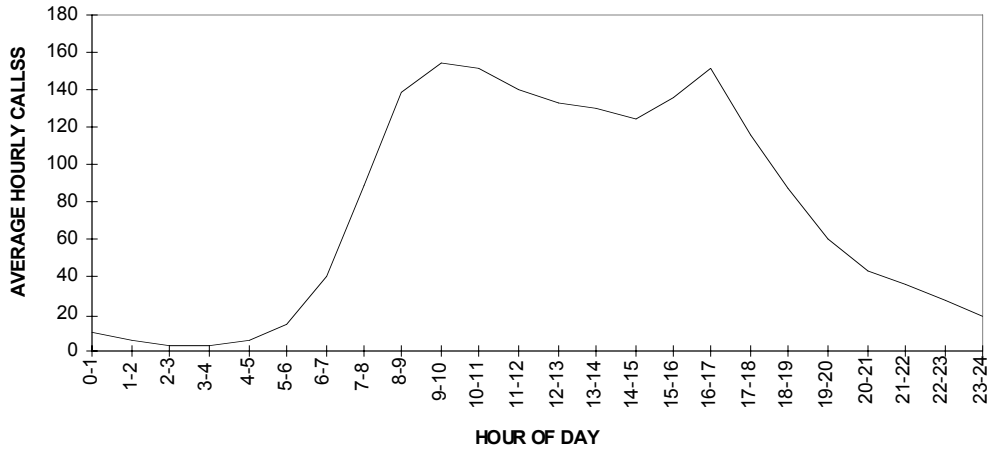


Figure 6b: Bay Area Average Hourly Call Volume: Weekday vs. Weekend

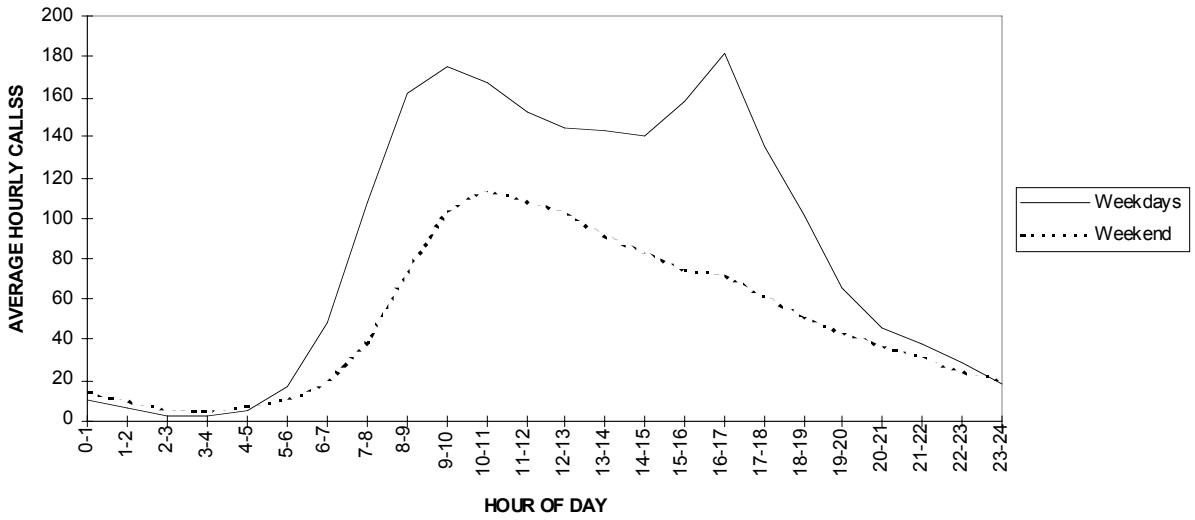


Figure 6c: Bay Area Average Hourly Traffic Call Volume

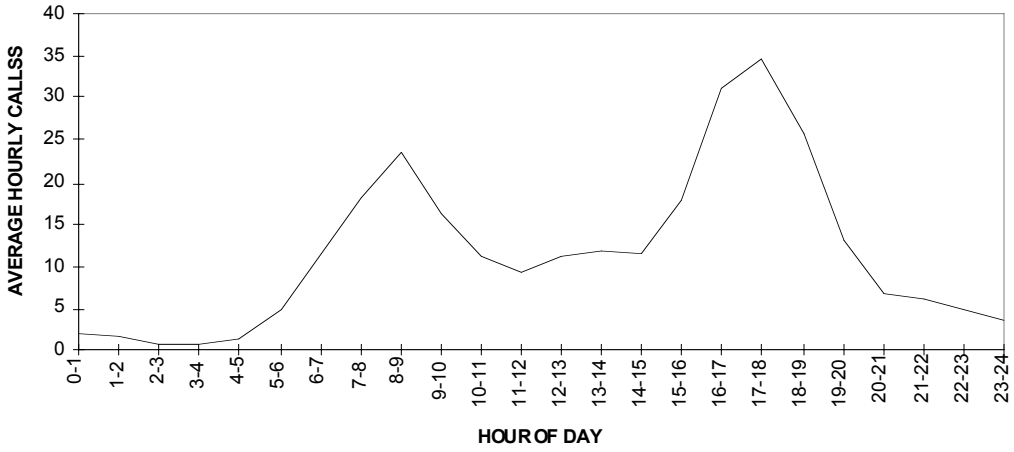


Figure 6d: Bay Area Average Hourly Traffic Call Volume: Weekday vs. Weekend

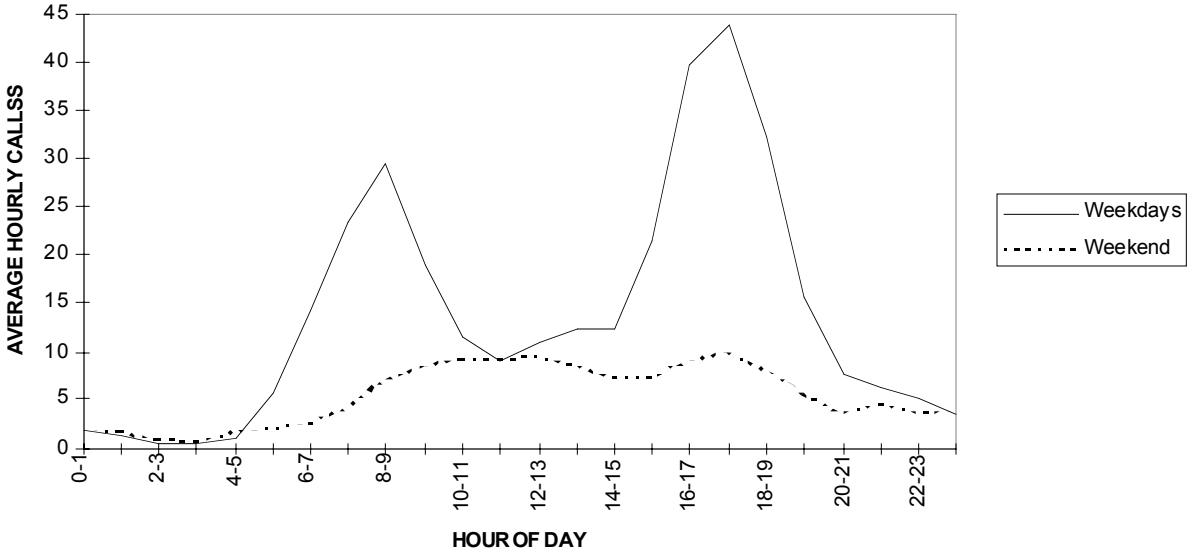


Figure 6e: Bay Area Average Hourly Transit Call Volume

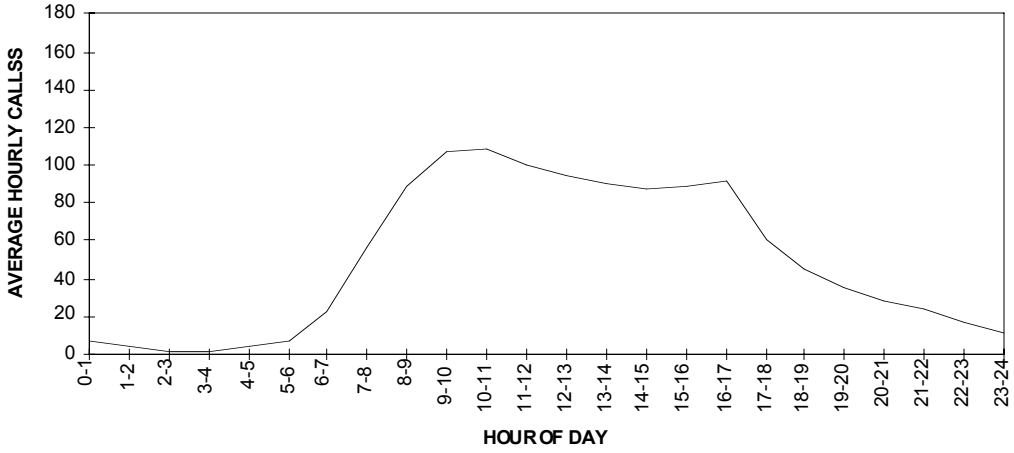
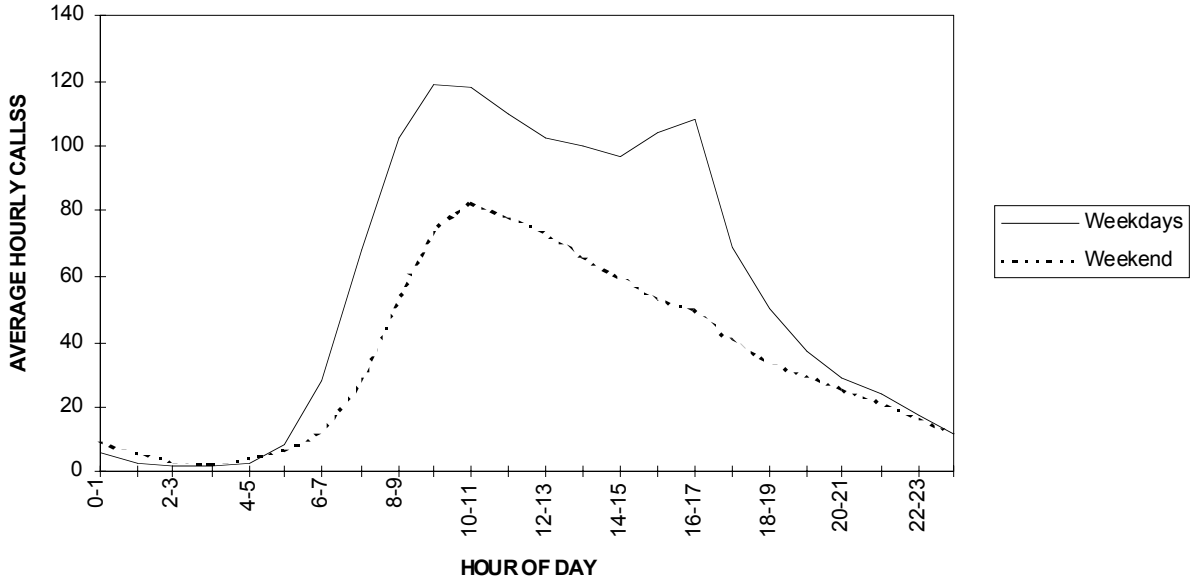
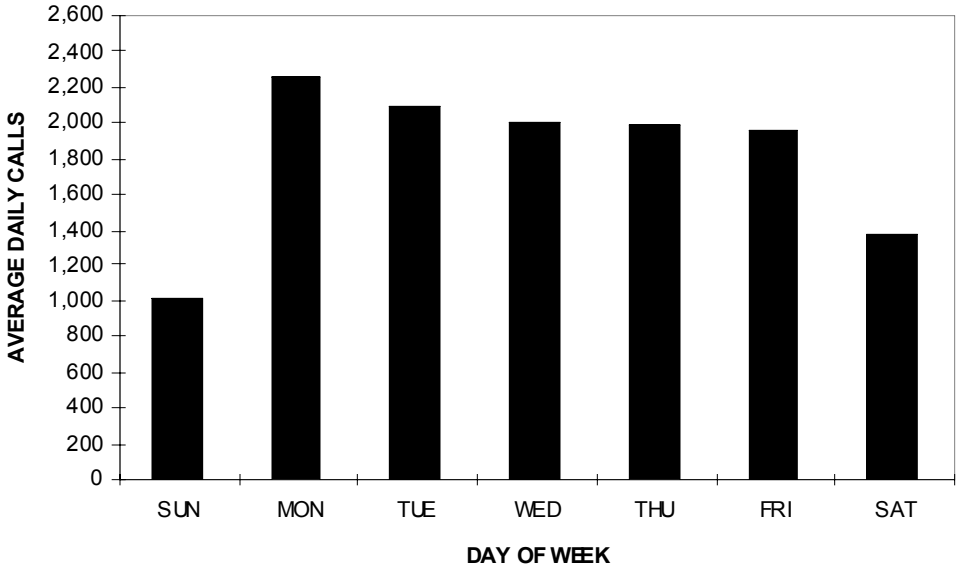


Figure 6f: Bay Area Average Hourly Transit Call Volume: Weekday vs. Weekend



The next figure (Figure 7) focuses on day-of-week call volume activity from September 1996 to December 1997 (excluding September 1997) for the Bay Area and the results are expected with weekday call volume greater than weekend call volume.

Figure 7: Average Day-of-Week Call Volume Bay Area-Wide



3.3.1.4 Call Durations

TATS usage and resource utilization in general can also be assessed by measuring call duration. The following tables (Tables 3a-3c) focus on call duration from September 1996 to December 1997 (excluding September 1997).[5] Table 3a 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 69.7 sec. (minimum) to 81.5 sec. (maximum). The average call duration for the OAKLAND area (34.6 sec.) is less than half that for SJ (69.7 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 3a). Callers are transferred to the transit service provider (TSP) instead of remaining within TATS to obtain information, such as for traffic. Thus, transit calls are much shorter in duration than traffic calls. Only total time within the TravInfo system, i.e. time until transfer to a specific TSP, is being measured, not the entire call duration to obtain information from the TSP.

In Table 3b, the average call durations are relatively close in value with a range of 63.5 sec (minimum) to 82.1 (maximum). This is due to the fact that for traffic calls, the caller remains in the TravInfo TATS to receive traffic information.

In Table 3a, the standard deviation for OAKLAND is significantly less in absolute terms (but not when viewed as a percentage of the average) 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 62.2 sec. (minimum) to 81.7 sec. (maximum). Traffic calls inquiries are made for any number of routes which results in a high degree of variability in traffic call duration which yield these large values for the regional standard deviations. When viewed as a percentage of the average, the ratio of the standard deviation to the average also varies little across regions with values ranging from 0.98 to 1.05 (seconds per second of speaking time). These values represent the variability in the time of talking for each second of talking.

In Table 3c (transit call durations), the standard deviation values are significantly smaller than for traffic calls and range from 17.6 sec. (minimum) to 35.9 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

[5] Once again including BART strike data would shift call durations downwards. Indeed many transit calls resulted during the BART strike and these calls are generally shorter than other types of calls for reasons explained in this section.

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 (1). When viewed as a percentage of the average, the ratio of the standard deviation to the average varies little across regions with values ranging from 0.74 to 0.83 (seconds per second of speaking time). Thus in absolute terms, there are differences in the standard deviations between OAKLAND and the other three regions. However, both the standard deviation and the average for OAKLAND are smaller than for the other three regions, thus in relative terms, there are no regional differences in the "normalized" standard deviation, i.e. the standard deviation per second of speaking time.

