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STUDY FOR ALAMEDA COUNTY 911

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PREFACE

This is the final report of the Study for Alameda County 911, a one-year examination of advanced 911 systems for possible implementation in Alameda County, California. The study was undertaken by the Alameda Regional Criminal Justice Planning Board in May of 1973 and a preliminary draft of this report was published in June 1974. Extracts and key findings have been presented at public safety symposiums in the interim. As of this writing, an application to LEAA for monies with which to implement an advanced 911 system on a trial basis is still pending.

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This study could not have been completed without the able assistance of Mr. Richard Olson, Mr. Van Bishop, Ms. Susan Crawford, of the project staff and Dr. Louis Radner of the MITRE Corporation. The support and guidance of the 911 Steering Committee and particularly that of its officers, Mr. Loren Enoch, Mr. Thomas Schneider and Mr. James Turner were vital to the project and deeply appreciated. The cooperation and the extremely practical input from the many members of the 911 Users Task Force were most helpful as was the technical assistance provided by Mr. Louis Martinez and his colleagues at the Aerospace Corporation.

Special thanks are due Mr. Art Graham and Mr. Jay Carwin of Pacific Telephone and Telegraph who ably represented and coordinated the participation of that fine organization; Mr. Joseph Kowchanski and Mr. William McMahon, who provided critical support to a complex undertaking; and to Mr. John Lenser and his entire planning board staff for providing the excellent environment the project enjoyed.

Overdue recognition is hereby extended to Mr. Jerry Strickling of Southwestern Bell, Mr. John Shepherd of Mountain States Bell, Dr. Kenneth McKay of AT&T, and Dr. Peter Goldmark of the National Academy of Engineering for the important roles they played in advancing the concept of automated 911 in years long past.

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INTRODUCTION

This report is organized in thirteen sections. An Executive Summary including the key project findings is followed by a short history of the study's origin and the reasons for conducting it. Section 3 examines the various privacy issues that were involved. It is an important section since concern for individual privacy influenced several key decisions.

The succeeding four sections describe the advanced 911 capabilities investigated and the study's findings concerning their operational value. Certain technical limitations to using the calling telephone number are examined in Section 8.

The development of alternative service plans and the computation of their relative manning requirements are presented in Sections 9 and 10. Section 11 is an evaluation of alternative technical approaches to providing location and supplementary information. The evaluation was conducted in the middle of the study and served to narrow the number of approaches to be costed and evaluated. The phone and data system costs for alternative systems are presented in Section 12.

The last section presents the final evaluation of sixteen possible 911 systems and concludes with the study's recommendation -- that a phased implementation of an advanced selective routing system be undertaken for Alameda County.

The figures and tables have been placed at the end of the report while the appendices have been collected in a separate Appendix volume.

1. EXECUTIVE SUMMARY

Objectives and Methods

The overall objectives of the project were: to assess the operational, economic and social feasibility of implementing an advanced 911 emergency telephone system in a complex metropolitan area such as Alameda County; to compare the projected cost-benefits of systems with selective routing, automatic number identification(ANI), and automatic location identification(ALI) with basic 911 system alternatives; and to do the preliminary planning for implementing such a system.

The operational benefits were projected by studying: 1) the relevance of telephone adresses to the incidents being reported over existing police and fire emergency lines; 2) the potential impact of anonymous calls no longer being made; and 3) the potential utility of supplementary dispatch support data(SDSD) being displayed at the answering public safety agency.

Alternative technical approaches to providing automatic location displays were formulated and evaluated with respect to display response time, reliability, privacy and capacity to provide useful information. The public's reaction to the key privacy aspect - government custody of telephone subscriber records - was sampled by a telephone survey of 300 listed and unlisted subscribers.

After studying the extent of Alameda County's overlap problem (the non-alignment of telephone switching and jurisdictional boundaries) and projecting the 911 call traffic from existing emergency call patterns, several selective routing and basic call distribution service plans were configured. The 911 call answering personnel requirements were projected for a selective routing and the two most promising basic service plans with the use of a programmed multi-server queuing model. Those results, plus the computer system requirements, the 911 circuit costs as provided by the telephone company, and the cost of an alternative dedicated 911 switcher were then used to project the relative costs of sixteen 911 systems of varying structure and informational capability. The utility, privacy, reliability and jurisdictional implications of each alternative were also considered by the local 911 Steering Committee in the final evaluation.

Key Project Findings

1. Selective routing appears to be the most feasible and cost-effective method of providing 911 service in a complex metropolitan area with extensive overlap problems. The system's recurring cost - approximately 36¢ per phone number per year - is less than two-thirds the personnel cost of a centralized answer-and-transfer facility.

2. For reasons of individual privacy, the original plan to accomplish ALI by providing updated telephone directory files to a public safety computer system is much less acceptable to

the community than one wherein subscriber information would be kept on a telephone company computer and released only when and while a 911 call is made.

3. A single modest minicomputer with large on-line storage could easily perform the ALI function for the 1,250,000 population of Alameda County. Although a second, serially connected minicomputer operated by the County would be necessary to append any SDSD (non-telephone information such as police beat, fire box and cross streets), a combined output could be displayed within 2 seconds of call answering.

4. 85 to 90 per cent of 911 calls would display a location suitable for dispatching purposes but only a quarter of the calls for fire and half the calls for police assistance originate at the exact address where the assistance is needed. Consequently, SDSD common to a small geographic area such as the side of a city block would have the greatest cost-effectiveness.

5. The display of a residential subscriber's name was found to have insufficient public safety value to offset the perceived threat to individual privacy, so long as the ALI has the installation location in detail, i.e. apartment number. Business and non-residential subscribers' names should be a part of ALI.

6. The acceptance by the general public of a 911 system with ANI and ALI is extremely high with only 5% reacting unfavorably to the idea. It would be acceptable to those most sensitive to the privacy aspects as long as an alternative method of summoning assistance anonymously is still available.

7. The value of 911 systems with automatic number identification was judged much greater than those without it. The additional value of having ALI and SDSD must await determination in an actual operational trial.

Relation to Other Research in the Field

Almost all prior 911 studies have been conducted only as a preliminary step toward implementing a basic 911 system in a particular locale. Considerations of selective routing or automatic information display were limited to observing their technical feasibility and noting that a great deal of telephone company development work would be required before they would be available. There were three studies which did produce relevant results.

(1) In early 1972, the GTE Services Corporation made a systems analysis of the "technical, economic and sociological consider-

ations associated with providing ALI in conjunction with... 911". After an excellent recap of 911's history and problems, the resulting report explored two methods of providing ALI to a central dispatching facility for the St. Petersburg, Florida area: use of the calling number (ANI) to reference computer files, and the installation of a "PIC" (Programmable Integrated Circuit) chip on every phone circuit which would transmit the location when electronically interrogated by the central answering facility. The report projected an annual ALI cost of $5.10 with the PIC approach and $.90 per phone number with the ANI approach. The comparable estimate from this study would be only $.55 per year. The GTE report briefly noted and schematized a combined selective routing and ALI system but offered no cost estimates. The report urged the installation of a pilot ALI system in one of several large cities.

As a result of its promising analysis, GTE sought an FCC opinion on the legality of a common carrier providing the necessary computer support for ALI under a variety of arrangements. (Section 64.702 presently restricts common carriers from furnishing data processing services to others.) Subsequent to the GTE report, the FCC Common Carrier Chief responded that all of the arrangements would be permissible since the data processing function was for the purpose of "providing an essential informational service to 911 subscribers that is incidental to the carrier's basic telephone communications services."

(2) The National Academy of Engineering's Crime Prevention Subpanel in cooperation with the Communications Division of the New York City Police Department conducted a 1970 study of the value of ALI. As documented in the GTE report, a survey of 602 police calls, including 282 requests for emergency service, showed that 18% of the emergency calls would have benefited significantly from ALI and 66% of the reporting phone locations were identical to the subject incident. These results were corroborated by the Alameda study which produced 16% and 58% for the same measures.

(3) The last study was the unreleased Bell Telephone Laboratory analysis made preliminarily to approaching Alameda County for a trial. This effort produced a conceptual design and some order-of-magnitude costs. It also laid out AT&T's fundamental position that the costs of advanced 911 would have to be paid for by government rather than incorporated into the base rate structure as is the case with "basic" 911. Since the study did not include the costs of a government computer and used extremely rough estimates of the call volumes and public safety requirements, the telephone company declined to make the study available for the project's review.

Unlike the previous efforts, this study involved extensive participation by all of the potentially affected public safety agencies, developed more reliable 911 call volumes and cost estimates, and thoroughly examined the increasingly important aspects

of privacy. As noted, Supplementary Dispatch Support Data was identified as something which would not be inherently available with an acceptable ALI system, but as something which could be safely and efficiently added at little additional cost.

Many police and fire departments are developing computer-assisted-dispatching (CAD) systems. All of these presently depend upon an operator manually keying in the location of the incident. These systems could be significantly enhanced with ALI. Automatic vehicle locator (AVL) systems are being installed on an experimental basis in several cities. By assembling CAD, AVL and ALI into a single system, the means would be available for automatically transmitting a tentative assignment address to the closest appropriate patrol vehicle when a 911 call is made, without any manual intervention. This possible elimination of call processing time from the total response cycle could produce dramatic response time improvements in urban areas with high patrol density.

Summary Recommendation

As a result of the study, it was the unanimous recommendation of the study participants that a selective routing 911 system be installed throughout Alameda County and the advanced informational features of ANI, ALI and SDSD be successively added and evaluated over a three-year period. This trial will permit a thorough evaluation of the different capabilities; the identification and solution of unforeseen problems; and the assembling of sufficient telephone costing data for the setting of tariffs elsewhere in the nation. It was further recommended that the National Institute of Law Enforcement and Criminal Justice conduct the evaluation in order to insure that the national needs for valid results are met.

2. BACKGROUND

Shortly after AT&T announced in 1968 the availability of "911" as a universal emergency telephone number, several public safety organizations, the National Academy of Engineering, and the National Institute of Law Enforcement and Criminal Justice asked AT&T to investigate the feasibility of an advanced 911 system with three capabilities that the "Basic 911" system did not have: selective routing, automatic number identification, and automatic location identification.

Selective routing would permit 911 calls to be routed according to the emergency jurisdictional boundaries rather than the telephone switching center boundaries. The lack of correspondence between the two sets of boundaries presently requires the establishing of a single common answering point for 911 systems -- a requirement that has greatly impeded the implementation of 911 in large multijurisdictional metropolitan areas.

Automatic Number Identification (ANI) would automatically display the telephone number of the party calling 911 and Automatic Location Identification (ALI) would display the telephone subscriber's address.

AT&T investigated the feasibility of such a 911 system and presented their findings to the Law Enforcement Assistance Administration in 1971. They reported that all three features were technically feasible and presented a conceptual design of a system to provide them. They noted that the necessary telephone switching equipment was not universally available to support such a system. Even where it was, sizeable costs would be involved which the telephone company was not prepared to absorb as it had those of Basic 911. Because of the uncertainties regarding the costs, the potential benefits and the privacy issues involved, AT&T recommended to LEAA that a pilot automated system be jointly evaluated before any others were developed. LEAA agreed, noting the proven correlation between arrival time and likelihood of apprehending a criminal. LEAA had also been receiving many requests for computerized command and control systems with which such an automated 911 system would have a natural tie-in.

LEAA and AT&T further agreed that an LEAA-funded trial should be conducted in a sizeable metropolitan area with the necessary advanced telephone plant, and the sort of problems an automated 911 system could help solve.

In 1972, after a preliminary order of magnitude costing by AT&T, the northern half of Alameda County -- the Oakland metropolitan area -- was chosen from a list of some twenty communities nominated by the telephone companies. It had the required telephone plant and facilities, it was a diverse and complex combination of municipalities with mismatched telephone switching boundaries, and its progressive public safety organizations could be counted on to take full advantage of

the advanced features. It also had an existing basic 911 system already operating in an island community -- the city of Alameda. This area, the second nominated, was subsequently identified as the "Beta" test area. (The "Alpha" area was St. Louis, Missouri, which had urged the development of such a system and even been preliminarily costed. It was found unsuitable as a trial area due to its much greater size and relative lack of automated telephone subscriber records.)

Three alternative systems were hypothesized with varying amounts of ANI and ALI for the various Beta area cities. LEAA reviewed these alternatives and the system concept with a group of knowledgeable public safety communication officials in July, 1972. They unanimously urged a trial of some sort and identified one plan as providing a suitable test bed.

LEAA, AT&T, and PT&T* representatives jointly approached the local government public safety officials with the idea of a trial project and got acceptance upon three conditions:

1. That any implementation be undertaken only after a locally directed one year study to determine the economic, operational, and jurisdictional desirability of a sophisticated system over a more conventional variety of 911.

2. That the project's scope be expanded to consider all of Alameda County, even though the southern and eastern portions might not have the necessary telephone switching facilities for the advanced variety.

3. That the study produce a plan for implementing 911 of some sort throughout the county in compliance with recently enacted state legislation.

The insistence on a lengthy preliminary study was the result of many local uncertainties concerning the desirability of selective routing, the ongoing costs of the advanced features, and the operational impact on the public safety agencies. Alameda County and its citizens were already in the middle of a large "technologically feasible" system implementation -- BART -- which was proving significantly more costly and less effective than its billing. In view of that advanced rapid transit system's cost overruns and performance shortcomings, the county was understandably hesitant to undertake another pioneering project.

It was felt that the study should be conducted locally with strong input from the organizations that would be affected by its outcome. A project director, hired expressly for that purpose, should be under the direction of a steering committee composed for the most part of local governmental and public safety representatives.

*Pacific Telephone and Telegraph -- the Bell company serving all of Alameda County and most of California.

The geographic expansion of the project to include all of Alameda County was a political necessity. The Beta area happened to include that portion of the county which was the principal beneficiary of existing county programs and excluded the municipalities and unincorporated areas which were paying proportionately more for them. The Beta area project was identified as just one more program. The county government, which was a principal candidate for assuming any local costs, has a very strong policy of providing services only when they can be provided throughout the county. Consequently, even Beta area cities felt a county-wide project was prefereable. Lastly, the state requirement to provide a plan for implementing 911 by 1975 applied to all of Alameda County.

It was pointed out by LEAA and AT&T that the telephone switching equipment necessary for an advanced 911 might not be available in the southern and eastern portions of the county. This was acknowledged by the local officials, but they insisted upon the project being expanded to include the county subject to those equipment limitations. This represented a 50 percent increase in the target population and doubled the number of central offices which had to be considered.

These conditions were accepted by LEAA and a study grant in the amount of $150,000 was awarded by the National Institute of Law Enforcement and Criminal Justice. Additional technical assistance was provided in the form of a technical man year from the Aerospace and MITRE corporations. These not-for-profit firms have on-going contracts with the Institute to perform requirement and evaluation studies of equipment systems.

3. PRIVACY

In retrospect, the original AT&T proposal's most surprising aspect was its lack of concern for the privacy implications. Certainly, increased concern for individual privacy and the possible abuse of governmental and automated records was the most marked influence on the 911 study. Organizationally, it stimulated the appointment of three public members to the 911 Steering Committee and their inclusion in a special five person Privacy Subcommittee.

This subcommittee involved itself with all of the various operational and technical alternatives that had a privacy consideration. With respect to the conduct of the study itself, privacy considerations necessitated the hypothesizing and evaluation of several complex information systems, and the conduct of several special studies.

Unlisted Subscribers

The earliest concern was over the release of information concerning non-published or unlisted subscribers, either en masse or when they placed a telephone call. "Reverse directories" which list phone subscriber information in number or address order have been used by police and fire departments for years in support of their investigative and communication operations. Nevertheless, these directories contain only published number information and police needing information on others must contact the phone company's special agents on an individual request basis. Some consideration was given to omitting non-published subscribers from ANI and ALI systems, or only including them if they did not object on a mail-back form. Other alternatives such as delegating the issue to individual city councils to decide for their jurisdiction or establishing a third class of subscriber service "unlisted except for 911 purposes" were briefly considered.

To determine the extent of the problem, PT&T provided a tabulation of published and non-published installations for all of the central offices in the study area.[1] It showed that 29.2% of residential subscribers and 5.6%* of business subscribers have unlisted phones. The highest residential rates were 38% and occurred in the middle-class suburbs, particularly the most rapidly growing and homogeneous areas. The lowest rates were 17% and occurred in Berkeley and the more established communities. Although several sociological explanations could be advanced, the fact that new residential phone installations are more likely to be unlisted than old installations suggests that unlisted numbers are on the increase.

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* 2.7% of which are semi-public pay phones.

[1] See Table 1.

It was therefore decided that a 911 system that excluded all or a significant portion of unlisted subscribers would be unsuitable.

Caller Anonymity

If a 911 system were to automatically identify the source of the call, it would undoubtedly reduce the number of false fire alarms, bomb threats, and other malicious calls. It might also result in crimes, accidents, and other emergencies not being reported by individuals who would do so if they could remain anonymous. To estimate the magnitude of this problem, a study[1] was made of some 200 anonymous calls placed with three police departments and collateral information was collected for 911 systems that have a call tracing capability. The results showed that less than 4% of incoming calls are made anonymously and most of these involve routine incidents. Although the five other cities checked had advertised trace capability and successfully reduced their false alarms, they still receive and accept "anonymous" calls. The loss of anonymity was therefore thought to have no operational liability. The Privacy Subcommittee reviewed these findings and concluded that the loss of 911 caller anonymity would be an acceptable condition for obtaining other system benefits, provided that there was another published number available for a citizen wishing to remain anonymous.

Privacy Survey

Regardless of how well the system was designed or programmed in an effort to achieve individual privacy, it was obvious that the public's acceptance of such a system was going to be the all-important consideration in whether it was ever installed.

The project accordingly made a telephone survey of 311 residential subscribers to determine their general reaction to a 911 with automatic identification features and their reaction to providing subscriber files to "the governmental agency in your community answering 911 calls." The survey included 206 non-published and 105 published subscribers. It was conducted and tabulated by the Surveys and Statistics Division of PT&T under the close supervision of the project office. Its findings were:

1. 88% had a favorable reaction and 5% had an unfavorable reaction to the general concept of 911 with automatic identification of number and address.

2. Only 81% approved when the possibility of giving subscriber files to a government computer was specified, but another 7% approved when telephone company custody was designated.

3. There was no significant difference in any of the responses between published and non-published customers.

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[1] See Appendix B.

The survey report includes an interesting range of customer comments as to why they would favor or disfavor such a system. The report and the questionnaire are included as Appendix A.

It is worth noting that 75% of those polled could not recall previously having heard of 911 even though a system was implemented in the City of Alameda in April, 1970, and mandatory state-wide legislation had been enacted.

Display of Caller's Name

The original AT&T proposal included "the furnishing of data to the municipalities to convert the calling telephone number to name and address." This concept was graphically presented to government officials in Alameda County and elsewhere.

At a preliminary Steering Committee meeting, PT&T mentioned the possibility that name might not be necessary to effect an emergency dispatch. The project office reviewed this possibility with various individual police and fire representatives and found general agreement. Although the name might be useful, it would only be of extreme value in trying to locate an apartment from a street address or business which was better known by its name. The name of a business could provide the responding organization with a further indication of the likely character of the incident. PT&T agreed to provide the specific service address of phone installations instead of either the billing or directory address. This would identify particular apartments, shops within an arcade, etc. PT&T also acknowledged the public safety need for business names and said that their privacy apprehension only extended to residential subscribers. Insofar as this appeared to satisfy the possible 911 requirements and would improve the likelihood of the file provision, the project dropped further consideration of residential name. In particular, the privacy survey referenced only telephone number and address in order to focus on the more important question of government file custody.

The dropping of residential name was subsequently challenged at a meeting of the Users Task Force by police representatives who said that it would be most useful with a computer-assisted dispatching system in that it would require less keying of dispatch transactions. Even with manual systems it would be useful in locating addresses incorrectly listed or garbled in radio transmission. It would avoid confusing first and last names and assist in spelling unusual names.

A short study[1] of dispatch tickets of the Oakland Police Department was made to determine the consistency between the name of the complainant and the telephone subscriber, i.e., how often was the name given the police the same name as listed in the directory. Of the 69 that were traceable in available directories, 61% had identical surnames. The users' desires, the phone company's reservations, and the study results were presented to the Steering Committee.

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[1] See Appendix C.

Apprised of the ease with which name could be added at some future time, the Steering Committee unanimously agreed to drop further consideration of residential name for privacy reasons.

Other Privacy Design Factors

The largest privacy concern was the possible interfacing of a 911 system with another criminal justice information system and the automatic association of criminal history or intelligence information with the caller. While configuring alternative systems with varying privacy, several interim conclusions were reached:

1. If a central government 911 computer capability were required, it should be completely independent of the existing criminal justice PIN network. It should be operated by an organization with a public safety rather than a law enforcement orientation and preferably located away from other governmental record systems in order to increase its real and perceived independence.

2. If a central government computer contained telephone directory information, it should be engineered and programmed so that user display terminals were for output only. The only inputs possible should come from telephone company station equipment activated by an incoming 911 call.

3. A capability of associating supplementary public safety information on a small geographic basis was much more desirable from a privacy standpoint than one which could tag individual phone numbers or addresses.

4. In a related area; the identity, location, or phone number of a 911 caller should not be displayed until the call is answered. This will preclude discriminatory answering.

4. SELECTIVE ROUTING

The underlying need for selective routing is shown by Figure 1, "Alameda County Central Offices and Municipalities." With the exception of the city of Alameda (between Oakland and the San Francisco Bay) none of the municipal boundaries (dashed lines) coincide with the central office service area boundaries (solid lines). The cities of Oakland and Piedmont, for example, share three telephone central offices. The map is still a simplification since minor overlaps too small to depict occur along other seemingly contiguous boundaries. Although only problems internal to Alameda County are shown, sizeable communities in Contra Costa County to the north are served by the Solano Avenue and San Ramon Boulevard telephone facilities. Even if the telephone company were to expend the enormous sums to realign their switching plant, the unpredictable growth and annexation patterns could easily invalidate it.

The concept of selective routing emergency telephone calls was probably first advanced by Roger W. Reinke, then Assistant Director for Field Operations of the IACP. In his February, 1968, Police Chief article, he proposed the establishment of a universal police telephone number. In addition to recommending a display of the calling number, he perceptively noted that "if it were possible to identify automatically the calling number (as in Belgium), would it not be possible to relay the call to the appropriate police agency without resorting to a central dispatch point? The telephone companies would have to answer this. . ." The text of the lengthy article understandably makes no reference to 911, since it was written several weeks prior to AT&T's precipitative announcement.

Since then, the concept has frequently been rediscovered and advanced by various public safety technologists, but always in its basic form:

1. The telephone central office serving the 911 caller recognizes a 911 call as such and requiring special handling.

2. It captures the calling number, as if for long distance billing, and forwards both the number and the call to an advanced programmable electronic telephone switch.

3. The electronic switch holds the call long enough to retrieve from a data file the proper 911 destination for that calling number.

4. The call is then connected to the designated public safety answering point.

Theoretically, calls originating within an electronic central office's service area could be selectively routed without being forwarded to another office. The point is academic since it will be several decades before most of the existing electromechanical switches are replaced with Electronic Switching Systems (ESS). Even then, the extra storage and updating economics appear to dictate the use of only a few ESS offices in a metropolitan area. Although nine ESS offices are in or scheduled for Alameda County, only two would be used for selective routing.

As an alternative approach, the project investigated the possibility of using a special electronic switch which would switch 911 calls, and only 911 calls, for the entire area. This approach has several advantages over using an existing telephone company switch when a combined ANI-ALI-Selective Routing system is considered. It could use more technologically advanced and cheaper storage devices and perform all of the data processing functions required for ALI. Offsetting this and a slightly reduced cost are the facts that the switches available do not have an operationally demonstrated reliability history and would not be considered by the telephone company for a trial demonstration (see Final Evaluation of Alternatives).

The capability of forwarding the calling number was a more critical local requirement, since any selective routing approach and all of the advanced 911 capabilities depend upon it. Capturing the calling number for billing purposes is quite widespread even among electromechanical installations. All but panel switches can be modified for automatic message accounting. Many merely punch it and the toll information on paper tape. The tapes are then daily forwarded to the phone company's accounting department for computerized bill preparation. Other offices (called CAMA offices for centralized automatic message accounting) forward the calling number with long distance calls to toll offices. There, the automatic message accounting can be economically performed for several end offices. Although automatic message accounting has an obvious benefit in saving operator manpower, the capability of forwarding a calling number is only marginally justified by telephone accounting economies.

The biggest stimulus to number forwarding was the introduction of Traffic Service Position System (TSPS). This advanced system permits the more flexible and economical consolidation of costly operator functions into a few facilities for a large area. With the computer-based TSPS, every call requiring operator involvement is forwarded to a traffic service position after the caller has performed as much of the dialing operation as possible. There the operator intercepts the pay phone call, the person-to-person call, etc., and completes it with the benefit of special rate and status displays.

The TSPS computer requires the calling number in order to compute coin charges and support the other TSPS functions in an efficient manner. Because TSPS will often pay for itself through operator savings in three or four years, it has become a powerful stimulus to

automatic number forwarding throughout the telephone system. Ironically, the move to TSPS has accelerated the unfamiliarity of telephone operators with the locales from which "O" calls originate, and thus provides an additional incentive to the telephone company to get out of the emergency call answering business.

TSPS was introduced throughout the Beta test area in 1973. It was tentatively scheduled for the remainder of Alameda County an unknown number of years later. It was only after the study was several months along that PT&T was able to assure itself and the project office that the number forwarding equipment would be available throughout the county in time for a mid-1976 implementation of 911. This put the entire county on a comparable basis and greatly facilitated the uniform examination of alternative 911 approaches.

Internal Selective Routing

One of the anticipated benefits of selective routing has been the possibility of preferentially routing calls to particular call answering consoles within a large PSAP* such as Oakland might have. This is done in New York City on a borough basis and in the Philadelphia and Chicago police departments according to central office area boundaries. It has the benefit of being able to position the call answerers close to particular radio dispatchers where they can provide prompt clarification of field assignments and closely coordinate the response to incidents in progress. By limiting the origin of calls which a particular call answerer must handle, internal selective routing facilitates area familiarity, awareness of resource availability, and identification of redundant calls. It is only useful when the overall dispatching operation is so large it requires two or more assignment channels and dispatching zones. The disadvantages of such geographic radio divides are an increased parochialism on the part of the radio dispatchers, a limitation on a field unit's knowledge of incidents elsewhere in the city, and the requirement for additional frequencies and call answering personnel.

The only Alameda County dispatching facility with multiple assignment channels is the Oakland Police Department. Despite an assignment volume that would normally necessitate three or more channels, Oakland uses two. It is able to do so with highly proficient dispatchers and advanced techniques such as mobile data terminals and special function channels which reduce dispatcher workload. Because the department opposes further channel divides and has insufficient call answerers on even a pooled basis, it was not interested in pursuing internal selective routing during the study.

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* PSAP is an acronym for Public Safety Answering Point, the facility where a 911 call is initially answered.

5. AUTOMATIC NUMBER IDENTIFICATION (ANI)

Automatic Number Identification exists in Belgium and is used in conjunction with their 900 emergency telephone number. A display of the six-digit calling number is available to the call answerer in each of their 16 PSAPs.

One of the obvious public safety values of ANI is the discouraging of false fire alarms and other malicious calls to public safety organizations. Although fire box alarms register a much higher false alarm rate than phoned alarms (80% versus 10%, in some cities), the cities that have eliminated their box systems have often experienced a doubling of their phoned false alarms.

The cost of false fire alarms is very difficult to assess. During 1972, there were 42,089 fire alarm responses for Alameda County for only 12,950 fires. Although data on malicious false alarms versus "good faith" reports is not available, a reasonable estimate would be 8,000 to 10,000 additional responses a year. The financial cost in terms of equipment use, delay in handling a second alarm, accidents en route, etc., would be difficult to assess. Since firemen must be on duty anyhow and the false character of an alarm can be quickly determined, the dollar cost is probably minor. The most obvious benefit would be to the morale of firefighters who have difficulty staying "up" for alarms that are more likely to be false than not.

Having ANI when a distressed caller gives inadequate information would be of great assistance. It would permit the call answerer to call back for the missing information. This is the purpose of "automatic ring back", an extra cost enhancement to basic 911 systems. Some small cities may be able to trace a call with coordinated telephone assistance in ten to fifteen minutes, but in a complex area like Alameda County, it would require half an hour*. This is too long to make a part of regular communication center procedures.

Another basic 911 enhancement is "called party hold" which permits a line to be held open while the call is traced. While it is useful for discouraging false alarm callers and occasionally for locating callers who have lapsed into unconsciousness, etc., it is a very slow substitute for ANI.

An additional advantage to ANI would be its assistance in eliminating transcription errors. The project staff encountered several instances where even competent call answerers misrepeated the phone number given them. Having an ANI display would be one less chance for error.

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* PT&T estimate

ANI could be used to manually establish a missing address with the use of a reverse directory. Although it would not be as useful as ALI, it would permit responses to be initiated within a few minutes, providing the number were listed and not too recently installed. Reverse directories are normally printed only once a year.

Faced with the high cost of police manpower and a rising workload, many police departments take minor reports over the telephone. Some record the particulars on the initial call while others, like Oakland, use a call-back procedure to balance workload. The call-back procedure will become more prevalent if the choice is between using an expensive 911 circuit or a regular telephone line. ANI would greatly assist such a procedure.

6. AUTOMATIC LOCATION IDENTIFICATION (ALI)

Without location information, providing emergency assistance is an exercise in futility. More sophisticated procedures for tracing calls is not the answer for situations where precious seconds may mean life or death, the preventing of a crime or the reporting of it. One of the principal advantages of call boxes and signal transmitting alarms is the rapid and unambiguous identity of where the assistance is needed. Unfortunately, the telephone is by far the most common method of summoning assistance, and its users are frequently unable to provide location.

A survey by the National Academy of Engineering at the New York Police Department found that in 18% of their emergency calls, an ALI capability would have saved considerably more than 10 to 20 seconds in processing the call. The sample included callers too confused or incoherent to give an address, and who had to be asked to repeat their location several times. Others were foreign speaking, young chidren, and strangers who did not know exactly where they were.

The problem of getting a correct location is compounded when the call answerer is servicing an area with many duplicate street names, or the caller insists on giving a local reference such as "next to the Sears store" or "across from the college." Some consolidated fire dispatching centers make a cross-check of the caller's phone number with a telephone central office map, not only to detect false reports, but to eliminate ambiguities between common streets.

Even with ALI information automatically provided to the call answerer there would be certain cases where it would be of minimal use. The caller may be reporting an incident at some distance from where he is, and complete dependence upon the displayed address would be misleading. The National Academy of Engineering survey found that in 66% of the cases "the telephone location was identical to the incident location." The project conducted its own study to verify those results and to determine how far away the remote callers were (Appendix D). After listening to 963 tape-recorded calls placed to seven agencies, it was found that only 52% of the police calls and 40% of the fire calls originated exactly at the incident. Nevertheless, 85 to 90 percent of all calls to both services originated "within a few addresses" of the caller. In those cases, the displayed location would be sufficiently close for the selection of emergency units and the dispatching of them to the vicinity.

The project study also found that nine percent of the callers had difficulty in communicating their location. A fifth of these instances arose because the caller did not know the street address being called from. Although this nine percent is less than an

eighteen figure registered in the New York City study, it is still a significant amount. (An incident reported during a site visit to the Hayward Fire Department concerned a baby-sitter who had to physically check the house number and then a street sign while reporting a burning sofa. Even then she gave an incorrect street name). ALI would help greatly in such cases.

Although the project did not set out to collect information on transcription and recording errors, numerous instances were accidentally encountered during the project. Incorrectly repeated addresses and dispatch tickets with transposed or missing digits were distressingly common. One study found four obvious transcription errors out of a sample of 69 dispatch tickets.

Several large command and control systems have been installed which use the incident location as a primary input. Keying it in is the most time-consuming part of the procedure. With ALI, a ready input could be had for 911 calls, the most important calls to be processed.

After considerable discussion with the users, it was determined that the following elements should be included in an ALI display:

a. Apartment or unit number
b. House number
c. Street name
d. Municipality
e. Zip Code
f. Business name
g. An indicator for public and semi-public pay phones.
h. An indicator if there were off-premises stations associated with the number.
i. Block face
j. ANI

With the exception of block face, all of the information items are presently available from regular telephone company records. Block face is described in the subsequent section.

Although Zip Code was considered least valuable by most of the users, it would serve to eliminate street name ambiguity in unincorporated areas and was included for that purpose.

The inclusion of ANI in the ALI display would permit the latter to be used as the exclusive visual reference during the bulk of the call processing. Since ANI would also be displayed on the phone answering equipment, it would provide a valuable means of verifying that the ALI displayed related to the call in progress.

The method adopted for outputting ALI was a visual CRT display. This mode has the speed to facilitate cross-checking with the caller's

early statements; it is silent -- an important characteristic in a communications environment; and is significantly cheaper and more reliable than a hardcopy printer. It was felt that the independent logging of ANI with time and answering position would adequately satisfy any need for subsequent ALI reference.

To maximize the utility of ALI, a design goal of two seconds response time was adopted. It was felt that this was well within the general capabilities of a computer-based ALI system.

7. SUPPLEMENTARY DISPATCH SUPPORT DATA (SDSD)

In addition to ANI and ALI, a third category of information was identified for possible display with 911 calls. It was termed Supplementary Dispatch Support Data or SDSD. SDSD is information beyond address and business name which could assist in dispatching emergency services. It includes such things as police beat designation, fire box area, and ambulance zone. Unlike ALI, whose value is readily recognized, the value of SDSD is only appreciated by those familiar with public safety dispatching operations and the process by which an assignment is formulated from a call. In the Oakland Police Department, for example, the call answerer must refer to a set of house-number-range tables to determine the beat in which an incident occurred. The beat must be noted on the dispatch ticket before the latter can be sent to the radio dispatcher. In fire departments, similar tables and/or "run cards" must be used before a dispatch can be initiated. Large computerized command-control systems have been and are being built for millions of dollars whose partial justification is the ability to retrieve SDSD. The project staff reviewed such a system at the Dallas Police Department.

The capability of automatically displaying SDSD was an initial attraction of automated 911. SDSD's availability was inherent in the ALI method originally proposed by the telephone company. By giving the directory files to public safety agencies, the agencies would be free to associate SDSD with the records on their own computer. It was only when the review of this ALI method was made a part of the study project that SDSD had to be identified for separate consideration. There are two basic types of SDSD: zonal and number-related.

Zonal SDSD

Zonal SDSD is information that would be common to all 911 calls originating from a small geographic area such as the side of a city block. Such SDSD as police beat, fire box, or other service jurisdiction could be maintained on a zonal basis. Information showing the approximate location of the caller's address (cross streets, X-Y coordinates) could also be carried on a zonal basis. Since zonal SDSD deals primarily with the relationship of streets, house number ranges, and jurisdictional boundaries, it would be relatively easy to establish from maps and existing data sources. Once established, zonal SDSD would require a minimum amount of updating to reflect street and jurisdictional changes.

Number-Related SDSD

Number-related SDSD is information that pertains only to a

particular calling number or a particular address. The two sorts of number-related SDSD considered by the project were medical information and fire hazard information. If number-related SDSD were developed, even on an exception basis, it would be very difficult to establish and maintain.

Use of Block Face

If the side of a city block or "block face" were used as the unit for storing and retrieving zonal SDSD, 90,000 such records would cover all of Alameda County. This is significantly less than the 500,000 records that would be required to carry the same information on a number-related basis.

Telephone Company Position

The telephone company quite properly opposes carrying SDSD on any ALI computer that they would own or operate. Aside from the problem of updating information that has no value to telephone company operations, there are very strict legal regulations prohibiting the common carriers from providing such data processing services. For that matter, there might be objections from the public sector in providing the telephone company with sensitive number-related SDSD that was given government solely for public safety emergency purposes. As a result of these laws, policies, and considerations, it is certain that a governmental computer must be involved if any SDSD is to be provided on a 911 call.

After considerable discussion and in recognition of the legitimate value of SDSD for emergency service purposes, the telephone company has agreed in principle to the inclusion of a zonal reference (specifically, a six-digit block face identity number) with any ALI that would come from their computer. This would greatly simplify the problem of adding zonal SDSD to the ALI provided by the telephone company. The additional updating required at the telephone company would be minimal and the numbers might have value to telephone company operations. Since block face numbers are being developed for all metropolitan areas throughout the country, their use could be a standardized interface for other automated 911 systems.

For 911 calls, number-related SDSD is much less important than zonal SDSD. This was the conclusion of a special committee of the Users Task Force that reviewed the general problem of SDSD. Medical conditions would provide scant additional utility to a system that could provide the caller's address. Fire hazard information was thought to have a great deal of value, but its inclusion in a 911 system was not considered justified if no other access to it were possible. Such an alternative method of accessing SDSD had great

appeal to public safety users. It would permit them to retrieve correct information even though the 911 caller was at a different address. Other addresses such as those called in over non-911 circuits or radioed back by field units could be used to retrieve SDSD. Since such access was not acceptable for a system with government custody of subscriber files, the value of those approaches was diminished.

The initial position of the Steering Committee concerning SDSD was that it was a needless embellishment which would only increase the complexity of the 911 system without assisting the citizen. When made aware of this inclination, the Users Task Force sought a hearing with the Steering Committee, and a representative delegation made an effective presentation of how important they regarded SDSD in meeting the problems of emergency service. Their presentation is included as Appendix E. On the strength of their arguments, the Steering Committee agreed to continue consideration of approaches with an SDSD capability.

8. TECHNICAL LIMITATIONS ON USE OF ORIGINATING NUMBER

The use of the originating number for Selective Routing, ANI, and ALI has its limitations. The problem of a caller reporting an incident at another location was discussed for ALI. Other limitations are a result of the technical limitations of the telephone switching system and the variety of telephone services installed.

Multi-Party Stations

The most frequently cited limitation to ANI and functions dependent upon it are the use of multi-party phone lines where as many as eight subscribers may share a single circuit. Out of 470,000 Alameda County subscribers, only 1,353 have multi-party service. Of these, 1,211 have two-party service, which does not present a problem. (Central offices can identify the station on two-party lines and forward the appropriate ANI.) The remaining 132 consist of 41 8-party and 91 4-party subscribers in the unincorporated areas surrounding the eastern cities of Livermore and Pleasanton.

Even though eight subscribers may be on a common circuit, each has an individual seven-digit number and may be called directly from elsewhere in the system. This number cannot be automatically forwarded as ANI, but a pseudo-ANI could be. This might be simply an indication that a multi-party station was originating the call, or the identity of the particular multi-party circuit. In Alameda County the former would suffice since all multi-party calls should be selectively routed to the county's PSAP. The originating central office's identity (Sunol, Pleasanton, or Livermore) could also be provided for further assistance in resolving the origin. Since multi-party problem stations only constitute .028% of the potential 911 callers and are located in areas with relatively low 911 need, their specific ANI treatment has been deferred.

Foreign Exchange Service

Foreign exchange service offers a different sort of problem. Subscribers, particularly business subscribers wishing to retain their old telephone number after moving to another service area, or desiring access to a larger extended service area, sometimes install telephones connected to a distant or "foreign" central office/exchange. Since such service requires dedicated circuits between the subscriber's regular office and the one serving his prefix, a sizeable premium is charged. Depending upon 911 availability, several conditions can exist:

1. If the subscriber's regular central office does not have 911, there is no problem. He would be unlikely to dial 911 since it would not be locally available. This is comparable to areas close to exclusionary 911 systems.

2. If the subscriber's regular central office does have 911, and his foreign exchange office does not, there is a problem, particularly if the foreign exchange does not have a "911 not available here" recording or other appropriate intercept mechanism. The caller would have to redial 911 on a local line or refer to his phone book.

3. If the subscriber's local office and his foreign exchange office both have 911, the problems depend upon the type of system or systems serving the separate offices:

   a. If the foreign exchange office has selective routing and/or ALI, the problem can be automatically handled or easily recognized.

   b. If both offices are part of the same basic system, there is no problem since the same call answerer would process the call.

   c. If separate basic systems are involved, the foreign exchange PSAP might dispatch assistance to the right address in the wrong city. Several apparently undetected instances of this were encountered during the study.

The problems with foreign exchange service can be expected to increase as 911 becomes more universal. It is added justification for having alternative published public safety numbers and having the 911 operator identify his particular PSAP, such as "Hayward 911." It would be additional argument for selective routing if foreign exchange service were more widespread. The phone company estimates that less than 5% of all business stations in Alameda County have such service (which would be 0.1% of the potential calling population).

Off-Premise Service

Many large business and other organizations with dispersed facilities channel all of their telephone traffic through central switchboards located at their main office. In smaller organizations, off-premise extensions to a centrally located number may be located in detached buildings or remote facilities. There are three problems from such arrangements.

1. The extension or station may be so remote from the main number's installed location that it lies outside or in a different 911 service area. This would result in the sort of situations already mentioned for foreign exchange service.

2. Because ANI would only identify the main station number, its value would be limited for tracing and call-back purposes.

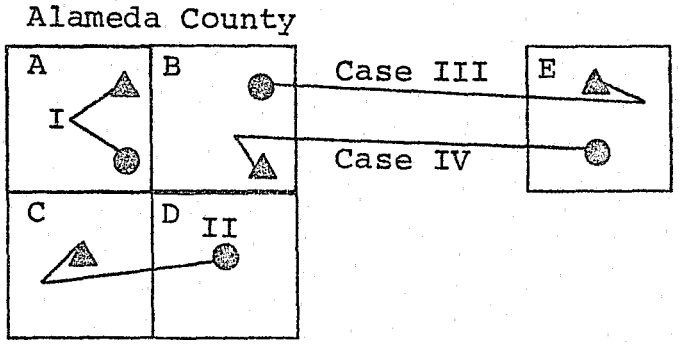
3. Similarly, ALI would be difficult to assign. This might be partially compensated for by flagging the ALI as being for a switchboard or a number with off-premises extensions. This would alert the call answerer to possible location and call-back problems.

Off-premises extensions and stations occur almost exclusively with business numbers and, like foreign exchange numbers, the most likely 911 callers would be business people familiar with that situation.

To determine the potential extent of the problem, PT&T provided a tabulation of off-premises installations for the various central offices in Alameda County. Counts for four cases were provided.

I	Off-premises station in Alameda County which is located in the same central office area as the primary station or switchboard.	5,710
II	Off-premises station whose primary station is located in a different central office area, both being within Alameda County.	3,112
III	Off-premises station in Alameda County whose main number or serving central office is located in another county (or state!).	233
IV	Station in another county served by an Alameda County central office.	184
	TOTAL	9,239
	As a percentage of Alameda County main stations	1.97%

The various Cases I, II, III, and IV are illustrated on the following page.



A, B, C, D = Central office areas in Alameda County

E = Central office areas elsewhere

▲ = main station

◍ = off-premises stations

As a percentage of total main stations, the number of off-premises stations is quite small. As a percentage of published business numbers, it is 10%. By far the largest concentration of off-premises stations is located in the central offices serving the most commercialized areas. Other concentrations are located in the central offices serving the University of California (Bancroft), the Oakland Airport (Hesperian North), and other major Centrex facilities. Since Centrex stations were included in the tabulation, the extent of the off-premises problems is accordingly inflated for reasons subsequently described. A PT&T representative estimated the Centrex component at 50%.

Because 65% of the off-premises stations are located within the same central office as the main station (Case I), there would be correct routing of their 911 calls at least that portion of the time with any sort of basic 911 system. Even with selective routing, an Oakland PSAP would still correctly receive an estimated 50% of the calls originating from off-premises stations.

In order to facilitate the call answerer in these and other circumstances, it is felt that an indication of off-premise calling capability should be associated with an ALI display.

Switchboards

The data assembled for off-premises stations did not include the PBX and other switchboards which have exclusively on-premises stations. There is no information available from the phone company on how many of theirs or customer-owned switchboards are installed.

Most advanced switchboards utilize the "9" digit to attach an outside line. The effect of dialing "9-1-1" instead of "9-9-1-1" would be an incompleted dialing sequence as far as the common carrier system was concerned. On the other hand, the dialing of "9911" instead of "911" from a switchboard station should serve to remind the caller that he is calling from an unidentifiable station and he should alert the answerer to his particular whereabouts.

Centrex systems are becoming increasingly common and have a distinct advantage over other switchboards. Even though an outside line must be secured with a preliminary "9", the particular Centrex station's ANI would be forwarded through an advanced 911 system. It would be available for call-back and detailed ALI.

9. ALTERNATIVE SERVICE PLANS

Throughout the conduct of the study, the term "service plan" was used to describe the phone switching arrangements which would control the 911 call traffic flow. In particular, the service plan identifies where the first call answerer would be located for 911 calls originating from particular areas and how the call would be routed from there to where the dispatch would be made.

In order to evaluate a selective routing service plan with non-selective routing alternatives, it was necessary to determine the amount of mismatch that existed between the telephone company central office boundaries and the emergency agencies' jursidictional boundaries.