As there are significant differences in the absolute standard deviation values for traffic relative to transit calls (Table 3b vs. Table 3c), significant differences also exist with respect to the relative standard deviations (range 0.98 to 1.05 for traffic calls and range of 0.74 to 0.83 for transit calls). Again these differences are due to the nature of the calls as explained above.

Table 3a: Overall Call Duration Measures

REGION	AVERAGE (sec)	STANDARD DEVIATION (sec)	NUMBER OF CALLS
OAKLAND	34.6	41.1	726,023
S.F.	70.8	71.1	101,354
SAN JOSE	69.7	64.1	46,067
SANTA ROSA	81.5	80.7	9,302

Table 3b: Call Duration Measures (Traffic Calls)

REGION	AVERAGE (sec)	STANDARD DEVIATION (sec)	NUMBER OF CALLS
OAKLAND	76.7	80.6	55,465
S.F.	73.5	72.6	46,577
SAN JOSE	63.5	62.2	26,711
SANTA ROSA	82.1	81.7	4,341

Table 3c: Call Duration Measures (Transit Calls)

REGION	AVERAGE (sec)	STANDARD DEVIATION (sec)	NUMBER OF CALLS
OAKLAND	23.7	17.6	530,611
S.F.	37.1	28.0	33,091
SAN JOSE	33.2	27.4	11,211
SANTA ROSA	47.3	35.9	1,819

3.3.1.5 Transit Calls

The next set of figures (Figures 8a - 8b) show the overall quarterly distribution of selected transit service providers from October 1996 to December 1997. Figure 8a covers each quarter (October-December 1996, January-March 1997, April-June 1997, July-September, October-December 1997) and 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 8b).

From October 1996 through June 1997, Figure 8a consistently shows that AC Transit[6], 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, again from October 1996 through June 1997, 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. For SCVTA, there is steady growth in the amount of inquiries to this TSP, from 0.5% to 1.2%.

Transit calling behavior changes starting in September 1997, and this is first reflected in the quarter July - September 1997, due to the BART strike that occurred that month. There is a drop in AC Transit call volume *proportion* to 78% and a drop in the BART *proportion* to 4% of the total (Figure 8a). The "other" category increases to a 10% share. These changes reflect the fact that, in the wake of the BART strike, there were more calls to all TSPs but the increase in calls to other TSPs (besides BART and AC Transit) was larger than the increase in calls to both BART and AC transit. This resulted in a smaller share of the pie for both BART and AC Transit. Figure 8b shows the breakdown for "Other" TSPs which accounts for 10% of overall

[6] 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.

transit calls: Alameda-Oakland Ferry 25%, CCCTA 23%, Golden Gate 8%, MUNI 20%, SCVTA 11% and other smaller TSPs 13%. It should be kept in mind that these percentages reflect proportions not absolute numbers. From the 3d to the 4th quarters, two "other" TSPs, MUNI and Golden Gate, have percentages that decline from 25% to 20% and from 11% to 8% respectively, however in absolute terms call volumes increased from 1,544 to 3,987 for MUNI and from to 708 to 1,606 for Golden Gate. Call volume for Alameda-Oakland Ferry, CCCTA and SCVTA increased even more than for MUNI and Golden Gate resulting in the smaller percentage share for the latter two TSPs. Overall, transit call volume increased from 108,694 in the 3d quarter to 214,849 in the 4th quarter. All of that increase was due to the BART strike. Indeed, in the 5th quarter, October - December 1997, transit call volume fell back down to 99,291 (see Table 4 below).

In the 5th quarter, AC Transit and SAMTRANS-CALTRAIN proportions returned to their pre-strike levels of, respectively, 86% and 3% (Figure 8a). BART remained at the 4th quarter levels of 4%. Figure 8b shows the breakdown for "Other" TSPs that account for approximately 5% of all transit calls: Alameda-Oakland Ferry 7%, CCCTA 14%, Golden Gate 8%, MUNI 20%, SCVTA 11% and other smaller TSPs 13%.