With the assistance of the phone company, a map of the county was constructed with the boundaries of both the emergency jurisdictions and the PT&T central offices serving them. Although the project was unable to get a tabulation of telephone stations by municipality and central office, a percentage breakdown was made from the map by a staff member quite familiar with the areas involved.[1] Questionable overlaps and areas that might not have any phones even if they did overlap were checked in detail against street maps and detailed central office maps. The problem was compounded by the phone company's practice of maintaining separate tariff and engineering maps. The former were the only publicly available maps and did not reflect the current switching network. Although they indicated that the Fruitvale Office served only Oakland, for example, a subsequent check found several hundred of the Fruitvale exchange's 32,000 numbers located in the city of Piedmont.

It was also necessary to identify those areas which would have the necessary telephone equipment to support selective routing by the time of a possible 1976 demonstration. The capabilities were known to exist in the East Bay exchange, which was the original Beta area, but additional ESS machines had been installed or were scheduled to be brought into operation since that proposal was made. After a prolonged review of their plant extension plans, PT&T announced to the Steering Committee that selective routing could be provided throughout Alameda County by 1976.

Selective Routing Service Plans

The most favored selective routing alternatives were relatively simple to identify after discussions with the Users Task Force. With extremely few exceptions, each municipality wished to receive its own 911 calls and either directly dispatch both police and fire or directly dispatch police and transfer calls for fire dispatch. The exceptions were those communities, not necessarily the smallest, which were

[1] See Figure 2.

considering consolidated dispatching for other reasons than an inability to answer their own 911 calls. The largest of these was the "Tri-City" area composed of Fremont, Union City, and Newark. The Fremont Police Department already performs several supportive services for the smaller Newark department and has many programs and projects in common with the Union City department. Similarly, the relatively isolated Valley cities of Pleasanton and Livermore have a strong commonality of interests and mutual emergency service concerns. Although each is principally served by a separate central office, they wished to pursue the possibility of a joint dispatching center in conjunction with several neighboring fire districts. The city of Berkeley and the University of California are also interested in investigating a joint 911 answering facility since there is a great deal of misdirected telephone traffic between these two jurisdictions.

The project office prepared additional selective routing alternatives which would consolidate the call answering/dispatching functions of smaller municipalities with each other and/or larger communities for the Steering Committee's consideration. Most followed the lines that would result from a major consolidation of municipalities into larger political units.

Non-Selective Routing Plans

To establish feasible service plans without selective routing, the composition of 911 traffic that would be handled by each central office was projected. For each central office, the municipality or jurisdiction with the majority of 911 traffic was considered to be the PSAP for that area. This most-fragmented approach resulted in ten PSAPs serving 15 jurisdictions and was identified as the basic Multiple PSAP Service Plan.

Each of the five jurisdictions which ended up without a PSAP under this plan happened to be completely served by a single PSAP. The three PSAPs which would receive those calls were given multi-jurisdictional identities and considered to be their serving PSAP.

PSAP	Located At	Also Serving
North Consolidated	Berkeley	Albany, Univ. of California
Oak-Emery-Piedmont	Oakland	Emeryville, Piedmont
Fremont-Newark	Fremont	Newark

The remaining seven were identified by the name of the jurisdiction served.

Each of the PSAPs under the Multiple PSAP Service Plan had two areas: an answering area made up of the central offices for which

it would receive calls, and a service area composed of the jurisdictions for which it would dispatch emergency assistance. (The assumption was made that direct dispatching could be performed for all functions and all served jurisdictions at the PSAP.) The amount of correspondence between the answering area and the service area varied widely for the PSAPs. The city of Alameda had complete correspondence between boundaries while the Union City PSAP would have to transfer more than 30% of its calls to the serving PSAP. (See tabulation on page 31.) Two deficiency variables were computed. 1) For the serving PSAP's citizenry, the portion of their calls which would require a transfer from another PSAP. 2) For the PSAP, the additional call answering required to handle misdirected calls. The greatest mismatches occurred for the PSAPs serving Hayward and the unincorporated part of Alameda County. The County PSAP would be making almost half of its dispatches from transferred calls, and Hayward would be transferring almost 30% of the calls it answered to other PSAPs. The North Consolidated PSAP had a high transfer workload, but most of these were destined for Contra Costa County and could not be reduced by consolidation within Alameda County. From a percentage standpoint, Union City had a greater transfer workload, but it involved only 14 calls a day.

Successively higher levels of consolidation were developed by the project office in order to (1) minimize the amount of secondary dispatch and transfer workload, and (2) reduce the number of PSAPs, particularly the low volume PSAPs which could be economically consolidated with each other.

Other possible consolidations involved jurisdictions which were known to have a high community of interest as evidenced by joint projects, mutual aid activity, and comments made during site visits. These plans involved groupings which could be made independently in many instances, e.g., two PSAPs in southern Alameda could be consolidated without affecting a potential consolidation in eastern Alameda County.

The highest level of consolidation involved a single PSAP which would answer 911 calls for the entire county, less the city of Alameda. (The city has been operating a 911 service for some time and has no mismatching boundary problems. They were not interested in any consolidation which could impair their present direct dispatching operation.) This completely consolidated service plan was identified as the Central PSAP plan.

These alternatives and their effect on 911 traffic flow were reviewed at several regional meetings with the city managers, service chiefs, and task force representatives of the communities to be affected. The city of Hayward, which had the greatest range of possible consolidations, was separately briefed.

Several reactions to the service plan alternatives were registered:

MULTIPLE PSAP TRANSFER TRAFFIC (DAILY)

ANSWERING PSAP	A Calls Rec'd From Answering Area That Must Be Transferred To Another PSAP	B Calls Rec'd From Answering Area That Can Be Dispatched Without Transfer	C Calls Transferred From Another PSAP for Local Dispatch	Total Calls Dispatched B + C	Percent of Transfer Dispatch for Citizens C/(B+C)*100	Percent of Additional Answering at PSAP A/(B+C)*100
Alameda	--	104	--	104	0	0
North Cons.	87	310	11	321	3.4%	27.9%
Oak-Em-Pied.	33	1,126	28	1,154	2.4%	2.9%
San Leandro	8	91	23	114	20.2%	7.0%
Uninc. Ala. Co.	16	109	103	212	48.6%	7.5%
Hayward	82	186	10	196	5.1%	41.8%
Union City	14	28	3	31	10.0%	45.2%
Fremont-Newark	4	247	3	250	1.2%	1.6%
Livermore	4	74	1	75	1.3%	5.3%
Pleasanton	9	28	2	30	6.7%	30.0%
AVERAGE					(9.8%)	(16.9%)
COUNTY AS A WHOLE	257*	2,303	184	2,487	7.4%	10.3%

* Includes 73 calls to be transferred to Contra Costa County.

1. As anticipated, all of the municipal representatives expressed strong preference for a selective routing system which would avoid any transfers.

2. Among the more cohesive jurisdictions, consolidation on a local level was preferred to centralized county answering.

3. The higher the level of consolidation, the less willingness to give up the dispatch function as well as call answering.

4. There was better reception to consolidation among fire service organizations than police departments. This conformed to the general fire service attitude toward geographical consolidation but may also reflect a reluctance to have a rival department within their city answer their calls.

5. Municipal PSAPs with high transfer traffic between themselves and the Sheriff's Office under the Multiple PSAP plan were particularly reluctant to consolidate with the county on a piecemeal basis. Their police departments had their dispatching done by the Sheriff until relatively recently, and many who had fought hard to get their own dispatching operation were still bothered by prior experiences. Consolidation with another municipal PSAP, particularly one smaller than themselves, was preferred.

6. Several neighboring municipalities were interested in setting up regional fire dispatching centers that would be fed calls from individual municipal police PSAPs. This was particularly true for fire departments that were presently being dispatched by police operators or were so small that their call answering was economically burdensome.

Limited Selective Routing

It was apparent that there were several central office areas that were particularly troublesome and could use selective routing to much greater advantage. A set of service plans was developed based on limited selective routing for the Steering Committee's consideration.

These "limited" service plans were based on the Multiple PSAP plan and its various consolidated alternatives with routing applied to minimize the mismatches. This routing sometimes generated as a by-product the possibility of a small municipality having its own PSAP, even though larger municipalities were still consolidated.

It is important to note that the project office had no method of costing these alternatives or even judging how sensitive the selective routing costs would be to the number of central offices or subscribers involved.

One-Roof Call Answering

The possibility of a centralized "one-roof" service plan was briefly considered by the project during the early months. The 911 call answering, and possibly the dispatching operations of the various organizations, would be physically co-located at a central county facility but performed by personnel from the served jurisdictions. Internal Selective Routing would be used to direct calls to the proper answering consoles while back-up answerers and language translators could be pooled. It had the advantage of facilitating mutual aid operations and shortening the data communication links to a central computer.

The "one-roof" approach was considered acceptable by the fire districts, the smaller fire departments, and the County Division of Communications. It was opposed by the police departments and the cities in both its call answering and dispatching form. With one-roof call answering, the departments would be unable to pool their 911 answering with their non-emergency and administrative call workload. One-roof dispatching would require extensive voice and radio links between the dispatch facility and the various departments -- more than enough to offset any data communication savings. Since either form would require selective routing, the approach was regarded as a needless compromise of their operational autonomy and was not endorsed by any of the cities.

The project office presented fourteen possible service plans at the Steering Committee's January meeting. These consisted of five with no selective routing, five with limited selective routing, and four with maximum selective routing, including a one-roof approach. A smaller set of each was identified as the more feasible, and it was recommended to the committee that at least one or two of each category be priced by the telephone company as part of a further evaluation.

The phone company felt that three plans were the maximum it could price within the study time constraints and recommended the costing of one from each category. After the Steering Committee showed divided preference between the most decentralized and completely centralized plans of the alternatives with no selective routing, it was agreed to price both the Multiple PSAP and the Central PSAP plans and forego costing the limited selective routing alternatives. The most decentralized of the plans involving selective routing was selected as the third plan on which the project should concentrate.

10. COMPARATIVE CALL ANSWERER MANNING REQUIREMENTS

From among the variety of service plans advanced, it was decided, for reasons mentioned elsewhere in this report, to evaluate three systems, and their variants, in detail. These systems were: (1) Selective Routing of 911 calls via the telephone company switching system to fifteen separate answering points; (2) routing of 911 calls via the telephone company central offices to ten Multiple PSAPs; and, (3) routing of all 911 calls to a Central PSAP. The Selective Routing alternative, which is schematically shown in Figure 3, involves the least amount of secondary handling of calls since, prior to reception by the PSAP, they would have been automatically switched to the proper PSAP. The Multiple PSAP alternative shown in Figure 4 and the Central PSAP alternative shown in Figure 5 both involve a significantly greater amount of secondary call handling.

Assumptions

In order to properly evaluate the service plans under consideration, it was necessary to forecast the expected 911 call volumes to be handled by each answering point, to deduce the expected call processing time on the part of the answerers, and to use these values to arrive at a projected level of manning for each answering point. In the light of the complexity involved in the various service plans, it was necessary to keep focused on the basic task of fairly evaluating the significant differences between the service plans being considered. Consequently, a number of assumptions were made as to how each plan would function which, whether or not conforming to a real-world situation, do allow for equitable comparisons:

1. Use of Emergency Line Traffic. The number of 911 calls which could be anticipated was one of the most difficult variables to establish. This was in part due to the sketchy records available from the various dispatching agencies, but also to the differences of opinion among the call-answering personnel in the various agencies as to which calls should be considered "911" calls. The Users Task Force unanimously agreed that 911 should be used for the hard-core, life-or-death, seconds-are-vital emergency calls, but opinions as to which additional calls should also be considered "911" calls varied widely.

   In the two very successful 911 installations visited by the staff, calling 911 was also the principal means of summoning any sort of police presence. In both cases, more than 80% of the police dispatches were the result of 911 calls.

A spokesman for one installation strongly encouraged a loose 911 criteria saying, "I sometimes wish the word 'emergency' was never invented." In the other agencies in these same areas, particularly those not operating their own communication center, a much smaller portion of their activity was initiated by citizens calling 911. Like the other suburbs served by Omaha's system, Bellevue, Nebraska, carries an alternate seven digit emergency number in the front of the phone book and less than 15% of their assignments are initiated as a result of a 911 call. It should be noted that California legislation specifies that 911 will be the primary emergency reporting number and will be advertised as such.

In consultation with a number of emergency answering center officials, the staff chose the current emergency line traffic as the basis for evaluating alternative service plans. Such existing emergency number traffic reflects the variations in local "emergency" criteria, variations which will not necessarily disappear after the implementation of a 911 service. It was thought to be a more readily available measure for the project's use. And it was felt that all current emergency traffic would, in fact, shift to the 911 lines once they were available.

2. Ignoring Administrative Calls. It should be pointed out that the computation of call answering requirements solely on the basis of 911 calls ignores the manning required for answering administrative and non-emergency calls. This modeling simplification is justified since those calls would have to be answered by the dispatching agency under any of the service plans and the purpose of the model was to compare the relative manning requirements. Unquestionably, the present call answering resources of some agencies will have to be increased to comply with 911. Some are presently so undermanned that the telephone company operator has difficulty in getting an answer when transferring an emergency call to the agency. For others, just the modest increase in incident reporting that always accompanies a 911 installation will require additional call answerers. Again, this is a consequence of having 911 of any variety.

3. Duplicative Call Answering. The centralized call answering requirements, where that option was considered, were thought of as being in addition to the local agency answering requirements (except for the savings a police department would realize in not having to bother with fire calls). This duplicative answering might be considered to omit certain local manpower savings that would occur under a centralized answering approach if a 911 call could be transferred directly to the local dispatcher

and not be routed through a local call answerer. In point of fact, this call-answering is not redundant in agencies so small that the call answerer is also the dispatcher. In organizations big enough to have separate call answerers, the dispatcher does not take calls, but concentrates on radio control. Although some departments have a technical capability of transferring calls directly to the dispatcher, this is principally for show and very rarely used. At most, the dispatcher will monitor a call when signaled by the answerer in order to get an address. It is, therefore, reasonable to assume that transferred 911 calls would be similarly treated and not result in any answerer savings at the dispatching facility.

Call Answerer Analysis Model

Queuing theory was used to derive the basic set of equations employed in evaluating differences in service as the call volumes, call processing times, and number of servers varied. The equations are as follows:*

$$P(o) = \left[\sum_{n=0}^{s-1} a^n/n! + ((a^s/s!) \times (1 - a/s)^{-1})\right]^{-1}$$

$$P(GTO) = P(o)\ a^s/s!(1 - a/s)$$

$$P(GTt) = e^{-sut(1 - p)}[P(GTO)]$$

$$P(WGTt) = e^{-sut(1 - p)}$$

where

P(GTO) = the probability that <u>any</u> call waits

P(GTt) = the probability that any call waits more than <u>t</u> seconds

P(WGTt) = the probability that, given a call waits, it waits more than <u>t</u> seconds

s = the number of call answerers

m = the number of calls received per minute

u = the number of calls processed per minute

a = m/u and p = m/su

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* see "Introduction to Operations Research" by Frederick S. Hillier and Gerald J. Lieberman (San Francisco: Holden-Day, 1972).

also see Appendix F.

A program was written which calculated these probabilities as the number of servers varied from 1 to 20, the call processing time varied in 5 second increments from 5 to 200 seconds, and the call arrival rate varied per the expected call volumes.

It must be noted that the equations used assume that the distribution of call arrivals per unit time was Poisson, i.e., that the distribution of interarrival times is exponential and that the distribution of call processing times is exponential. A test was conducted at the Oakland Police Department Communications Center to measure the interarrival times of incoming calls on their seven incoming emergency lines. The data collected for four separate eight-hour intervals was then graphed to show the distribution. Reference to Figure 6 shows that the actual distribution closely approximates a true Poisson distribution. Since the differences between assuming that the distribution of call processing times is constant or exponential are insignificant for the 911 study purposes as is shown by Appendix F , it was felt to be safe to use the assumption that they were exponential.

Call Volume Estimates

Initially, an estimate of the expected 911 call volumes at the police departments was made by comparing the Part I crime rates and 911 call volumes in Alameda City, Omaha, Seattle, and New York, where 911 systems are already in place; with the Part I crime rates in the cities of Alameda County other than Alameda City. Figure 7 is a graph of the results which were used as a very rough, though useful, estimate.

Starting on November 7, 1973, the incoming calls on each of the seven emergency lines, five non-emergency lines, and three business lines at the Oakland Police Department were counted on an hourly basis for a total of thirty-three days. These lines are reserved for incoming calls only and, while efforts are made to prevent the practice, emergency calls do come in on the non-emergency lines and vice-versa. For this data gathering, a line counter leased from the telephone company and installed at the communications center was utilized.

During the latter part of this same period, the telephone company installed counters at their central offices on the emergency incoming lines and counted the number of incoming calls. The comparative results of this dual data collection were as follows:

Date	Count at Oakland PSAP	Count at Telephone Central Office	Percentage Difference
November 28	529	646	22.1
November 29	551	657	19.2
November 30	622	696	11.9
December 1	874	1,026	17.4
December 2	725	819	13.0
December 3	709	920	29.8
December 4	575	753	31.0
TOTAL	4,585	5,517	20.3

The 20 percent difference between the two sets of figures invalidated the telephone company's technique of gathering call volumes from the central offices. This was particularly unfortunate in light of the fact that the telephone company had used this technique on all of the emergency lines for all the agencies in the county. However, it was fortunate that a dual data collection was made and the error discovered.

In the hope that a correlation could in some way be found between the telephone company data and that collected at the PSAP, an experment was set up whereby incoming calls to the Fremont Police Department would be counted manually at the department and at the central office. In case no correlation could be found, the data collected in Fremont would be useful in estimating 911 call volumes. No correlation was found as Figure 8 shows and, while various people hazarded guesses as to the cause, no clear explanation for the telephone company overcounting has been found.

The consequence of the call volume counting effort was that the project had accurate volumes for Oakland in December (615) and Fremont in January (154). These two cities account for 44 percent of the population and 53 percent of the Index crimes in the county; and, whereas Oakland is a typical inner city, Fremont is a typical, rapidly growing suburb. The task was to project the call volumes for the rest of the county. The following procedure was employed.

The percentage distribution of population by municipality was compared with the percentage distribution of Index crimes by municipality and the latter, since it more accurately reflects the social

problems and, thus, the social conditions which would result in a call for emergency services, was chosen as the factor to use in distributing call volumes among the cities and unincorporated county areas.

Fremont's ratio of emergency calls to index crimes was slightly greater and still produced calls/capita rates significantly less than frequently cited. It was therefore adopted and the results further adjusted upwards 55% for the following reasons:

30% because the sample was taken at the end of January, a very low volume month for dispatch activity.

15% to account for the effect of adding fire and ambulance calls.

10% due to anticipated increases because of the increased general utility of 911.

In the case of nine of the fourteen jursidictions, an additional 5 or 10 percent was added because of the peculiarities of the local municipality. Figure 9 shows the results and compares the projected 911 calls/day with the planning figure of 2.5 calls/1,000 population recommended by Seattle.

These conservative call volumes were then used to project the call volumes to be expected with the three service plans (Selective Routing, Multiple PSAPs, and Central PSAP) at each of the answering points. Figures 10, 11, and 12 show the results of these allocations. At the same time, using the following ratios based on previous call volume studies in Oakland, the watch volumes and busy-hour-during-watch call volumes were derived.

First Watch Volume (001 - 0800) = 23% x Daily Volume

First Watch Busy Hour Volume = 25% x First Watch Volume

Second Watch Volume (0801 - 1600) = 30% x Daily Volume

Second Watch Busy Hour Volume = 21% x Second Watch Volume

Third Watch Volume (1601 - 2400) = 47% x Daily Volume

Third Watch Busy Hour Volume = 18% x Third Watch Volume

The differences between the total for the Selective Routing plan (2,895) and the total for the Multiple PSAP and Central PSAP plans (2,969) is explained by the fact that the latter two plans involve receiving and transferring calls for the adjacent Contra Costa County.

Call Answering Performance

One of the mandatory standards issued by the State of California's General Services Division concerned the call answering performance to be provided at a PSAP. It is as follows:

> "During the average busy hour of each shift of the busy day, all calls will be answered within 10 seconds. To meet this standard, consideration must be given to the number of 911 lines, answering positions, and call processing time, etc."

While reviewing the draft of their standard, the project pointed out that a standard specifying "all calls" was not a suitable one for queuing analysis. Some probability measure, no matter how high, was required. Despite considerable discussion and a temporary reconsideration, the standard was issued as noted. The project staff, therefore, adopted the probability standard that at least 90% of the calls would be answered within ten seconds. It should be noted that since an integral number of servers had to be selected, the resulting performance was well above 90% in almost all cases, and better than 99% for the smaller PSAPs on every watch with every service plan.

Call Processing Times

At the same time that the call volumes were being collected in Oakland and Fremont, call processing times were also collected. Call processing time is distinguished from call talk time in that processing time is the total time the answerer is unavailable to answer another incoming call due to being tied up with the record-keeping activities related to the call being serviced. Talk time is the time actually on the line and may be used for computing circuit requirements but not manning requirements. Figures 13 and 14 show the results of the data collection effort.

In the case of Fremont, the average processing time for a sample of 51 calls on emergency lines was 87 seconds; while in Oakland, with a sample of 429 calls on emergency lines, the average processing time was 115 seconds. For the purposes of the 911 study, an average call processing time of 100 seconds was selected.

It was assumed that a call could be transferred from a central PSAP to a secondary PSAP in considerably less time than it would take to fully process a call. Just how quickly was discussed with a variety of knowledgeable sources including TSPS telephone operators, supervisors of existing 911 facilities, and other police communication personnel. The State technical standards also specified that the transferrer had to stay on the line to assure that the connection was made and the conversation initiated. Several 911 facilities

noted that the caller frequently dropped off the line with the result that the dispatch had to be relayed despite a transfer policy. From these considerations, it was decided that a 45 second transfer time for a central PSAP was a reasonable estimate and that ten more seconds could be saved if ALI were available to assist the central call answerer in selecting the proper jurisdiction. Although the Multiple PSAP Service Plan would dilute the 100 second call processings with some 45 second (or 35 second) call transfers, the multi-server queuing model used could not readily accommodate such a mix of transactions. One hundred seconds was therefore also used in computing the Multiple PSAP manning requirements.

Manpower Computation

Using the tables generated in the analytical model; the distributed call volumes indicated in Figures 10, 11, and 12 ; and a processing time of 100 seconds except as previously noted; the call answerer requirements were developed for each watch and for each day. The manning requirements (number of call answering employees) were taken at 5/3 the daily requirements to allow for weekends, holidays, vacation, sick time, and other relief requirements.

The results show that for Alameda County, a central PSAP Service Plan with transfer dispatching would require approximately 10% more manpower than a Selective Routing Service Plan and 5% more than a Multiple PSAP Service Plan.