Figure 8a: Distribution of Transit Calls for Transit Service Providers with "High" Call Volume: October 96 - December 97

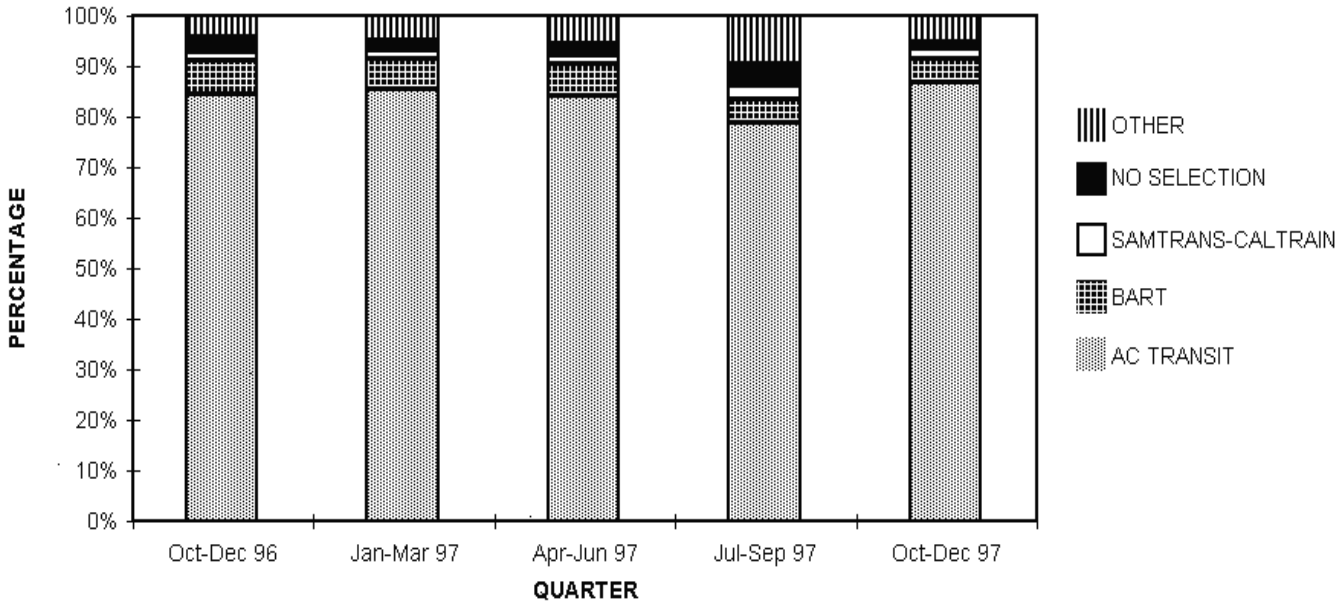
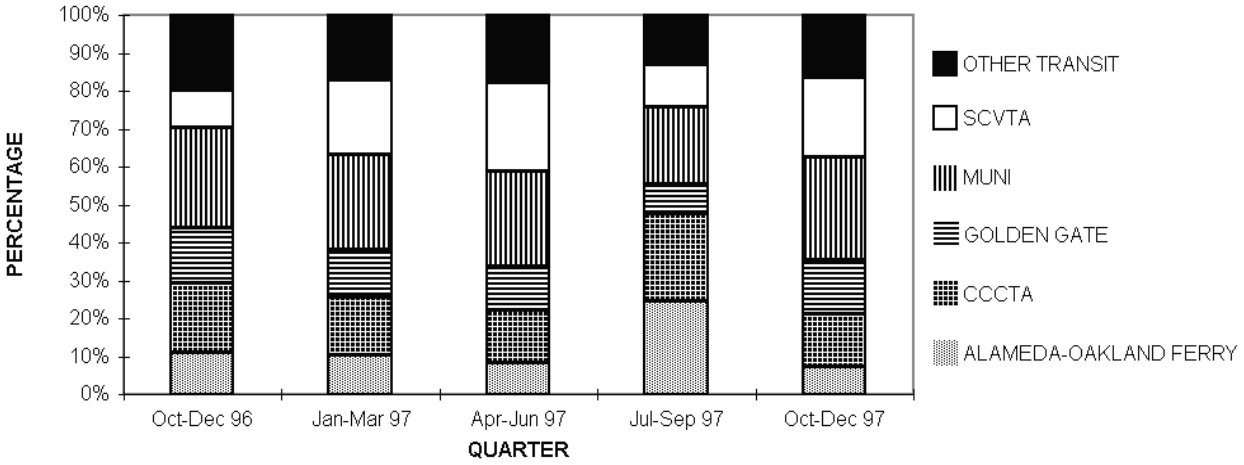


Figure 8b: Quarterly Distribution of Transit Calls for "Other" Transit Service Providers: October 96 - December 97



3.3.1.6 Top Level Menu Selections

Table 4 below depicts the quarterly distribution of top level menu selections as well as the total for the entire five quarter period (October 1996 through December 1997). Overall there is very little overlap in menu selections during individual phone calls. From September 1996 to December 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. Traffic selections decreased in the third quarter to 19,962 and stabilized at around 24,000 in the fourth and fifth quarters (the BART strike, which occurred in September 1997, during the fourth quarter had no sizable effect on traffic selections)[7]. Transit call volume also decreased from the first quarter to the second due to reduced publicity after the start-up of TravInfo. From the second to the fifth quarter, transit call volume oscillated between 99,000 and 109,000, with the exception of the fourth quarter when calls more than doubled at close to 215,000 due to the BART strike.

For details on upper-level menu call volume changes for the first three quarters refer to (1). Carpooling call volume, Option 3, greatly increased from the third to the fourth quarters and dropped significantly from the fourth to the fifth quarters. The significant increase of the fourth quarter was due to people seeking alternatives in the wake of the BART strike. The drop of the fifth quarter resulted from the end of the BART strike. Call volume in the fifth quarter was, nonetheless, close to twice what it was in the second and third quarters. This was due to a spike in carpooling call activity in December.[8]

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[7] During the BART strike media blitz, TravInfo was referred to as a transit, rather than traffic, hotline.

[8] The December increase was the result of changeable message signs posted at all Bay Area bridges at the beginning of the third week of December that advertised the TravInfo telephone number. The signs instructed drivers to call the TravInfo telephone number to get information about the toll increase on Bay Area Bridges (effective January 1, 1998). When calling in, callers were told about the toll hike and instructed to press 1 for transit or 3 for carpooling. This resulted in higher carpooling call volume in December, particularly week 3.

The Highway Construction call volume, Option 4, fell by a little over 50% from the fourth to the fifth quarters. This drop is due to the fact that call volume was higher than normal in the fourth quarter due to the BART strike which had system effects on all menu options (people experimented with the system). In the third quarter, call volume was also higher than normal due to a spike in April resulting from changes within Option 4 (it was changed from an option covering work on a major freeway in San Francisco (Central Freeway), to one covering highway construction work in general).

System Information call volume, Option 6, more than doubled from the third to the fourth quarters and then increased by another 50% from the fourth to the fifth quarters. This was due once again due to the BART strike and to the addition of new submenus starting in late June 1997.

Table 4: Quarterly Upper Level Menu Selections, October 1996 - December 1997

	Oct-Dec '96	Jan- Mar '97	Apr-Jun '97	Jul-Sep '97	Oct-Dec '97	TOTAL
1. TRANSIT	113,110	103,484	108,694	214,849	99,291	639,42
AC Transit	95,419	88,415	91,133	163,873	82,600	521,44
2. TRAFFIC	36,832	25,196	19,962	24,515	24,118	130,62
3. CARPOOLING	898	1,184	1,208	12,987	2,386	18,663
4. CENTRAL FREEWAY/ HIGHWAY CONSTRUCTION UPDATE	1,644	594	1,236	1,296	724	5,494
5. OTHER	6,910	5,238	1,859	2,231	1,173	17,41
6. SYSTEM INFORMATION	3,895	1,700	1,765	4,249	6,561	18,17(
7. BAY BRIDGE COMMENT	-	-	1,155	-	-	1,155
NO SELECTION	*	*	9,742	24,293	11,393	
ROTARY DIAL OUT	12,662	15,669	17,297	27,048	14,333	87,009
TOTAL	**178,601**	**161,371**	**161,272**	**310,345**	**158,861**	**970,45**

- = Bay Bridge comment option was available only during third quarter period (April-June 997).
* = 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 the "*"). On-going investigation into this problem will be performed until it is resolved.

3.3.1.7 Traffic Route Selections

The next group of tables (Tables 5a-5b) and figure (Figure 9) focus on the route selections made within the traffic menu category from September 1996 to December 1997.

Table 5a shows which routes are selected most frequently within the traffic menu during the aforementioned reporting period. A total of sixty-one routes were available for selection as of June 1997. From the end of June 1997 to December 1997, an additional 16 routes or expressways were added to the TATS system. 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 85.4% of all routes selected.

The routes shown are divided by region and by bridges. From September 1996 to December 1997, the average number of routes selected per traffic call was 2.7. Four (880, 80, 580 and 680) out of the top five selected routes are in the East Bay one-half of the top ten selected routes are in the East Bay and the East Bay accounts for at least 34.6% 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 17.5%, 11.1% and 7.9% 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, 80 and 37.

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, 8.8% of all routes selected from the OAKLAND TATS are for E880. The top ten routes per region account for between approximately 35% and 55% of all route selections per region. Several of these route selections correspond to the worst congestion locations in the San Francisco Bay Area (See (1), Section 3.3.1.8 and Appendix C).

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[9]. 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 (nine out of the top ten are East Bay routes) and for calls coming into the SJ TATS, seven 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 (with the sole exception of N101 in San Francisco). Routes BAY BRIDGE, E680 and P101 are selected by callers in three of the four TATS regions and E80 is the most popular route. Route E880 is selected by callers in all four TATS regions.

[9] E, N, P, S, SF stand respectively for East Bay, North Bay, Peninsula, South Bay and San Francisco. For example, P101 stands for route 101 in the Peninsula region of the Bay Area.

Table 5a: Route Selection Rankings

REGION/BRIDGE	ROUTE	TIMES SELECTED	PERCENTAGE	RANK
EAST BAY	880	23,393	6.5%	1
EAST BAY	80	22,264	6.2%	2
PENINSULA	101	20,233	5.6%	3
EAST BAY	580	15,962	4.4%	4
EAST BAY	680	15,708	4.3%	5
SOUTH BAY	17	14,715	4.1%	6
BRIDGES	BAY	13,873	3.8%	7
SOUTH BAY	101	12,491	3.5%	8
SAN FRANCISCO	101	11,372	3.1%	9
EAST BAY	24	10,472	2.9%	10
PENINSULA	280	9,812	2.7%	11
BRIDGES	SAN MATEO	8,569	2.4%	12
SAN FRANCISCO	80	8,310	2.3%	13
SOUTH BAY	280	7,984	2.2%	14
NORTH BAY	101	7,643	2.1%	15
SOUTH BAY	680	7,208	2.0%	16
SOUTH BAY	85	7,031	1.9%	17
PENINSULA	92	6,508	1.8%	18
SOUTH BAY	237	6,486	1.8%	19
EAST BAY	92	5,988	1.7%	20
SAN FRANCISCO	280	5,464	1.5%	21
EAST BAY	4	5,213	1.4%	22
BRIDGES	DUMBARTON	5,212	1.4%	23
EAST BAY	238	4,877	1.3%	24
EAST BAY	980	4,852	1.3%	25
EAST BAY	84	4,780	1.3%	26
NORTH BAY	80	4,773	1.3%	27
EAST BAY	2*	4,386	1.2%	28
BRIDGES	GOLDEN GATE	4,367	1.2%	29
EAST BAY	13	4,066	1.1%	30
SOUTH BAY	87	3,756	1.0%	31
SOUTH BAY	2*	3,697	1.0%	32
NORTH BAY	37	3,588	1.0%	33
NORTH BAY	2*	3,532	1.0%	34
EAST BAY	242	3,531	1.0%	35
SAN FRANCISCO	1	3,517	1.0%	36
PENINSULA	1	3,493	1.0%	37
TOTAL		309,126	85.4%	

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

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

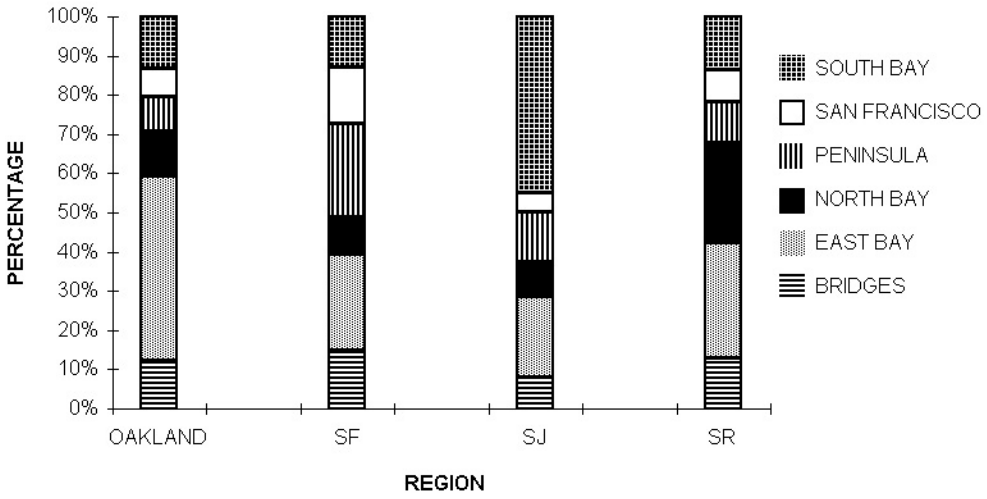
OAKLAND (510) ROUTE (%)		**SF (415)** ROUTE (%)		**SJ (408)** ROUTE (%)		**SR (707)** ROUTE (%)	
E880	8.8%	P101	12.3%	S17*	13.4%	E80	8.1%
E80	8.0%	SF101	6.3%	S101	7.8%	N101	5.8%
E580	6.6%	E80	6.0%	S280	5.2%	E680	3.9%
E680	5.9%	BAY BRIDGE	5.6%	S85	4.8%	N80	3.5%
E24	4.3%	P280	5.2%	P101, E880	4.7%	BAY BRIDGE	2.7%
BAY BRIDGE	3.9%	E880	4.6%	E680	4.1%	N2**, N37	2.4%
P101, SAN MATEO	2.1%	SAN MATEO	3.8%	S680	3.9%	E24	2.3%
E4, SF101, S17, SF80	2.0%	SF80	3.7%	S237	3.2%	E880, SF101,	2.2%
S680, E980, E92	1.9%	N101	3.5%	P280	2.7%	G. GATE	2.1%
E238, S101	1.8%	S101	3.4%	S880	2.3%	E580, N680	2.0%

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

Figure 9 shows 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 (47% from Figure 9) and SJ TATS calls are mainly interested in South Bay routes (45% from Figure 9). Twenty to thirty percent of routes selected from calls received outside the OAKLAND TATS are East Bay routes. Approximately thirteen percent of the routes selected from calls received outside the SJ TATS are South Bay routes. The SR TATS is the one TATS in which "local" routes do not constitute a plurality of selected routes within that region. For example, North Bay routes constitute 25% of route selections from the SR TATS, whereas East Bay routes constitute 29% of route selections from this same TATS. Within the SF TATS, 38% of the routes selected are from SF and the Peninsula.

Figure 9: Regional Distribution of Route Selections



NB:

Total route selections originating in Oakland: 170,074 of which Bridges = 20,764; East Bay = 80,070; North Bay = 18,982; Peninsula = 15,335; San Francisco = 12,232; South Bay = 22,691

Total route selections originating in San Francisco: 105,987 of which Bridges = 15,423; East Bay = 26,226; North Bay = 9,954; Peninsula = 25,167; San Francisco = 15,431; South Bay = 13,786.

Total route selections originating in San Jose: 68,867 of which Bridges = 5,291; East Bay = 14,211; North Bay = 6,154; Peninsula = 8,685; San Francisco = 3,483; South Bay = 31,043.

Total route selections originating in Santa Rosa: 16,940 of which Bridges = 2,173; East Bay = 4,985; North Bay = 4,312; Peninsula = 1,769; San Francisco = 1,400; South Bay = 2,301.

3.3.1.8 BART Strike

BART is a major San Francisco Bay Area rail transit system. The BART strike, which occurred in September 1997, had a significant effect on overall call volume during that month. Overall, however, the BART strike did not have any lasting effect on the TATS call volume. The overall call volume went from 57,730 in August to 196,606 during September and then returned to a "normal" level of 56,589 in October (see Section 3.3.1.1).

The strike began on Sunday September 7 and service resumed on Monday September 15. Table 6 illustrates how the strike impacted TATS call volume, week by week, during the month of September. The BART strike mostly had an effect on Transit call volume data. Normally, transit call volume is on the order of 8-10 thousand calls per week (85% of which are AC Transit calls). During the first week of September (actually Sunday August 31- Saturday September 6), right before the advent of the strike, transit call volume was at approximately 20,000, double its normal volume. During week 2 , when the strike was in full swing (Sept. 7-13), transit call volume increased to approximately 95,000 calls. By week 3 (Sept. 14-20) the strike was virtually over and transit call volume was almost back to normal at 10,877 calls. Most of the increase in transit calls was attributable to calls for the AC Transit system, which uses the TravInfo hotline as its main telephone line for customers. Of the 138,306 transit calls during the month of September, 107,273 were for AC Transit. TATS calls requesting a transfer to BART numbered 5,058. During the same period, some 8,000 transit callers did not request any transit information (although they likely listened to a floodgate message about the BART strike activated as soon as the transit menu was entered).

The strike had only a relatively minor effect on traffic call volume. Typically, traffic call volume is on the order of 1,500 to 2,000 calls per week for the whole TATS system. During week 2, traffic call volume doubled to 3,915. By week 3, traffic call volume was back to normal at 1,765. Part of the reason the BART strike had so much effect on transit and little effect on traffic is that during the strike most media outlets (primarily television stations) mentioned the TravInfo telephone number but described it as a transit hotline.

The strike also had a significant impact on call volume for the carpooling menu selection. Typically carpooling call volume is on the order of 80-140 calls per week. By week 1, carpooling call volume was already at 845 and by week 2 it had increased dramatically to 10,757. The effect, however, was not long-lasting. By week 3 carpooling call volume was at 192 and by week 4 it was back down to 112. It is also worth noting that during September 1997 a sizable portion of callers actually did not select any information. During "normal" months "Rotary Dial Out" [10] call volume is on the order of 5,500 calls per month. For September 1997 it was 15,660. One can thus realistically assume that approximately 10,000 of those calls did not result in an actual selection.[11] Adding that number to the calls for which no selection was made amounts to about 27,500 calls or 14% of all calls made during September 1997.

[10] Function whereby when no menu is chosen after the list of menus is heard, the caller is automatically transferred to the main TSP of the region from which the call was made.

[11] All the caller hears is "If you don't have a touch-tone phone please stay on the line and you will be connected to a transit operator." There is no mention of which transit operator the caller will be transferred to. It is thus likely that for most of these 10,000 callers, they either did not make a menu selection in time or were simply experimenting to see which transit operator they would be connected to and not actively selecting.

Table 6: Overall Call Volume to TATS System: September 1997

	WEEK 1	WEEK 2	WEEK 3	WEEK 4	TOTAL
1. TRANSIT	20,262	94,962	10,877	9,242	**138,306**
2. TRAFFIC	1,535	3,915	1,765	1,746	**9,613**
3. CARPOOLING	845	10,757	192	112	**11,954**
4. CONSTRUCTION UPDATE	76	337	68	71	**574**
5. OTHER	172	677	161	122	**1,171**
6. SYSTEM INFORMATION	378	1,153	358	242	**2,114**
NO SELECTION	1,727	13,322	1,511	788	**17,626**
HANG UP	1,615	12,765	1,403	725	*16,749*
CALL TIMED OUT	112	557	108	63	*877*
ROTARY DIAL OUT	2,466	9,721	1,456	1,532	**15,660**
TOTAL	**27,341**	**134,056**	**16,893**	**13,767**	**196,606**

NB: Week 1 = Sunday August 31- Saturday September 6, Week 2 = Sept. 7-13, Week 3 = Sept. 14-20, Week 4 = Sept. 21-27. Total = Sept. 1-30

3.3.2 TATS Port Use

This section describes TATS port use and focuses primarily on the time period during and immediately after the BART strike, approximately the month of September 1997[12]. Port use analysis for the period of September 1996 through June 1997 is documented in (1). Port use behavior from July 1997 through December 1997, except for September 1997, is exactly the same as that documented in (1). The analysis performed was for each of the four regions. The measure of performance is port utilization (percentage of time) of all publicly available voice ports during AM and PM peak periods for each of the four regional TATS nodes.