Service Plan	Manning Required*
Selective Routing	211
Multiple PSAP	223
Central PSAP	234

It must be re-emphasized that the assumptions made and the techniques employed had as their sole purpose the derivation of call volumes and manning requirements for comparing the three service plans and not to project actual manning which will depend upon actual volumes, actual processing times, and the answering policies of the individual PSAPs.

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*Does not include any supervisory or administrative personnel such as would be required at a new centralized 911 answering facility.

11. EVALUATION OF ALTERNATIVE ALI-SDSD METHODS

In addition to numerous service plans, a wide variety of technical alternatives were developed for providing ALI or ALI-SDSD information. Each had significant implications with respect to the issues of privacy, provision of SDSD, and performance. A preliminary evaluation of the approaches was made to the Steering Committee so that the least promising could be discarded. The balance of this section is that evaluation.

Six methods by which a 911 call answerer could receive ALI and SDSD were identified. These are schematically shown in Figure 15. All of the approaches, of course, assume that Automatic Number Identification (ANI) would be available at the answering centers (PSAPs).

In Approach A, the telephone company would retain all files and at the time a 911 call is answered, would transmit to the right answering station only ALI information. (It is estimated that among all the PSAPs, there would be up to 62 displays or computer terminals.) Approach B would, in addition to providing ALI data from the telephone company computer, provide SDSD information by routing the call through a government computer where the SDSD data would be appended to the message to be displayed at the answering position. In this latter case, the telephone company would retain the subscriber files while the government would maintain the SDSD data files. Approach C is the same as Approach B except that instead of using one central government computer to provide SDSD information, up to 14 local computers would be used to perform the same task. These local computers could be used for other tasks than adding SDSD information to 911 calls coming into the PSAP. Approach D is the same as Approach B except that the government would now have the individual subscriber files and the two separate computers would be combined into one. Approach E differs from D in that the 911 SDSD and ALI data is fed to a local command and control computer for additional processing. Approach F is the same as D except that the one central computer in D has been replaced by a number of local machines each of which would have to contain the subscriber files pertaining to the local jurisdictional area. It can be seen then, that three of the approaches (A, B, and C) allow the telephone company to retain the subscriber files while D, E, and F require the release of these files either to a central government computer (D and E) or to local PSAP machines (F).

It is possible to consider various combinations of these approaches once the basic question -- whether or not subscriber files will or will not be released to government -- has been answered. For instance, Approach D could be used by the smaller cities while the larger cities were using Approach E with their own local command

and control systems. Similarly, a combination of Approaches A, B, and C are all possible using the same telephone company computer system. However, for evaluation purposes, the study considered the systems to be separate.

The six approaches were evaluated along five different dimensions:

1. Privacy
2. Response time
3. Reliability and availability
4. Provision of SDSD
5. Operating cost

The first four are discussed below while cost was included as a part of the total system evaluation.

Privacy

There are five potential threats to privacy or confidentiality from a sophisticated 911 system with ALI-SDSD capabilities. They are:

1. Real time interface with other files of information that are not necessary for making an emergency response.

2. Release of a particular unlisted number.

3. Release of directory files or updates to mailing lists or salesmen.

4. Accumulating emergency telephone traffic information for improper subsequent use.

5. Release of proprietary telephone company installation records to competitors.

Several assumptions were made in evaluating these threats:

1. It is easier to exercise privacy control, policy, and practices over a central government computer than several local computers.

2. ALI-SDSD terminals connected directly to a central government computer can be for display only and with no means for initiating an inquiry.

3. Local computers are liable to be general purpose computers with other criminal justice or non-911 applications.

4. There is slight chance that residential names would be included with ALI data in the future.

5. Users would be more sensitive to loss of real-time services than loss of updates.

6. The telephone company has no internal privacy problems.

The following evaluations are intended to demonstrate the relative resistance to each threat of the various ALI-SDSD methods. A scale of 1 to 5 has been used with 5 being the maximum resistance and 1, the least. Weighting of the various threats has been purposely avoided, although they have been listed as a citizen might view their severity.

Approaches	Telephone Co. has files			Central Gov't. has files		Local Gov't. has files
	A	B	C	D	E	F
Threats						
Real-time interface with other files	5	4	2	4	2	1
Release of a particular unlisted number	5	5	4	4	3	2
Release of directory or updates	5	5	5	4	4	2
Accumulating emergency telephone traffic data	5	4	3	4	3	2
Release of proprietary TelCo installation records	5	5	5	4	4	4
	25	23	19	20	16	11

Response Time

The time for a call answerer at a PSAP to get a display of the relevant ALI-SDSD data will vary by the particular method employed. The minimum response time has been computed on reasonable assumptions concerning message length, computer processing time, and circuit speeds for the different methods.

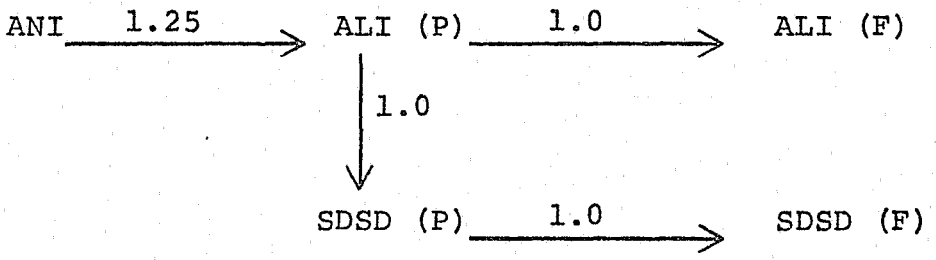
1. Data Message Length

   It is assumed that formatting of information to be displayed will occur at the last computer to process the ALI-SDSD message. All other transmissions will be packed and encoded to minimize transmission time. The lengths of the messages in eight bit characters are:

	Number of Characters Packed (P)	Formatted (F)
ANI (and position ID)	10	10
ALI	50	150
SDSD	25	50
ALI and SDSD	75	200

2. Computer Processing Time:

It is assumed that the greatest part of each computer's time will be required to access the files of directory of SDSD information. Since business numbers (25%) would require reference to separately stored names, 1.25 accesses are estimated to get packed ALI. Based on 20 ms (milliseconds) overhead for each computer and 40 ms for each access and associated processing, the following computer processing times would occur:



Computer Process	File Accesses	Time
ANI to ALI (F)	2.25	110 ms.
ANI to ALI (P)	1.25	70 ms.
ANI to ALI (F) + SDSD (F)	4.25	190 ms.
ANI to ALI (F) + SDSD (P)	2.25	110 ms.
ALI (P) to ALI (F) + SDSD (F)	3.00	140 ms.
ALI (P) to SDSD (P) to ALI (F) + SDSD (F)	2.00	100 ms.

3. Transmission Time:

It is assumed that data circuits will have the following speeds employed between the different equipment facilities (baud = bits/second):

PSAP to central computer	1200 baud
PSAP to local computer	9600 baud
Local computer to display	9600 baud
Central computer to display	2400 baud
Central computer to local computer	2400 baud
Central computer to central computer	4800 baud

This results in the following transmission times in milliseconds:

ANI at 1200 baud: 66 ms; at 9600 baud: 8 ms;
ALI (P) at 2400 baud: 165 ms; at 4800 baud: 83 ms;
ALI (F) at 2400 baud: 495 ms;
ALI (P) + SDSD (P) at 2400 baud: 248 ms;
ALI (F) + SDSD (F) at 2400 baud: 660 sm; at 9600 baud: 165;

4. Response Time:

Based on the above assumptions, the minimum response time for presenting an ALI-SDSD display would be:

Approaches	A	B	C	D	E	F
Phone to 1st computer (ms)	66	66	66	66	66	8
Processing (ms)	110	70	70	190	110	190
To 2nd computer (ms)	-	83	165	-	248	-
Processing (ms)	-	140	140	-	100	-
To display (ms)	495	660	165	660	165	165
Response Time in Seconds	.671	1.019	.606	.916	.689	.363

These times do not reflect the contention on the network from simultaneous 911 calls nor contention at the computers with any other processing that might be required. Nevertheless, since each circuit or dedicated computer

would be idle at least 93% of the time during the average busy hour, contention would not significantly affect the results.

SUMMARY:

All of the approaches would provide response times well below the 2 seconds set as a reasonable design goal.

Reliability and Availability

The reliability of the ALI-SDSD sub-systems is the cumulative unreliability of the various links in the processing chain. Since no computer or communication circuit is 100% reliable, adding it to an information system will reduce overall reliability. The telephone company has suggested .98 as a reasonable reliability factor to use for data circuits. That means that at any point in time there is only one chance in fifty that a particular circuit will fail in the succeeding 24 hours. The Aerospace Corporation has projected a reliability of .981 for a minicomputer supporting the ALI function using redundant file storage. Assuming that equally reliable computers and data circuits are available to the telephone company, the county government, or local PSAPs, the following table shows the relative reliability of the various approaches:

x = computer reliability = .981

y = point-to-point reliability = .98

Approaches	A	B	C	D	E	F
# of computers (x)	1	2	2	1	2	1
# of circuits (y)	2	3	2	2	2	0
Formula	xy^2	x^2y^3	x^2y^2	xy^2	x^2y^2	x
Reliability	.942	.905	.923	.942	.923	.981

Approaches A and D show identical reliability because they involve the same number of computers and data circuits to process an ALI request. Similarly C and E are the same but less reliable because of the addition of a local computer at the PSAP. Approach B is the least reliable and would fail 35 times a year without considering display terminal failures which are assumed equally likely to fail under each approach.

The availability of the system is more important to the users than reliability since it determines how much of the time the system can be used. This depends upon how long it takes to repair a failure as much as upon the frequency of failures. Availability of the various approaches was projected on the assumption that the mean time to repair would be 1.0 hour for any circuits, 1.0 hour for a central telephone company computer, 4.0 hours for a central government computer, and 8.0 hours for a local computer.

Approach	A	B	C	D	E	F
Hours lost to circuit outage/year	14.6	21.9	14.6	14.6	14.6	0
Hours lost to computer failure/year	6.9	55.0	103.1	48.1	144.3	96.2
Total hours lost/year	21.5	71.9	117.7	62.7	158.9	96.2
Availability	.9975	.9918	.9866	.9928	.9819	.9890

If a generous four hours a week were allowed for terminal outage, the resulting availability would be:

.974	.968	.963	.969	.958	.965

SUMMARY:

Although the reliability of Approach F is significantly higher than all of the other approaches, its availability is less than A, B, or D. There is only .016 spread in availability between all of the approaches and all meet the .95 availability that the Users Task Force accepted as a reasonable goal.

Provision of SDSD

The capability of providing SDSD was assessed for each of the methods as follows:

Approaches		Evaluation
"A"	Method A has no capabilities for providing SDSD of any variety or on any basis. If the telephone company retains the directory files, Methods B or C must be used for any SDSD.	WORST
"B"	Method B would certainly have at least zonal SDSD for the entire county on the central government computer. If number-related SDSD were included and inquiry access provided, the user terminals would still not have access to the directory files.	BEST
"C"	With this method or in conjunction with Method A, SDSD would only be available to those PSAPs planning a computerized command and control system, since SDSD itself would probably be insufficient justification for a local computer. A small PSAP could contract SDSD support from a large automated PSAP (e.g., Piedmont and Oakland), but this is a variant of Method B.	FAIR
"D"	This method could provide the same SDSD as Method B, but inquiry access would involve the computer with the telephone directory files. For this reason, it is considered less desirable than Method B.	GOOD
"E"	With zonal SDSD on the central computer, a smaller local computer could provide number-related SDSD and the other command control functions justifying it. In this case, inquiry access would not involve the computer with the telephone directory files but would limit number-related SDSD to large PSAPs.	FAIR
"F"	This method has the same liabilities as Method C and no basis for any SDSD standardization. A PSAP might use its present police beats as the framework for aggregating SDSD and the cost of subsequent modification might inhibit change.	POOR

While no single approach was, as a result of this evaluation, singled out as being clearly superior to all others, certain conclusions were reached. Because of the feeling that to release telephone subscriber files to government would increase the potential for misuse of those files, approaches involving such release (D, E, and F) were discounted.

Two potential systems then remained to be evaluated: Approach A, which provides ALI information only; and Approach B, which provides both ALI and SDSD information. It was felt that both of these approaches should be costed and considered in the final evaluation of 911 systems.

Approach C involved increased cost due to the number of computers required for the various PSAPs. It had a slightly greater privacy threat than B and as only three municipalities were even considering a computerized dispatching system, it was withdrawn from further consideration.

12. PHONE AND DATA SYSTEM COSTS

The procedures for arriving at the costs for the several alternatives were complicated by the variety of the systems under consideration. Consequently, the costing efforts were divided among the project staff, the telephone company, and the Aerospace Corporation. The project office undertook the costing of the data processing system and data network which would be required to support the approaches involving ALI and SDSD information. The telephone company provided the costs for selective routing, for the provision and display of ANI, and for the equipment necessary to interface the ALI-SDSD system with the rest of the network. The Aerospace Corporation provided component costs estimates in support of the project staff's assignment and costed an alternative selective routing-ALI-SDSD approach which would not involve using a telephone company ESS for selective routing.

Within their area of costing responsibility, the telephone company refused to provide detailed breakdowns of their total figures. Instead, they provided a lump initial and monthly recurring charge for each of the system alternatives priced. These quotes were ostensibly based on actual costs and included no allowance for: development of special equipment, return, equipment replacement, or cost of working capital. They did not include the agencies' existing station equipment costs and represented the increased cost of adding the advanced ANI features to those phones, call directors, etc. Exceptions to the cost basis pricing were basic 911 alternatives for the Multiple and Central PSAP approaches. These were quoted according to the established policy of not charging the user for inter-office facilities, etc., for basic 911 systems.

The phone company accepted as inputs the project office's volume estimates for the various PSAPs, the level of service required between primary and secondary offices, and the ANI's display and transfer requirements. The estimates of the ALI-SDSD costs made by the project office were accepted by the telephone company as being their estimates also (within 20%) for those alternatives wherein the telephone company would provide the ALI information. The equipment costs for the ALI-SDSD network were based upon figures generated by the Aerospace Corporation. These data network costs were, to a great extent, independent of the particular service plan under consideration since the ALI-SDSD information would have to be available at the dispatching agency, no matter how the calls were routed.

The software development costs were prepared by the project office and based on the assumption that the work would not be done by a contractual software firm, but most likely by Alameda County under the direction of somebody thoroughly conversant with the system concept, the proposed file structures, etc.

The Aerospace Corporation had been asked to investigate the possibility of accomplishing the selective routing task with a special telephone switch toward the end of the project. This alternative, known as the Distributed Voice/Data approach, was included as an alternative in both its ALI and SDSD form.

Aerospace provided the telephone and data system costs to the project office. The estimates of recurring telephone costs were subsequently adjusted upwards by the project office to make the number of circuits and other capacities comparable to the advanced PT&T systems under consideration.

The one-time and recurring charges for the various telephone and data processing components of the alternative systems are given in the Table 2.

13. FINAL EVALUATION OF 911 ALTERNATIVES

The alternatives to be evaluated consisted of sixteen combinations of service plans and capabilities for providing information. The alternatives were labeled with a combination of the two key characteristics:

Service Plan

A. Selective Routing -- the automatic switching of 911 calls according to municipal and unincorporated jurisdictional boundaries without concern for telephone switching boundaries.

B. Multiple PSAPs -- the routing of 911 calls originating within a group of telephone central office areas to one of ten regional public safety answering points. At the PSAP, a direct dispatch is made 75 percent of the time. In the remaining instances, the call is transferred to either a decentralized dispatching facility or, to compensate for boundary mismatch, another dispatching agency.

C. Central PSAP -- the receiving of all 911 calls at a central Alameda County 911 answering facility for subsequent transfer to the correct dispatching agency on the basis of function and geographical jurisdiction.

Information Capabilities

A. Basic -- the receipt of a 911 call without any additional information than that the caller dialed 911.

B. Enhanced -- the identity of the call's general area of origin (telephone central office area) and the ability to hold the call for tracing purposes. These features are presently available for 911 and not considered "advanced".

C. ANI -- automatic display at the PSAP of the seven digit calling number.

D. ALI -- Automatic Location Identification.
The automatic display of the 911 calling phone's installation address and, for non-residential numbers, the subscriber's name. All ALI systems have ANI capabilities.

E. SDSD -- the display of Supplementary Dispatch Support Data in addition to the ALI and ANI information at the call answering position.

A Selective Routing Only system was also evaluated. It would not have any information display capabilities. Due to switching limitations, called party hold is not available with a selective routing system.

Two additional systems were based on performing the selective routing and the ALI-SDSD processing functions at a single Distributed Voice/Data facility: a DV/D ALI system and a DV/D SDSD system. For purposes of the evaluation, the very questionable assumption was made that PT&T would be willing to operate a DV/D ALI facility for an Alameda County trial. The DV/D SDSD system would have to be operated by government.

Five parameters were compared in analyzing each of the sixteen alternatives. The parameters and the weighting of each are:

Utility Value	25%
Net Cost	24%
Privacy	20%
Reliability	16%
Jurisdictional Consideration	15%

Each is described below and tabulated in Table 3.

The weighting of the diverse parameters was recognized as being highly judgmental, as was the scale used in establishing component scores. Originally, reliability was also assigned 15% (and Cost 25%) but was increased to 16 so that the component scores could be added directly without weighting.

Utility Value

All of the alternatives have the significant threshold value of providing a single easy-to-remember number for summoning emergency assistance. Five additional utility capabilities have been identified and assigned 25 points as indicated.

A. Audit Trail -- 3 points maximum

The called party hold feature of enhanced 911 will provide an audit trail for identifying the origin of false alarms and other malicious 911 calls. To use it, the line must be held open and PT&T asked to make a trace. Systems with ANI greatly facilitate this function and are given the maximum points. A minimum audit value is given to a Selective Routing Only system since PT&T could log the origins of calls passing through their switch in support of particular investigations.

B. ANI Display -- 10 points

Provision of the calling number to the public safety call answerer and the dispatching organization permits the calling back to correct incomplete or inaccurate information; allows low priority 911 calls to be returned later with greater confidence; facilitates record-keeping; and in the case of exceptional emergencies, the caller's address can be determined within a few minutes. For this reason, systems with ANI are assigned 10 points in addition to the maximum audit score.

C. ALI -- 7 points

ALI provides the caller's location for rapid dispatch to incidents in progress; early recognition of multiple calls on the same incident; reduction in transcription errors and confusion with similar sounding addresses.

D. SDSD -- 3 points

Provision of zonal SDSD will facilitate the dispatch process, particularly for larger and growing cities, and will assist in directing field units to unfamiliar locations. Since the government computer required for SDSD could be queried by call answerers and dispatchers, it could facilitate retrieving information on recent calls.

E. Management Reports -- 2 points

The SDSD systems also permit the economical capture of 911 call traffic data for resource allocation and other public safety management purposes. A similar but less accessible or flexible capability exists if the only on-line computer is operated by the telephone company. Since this would be the case with ALI systems, they are given 1 point.

Net Cost

For comparison purposes, cost is taken to be composed of three elements: (1) 8% of the initial cost divided by 12 (monthly interest on capital investment); (2) monthly charges for the telephone and data system; and (3) the monthly cost for answering personnel beyond the minimum required. The latter was computed on an average call answerer cost of $1,200/month. A maximum of 24 points was allocated to the least expensive alternative (Multiple PSAPs Basic: $18,322) and 0 points to the most expensive (Central PSAP SDSD: $58,380). The remaining alternatives were allocated points to the nearest tenth by interpolating their net monthly cost between the two extremes.

Privacy Aspects

There are two privacy aspects to be considered: the right, if any, of a 911 caller to remain anonymous, and the safeguarding of general telephone subscriber information from misuse.

A. Caller Privacy -- 5 points

As noted previously, the capability of holding a call for trace purposes, the display of ANI, and the display of ALI must all be regarded as less private systems than the basic 911. Similarly, the provision of supplementary dispatch support data (even zonal) must be considered less private. Caller privacy has been given the following weights:

No Display	5
Enhanced	4
ANI	3
ALI	2
SDSD	1

B. Subscriber Privacy -- 15 points

The privacy loss to subscribers in general is a far greater threat since it involves all telephone subscribers and not just those choosing to make a 911 call. Some have argued that a real-time retrieval system within the telephone company is itself a significant privacy threat. Nevertheless, that capability is regarded as a minor risk in this evaluation and given 14 points. The big subscriber privacy risk occurs in systems requiring advance provision of directory data to a government-operated computer system. Almost all SDSD approaches have been configured with multiple computers to avoid this threat and have been given the same subscriber privacy rank as ALI (14). The exception, a distributed data/voice system operated by government, requires directory files for selective routing as well as ALI. For that reason, it has been assigned the very low subscriber privacy value of 5.

Reliability

Assessing the relative reliability of the alternatives is extremely difficult because of the many uncertainties and the many unknowns involved. For the purpose of this analysis, much greater weight is given to the reliability of the voice communication system than to the ANI-ALI-SDSD system. Being able to get a 911 call to a public safety answering point is considered three times as important as the reliability of the data system.

A. Voice Switching Reliability -- 12 points

1. Configuration Reliability -- 3 points

The greater the number of switching operations required in routing a 911 call from a subscriber to a PSAP, the greater the number of circuits and switching facilities susceptible to malfunction. The systems with neither selective routing nor traffic concentrators involve only one switching operation and two circuits. The others require two switching operations and three circuits. Therefore, the advanced and enhanced approaches for multiple and central PSAPs are ranked higher from this standpoint (2).

From a reliability standpoint, the systems which require an additional manual transfer to the dispatching agency are also dependent upon transfer circuits in the PSAP's station equipment. Although selective routing and multiple PSAPs are roughly comparable with respect to this arrangement (13% and 25% of 911 calls transferred), central PSAP systems require 100% transfer and are ranked a point lower because of it.

2. Equipment Reliability -- 5 points

The relative reliability of the equipment to be employed is very difficult to assess. The ESS switch to be used in the selective routing approach (specifically, the #1 two wire variety) had a design goal of two hours down in 40 years of operation. Over 450 have been installed and cumulatively have provided over 1500 years of everyday telephone switching services throughout the nation.

Aside from the software changes, the modifications to the ESS switchers would consist only of increasing the amount of permanent and semi-permanent storage capacity. It would not involve any new components that have not already received extensive operational use. Bell Laboratories, which designed the ESS and discarded the idea of a special switch, is generally recognized as the foremost reliability engineering organization in the world.

The alternative selective routing approach would employ a recently developed electronic commercial switch with a designed reliability of 14 years mean time between failure. It has considerable reliability designed into it by virtue of redundant circuitry and other advanced technology developed for military and aerospace systems. Although the major components of such a switching system are readily available, the principal suppliers of the voice switch do not have a similar system yet in operation.

In evaluating the reliability of the two types of electronic switching equipment for a demonstration project, heavy weight is given to the proven performance of the ESS.

3. Maintenance Responsibility -- 4 points

System availability is not only dependent upon reliable equipment and circuits, but also upon the capabilities of the maintaining organization to quickly locate problems and take corrective actions. The telephone company would have an advantage in this regard, particularly with respect to calamitous natural disasters that might knock out a critical central switcher. The amount of knowledgeable and technical resources which it could focus on system restoral would be impossible for government or industry to match.

A distributed data/voice system operated by the phone company is ranked between the two extremes to reflect the uniqueness of the switching equipment they would be maintaining. (2 points)

B. Reliability of the Data Information System -- 4 points

1. Aside from the distributed voice/data approaches, the ANI, ALI, and SDSD data features represent increasing complexity and unreliability.

SDSD requires a TelCo computer, a government computer, three data circuits, and a CRT display. The two computer approach would divide data network responsibility between government and the telephone company. Somewhat offsetting this would be the availability to a central customer of autmated performance records. It is given the lowest reliability rank. (1)

ALI would not require a government computer and only two data circuits. (2)

ANI would not require any computers, data circuits, or CRT displays. It would have the highest reliability rank. (4)

2. The distributed voice/data approaches should provide greater data reliability than the ESS approaches because of the simpler data flow and the earlier capture of ANI. Both ALI and SDSD require the same network configurations and would consequently have the same data system reliability. The consolidation of the selective routing and ALI-SDSD processing functions in the same minicomputer would make the testing and

maintenance of data programs more difficult to perform. Nevertheless, a higher data system reliability is assigned to the distributed voice/data approaches. (3)

3. All 911 systems without data features are given the same maximum weight as an ANI approach. (4)

Jurisdictional Considerations

As a premise, it is assumed that it is most desirable for a citizen to reach his own jurisdiction without a transfer. Not only does it lodge responsibility for handling the call with his own municipality, but it keeps all of the decision-making at that level. What should or should not be accepted as a 911 call would be decided by the local public safety agency and people more knowledgeable about the prevailing availability of resources. Even if the municipality elects to have a decentralized fire dispatching operation, a local call answerer is in a better position to coordinate multi-function responses to incidents than a central call answerer. From the standpoint of political acceptability, the selective routing approaches rank extremely high. All of the operating organizations contacted in the course of the study have expressed preference, sometimes extreme, for selective routing. For this reason, the selective routing approaches are assigned a maximum of 15 points.

The government-owned voice switcher is assigned one less jurisdictional point because that voice switching equipment would impose a slight additional interjurisdictional dependency.

Most, but not all, of the public safety organizations and municipalities contacted prefer a multiple PSAP system over a central PSAP system. This would result in direct dispatching for approximately 75 percent of the calls, and for some cities, as much as 98 percent. Nevertheless, it would require multiple intermunicipality dependencies between neighboring cities. For this reason, the multiple PSAP approach has been allocated only slightly more jurisdictional points (6) than a central PSAP approach (4).

Analysis, Findings and Recommendations

The resulting cumulative scores range from a low of 48.1 (Central PSAP Enhanced) to a high of 77.9 (Selective Routing ANI) with an average and median of 64.* When organized according to service plan, several relationships become apparent.

	Basic or Only	Enhanced	ANI	ALI	SDSD	Average
Selective Routing	72.6	----	77.9	74.9	75.4	75.2
Distributed Voice/Data	----	----	----	74.6	64.8	69.7
Multiple PSAP	64.0	66.5	66.0	63.0	63.5	64.6
Central PSAP	50.2	48.1	54.8	56.1	56.0	53
Average	62.3	57.3	66.2	67.2	64.9	

Evaluation Scores Arrayed By Type

The multiple PSAP systems as a group and individually rank well below their selective routing counterpart. The central PSAP systems are the worst in each classification. Even if the jurisdictional disadvantage of multiple and central systems were omitted from consideration (9 and 11 points respectively), these relationships would be unaltered.

Finding #1. A selective routing system is much preferred for Alameda County over a central PSAP or even a multiple PSAP system.

Among the systems with selective routing capabilities, the Distributed Voice/Data SDSD is clearly the most inferior.

Finding #2. Alameda County should not go into the emergency telephone switching business.

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*See Table 3.

The following table shows the remaining five systems and their component scores as a deviation from their average. Jurisdiction has been omitted since all five have identical scores.

System		Utility	Cost	Privacy	Reliability
Selective Routing:					
(77.9)	ANI	-3.2	3.0	1	2
(74.9)	ALI	4.8	-4.0	-1	0
(75.4)	SDSD	8.8	-4.5	-2	-1
(72.6)	ONLY	-15.2	7.7	3	2
Distributed V/D:					
(74.6)	ALI	4.8	1.3	-1	-3

Component Deviance of Top 5

Although there is only a 2.5 total point spread between the ranking Selective Routing ANI and the second place Selective Routing SDSD system, they differ by 12 points in estimated utility value. The ALI system, which technically is a necessary intermediate step, ranks behind them. If privacy were ignored or scored differently, the ALI, ANI, and SDSD systems would all be within a fraction of a point of each other.

Finding #3. Although this exercise identifies Selective Routing ANI as the optimal system, there is no clear basis for selecting it over an ALI or SDSD system.

This last finding clearly endorses the original proposal of a pilot implementation and an actual evaluation of the various alternatives. It was recommended to the Steering Committee that a phased implementation of a Selective Routing SDSD system be undertaken with LEAA funds and that the phases be of sufficient duration to allow an operational evaluation of the ANI and ALI capabilities.

The Steering Committee reviewed the final Evaluation of Alternatives and unanimously concurred in the recommendation.

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FIGURES
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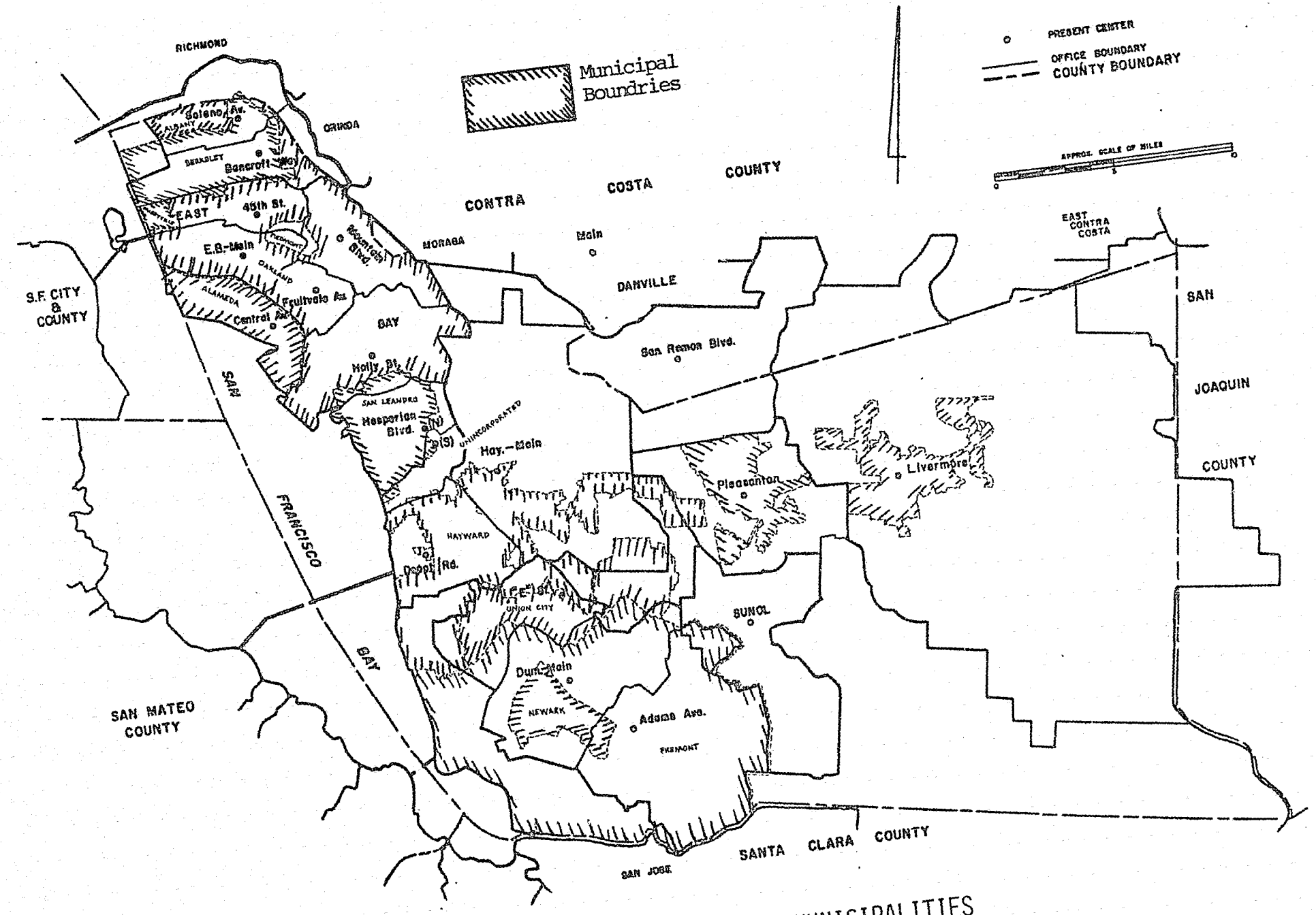
TABLES



ALAMEDA COUNTY CENTRAL OFFICES AND MUNICIPALITIES

Figure 1

ORGANIZATIONAL STATISTICS - ALAMEDA COUNTY POLICE DEPARTMENTS CY 1972

JURISDICTION	Est. 1972 Population	% of County	Land Area (sq. miles)	Sworn Officers	% of County	Per 10,000 Pop.	Total Personnel	Sedans	FBI Index Crimes	% of County	Per 10,000 Pop.	Total Felonies	% of County	Per 10,000 Pop.	Total Arrests	% of County	Per 10,000 Pop.
ALAMEDA	74,500	6.6	11.8	83	4.1	11	97	21	2461	4.3	330	3854	3.9	517	2719	3.3	365
ALBANY	14,700	1.3	1.3	26	1.3	18	27	7	458	0.8	312	719	0.7	489	731	0.9	497
BERKELEY	116,500	10.3	18.1	176	8.8	15	215	70	6946	12.2	596	14052	14.3	1206	6969	8.5	598
EMERYVILLE	3,200	0.3	1.0	19	0.9	59	23	7	384	0.8	1200	705	0.7	2203	335	0.4	1047
FREMONT	119,500	10.5	96.5	103	5.1	9	143	21	4944	8.7	414	7476	7.6	626	5283	6.5	442
HAYWARD	97,600	8.6	48.0	112	5.6	12	142	35	4662	8.2	478	7406	7.5	759	5903	7.2	605
LIVERMORE	45,000	4.0	14.3	36	1.8	8	48	11	1687	3.0	375	2700	2.7	600	1703	2.1	378
NEWARK	30,200	2.7	8.0	31	1.5	10	42	16	757	1.3	251	1655	1.7	548	1407	1.7	466
OAKLAND	362,000	31.9	54.0	699	34.8	19	950	196	24804	43.5	685	45276	45.9	1251	39325	48.0	1086
PIEDMONT	10,900	1.0	1.8	21	1.0	19	22	7	285	0.5	261	392	0.4	360	536	0.7	492
PLEASANTON	28,400	2.5	12.9	23	1.1	8	30	10	649	1.1	229	1053	1.1	371	993	1.2	350
SAN LEANDRO	70,500	6.2	15.0	84	4.2	12	114	33	2694	4.7	382	4183	4.2	593	3525	4.3	500
UNION CITY	24,000	2.1	14.0	26	1.3	11	32	10	703	1.2	293	1019	1.0	425	1160	1.4	483
U.C., BERK.	--	--	--	87	4.3	--	93	--	870	1.5	--	1843	1.9	--	775	0.9	--
SHERIFF	138,000	12.2	482	485	24.1	35	704	90	4739	8.2	343	6157	6.2	446	10480	12.8	759
COUNTY TOTAL	1,134,500	100.0	733	2001	100.0	18	2682	562	57043	100.0	503	98543	100.0	868	81844	100.0	721

Figure 1a

ORGANIZATIONAL STATISTICS - ALAMEDA COUNTY

FIRE PROTECTION ORGANIZATIONS CY 1972

ORGANIZATION	1972 Population Served	Land Area Served (Sq. Miles)	Personnel			Total Vehicles	Stations	Alarms	Percent of County	Fires	Percent of County	Fire Loss ($)	False Alarms	Inhalator and Resuscitator Calls
			Regular	Percent of County	Volunteer/ Auxiliary									
Alameda County Civil Defense	---	---	0	0.0	21	4	1	64	0.2	31	0.2	---	0	0
Alameda County Fire Patrol	---	---	13	0.8	0	5	1	354	0.8	276	2.1	---	50	28
Alameda Fire Dept.	74,500	11.8	102	6.4	0	18	4	1,522	3.6	786	6.1	1,937,603	164	443
Albany Fire Dept.	14,700	1.3	23	1.4	0	7	1	638	1.5	100	0.8	117,445	55	320
Ashland Fire Protection Dist.	15,000	2.6	17	1.1	12	5	1	488	1.2	164	1.3	118,081	22	184
Berkeley Fire Dept.	116,500	18.1	182	11.4	0	27	7	4,593	10.9	1,178	9.1	1,063,483	936	1,094
Ca. Div. of Forestry	---	---	9	0.6	0	7	1	325	0.8	121	0.9	134,810	35	0
Castro Valley Fire Protection District	45,000	13.0	45	2.8	0	11	3	874	2.1	367	2.8	---	73	182
Cherryland Fire Protection District	14,000	2.0	15	0.9	10	5	1	415	1.0	213	1.6	61,453	12	117
Emeryville Fire Dept.	3,200	1.0	38	2.4	0	8	2	247	0.6	28	0.2	12,547	34	116
Fairview Fire Protection District			7	0.4	20	7								
Fremont Fire Dept.	119,500	96.5	106	6.7	0	28	8	2,924	6.9	1,380	10.7	526,262	206	306
Hayward Fire Dept.	97,600	48.0	128	8.0	0	31	6	2,735	6.5	911	7.0	622,176	207	502
Livermore Fire Dept.	45,000	14.3	33	2.1	22	14	3	762	1.8	440	3.4	119,094	114	105
Newark Fire Dept.	30,200	8.0	22	1.4	0	6	2	802	1.9	412	3.2	557,257	70	230
Oakland Fire Dept.	362,000	54.0	658	41.3	0	120	27	20,256	48.1	4,633	35.8	4,029,748	7,950	4,341
Piedmont Fire Dept.	10,900	1.8	23	1.4	0	8	1	938	2.2	114	0.9	190,836	64	95
Pleasanton Fire Dept.	28,400	12.9	24	1.5	20	11	3	559	1.3	298	2.3	216,980	33	76
East Bay Regl. Park	---	47.0	1	0.1	60	40	6	119	0.3	85	0.7	---	9	2
San Leandro Fire Dept.	70,500	15.0	84	5.3	0	20	5	1,781	4.2	643	5.0	575,238	32	872
San Lorenzo Fire Dept.	25,000	2.6	17	1.1	14	5	1	433	1.1	101	0.8	101,850	53	152
Tennyson Fire Protection District		0.9	0	0.0	10	2	1							
Union City Fire Dept.	24,000	14.0	20	1.3	19	9	2	650	1.5	326	2.5	64,450	50	102
Valley Community Service District	20,000	11.0	25	1.6	17	7	2	610	1.4	343	2.6	212,830	49	79
COUNTY TOTAL	1,134,500	733.0	1,592	100.0	225	405	68	42,089	100.0	12,950	100.0	10,662,143	10,218	9,346

Figure 1b

ESTIMATED DISTRIBUTION OF TELEPHONES
AMONG ALAMEDA COUNTY CENTRAL OFFICES

CENTRAL OFFICE	SERVED JURISDICTION	% OF PHONES	ESTIMATED NUMBER OF TELEPHONES	PERCENT OF JURISDICTION
Solano Avenue (29,823)	Albany	25%	7,456	100%
	Berkeley	40%	11,929	23%
	(Contra Costa County)	(35%)	(10,438)	
Bancroft Way (41,198)	Berkeley & U.C.	90%	37,078	73%
	Oakland	10%	4,120	3%
45th Street (38,435)	Berkeley	5%	1,922	4%
	Emeryville	10%	3,843	100%
	Oakland	75%	28,827	18%
	Piedmont	10%	3,843	52%
East Bay Main (54,001)	Oakland	95%	51,301	32%
	Piedmont	5%	2,700	36%
Mountain Blvd. (7,874)	Oakland	97%	7,638	5%
	Piedmont	3%	236	3%
Fruitvale (32,140)	Oakland	98%	31,497	19%
	Piedmont	2%	643	9%
Holly Street (44,396)	Oakland	85%	37,737	23%
	San Leandro	15%	6,659	19%
Hesperian North (29,591)	San Leandro	95%	28,111	80%
	Uninc. Ala. County	5%	1,480	4%
Central Avenue (27,394)	Alameda	100%	27,394	100%
Hesperian South (14,800)	Hayward	1%	148	1%
	San Leandro	1%	148	1%
	Uninc. Ala. County	98%	14,504	39%

Figure 2

(continued on next page)

CENTRAL OFFICE	SERVED JURISDICTION	% OF PHONES	ESTIMATED NUMBER OF TELEPHONES	PERCENT OF JURISDICTION
Hayward Main (36,417)	Hayward	59%	21,486	49%
	Union City	1%	364	4%
	Uninc. Ala. County	40%	14,567	39%
Depot Road (21,301)	Hayward	94.5%	20,129	45%
	Union City	.5%	107	1%
	Uninc. Ala. County	5.0%	1,065	3%
"E" Street (11,724)	Fremont	4%	469	1%
	Hayward	18%	2,110	5%
	Union City	75%	8,793	89%
	Uninc. Ala. County	3%	352	1%
Dumbarton Main (27,905)	Fremont	61%	17,022	50%
	Newark	36%	10,046	97%
	Union City	2%	558	6%
	Uninc. Ala. County	1%	279	1%
Adams Avenue (17,319)	Fremont	97%	16,799	49%
	Newark	2%	346	3%
	Uninc. Ala. County	1%	174	1%
Pleasanton (9,784)	Livermore	1%	98	1%
	Pleasanton	83%	8,121	97%
	Uninc. Ala. County	16%	1,565	4%
Livermore (16,477)	Livermore	95%	15,653	99%
	Pleasanton	1%	165	2%
	Uninc. Ala. County	4%	659	2%
Sunol (358)	Uninc. Ala. County	100%	358	1%
San Ramon (8,486)	Pleasanton	1%	85	1%
	(Contra Costa County)	(75%)	(6,365)	
	Uninc. Ala. County	24%	2,036	6%

469,423 = Total Phones

Less Contra Costra County = 452,620

Figure 2 (cont'd)