Port utilization is described for each of the four regions for the AM (7-9 AM) and PM (4-6 PM) peak periods, respectively, as follows:

- Oakland (Figures 10a & 10b)
- San Francisco (Figures 10c & 10d)
- San Jose (Figures 10e & 10f)
- Santa Rosa (Figures 10g & 10h)

[12] The BART strike began on Sunday, September 7, 1997 and service resumed on Monday, September 15, 1997.

Some variation in the length of the peak periods was present due to specific requests made by TIC operations to capture port use statistics during additional time periods[13]. Port utilization for each region is defined as the total time used over all publicly available voice ports[14] divided by the total time available (approximately 7200 seconds for each of the morning and afternoon peak periods).

As can be observed by examining the x-axis for the figures, some data is missing that resulted from failed downloads and other causes. This does not, however, prevent the general trend from being easily detected. There are differences between AM and PM port usage for each of the four regions, with PM port use generally larger than AM port use. Note also the steady reduction along the port utilization scale on the y-axis for AM and PM for Figures 10a, c, e, and g and Figures 10b, d, f, and h, respectively. This indicates that as expected, port use is greatest for the Oakland region, and successively decreases for the San Francisco, San Jose, and finally for the Santa Rosa region.

With respect to the Oakland region for which an analysis was performed during the ten month time period of September 1996 through June 1997, port utilization over all 53 publicly available voice ports during the AM and PM peak periods averaged 2.3% and 2.7%, respectively. Figures 10a and 10b show that almost immediately after BART service resumed, port utilization returned, on average, to the same percentage values which existed prior to the BART strike and remained at these levels throughout the remainder of September, 1997. Moreover, port usage remained at these same levels for the remainder of the reporting period through December 1997. As can also be observed from examining Figures 10c through 10h, port utilization displayed an expected spike for each of the three other regional TATS during the week of the BART strike, and then reverted to pre-strike usage levels and remained there throughout the remainder of the reporting period.

[13] Actual morning and afternoon time periods for port use data downloads were not always exactly 7200 seconds in length. During the first few days of the BART strike, port use statistics were collected during an expanded morning peak period (approximately 5 AM to 9 AM at the request of TIC operations). Other occasional variability on the order of a few minutes was present due to scheduling difficulties, data download failures requiring retries, etc. These deviations from the 7200 second nominal time period was accounted for in all calculations where necessary.
[14] The total number of publicly available voice ports for the Oakland, San Francisco, San Jose, and Santa Rosa regions are 53, 45, 37, and 22, respectively.

Figure 10a: Oakland Region Port Use During and Immediately After BART Strike AM Period

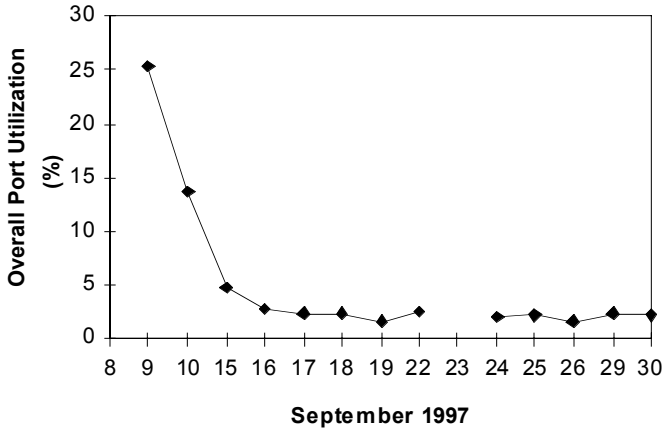


Figure 10b: Oakland Region Port Use During and Immediately After BART Strike PM Period

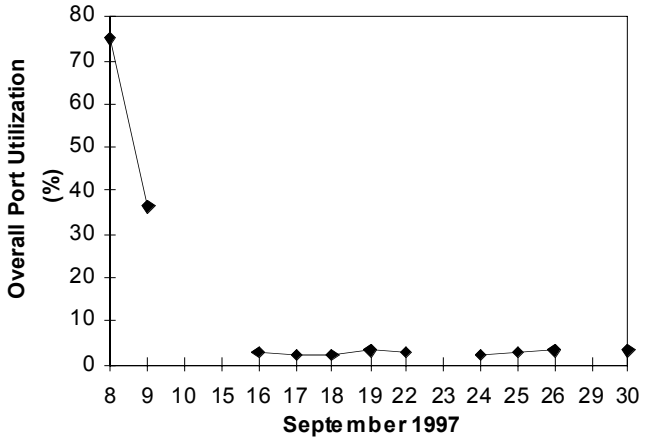


Figure 10c: San Francisco Region Port Use During and Immediately After BART Strike AM Period

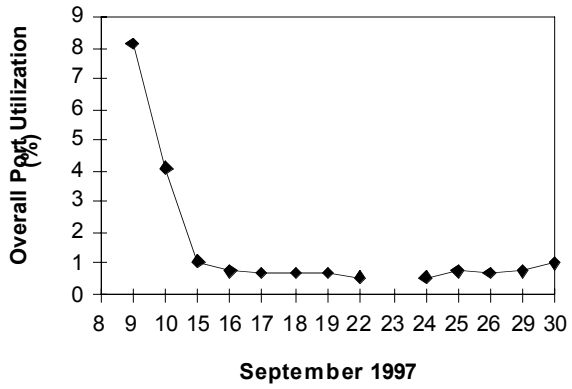


Figure 10d: San Francisco Region Port Use During and Immediately After BART Strike PM Period

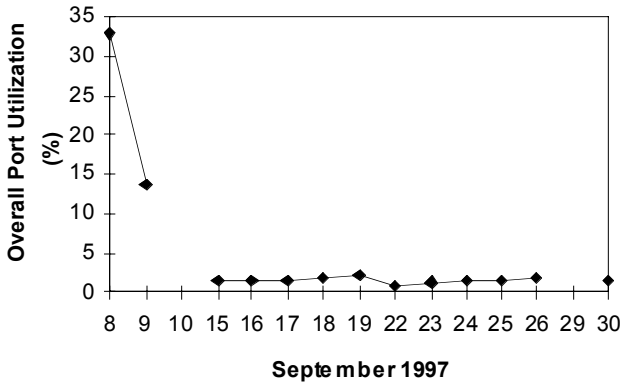


Figure 10e: San Jose Region Port Use During and Immediately After BART Strike AM Period

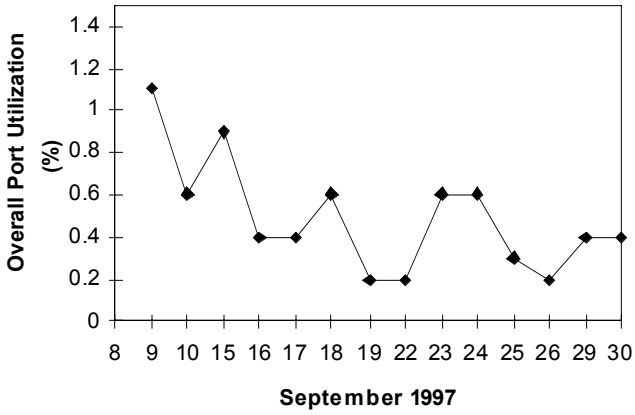


Figure 10f: San Jose Region Port Use During and Immediately After BART Strike PM Period

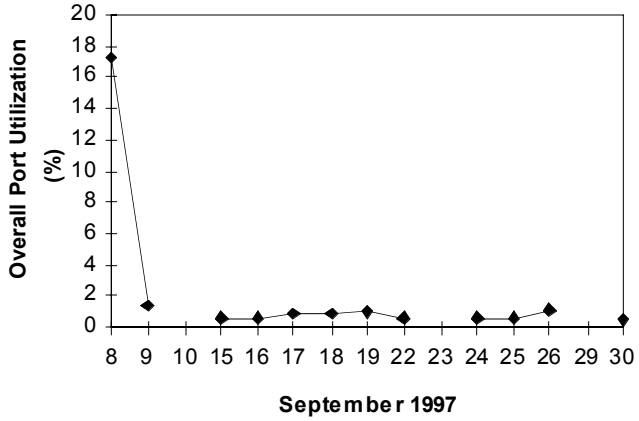


Figure 10g: Santa Rosa Region Port Use During and Immediately After BART Strike AM Period

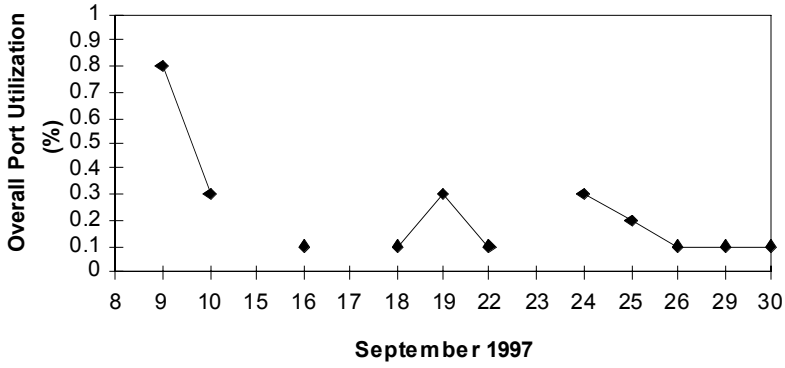
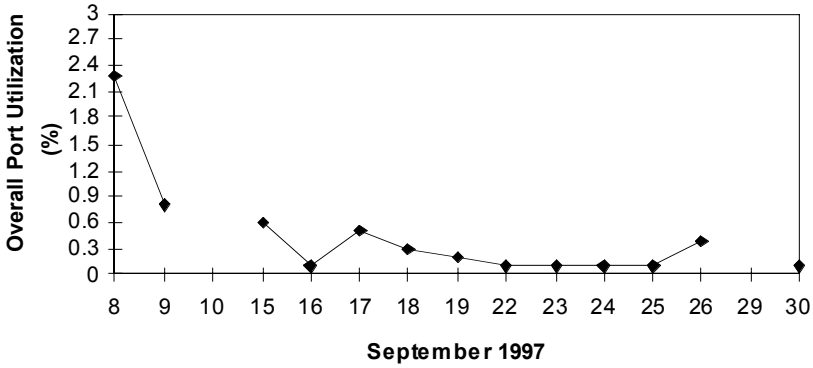


Figure 10h: Santa Rosa Region Port Use During and Immediately After BART Strike PM Period



3.3.3 LDS Activity

This section describes LDS usage between November 1, 1996 and December 31, 1997 relative to several measures. TIC Acceptance Testing continued into September and October 1996 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 (in the range of several MB per week) continuously throughout the reporting period. Two registered participants began downloading data on a fairly regular basis starting in early May, 1997 (one downloaded less than 150 KB per week, the other downloaded similar amounts until late July 1997 and then began downloading between 1 and 2 MB per week).