SELECTIVE ROUTING SERVICE PLAN

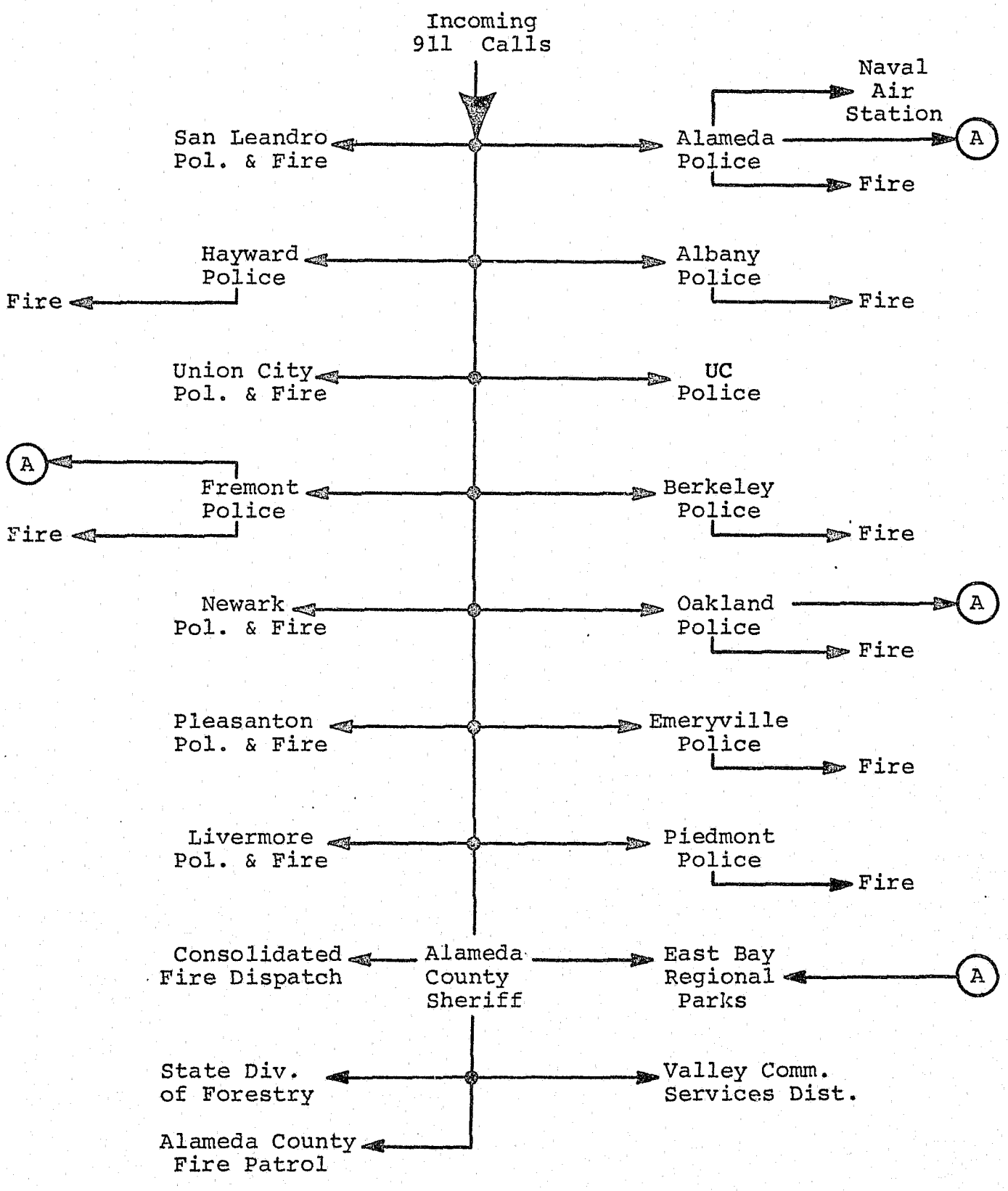


Figure 3

MULTIPLE PSAPS SERVICE PLAN

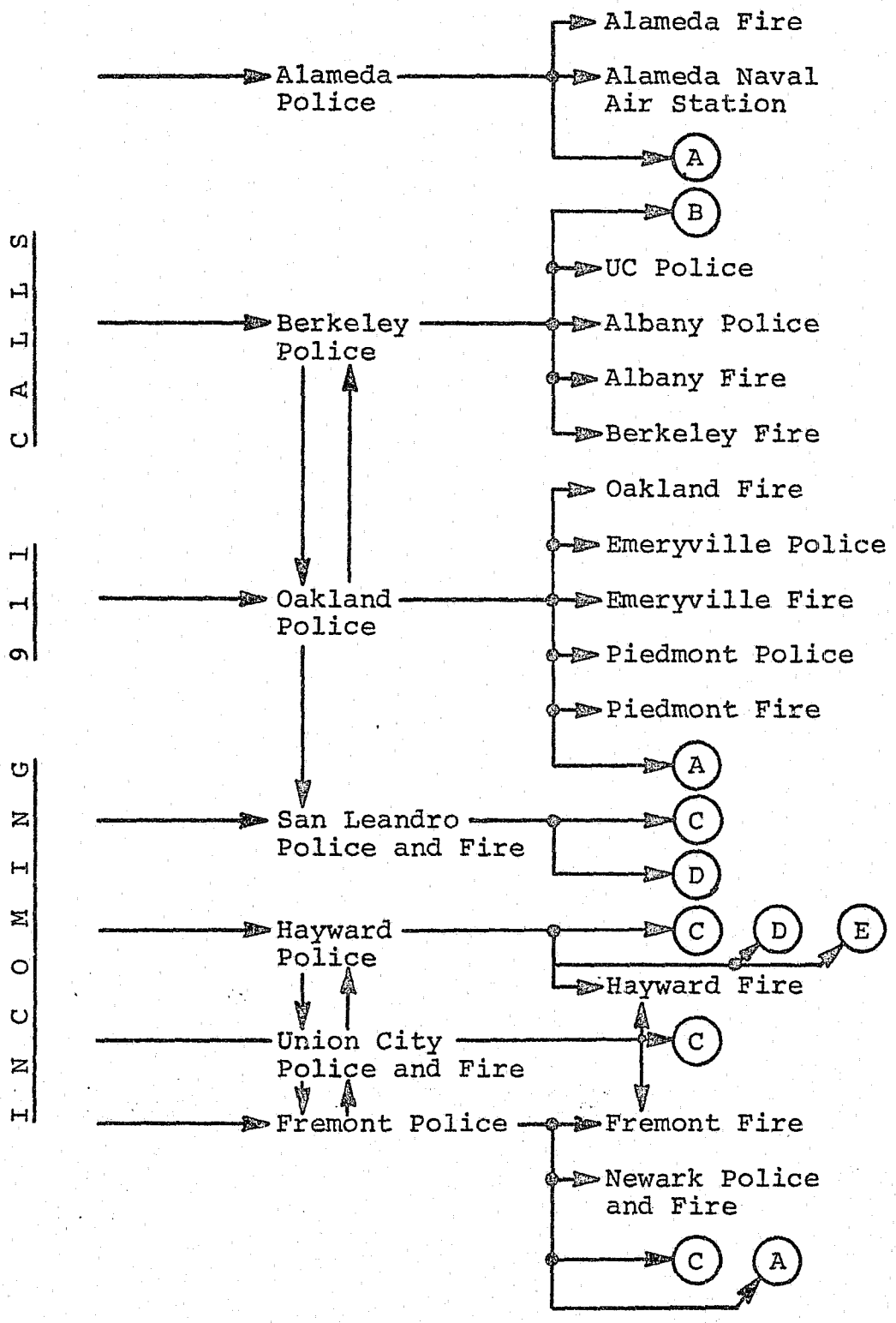


Figure 4

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MULTIPLE PSAPS SERVICE PLAN

(continued)

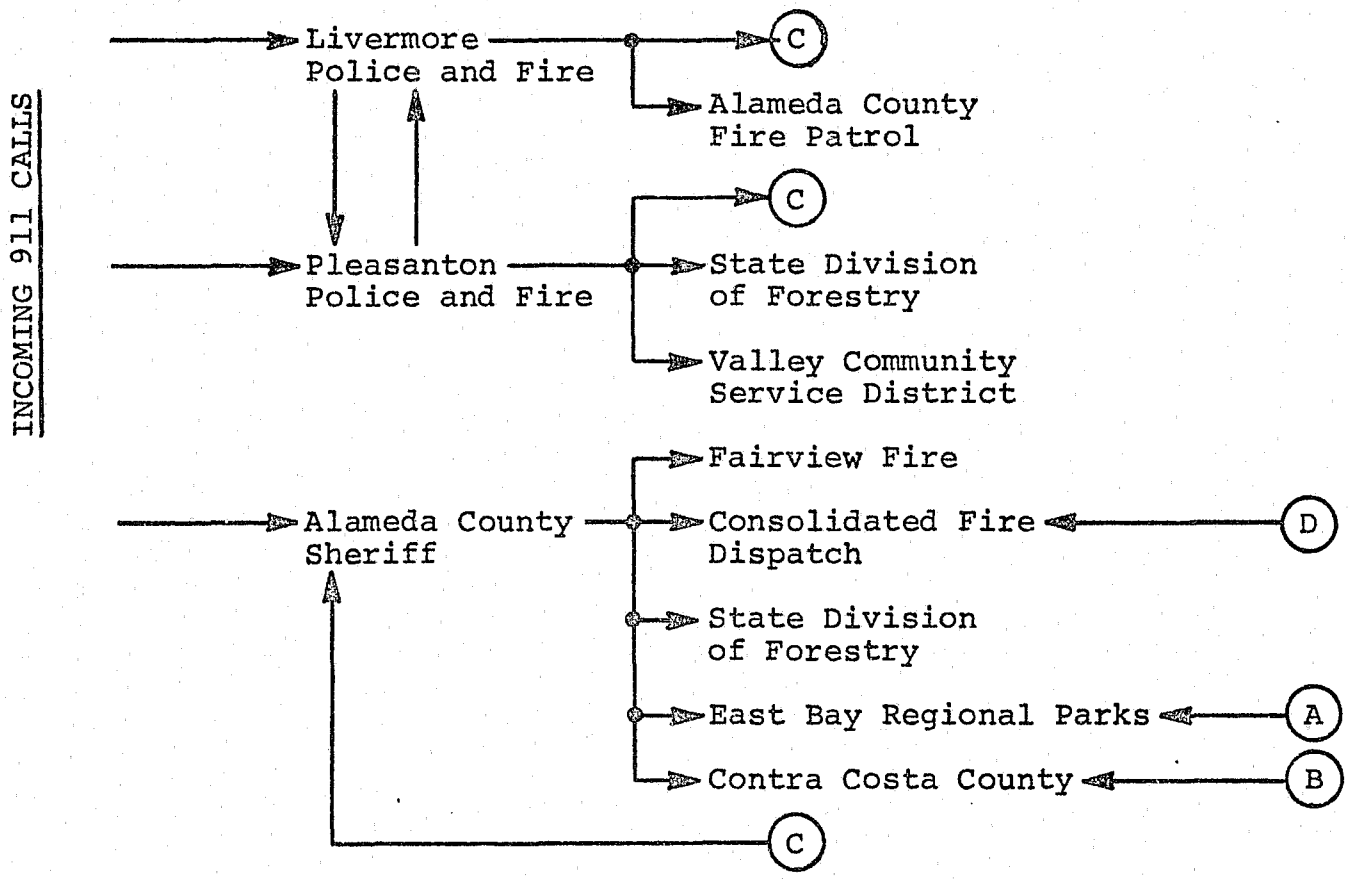


Figure 4 (cont'd)

CENTRAL PSAP SERVICE PLAN

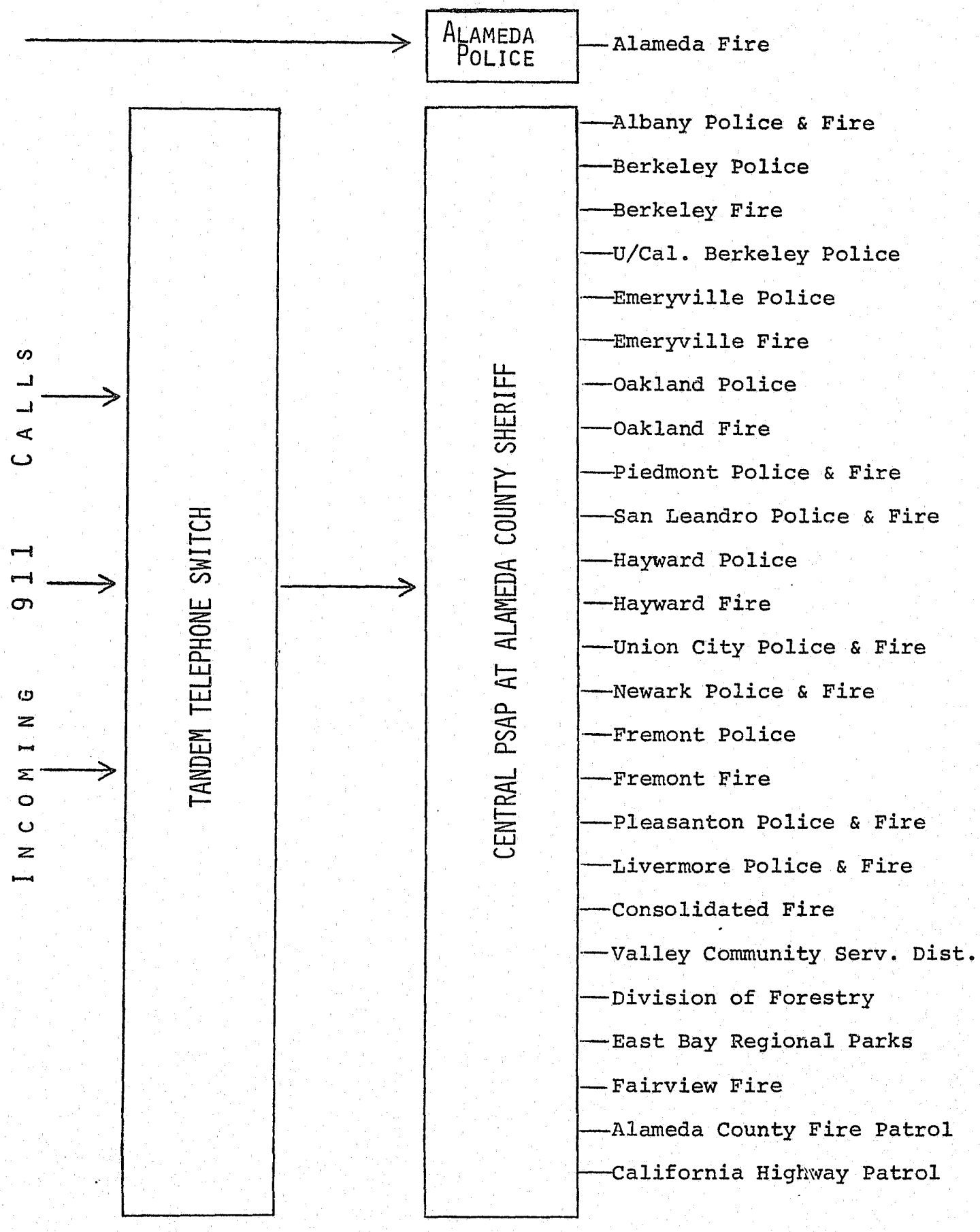


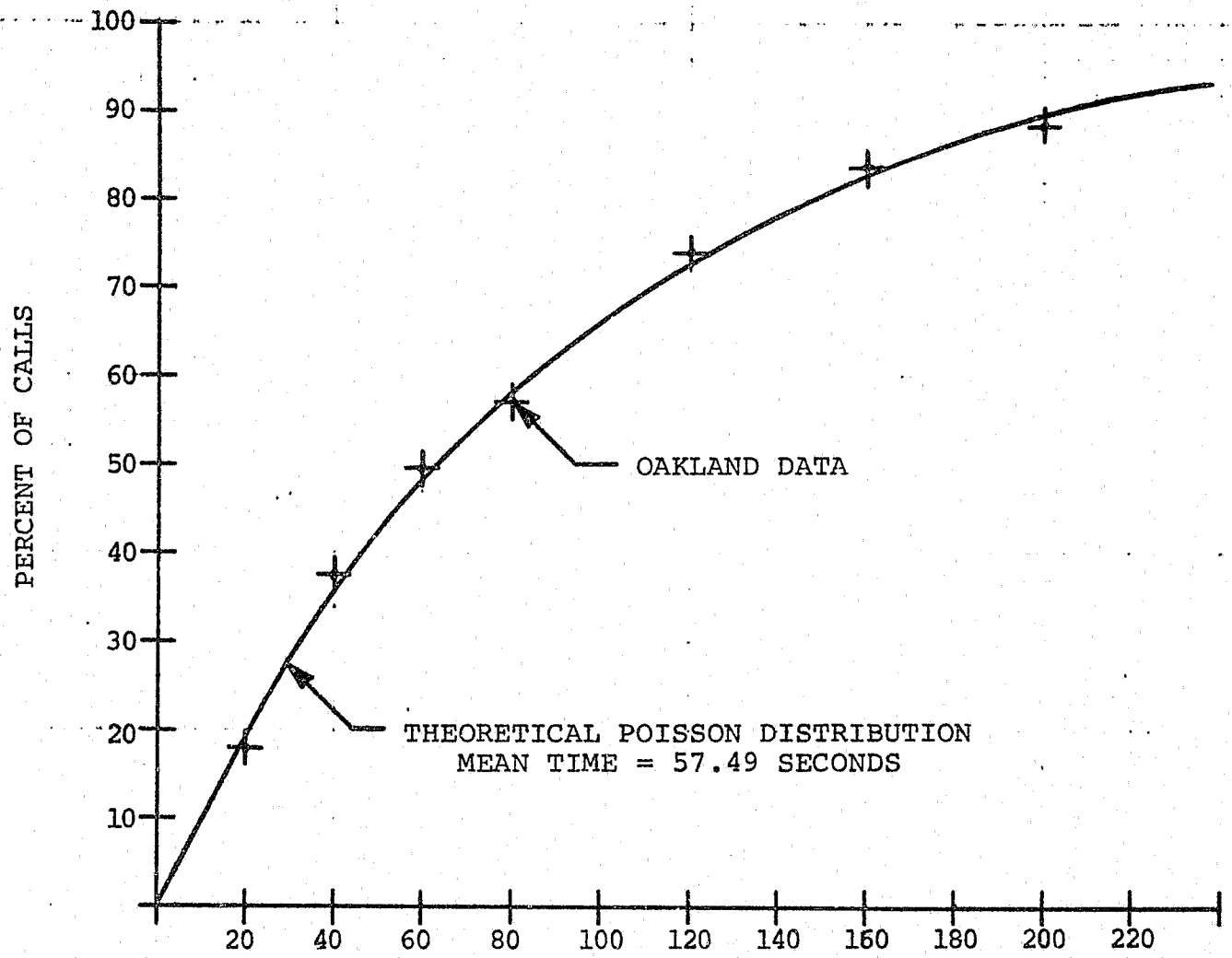
Figure 5

AGGREGATE TIME BETWEEN CALLS

OAKLAND POLICE DEPARTMENT

(2/13,18,19/74)

TOTAL 1,996 CALLS



MAXIMUM TIME BETWEEN CALLS, SECONDS

Figure 6

PRELIMINARY 911 CALL VOLUME ESTIMATES: Alameda County

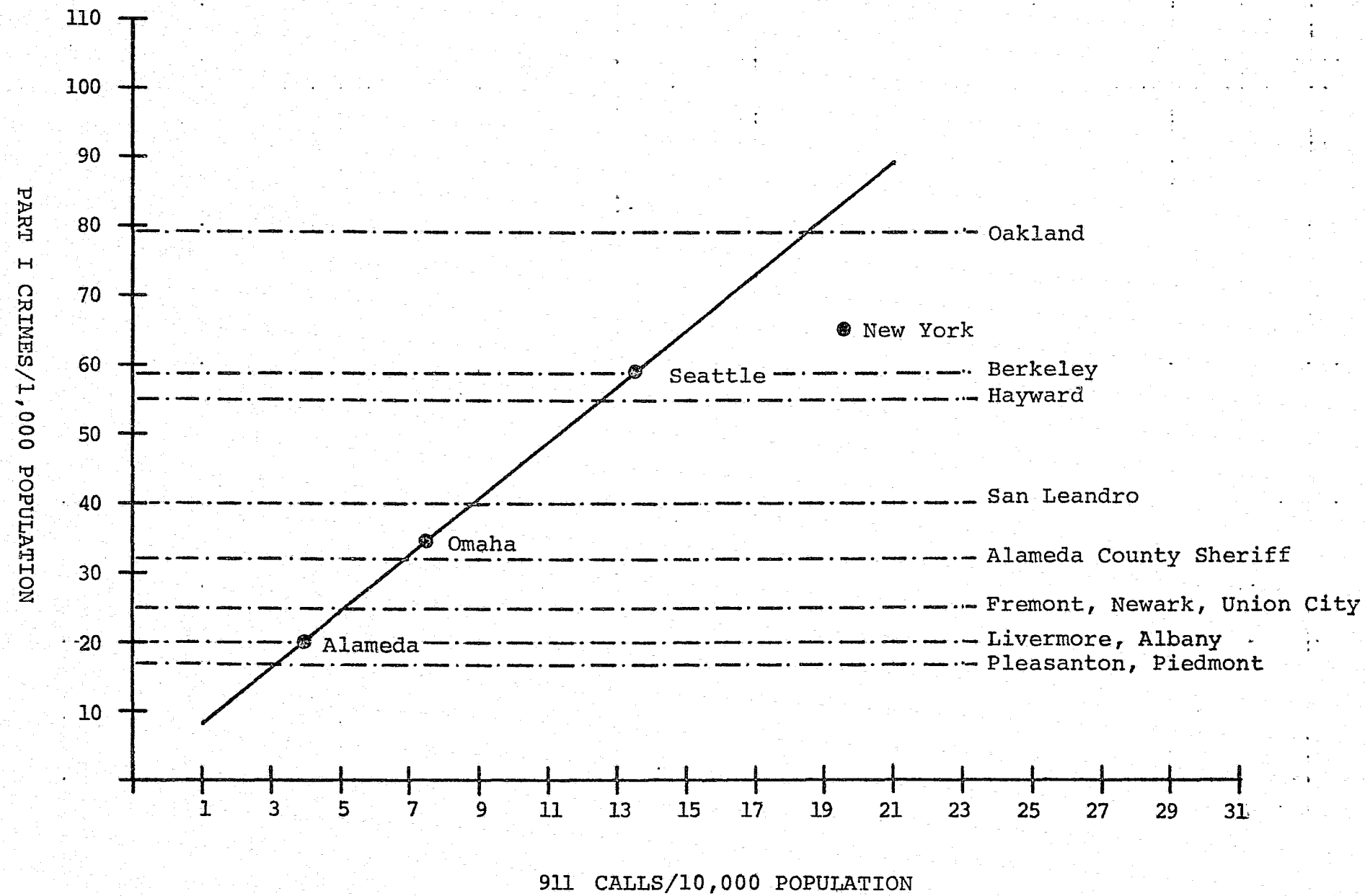


Figure 7

FREMONT POLICE DEPARTMENT: CALL VOLUME COUNT BY HOUR
Emergency Lines Only

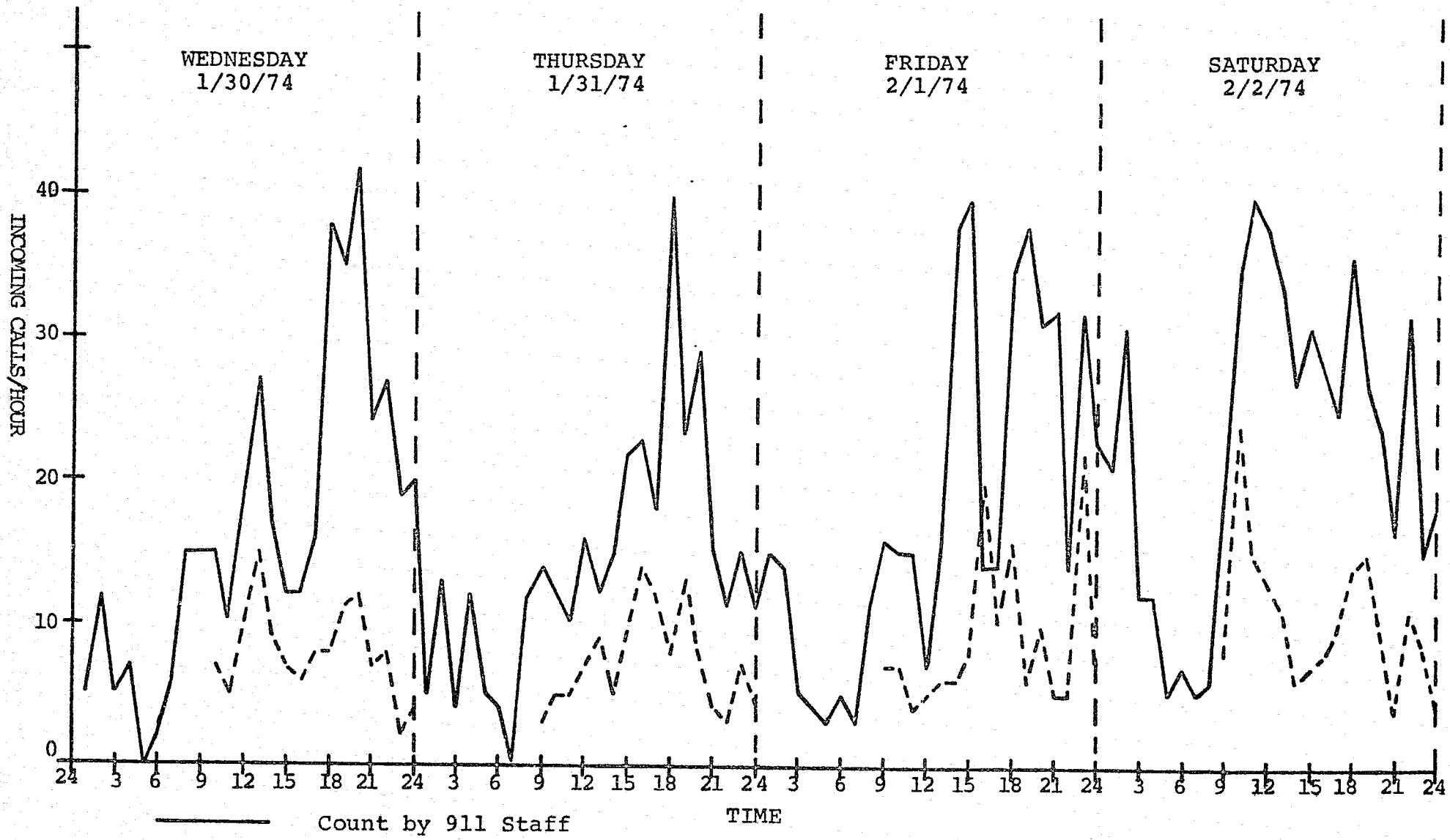


Figure 8

DAILY 911 CALL VOLUME PROJECTIONS

JURISDICTION	Current Emergency Telephone Call Volumes	55% Increase Adjustment* Plus an Additional	Projected 911 Call Volume	Seattle Recommended Planning Figures of 2.5/1000 Popul.	Explanation for Additional Increase
OAKLAND	773	10%	1,276	905	Oakland has 2 numbers listed in front of phone book for police service and is currently giving poor service in answering telephones.
BERKELEY	216	5%	346	292	University of California located within jurisdiction.
FREMONT	154	5%	247	286	High population growth currently underway.
UNINC. ALAMEDA CO.	148	10%	245	280	Significant increase for population growth, CHP calls, and current misdirected calls going to municipal jurisdictions.
HAYWARD	145	--	225	242	
ALAMEDA	77	--	120	186	
SAN LEANDRO	84	--	131	176	
LIVERMORE	53	5%	85	109	High population growth currently underway.
NEWARK	24	5%	39	74	High population growth currently underway.
PLEASANTON	20	10%	33	68	Extremely high population growth.
UNION CITY	22	5%	36	50	High population growth.
ALBANY	14	--	22	37	
PIEDMONT	9	--	14	27	
EMERYVILLE	15	5%	24	8	Extremely high industrial area and increased daytime population.
TOTALS	1,754	--	2,843	2,740	

*55% standard increase based on:

1) 15% addition for fire calls
2) 30% increase because sample call volumes were obtained during low volume month
3) 10% increase (national standard) for making 911 available to citizens

Figure 9

SELECTIVE ROUTING SERVICE PLAN - CALL ANSWERER REQUIREMENTS

PUBLIC SAFETY EMERGENCY DISPATCH AGENCY	911 VOLUME		FIRST WATCH 0001 - 0800				SECOND WATCH 0801 - 1600				THIRD WATCH 1601 - 2400				TOTALS	
	PSAP Aver. Call Volume	Secondary Ans. Point Trans. Vol.	Average Volume 1st Watch	Average Busy Hour	Call Answerer Reqmts.	% Calls Ans. W/I 10 Sec.	Average Volume 2nd Watch	Average Busy Hour	Call Answerer Reqmts.	% Calls Ans. W/I 10 Sec.	Average Volume 3rd Watch	Average Busy Hour	Call Answerer Reqmts.	% Calls Ans. W/I 10 Sec.	DAILY CALL ANSWERER REQMTS.	MANNING REQUIRE-MENTS
Alameda Police	122	—	28	7	2	98.6	37	8	2	98.2	57	11	2	96.6	6	10
Alameda Fire	—	17	—	—	1	99.+	—	—	1	99.+	—	—	1	99.+	3	5
Albany Police	23	—	—	—	1	99.+	—	—	1	99.+	—	—	1	99.+	3	5
Albany Fire	—	3	—	—	1	99.+	—	—	1	99.+	—	—	1	99.+	3	5
Berkeley Police	303	—	69	18	2	91.4	92	19	2	90.5	143	26	3	96.8	7	11
Berkeley Fire	—	54	12	3	1	92.4	16	3	1	92.4	25	5	2	99.3	4	6
U/Ca. Police	50	—	11	3	1	92.4	15	3	1	92.4	23	5	2	99.3	4	6
Emeryville Police	25	—	—	—	1	99.+	—	—	1	99.+	—	—	1	99.+	3	5
Emeryville Fire	—	4	—	—	1	99.+	—	—	1	99.+	—	—	1	99.+	3	5
Piedmont Police	15	—	—	—	1	99.+	—	—	1	99.+	—	—	1	99.+	3	5
Piedmont Fire	—	2	—	—	1	99.+	—	—	1	99.+	—	—	1	99.+	3	5
Oakland Police	1,298	—	295	73	5	95.4	392	82	5	92.8	611	108	6	92.7	16	25
Oakland Fire	—	197	45	11	2	96.6	59	12	2	96.0	93	16	2	93.1	6	10
San Leandro Police & Fire	133	—	30	8	2	98.2	40	9	2	97.7	63	12	2	96.0	6	10
Hayward Police	229	—	52	13	2	95.4	69	15	2	93.9	108	19	2	90.5	6	10
Hayward Fire	—	35	—	—	1	99.+	—	—	1	99.+	—	—	1	99.+	3	5
Union City Police & Fire	36	—	—	—	1	99.+	—	—	1	99.+	—	—	1	99.+	3	5
Newark Police & Fire	40	—	10	3	1	95.0	12	3	1	95.0	18	4	2	99.6	4	6
Fremont Police	251	—	57	14	2	94.6	76	16	2	93.1	118	21	3	98.3	7	11
Fremont Fire	—	39	10	2	1	95.0	12	3	1	92.4	17	3	1	92.4	3	5
Pleasanton Police & Fire	34	—	—	—	1	99.+	—	—	1	99.+	—	—	1	99.+	3	5
Livermore Police & Fire	87	—	20	5	2	99.3	26	6	2	99.0	41	8	2	98.2	6	10
Alameda County Sheriff	249	—	57	14	2	94.7	75	16	2	93.1	117	21	3	98.3	7	11
Consolid. Fire Dispatch	—	28	—	—	1	99.+	—	—	1	99.+	—	—	1	99.+	3	5
Valley Cons. Fire Dist.	—	6	—	—	1	99.+	—	—	1	99.+	—	—	1	99.+	3	5
East Bay Regl. Parks	—	5	—	—	1	99.+	—	—	1	99.+	—	—	1	99.+	3	5
State Div. of Forestry	—	2	—	—	1	99.+	—	—	1	99.+	—	—	1	99.+	3	5
Fairview Fire District	—	2	—	—	1	99.+	—	—	1	99.+	—	—	1	99.+	3	5
Alameda Co. Fire Patrol	—	1	—	—	1	99.+	—	—	1	99.+	—	—	1	99.+	3	5
Contra Costa County*	—	0	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Alameda Naval Air Sta.	—	8	—	—	—	—	—	—	—	—	—	—	—	—	—	—
911 Central Answr. Cntr.	—	0	—	—	—	—	—	—	—	—	—	—	—	—	—	—
TOTALS	2,895				41				41				48		130	211

Figure 10

MULTIPLE PSAPs SERVICE PLAN - CALL ANSWERER REQUIREMENTS

PUBLIC SAFETY EMERGENCY DISPATCH AGENCY	911 VOLUME		FIRST WATCH 0001 - 0800				SECOND WATCH 0801 - 1600				THIRD WATCH 1601 - 2400				TOTALS	
	PSAP Aver. Call Volume	Secondary Ans. Point Trans. Vol.	Average Volume 1st Watch	Average Busy Hour	Call Answerer Reqmts.	% Calls Ans. W/I 10 Sec.	Average Volume 2nd Watch	Average Busy Hour	Call Answerer Reqmts.	% Calls Ans. W/I 10 Sec.	Average Volume 3rd Watch	Average Busy Hour	Call Answerer Reqmts.	% Calls Ans. W/I 10 Sec.	DAILY CALL ANSWERER REQMNTS.	MANNING REQUIRE-MENTS
Alameda Police	122	—	28	7	2	98.6	37	8	2	98.2	57	11	2	96.6	6	10
Alameda Fire	—	17	—	—	1	99.+	—	—	1	99.+	—	—	1	99.+	3	5
Albany Police	—	20	—	—	1	99.+	—	—	1	99.+	—	—	1	99.+	3	5
Albany Fire	—	3	—	—	1	99.+	—	—	1	99.+	—	—	1	99.+	3	5
Berkeley Police	454	11	105	26	3	96.8	140	29	3	95.8	219	39	4	98.1	10	16
Berkeley Fire	—	54	12	3	1	97.5	16	3	1	97.5	25	5	2	99.3	4	6
U/Cal. Police	—	50	11	—	1	99.+	15	—	1	99.+	23	5	2	99.3	4	6
Emeryville Police	—	21	—	—	1	99.+	—	—	1	99.+	—	—	1	99.+	3	5
[illegible]ville Fire	—	4	—	—	1	99.+	—	—	1	99.+	—	—	1	99.+	3	5
iedmont Police	—	13	—	—	1	99.+	—	—	1	99.+	—	—	1	99.+	3	5
iedmont Fire	—	2	—	—	1	99.+	—	—	1	99.+	—	—	1	99.+	3	5
[illegible]and Police	1,345	27	311	78	5	94.0	414	87	6	97.2	646	114	6	90.8	17	27
[illegible]and Fire	—	197	45	11	2	96.6	59	12	2	96.0	93	16	2	93.1	6	10
[illegible] Leandro Police & Fire	116	26	32	8	2	98.2	43	9	2	97.7	67	12	2	96.0	6	10
[illegible]yward Police	313	10	73	18	2	91.4	98	20	3	98.5	152	27	3	96.5	8	13
[illegible]yward Fire	—	35	—	—	1	99.+	—	—	1	99.+	—	—	1	99.+	3	5
Union City Police & Fire	49	4	12	3	1	92.4	15	3	1	92.4	25	5	2	99.3	4	6
[illegible]ewark Police & Fire	—	40	10	3	1	92.4	12	3	1	92.4	18	4	2	99.5	4	6
[illegible]emont Police	292	3	67	17	2	92.3	89	19	2	90.5	139	25	3	97.2	7	11
[illegible]emont Fire	—	39	10	2	1	95.0	12	3	1	92.4	17	3	1	92.4	3	5
[illegible]leasanton Police & Fire	43	2	10	2	1	95.0	13	3	1	92.4	21	4	2	99.5	4	6
Livermore Police & Fire	91	1	21	5	2	99.3	28	6	2	99.0	43	8	2	98.2	6	10
[illegible]lameda Co. Sheriff	144	103	35	14	2	94.7	74	16	2	93.1	115	21	3	98.2	7	11
[illegible]onsolid. Fire Dispatch	—	28	—	—	1	99.+	—	—	1	99.+	—	—	1	99.+	3	5
[illegible]alley Cons. Fire Dist.	—	6	—	—	1	99.+	—	—	1	99.+	—	—	1	99.+	4	6
[illegible]st Bay Regl. Parks	—	5	—	—	1	99.+	—	—	1	99.+	—	—	1	99.+	6	10
[illegible]tate Div. of Forestry	—	2	—	—	1	99.+	—	—	1	99.+	—	—	1	99.+	7	11
[illegible]airview Fire District	—	2	—	—	1	99.+	—	—	1	99.+	—	—	1	99.+	3	5
[illegible] Co. Fire Patrol	—	1	—	—	1	99.+	—	—	1	99.+	—	—	1	99.+	3	5
[illegible]ontra Costa County*	—	74	—	—	-	—	—	—	-	—	—	—	-	—	-	—
[illegible]lameda Naval Air Sta.*	—	8	—	—	-	—	—	—	-	—	—	—	-	—	-	—
[illegible]11 Central Answr. Cntr.	—	0	—	—	0	—	—	—	0	—	—	—	0	—	0	0
TOTALS	2,969				42				44				52		138	223

Figure 11

CENTRAL PSAP SERVICE PLAN - CALL ANSWERER REQUIREMENTS

PUBLIC SAFETY AGENCY DISPATCH AGENCY	911 VOLUME		FIRST WATCH 0001 - 0800				SECOND WATCH 0801 - 1600				THIRD WATCH 1601 - 2400				TOTALS	
	PSAP Aver. Call Volume	Secondary Ans. Point Trans. Vol.	Average Volume 1st Watch	Average Busy Hour Call	Answerer Reqmts.	% Calls Ans. W/I 10 Sec.	Average Volume 2nd Watch	Average Busy Hour Call	Answerer Reqmts.	% Calls Ans. W/I 10 Sec.	Average Volume 3rd Watch	Average Busy Hour Call	Answerer Reqmts.	% Calls Ans. W/I 10 Sec.	DAILY CALL ANSWERER REQMTS.	MANNING REQUIRE-MENTS
Alameda Police	-	95	22	5	2	99.3	29	6	2	99.0	45	8	2	98.2	6	10
Alameda Fire	-	17	—	—	1	99.+	—	—	1	99.+	—	—	1	99.+	3	5
Albany Police	-	20	—	—	1	99.+	—	—	1	99.+	—	—	1	99.+	3	5
Albany Fire	-	3	—	—	1	99.+	—	—	1	99.+	—	—	1	99.+	3	5
Berkeley Police	-	248	56	14	2	94.7	75	16	2	93.1	117	21	3	98.2	7	11
Berkeley Fire	-	54	12	3	1	92.4	16	3	1	92.4	25	5	2	99.3	4	6
U/Cal. Police	-	50	11	3	1	92.4	15	3	1	92.4	23	5	2	99.3	4	6
Emeryville Police	-	21	—	—	1	99.+	—	—	1	99.+	—	—	1	99.+	3	5
Emeryville Fire	-	4	—	—	1	99.+	—	—	1	99.+	—	—	1	99.+	3	5
Piedmont Police	-	13	—	—	1	99.+	—	—	1	99.+	—	—	1	99.+	3	5
Piedmont Fire	-	2	—	—	1	99.+	—	—	1	99.+	—	—	1	99.+	3	5
Oakland Police	-	1,100	250	62	5	97.6	332	70	5	96.1	518	92	6	96.4	16	25
Oakland Fire	-	197	45	11	2	96.4	59	12	2	96.0	93	16	2	93.1	6	10
San Leandro Police & Fire	-	133	30	8	2	98.2	40	9	2	97.7	63	12	2	96.0	6	10
Hayward Police	-	194	44	11	2	96.4	59	12	2	96.0	91	16	2	93.1	6	10
Hayward Fire	-	35	—	—	1	99.+	—	—	1	99.+	—	—	1	99.+	3	5
Union City Police & Fire	-	36	—	—	1	99.+	—	—	1	99.+	—	—	1	99.+	3	5
Newark Police & Fire	-	40	10	3	1	92.4	12	3	1	92.4	18	4	2	99.6	4	6
Fremont Police	-	212	48	12	2	96.0	64	13	2	95.4	100	18	2	91.4	6	10
Fremont Fire	-	39	10	2	1	95.0	12	3	1	92.4	17	3	1	92.4	3	5
Pleasanton Police & Fire	-	34	—	—	1	99.+	—	—	1	99.+	—	—	1	99.+	3	5
Livermore Police & Fire	-	87	20	5	2	99.3	26	6	2	98.0	41	8	2	98.2	6	10
Alameda Co. Sheriff	-	209	47	12	2	96.0	63	13	2	95.4	98	17	2	92.3	6	10
Consolid. Fire Disp.	-	28	—	—	1	99.+	—	—	1	99.+	—	—	1	99.+	3	5
Valley Cons. Serv. Dist.	-	6	—	—	1	99.+	—	—	1	99.+	—	—	1	99.+	3	5
East Bay Regl. Parks	-	5	—	—	1	99.+	—	—	1	99.+	—	—	1	99.+	3	5
State Div. of Forestry	-	2	—	—	1	99.+	—	—	1	99.+	—	—	1	99.+	3	5
Fairview Fire District	-	2	—	—	1	99.+	—	—	1	99.+	—	—	1	99.+	3	5
Alameda Co. Fire Patrol	-	1	—	—	1	99.+	—	—	1	99.+	—	—	1	99.+	3	5
Contra Costa County*	-	74	—	—	-	—	—	—	-	—	—	—	-	—	—	—
Alameda Naval Air Sta.*	-	8	—	—	-	—	—	—	-	—	—	—	-	—	—	—
911 Central Answ. Cntr**	2,969	—	674	168	5	95.4	897	188	5	93.2	1,398	248	6	96.7	16	25
TOTALS	2,969	2,969			46				46				52		144	234

Figure 12

FREMONT POLICE DEPARTMENT: SAMPLE OF CALL PROCESSING TIMES AND CALL TALK TIMES

	EMERGENCY LINES			NON-EMERGENCY LINES			TOTAL LINES			
	#	Time (sec.)	Aver. Time	#	Time (sec.)	Aver. Time	#	Time (sec.)	Aver. Time	
1/30/74	54	3,624	67.1	29	1,928	66.5	83	5,552	67.7	TALK TIME
1/31/74	32	3,138	98.1	31	2,902	93.6	63	6,040	95.9	
2/1/74	33	1,568	47.5	35	2,253	64.4	68	3,821	56.2	
2/2/74	21	1,576	75.0	25	1,641	65.6	46	3,217	69.9	
2/4/74	19	1,758	92.5	14	1,199	85.6	33	2,957	89.6	PROCESSING TIME
2/5/74	12	936	78.0	26	3,166	121.8	38	4,102	107.9	
2/6/74	6	916	152.7	18	1,412	78.4	24	2,328	97.0	
2/7/74	14	830	59.3	20	1,331	66.6	34	2,161	63.6	
	140	9,906	70.8	120	8,724	72.7	260	18,630	71.7	Total for Talk Time
	51	4,440	87.1	78	7,108	91.1	129	11,548	89.5	Total for Processing Time
	191	14,346	75.1	198	15,832	80.0	389	30,178	77.6	

CALL ANSWERER REQUIREMENTS: FREMONT POLICE DEPARTMENT

Figure 13

911 STUDY: CALL PROCESSING TIMES ON PRIORITY LINES BY SHIFT:

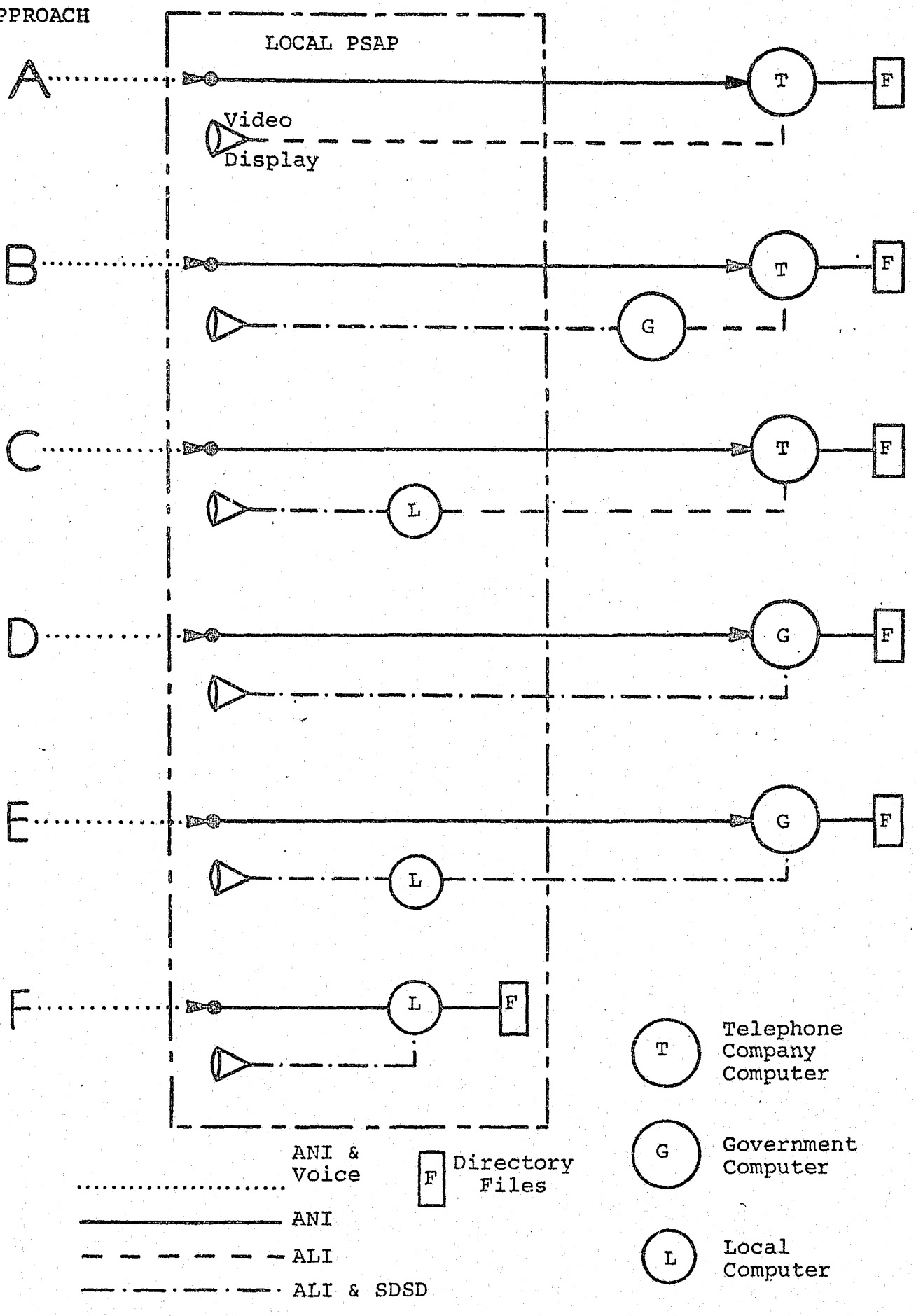
OAKLAND POLICE DEPARTMENT: RANDOM SAMPLE OF CALLS

12/3/73 - 2/9/74

SHIFT	TOTAL PRIORITY CALLS IN SAMPLE	AVERAGE PROCESSING TIME PRIORITY CALLS (SECONDS)	TOTAL NON-PRIORITY CALLS IN SAMPLE	AVERAGE PROCESSING TIME NON-PRIORITY CALLS (SECONDS)	TOTAL CALLS IN SAMPLE	AVERAGE PROCESSING TIME TOTAL CALLS (SECONDS)
2300-0700	70	145.	15	137.	85	144.
0700-1500	94	103.	205	101.	299	102.
1500-2300	265	112.	241	107.	506	109.
TOTAL	429	115.	461	105.	890	110.