Table 7 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. Etak downloaded close to 90% of all data yet it performed much fewer logons relative to Maxwell or Daimler-Benz. Etak performs approximately 1% of the number of logons that Maxwell performs, the ISP with the greatest number of logons.

During the first reporting period (11/96-06/97), 24 of the ISPs logged on to retrieve information. Most of these ISPs, however, rarely logged on, and when they did only a small amount of data were transferred. Out of the 24 ISPs accessing data during the first reporting period, 11 accessed the system only 1-3 times. During this first period, there were really only three regular users of data: Etak, Daimler-Benz and Maxwell.

During the second reporting period (07/97-12/97), more than half the ISPs no longer accessed TravInfo. Indeed, during this period only 9 out of the 24 ISPs (who previously had logged on) accessed the system. Of the 10 ISPs[15] accessing data from July to December 1997, 4 accessed data only 1-3 times. During this reporting period there were really only five regular users of data: Contra Costa Times, Etak, Daimler-Benz, Maxwell and Metro Networks.

Table 8 presents in more detail the size of each ISP's data transfers during the reporting period. The number of total bytes reflects total system usage, i.e. both input (to get lines of output) and output. The data transfer between Etak and the LDS represents approximately 90% of all data that are transferred between all ISPs and the LDS, with Contra Costa Times, Daimler-Benz and Maxwell downloading respectively 0.73%, 8.33% and 1.76% of all data. The remaining 21 ISPs downloaded 0.04% of all data from November 1996 through December 1997. Etak's interactive

[15] Digital DJ became a Registered Participant on 02/26/96 but only accessed data in the second reporting period 07/97-12/97.

queries have more "overhead", i.e. a verbose format, than other ISPs. This fact contributes significantly to the approximately 10-to-1 ratio between total bytes for Etak and the next highest data transfer (Daimler-Benz).

Table 7: Total Number of Logons by ISP: November 1996 - December 1997

ISP	11/96-06/97	07/97-12/97
Clarion	23	0
Contra-Costa Times	252	12,907
Daimler-Benz	21,840	207,129
Digital DJ	0	1
Etak	1,358	1,942
Fastline	1	0
Feldman	10	0
KCBS	11	2
KPIX	1	0
KTVU	1	0
Maxwell	46,272	50,140
Metro Dynamics	16	0
Metro Networks	52	39
Microsoft	33	0
Navigation Tech.	1	0
RIDES	5	3
Shadow	1	0
Small Business Connection	1	0
SmartRoute	2	0
SmartInfo	1	0
Subcarrier Systems	2	0
Telcontar	3	0
Toyota	4	0
TranSmart	1	12
TravRoute	31	1
TOTAL	69,922	231,854

Table 8: Total Bytes for Each ISP: November 1996-December 1997

	BYTES	% OF TOTAL	% OF TOTAL*
Clarion	169,184	0.00%	0.03%
Contra-Costa Times	34,393,795	0.73%	**6.71%**
Daimler-Benz	393,317,865	8.33%	**76.72%**
Digital DJ	2,997	0.00%	0.00%
Etak	4,209,583,882	89.14%	
Fastline	21,884	0.00%	0.00%
Feldman	15,199	0.00%	0.00%
KCBS	212,677	0.00%	0.04%
KPIX	52	0.00%	0.00%
KTVU	6,593	0.00%	0.00%
Maxwell	83,007,882	1.76%	**16.19%**
Metro Dynamics	18,326	0.00%	0.00%
Metro Networks	1,002,423	0.02%	0.20%
Microsoft	24,428	0.00%	0.00%
Navigation Tech.	2,280	0.00%	0.00%
RIDES	3,886	0.00%	0.00%
Shadow	609	0.00%	0.00%
Small Business Con.	731	0.00%	0.00%
SmartRoute	992	0.00%	0.00%
SmartInfo	52	0.00%	0.00%
SubSystem	2,130	0.00%	0.00%
Telcontar	1,098	0.00%	0.00%
Toyota	3,201	0.00%	0.00%
Transm	25,225	0.00%	0.00%
Travroute	443,018	0.01%	0.09%
TOTAL	4,722,260,409	100.00%	

***** 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 11a-11d) present the total weekly access for each ISP. Figure 11a 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 (1). Other drops in data access on the part of Etak seem to be specific to that ISP since other ISPs (namely Contra Costa Times, Daimler-Benz and Maxwell) did not experience drops in data access at the same time as Etak (see Figure 11b). In fact it is only in late April, that all the main ISPs (i.e. those downloading significant amounts of data) experienced a common drop in data access.

Figure 11a: Weekly Volume of Data Transferred: Total and Etak

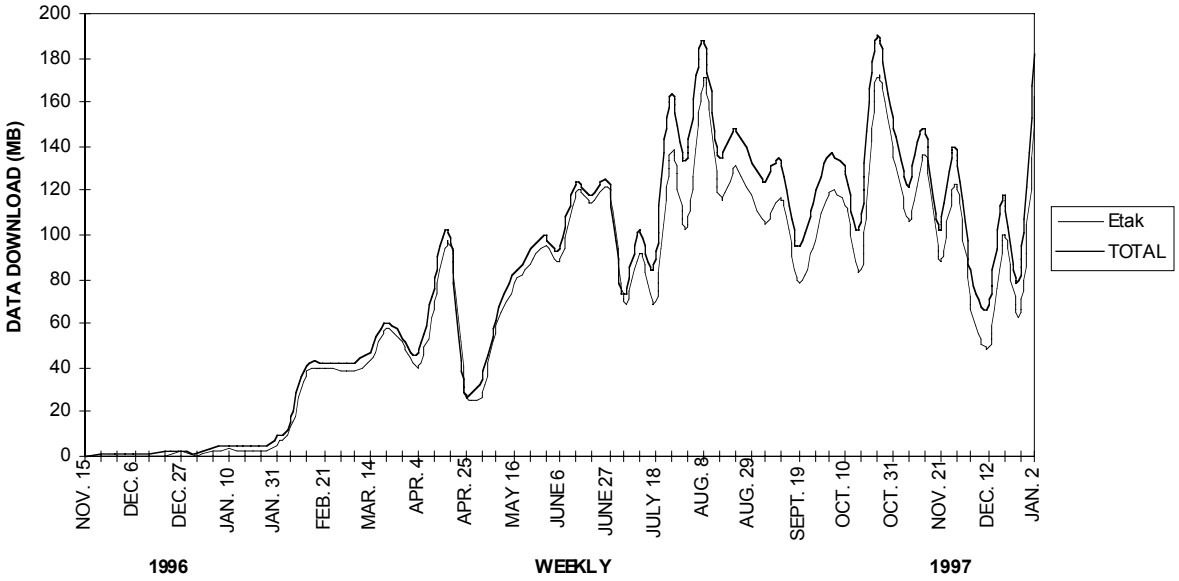


Figure 11b presents the next tier of ISP data downloads, which in this case includes Daimler-Benz, Maxwell and Contra Costa Times. Maxwell began downloading data, on the order of 1.5 MB per week, approximately one month before Daimler-Benz did. Daimler-Benz's downloading of data was more irregular in terms of quantity, but after early August 1997 it oscillated between 10 and 15 MB per week. In early August 1997, Contra Costa Times began downloading between 1 and 2 MB per week (very similar to Maxwell's data access). 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 11a.

Figure 11c 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 11a) and 10 megabytes (Figure 11b), respectively. It should be noted however that only two ISPs were downloading data after late July 1997, only one of which did so regularly (Metro Networks). Most ISPs downloaded data briefly then stopped.

The downloads for the fourth and final tier of ISPs is shown in Figure 11d. The vertical scale here is on the order of approximately 10 kilobytes. This figure shows how infrequently and how little data are downloaded by these ISPs. Note that all the ISPs in this category stopped accessing data after June of 1997.[16]

[16] Aside from RIDES which performed three additional downloads after June 1997.

Figure 11b: Weekly Volume of Data Transferred: Contra Costa Times, Maxwell and Daimler-Benz

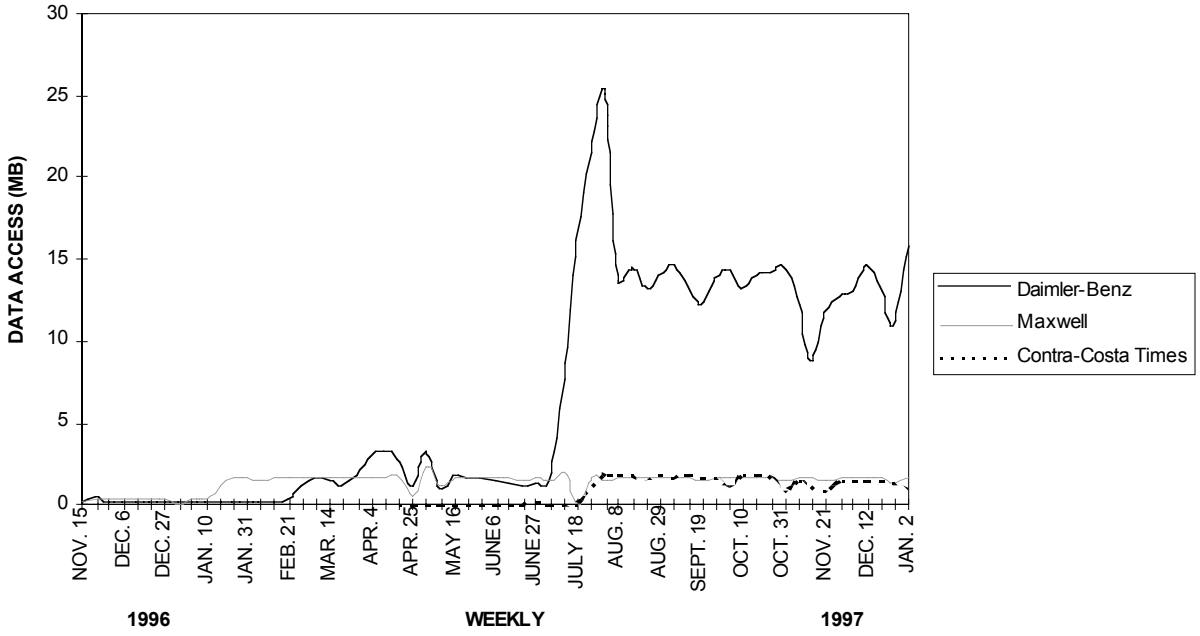


Figure 11c: Weekly Volume of Data Transferred: Third Tier ISPs

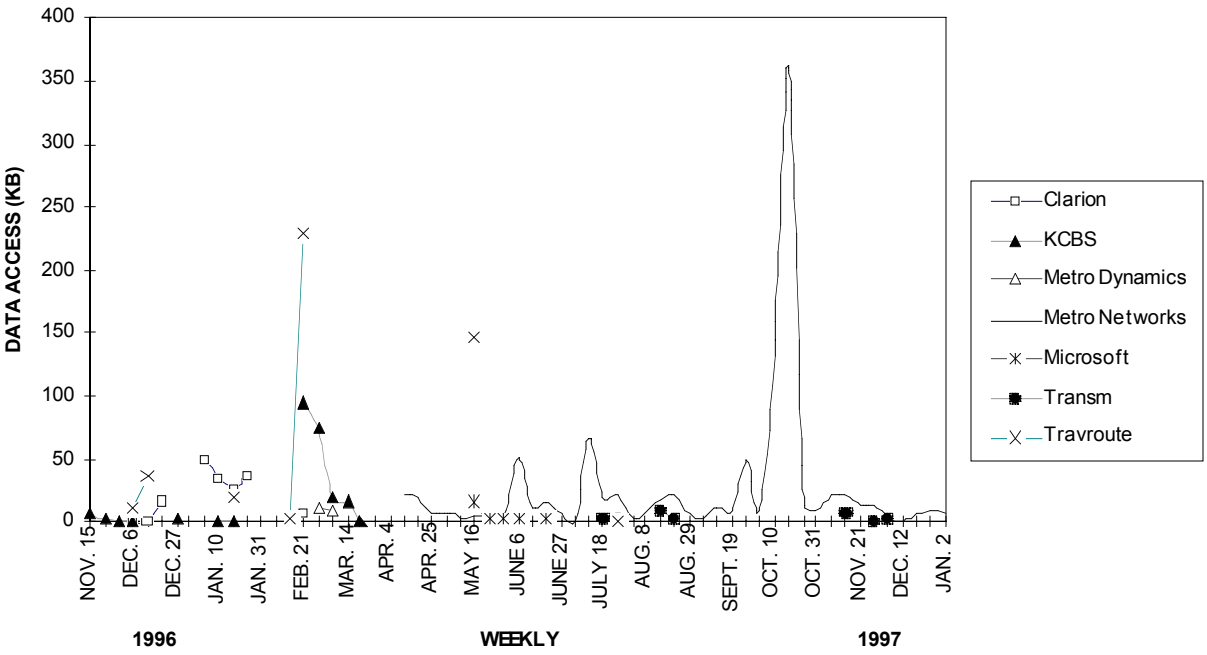
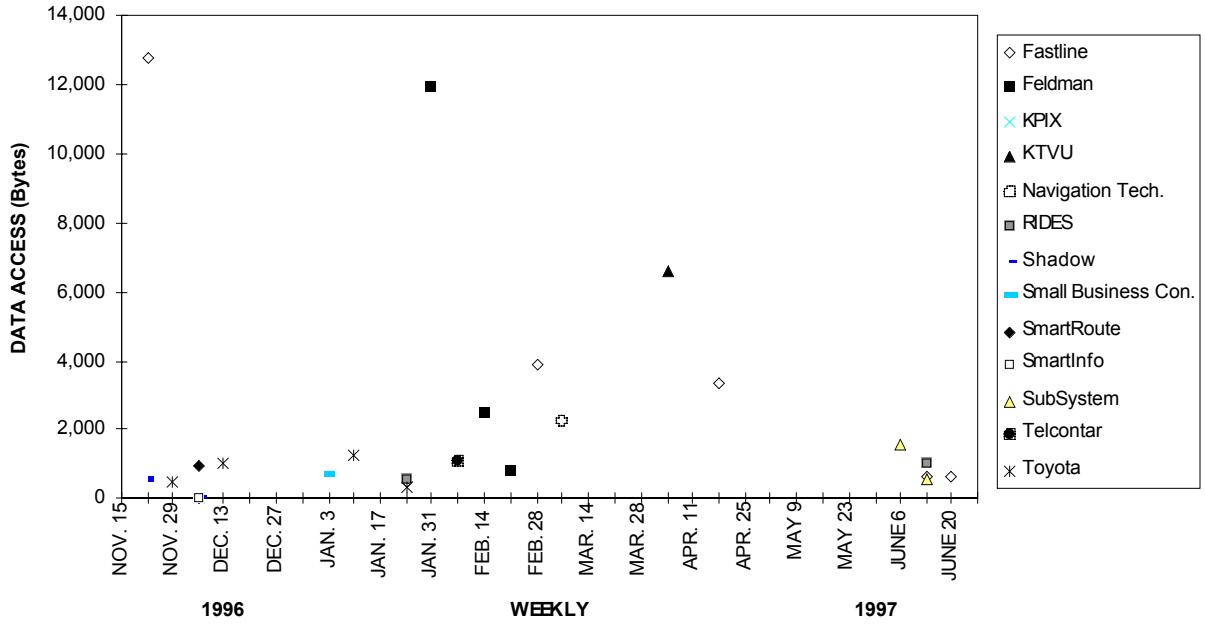


Figure 11d: Weekly Volume of Data Transferred: Fourth Tier of ISPs



The final three figures (Figures 12a-12c) depict the quarterly distribution of ISP data selections for 1997 for all ISPs except Etak, i.e. primarily Contra Costa Times, Daimler-Benz and Maxwell. PATH data downloads for Etak were suspended in March 1997 because Etak was downloading 95% of all data as can be seen in Figure 11a. It was thus felt that the following figures would be valuable to understand what selection non-Etak ISPs were making.

Figure 12a depicts the distribution of ISP selections by main category throughout 1997 by quarter. For each quarter (January-March, April-June, July-September, October-December), Speed & Congestion account for 89.6%, 83.4%, 56%, and 58% of the selections made, respectively. For each quarter, Traffic Incidents account for approximately 10.2%, 16%, 42%, and 38% of the selections, respectively. An individual selection corresponds to a line of output. The decrease in Speed & Congestion data access on the part of the ISPs likely reflects the generally poor quality of the loop sensors, the main source of such data (See (1), Section 3.4.2.7).

Figures 12b and 12c show the distribution for Speed & Congestion and Traffic Incidents, respectively, by county. In Figure 12b, the bar representing the distribution of ISP county selections for the January to March quarter shows a fairly even distribution among the nine Bay Area counties. This indicates that the ISPs were looking for data from all counties. In Figure 12b for the bar representing the July to September quarter would seem to indicate that the ISPs learned there was no data from Napa, Solano, and Sonoma counties.

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 December 1997. Approximately 62% of the ISPs (25 out of 40) downloaded data at one point or another, mostly infrequently and in small amounts (84% of the ISPs downloaded less than 400 KB per week for

any given week throughout the reporting period). After June 1997, only 25% (10 out of 40) of the ISPs still accessed the system, half of which very infrequently (1-3 times for 4 of the ISPs from 07/97-12/97). Throughout the reporting period, there were only four ISPs who regularly accessed data: Contra Costa Times (starting in May 1997), Etak, Daimler-Benz and Maxwell.