CALL PROCESSING TIMES: OAKLAND POLICE DEPARTMENT

Figure 14



SIX ALTERNATIVE ALI-SDSD APPROACHES

Figure 15

TELEPHONE INSTALLATION STATISTICS - ALAMEDA COUNTY

Telephone Co. Central Office	(1) Total Main Stations	(2) Residential Pub	(3) Residential Non-Pub	(4) Residential Total	(5) Business Pub	(6) Business Non-Pub	(7) Business Total	(8) Semi-public Pay Phones Pub	(9) Semi-public Pay Phones Non-Pub	(10) Semi-public Pay Phones Total	(11) Public Pay Phones	(12) Total Non-Pub, excl. pay phones
Solano Ave. (EB/LS)	29,823	20,952	4,497	25,499	3,871	103	3,974	100	74	174	176	4,674
Bancroft (EB/TH)	41,198	26,352	5,521	31,873	8,119	276	8,395	328	170	498	432	5,967
45th St. (EB/OL)	38,435	21,951	8,026	29,977	7,392	221	7,613	229	184	413	432	8,431
Fruitvale (EB/KE)	32,140	16,677	9,736	26,413	4,978	159	5,137	129	123	252	338	10,018
E.B. Main (EB/MN)	54,001	21,804	8,432	30,236	21,437	612	22,049	297	284	581	1,135	9,328
Mountain Blvd. (EB/MO)	7,874	5,906	1,231	7,137	666	20	686	26	5	31	20	1,256
Holly St. (EB/NE)	44,396	21,215	13,480	34,695	8,352	372	8,724	191	202	393	584	14,054
Central Ave. (EB/LA)	27,394	17,447	6,383	23,830	2,909	121	3,030	78	44	122	412	6,548
N. Hesperian (EB/EL)	29,591	15,576	6,133	21,709	7,261	183	7,444	77	106	183	255	6,422
EAST BAY EXCHANGE	(304,852)	(167,880)	(63,439)	(231,349)	(64,985)	(2,067)	(67,052)	(1,455)	(1,192)	(2,647)	(3,784)	(66,698)
Hayward Main (HAY/MN)	36,417	19,898	9,133	29,029	6,283	410	6,693	200	110	310	385	9,653
S. Hesperian (HAY/EL)	14,800	8,060	4,956	13,016	1,423	97	1,520	75	42	117	147	5,095
Depot Rd. (HAY/SU)	21,301	10,594	6,313	16,907	3,667	295	3,962	88	129	217	215	6,737
HAYWARD EXCHANGE	(72,518)	(38,550)	(20,402)	(58,952)	(11,373)	(802)	(12,175)	(363)	(281)	(644)	(747)	(21,485)
Dum. Main (FNK/MN)	27,905	15,407	8,175	23,582	3,702	268	3,970	76	76	152	201	8,519
"E" St. (FNK/GR)	11,724	6,183	3,804	9,987	1,505	165	1,570	32	68	100	67	4,037
Adams Ave. FNK/OL)	17,319	9,933	5,348	15,281	1,693	109	1,802	59	52	111	125	5,509
FREMONT-NEWARK EXCHANGE	(56,948)	(31,523)	(17,327)	(48,850)	(6,800)	(542)	(7,342)	(167)	(196)	(363)	(393)	(18,065)
Livermore (LVM)	16,477	11,182	3,051	14,233	1,904	145	2,049	40	37	77	118	3,233
Pleasanton (PLS)	9,784	6,721	1,991	8,712	877	94	971	23	29	52	49	2,114
Sunol (SUL)	358	212	65	277	57	9	66	4	4	8	7	78
San Ramon (DANVA)	8,486	5,361	1,717	7,078	1,172	132	1,304	22	19	41	63	1,868
GRAND TOTAL	469,423	261,429	107,992	369,471	87,168	3,791	90,959	2,074	1,758	3,832	5,161	113,541

Pub = Published in the telephone directory.
Non-Pub = Unlisted number.
Public Pay Phones (such as on street corners) are not listed in the telephone directory.

TABLE 1

September, 1973

TELEPHONE INSTALLATION STATISTICS - ALAMEDA COUNTY (By Percentages)

Telephone Co. Central Office	(1) % of Total County Main Stations	(2) Residential % Pub	(3) Residential % Non-Pub	(4) Residential % of Tot. Main Stations	(5) Business % Pub	(6) Business % Non-Pub	(7) Business % of Tot. Main Stations	(8) Semi-public Pay Phones % Pub	(9) Semi-public Pay Phones % Non-Pub	(10) Semi-public Pay Phones % of Tot. Main Stations	(11) % Public Pay Phones	(12) % Tot. Non-Pub (- pay)
Solano Ave. (EB/LS)	6.3%	82.4%	17.6%	85.4%	97.5%	2.5%	13.3%	57.5%	42.5%	.5%	.5%	15.7%
Bancroft (EB/TH)	8.7	82.7	17 3	77.4	96.8	3.2	20.4	65.9	34.1	1.2	1.5	14.5
45th St. (EB/OL)	8.2	73.2	26.8	77.9	97.1	2.9	19.8	55.4	44.5	1.0	1.1	21.9
Fruitvale (EB/KE)	6.8	63.2	36.8	82.1	96.9	3.1	16.0	51.2	48.8	.7	1.1	31.2
E.B. Main (EB/MN)	11.5	72.1	27.9	56.0	97.3	2.7	40.8	51.1	48.9	1.1	2.1	17.2
Mountain Blvd. (EB/MO)	1.7	82.8	17.2	90.6	97.1	2.9	8.7	83.9	16.1	.4	.2	16.0
Holly St. (EB/NE)	9.4	61.2	38.8	78.1	95.8	4.2	19.7	48.6	51.4	.8	1.3	31.7
Central Ave. (EB/LA)	5.8	73.2	26.8	87.0	96.1	3.9	11.1	63.9	36.1	.4	1.5	23.9
N. Hesperian (EB/EL)	6.3	71.7	28.2	73.3	97.6	2.4	25.1	42.1	57.9	.6	.8	21.7
EAST BAY EXCHANGE	(64.9)	(72.6)	(27.4)	(75.9)	(96.9)	(3.1)	(22.0)	(55.0)	(45.0)	(.9)	(1.2)	(21.9)
Hayward Main (HAY/MN)	7.8	68.6	31.4	79.7	93.9	6.1	18.3	64.6	35.4	.8	1.0	26.5
S. Hesperian (HAY/EL)	3.1	62.0	38.0	87.9	93.6	6.4	10.2	64.1	35.9	.8	.9	34.4
Depot Rd. (HAY/SU)	4.5	62.7	37.3	79.3	92.6	7.4	18.6	40.6	59.4	1.0	1.0	31.6
HAYWARD EXCHANGE	(15.4)	(65.5)	(34.6)	(81.2)	(93.4)	(6.6)	(16.7)	(56.4)	(43.6)	(.8)	(1.0)	(29.6)
Dum. Main (FNK/MN)	5.9	65.3	34.7	84.5	93.3	6.7	14.2	50.0	50.0	.5	.7	30.5
"E" St. (FNK/GR)	2.5	62.0	38.0	85.2	89.5	10.5	13.4	32.0	68.0	.9	.5	34.4
Adams Ave. (FNK/OL)	3.7	65.0	35.0	88.2	94.0	6.0	10.4	53.2	46.8	.6	.7	31.8
FREMONT-NEWARK EXCHANGE	(12.1)	(64.5)	(35.5)	(85.8)	(92.7)	(7.3)	(12.9)	(46.0)	(54.0)	(.6)	(.7)	(31.7)
Livermore (LVM)	3.5	78.6	21.4	86.4	92.9	7.1	12.4	51.9	48.1	.4	.7	19.6
Pleasanton (PLS)	2.1	77.1	22.9	89.0	90.3	9.7	9.9	54.2	55.8	.5	.5	21.6
Sunol (SUL)	.1	76.6	23.4	77.4	86.3	13.6	18.4	50.0	50.0	2.2	1.9	21.7
San Ramon (DANVA)	1.8	75.8	24.2	83.4	89.9	10.1	15.4	53.7	46.3	.5	.7	22.0
COUNTY AS A WHOLE	100.0	70.8	29.2	78.7	95.9	4.1	19.3	54.1	45.9	.8	1.1	24.1

TABLE 1 (cont'd)

September, 1973

NOTE: For each Central Office, columns (4), (7), (10) and (11) = 100%.

ONE-TIME COSTS AND MONTHLY OPERATING COSTS
FOR PHONE AND DATA SYSTEMS

	ONE-TIME DETAIL	MONTHLY DETAIL	ONE-TIME COSTS	MONTHLY OPERATING COSTS
Selective Routing with ANI			$ 970,000*	$22,000*
Selective Routing with ALI (and ANI)				
Selective Routing with ANI	$ 970,000*	$22,000*		
Telephone Company Minicomputer	72,000	850		
56 CRT's and Controllers	130,800	1,600		
Updating & Retrieval Software	51,100			
Geographic Base File Development	74,500			
ANI Circuits		1,610		
ANI Logging Printers		1,500		
ALI Circuits & Modems		960		
Administrative Personnel		2,000		
Operating Personnel		1,000		
	$1,298,400	$31,520	$1,298,400	$31,520
Selective Routing with SDSD (& ANI, ALI)				
Selective Routing with ANI	$ 970,000*	$22,000*		
Telephone Company Minicomputer	72,000	850		
High Speed TelCo Minicomputer to Govt. Minicomputer Circuit	10,000	50		
Government Minicomputer	52,000	520		
56 CRT's and Controllers	130,800	1,600		
Updating & Retrieval Software	51,100			
Geographic Base File Development	74,500			
SDSD File Preparation	23,000			
ANI Circuits		1,610		
ANI Logging Printers		1,500		
ALI Circuits & Modems		960		
Administrative Personnel		2,000		
Operating Personnel		2,320		
	$1,383,400	$33,410	$1,383,400	$33,410

*Quote on the part of Pacific Telephone & Telegraph

TABLE 2

	ONE-TIME DETAIL	MONTHLY DETAIL	ONE-TIME COSTS	MONTHLY OPERATING COSTS
Selective Routing Only			$ 550,000*	$17,000*
Distributed Voice/Data with ALI (and ANI)				
TelCo ANI Equipment & Engineering (107 lines)	$ 107,000			
ALI Software Design & Programming	60,000			
SDSD & Geographic Base File Storage	97,500			
Voice Switcher Software Programming	60,000			
Hardware Engineering & Integration	60,000			
ALI Computer System	48,500			
Data Communications System	39,000			
56 Remote Terminals (CRT)	106,400			
56 Telephone Stations	19,600			
Voice Switcher	130,000			
Integration Components	30,000			
Voice & ANI Lines from Central Office to ALI Computer		$ 8,156		
ANI Forwarding (est. @ $60/circuit)		6,420		
Data Lines & Termination Charges, ALI Computer to PSAPs		1,290		
Voice Lines & Termination Charges, ALI Computer to PSAPs		4,333		
Equipment Maintenance		3,680		
ALI Update Charges (est. @ 30¢/update)		3,630		
ALI File Maintenance		3,000		
	$ 758,000	$30,509	$ 758,000	$30,509
Distributed Voice/Data with SDSD (and ANI, ALI)				
Distributed Voice/Data with ANI & ALI	$ 758,000			
SDSD File Development	17,500			
Voice & ANI Lines from Central Office to ALI Computer		$ 8,156		
ANI Forwarding (est. @ $60/circuit)		6,420		
Data Lines & Termination Charges, ALI Computer to PSAPs		1,290		
Voice Lines & Termination Charges, ALI Computer to PSAPs		4,333		
Equipment Maintenance		3,680		
ALI Update Charges (est. @ 30¢/update)		3,630		
ALI File Maintenance		4,320		
	$ 775,500	$31,829	$ 775,500	$31,829

* PT&T Quote

TABLE 2 (continued)

	ONE-TIME DETAIL	MONTHLY DETAIL	ONE-TIME COSTS	MONTHLY OPERATING COSTS
Multiple PSAPs Basic			$ 1,500*	$ 3,812*
Multiple PSAPs Enhanced (with Office Identification & Called Party Hold)			$ 2,900*	$ 4,572*
Multiple PSAPs with ANI			$ 870,000*	$16,500*
Multiple PSAPs with ALI (and ANI)				
Multiple PSAPs with ANI	$ 870,000*	$16,500*		
TelCo Minicomputer	72,000	850		
56 CRT's and Controllers	130,800	1,600		
Update & Retrieval Software	51,100			
Geographic Base File Development	74,500			
ANI Circuits		1,610		
ANI Logging Printers		1,500		
ALI Circuits & Modems		960		
Administrative Personnel		2,000		
Operating Personnel		1,000		
	$1,198,400	$26,020	$1,198,400	$26,020
Multiple PSAPs with SDSD (and ANI, ALI)				
Multiple PSAPs with ANI	$ 870,000*	$16,500*		
TelCo Minicomputer	72,000	850		
High Speed TelCo Minicomputer to Govt. Minicomputer Circuit	10,000	50		
Government Minicomputer	52,000	520		
56 CRT's and Controllers	130,800	1,600		
Updating & Retrieval Software	51,100			
Geographic Base File Development	74,500			
SDSD File Preparation	23,000			
ANI Circuits		1,610		
ANI Logging Printers		1,500		
ALI Circuits & Modems		960		
Administrative Personnel		2,000		
Operating Personnel		2,320		
	$1,283,400	$27,910	$1,283,400	$27,910

*PT&T Quote

TABLE 2 (cont'd)

	ONE-TIME DETAIL	MONTHLY DETAIL	ONE-TIME COSTS	MONTHLY OPERATING COSTS
Central PSAP Basic			$ 900*	$ 3,930*
Central PSAP Enhanced (with Office Identification & Called Party Hold)			$ 3,600*	$12,516*
Central PSAP with ANI			$ 700,000*	$16,500*
Central PSAP with ALI (and ANI)				
Central PSAP with ANI	$ 700,000*	$16,500*		
TelCo Minicomputer	72,000	850		
62 CRT's and Controllers	141,600	1,775		
Update & Retrieval Software	51,100			
Geographic Base File Development	74,500			
ANI Circuits		1,610		
ANI Logging Printers		1,500		
ALI Circuits & Modems		960		
Administrative Personnel		2,000		
Operating Personnel		1,000		
	$1,039,200	$26,195	$1,039,200	$26,195
Central PSAP with SDSD (and ANI, ALI)				
Central PSAP with ANI	$ 700,000*	$16,500*		
TelCo Minicomputer	72,000	850		
High Speed TelCo Minicomputer to Govt. Minicomputer Circuit	10,000	50		
Government Minicomputer	52,000	520		
62 CRT's and Controllers	141,600	1,775		
Updating & Retrieval Software	51,100			
Geographic Base File Development	74,500			
SDSD File Preparation	23,000			
ANI Circuits		1,610		
ANI Logging Printers		1,500		
ALI Circuits & Modems		960		
Administrative Personnel		2,000		
Operating Personnel		2,320		
	$1,124,200	$28,085	$1,124,200	$28,085

* PT&T Quote

TABLE 2 (cont'd)

EVALUATION SUMMARY

911 SYSTEM ALTERNATIVES	UTILITY (25)	NET COST (24)	PRIVACY (20)	RELIABILITY (16)	JURISDICTION (15)	TOTAL (100)
SELECTIVE ROUTING ADVANCED:						
SELECTIVE ROUTING ANI	13	17.9	18	14	15	77.9
SELECTIVE ROUTING ALI	21	10.9	16	12	15	74.9
SELECTIVE ROUTING SDSD	25	9.4	15	11	15	75.4
SELECTIVE ROUTING ONLY	1	22.6	20	14	15	72.6
DISTRIBUTED VOICE DATA:						
DISTRIBUTED VOICE/DATA ALI	21	13.6	16	9	15	74.6
DISTRIBUTED VOICE/DATA SDSD	25	12.8	6	7		64.8
MULTIPLE PSAPS BASIC	0	24.0	20	14	6	64.0
MULTIPLE PSAPS ENHANCED	2	23.5	19	16	6	66.5
MULTIPLE PSAPS ADVANCED:						
MULTIPLE PSAPS ANI	13	13.0	18	16	6	66.0
MULTIPLE PSAPS ALI	21	6.0	16	14	6	63.0
MULTIPLE PSAPS SDSD	25	4.5	15	13	6	63.5
CENTRAL PSAP BASIC	0	13.2	20	13	4	50.2
CENTRAL PSAP ENHANCED	2	8.1	19	15	4	48.1
CENTRAL PSAP ADVANCED:						
CENTRAL PSAP ANI	13	2.8	18	17	4	54.8
CENTRAL PSAP ALI	21	2.1	16	13	4	56.1
CENTRAL PSAP SDSD	25	0	15	12	4	56.0

TABLE 3

911 SYSTEM ALTERNATIVES	UTILITY VALUE					
	AUDIT TRAIL (3)	ANI (10)	ALI (7)	SDSD (3)	MANAGEMENT REPORT (2)	TOTAL POINTS
SELECTIVE ROUTING ADVANCED:						
SELECTIVE ROUTING ANI	3	10	0	0	0	13
SELECTIVE ROUTING ALI	3	10	7	0	1	21
SELECTIVE ROUTING SDSD	3	10	7	3	2	25
SELECTIVE ROUTING ONLY	1	0	0	0	0	1
DISTRIBUTED VOICE DATA:						
DISTRIBUTED VOICE/DATA ALI	3	10	7	0	1	21
DISTRIBUTED VOICE/DATA SDSD	3	10	7	3	2	25
MULTIPLE PSAPS BASIC	0	0	0	0	0	0
MULTIPLE PSAPS ENHANCED	2	0	0	0	0	2
MULTIPLE PSAPS ADVANCED:						
MULTIPLE PSAPS ANI	3	10	0	0	0	13
MULTIPLE PSAPS ALI	3	10	7	0	1	21
MULTIPLE PSAPS SDSD	3	10	7	3	2	25
CENTRAL PSAP BASIC	0	0	0	0	0	0
CENTRAL PSAP ENHANCED	2	0	0	0	0	2
CENTRAL PSAP ADVANCED:						
CENTRAL PSAP ANI	3	10	0	0	0	13
CENTRAL PSAP ALI	3	10	7	0	1	21
CENTRAL PSAP SDSD	3	10	7	3	2	25

TABLE 3a

CONTINUED

1 OF 2

NET COST

911 SYSTEM ALTERNATIVES	(A) ONE-TIME COST	(B) MONTHLY INTEREST (8% of A/12)	(C) SYSTEM COST	(D) ANSWERING PERSONNEL	TOTAL (B+C+D)	POINTS ASSIGNED
SELECTIVE ROUTING ADVANCED:						
SELECTIVE ROUTING ANI	970,000	6,467	22,000	0	28,467	17.9
SELECTIVE ROUTING ALI	1,298,400	8,656	31,520	0	40,176	10.9
SELECTIVE ROUTING SDSD	1,383,400	9,223	33,410	0	42,633	9.4
SELECTIVE ROUTING ONLY	550,000	3,667	17,000	0	20,667	22.6
DISTRIBUTED VOICE DATA:						
DISTRIBUTED VOICE/DATA ALI	758,000	5,053	30,509	0	35,562	13.6
DISTRIBUTED VOICE/DATA SDSD	775,000	5,170	31,829	0	36,999	12.8
MULTIPLE PSAPS BASIC	1,500	10	3,812	14,500	18,322	24.0
MULTIPLE PSAPS ENHANCED	2,900	19	4,572	14,500	19,091	23.5
MULTIPLE PSAPS ADVANCED:						
MULTIPLE PSAPS ANI	870,000	5,800	16,500	14,400	36,700	13.0
MULTIPLE PSAPS ALI	1,198,400	7,989	26,020	14,400	48,409	6.0
MULTIPLE PSAPS SDSD	1,283,400	8,556	27,910	14,400	50,866	4.5
CENTRAL PSAP BASIC	900	6	3,930	32,400	36,336	13.2
CENTRAL PSAP ENHANCED	3,600	24	12,516	32,400	44,939	8.1
CENTRAL PSAP ADVANCED:						
CENTRAL PSAP ANI	700,000	4,667	16,500	32,400	53,567	2.8
CENTRAL PSAP ALI	1,039,200	6,928	26,195	22,800	55,923	2.1
CENTRAL PSAP SDSD	1,124,200	7,495	28,085	22,800	58,380	0

TABLE 3b

911 SYSTEM ALTERNATIVES	PRIVACY		
	CALLER PRIVACY (5)	SUBSCRIBER PRIVACY (15)	TOTAL PRIVACY POINTS
SELECTIVE ROUTING ADVANCED:			
SELECTIVE ROUTING ANI	3	15	18
SELECTIVE ROUTING ALI	2	14	16
SELECTIVE ROUTING SDSD	1	14	15
SELECTIVE ROUTING ONLY	5	15	20
DISTRIBUTED VOICE DATA:			
DISTRIBUTED VOICE/DATA ALI	2	14	16
DISTRIBUTED VOICE/DATA SDSD	1	5	6
MULTIPLE PSAPS BASIC	5	15	20
MULTIPLE PSAPS ENHANCED	4	15	19
MULTIPLE PSAPS ADVANCED:			
MULTIPLE PSAPS ANI	3	15	18
MULTIPLE PSAPS ALI	2	14	16
MULTIPLE PSAPS SDSD	1	14	15
CENTRAL PSAP BASIC	5	15	20
CENTRAL PSAP ENHANCED	4	15	19
CENTRAL PSAP ADVANCED:			
CENTRAL PSAP ANI	3	15	18
CENTRAL PSAP ALI	2	14	16
CENTRAL PSAP SDSD	1	14	15

TABLE 3c

RELIABILITY

911 SYSTEM ALTERNATIVES	VOICE SWITCHING: Configuration (3)	Equipment (5)	Maintenance Responsibility (4)	DATA SYSTEM (4)	TOTAL POINTS (16)
SELECTIVE ROUTING ADVANCED:					
SELECTIVE ROUTING ANI	1	5	4	4	14
SELECTIVE ROUTING ALI	1	5	4	2	12
SELECTIVE ROUTING SDSD	1	5	4	1	11
SELECTIVE ROUTING ONLY	1	5	4	4	14
DISTRIBUTED VOICE DATA:					
DISTRIBUTED VOICE/DATA ALI	1	3	2	3	9
DISTRIBUTED VOICE/DATA SDSD	1	3	0	3	7
MULTIPLE PSAPS BASIC	1	5	4	4	14
MULTIPLE PSAPS ENHANCED	3	5	4	4	16
MULTIPLE PSAPS ADVANCED:					
MULTIPLE PSAPS ANI	3	5	4	4	16
MULTIPLE PSAPS ALI	3	5	4	2	14
MULTIPLE PSAPS SDSD	3	5	4	1	13
CENTRAL PSAP BASIC	0	5	4	4	13
CENTRAL PSAP ENHANCED	2	5	4	4	15
CENTRAL PSAP ADVANCED:					
CENTRAL PSAP ANI	2	5	4	4	17
CENTRAL PSAP ALI	2	5	4	2	;3
CENTRAL PSAP SDSD	2	5	4	1	;2

TABLE 3d

END

7 [illegible]