Figure 12a: Quarterly Distribution of ISP Selections by Main Category: January-December 1997

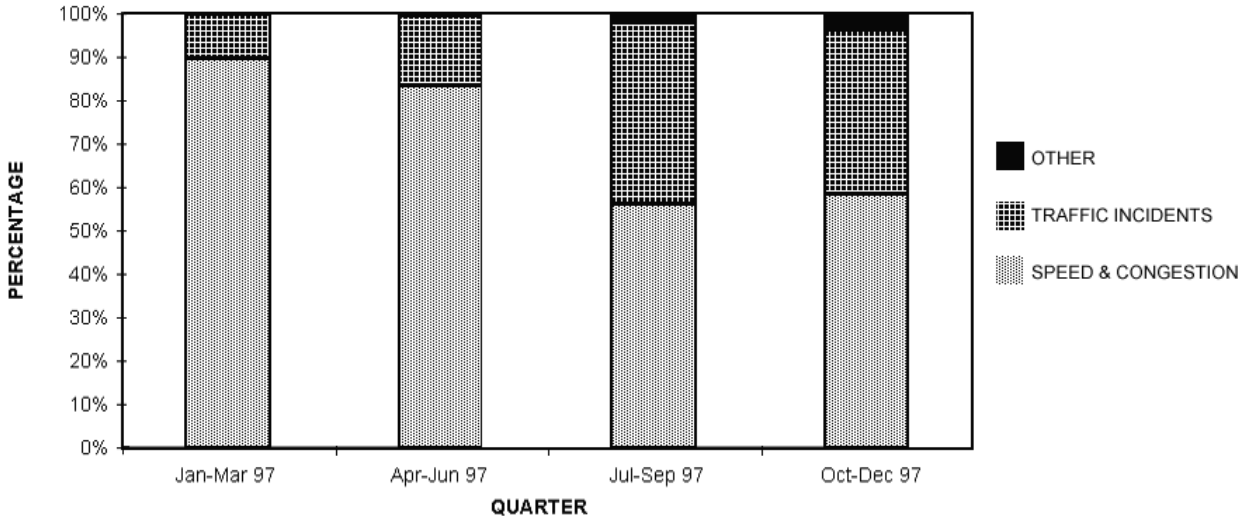


Figure 12b: Quarterly Distribution of ISP County Selections for Speed & Congestion: January-December 1997

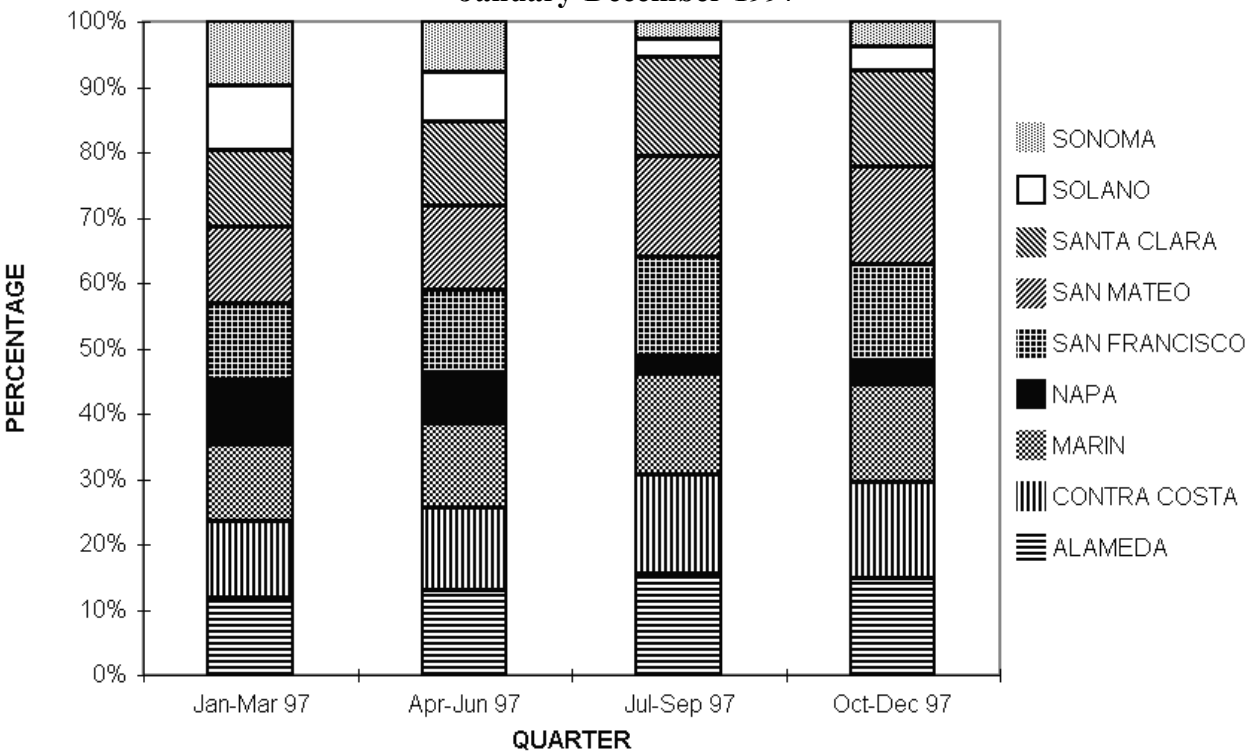
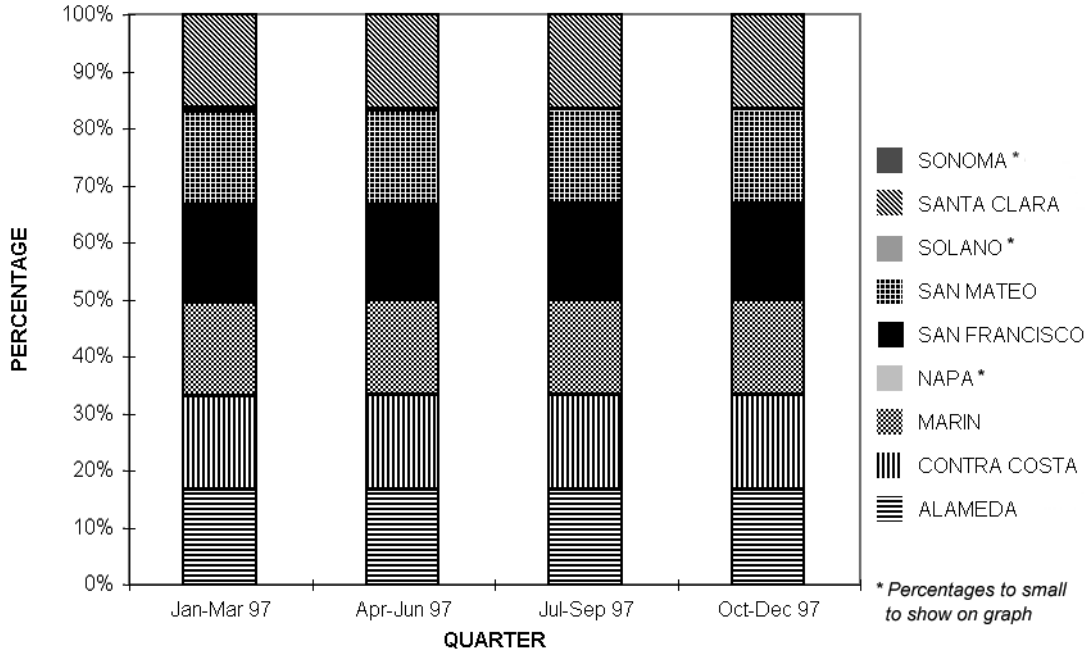


Figure 12c: Quarterly Distribution of ISP County Selections for Traffic Incidents: January-December 1997



NB: Figures 12a-12c do not include data for Etak. Also, Figures 12a-12c reflect query or menu selections not necessarily actual data downloaded, although there is clearly a strong correspondence between the two. In Figure 12b, 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.

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. Because of the unavailability of documented TIC Problem Reports for recurring problems from July 1997 through April 1998, system reliability cannot be analyzed in a consistent fashion throughout the FOT period. Instead, system reliability will be analyzed during the following two time periods for which complete data is available: January-June 1997 and May-September 1998.

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 evaluation component, a report documenting (1) operator tasks and job responsibilities and (2) TIC/operator interfaces and the working environment (See (2)) is currently being prepared. A third survey instrument has been developed and is currently being implemented that is focusing on TIC operational effectiveness at a more general level than prior work to identify both areas of achievement as well as potential technical and institutional barriers to successful TIC operations. In addition to this ongoing work, the

response time analysis portion of the evaluation will be performed in two phases based on data from the winter and summer of 1998.

5. PRELIMINARY CONCLUSIONS

This evaluation report documents the first sixteen months of TIC operations for the twenty-five month TravInfo FOT and focuses on two of the four primary TIC evaluation components: system reliability and communications interface. Based on the performance of the TIC during this time period, conclusions, though still preliminary, may nevertheless be offered and are be valuable. Such conclusions should, however, be understood in this context.

During the first sixteen 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), except during the period immediately prior to, during, and subsequent to the BART strike. 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.[17] Furthermore, during the September 1996 to December 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 obscuring part of goal 1.c.

[17] 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 (3) 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.

Data access by the private sector has also been very limited. Access by the private sector participants, monitored from November 1996 to December 1997, is essentially limited to three ISPs, one of which downloads approximately 90% 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 between 55% and 85% of data accessed by ISPs is speed and congestion data (Figure 12a), which relies on loop sensors approximately 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.

TravInfo has, however, given three ISPs (Etak, Maxwell, and Contra Costa Times) the opportunity to use TravInfo data to create web sites containing traveler-related information[18], thus providing the public a non-TATS media outlet of this data. Though the extent of the dissemination, i.e. the volume of such web site accesses or "hits", is unknown, most of the information offered (speed and congestion data) is based on loop detectors, which as stated above, have been an unreliable source of data.

6. REFERENCES

1. M. A. Miller and D. Loukakos, "TravInfo Evaluation (Technology Element) Traveler Information Center (TIC) Study (September 1996 - June 1997)", California PATH Working Paper, UCB-ITS-PWP-98-7, California PATH, University of California Berkeley, (1998).

2. M. A. Miller and R. Hall, "TravInfo Field Operational Test Traveler Information Center (TIC) Study (Technology Evaluation Element) Implementation Plan", California PATH Working Paper, UCB-ITS-PWP-95-14, California PATH, University of California Berkeley, (1995).

3. Y.B. Yim, R. Hall. R. Koo and M. A. Miller, 1998. *TravInfo Evaluation, Traveler Response Element: Traveler Advisory Telephone System (TATS) Study Phase 1 Results*, Unpublished California PATH Working Paper.

[18] The internet web addresses for Etak, Maxwell, and Contra Costa Times are, respectively, http://www.etaktraffic.com/, http://www.maxwell.com/yahootraffic/SF/, and http://www.hotcoco.com/traffic/.