APPENDIX

TO

STUDY FOR ALAMEDA COUNTY

911

A - AUTOMATED 911 PRIVACY SURVEY

B - STUDY OF ANONYMOUS PHONE CALLS

C - NAME AS A COMPONENT OF A.L.I.

D - STUDY TO DETERMINE POTENTIAL VALUE OF A.L.I.

E - SUPPLEMENTARY DISPATCH SUPPORT DATA (SDSD): A PRESENTATION

F - QUEUING ANALYSIS OF 911 EMERGENCY CALL ANSWERING

RESIDENCE CUSTOMERS REACTIONS TO AUTOMATIC IDENTIFICATION OF CALLING NUMBER AND LOCATION ON CALLS TO "911"

APPENDIX A

PACIFIC TELEPHONE AND TELEGRAPH COMPANY
General Administration Accounting
Surveys and Statistics
November, 1973

TABLE OF CONTENTS

Background

In 1968, the Bell System offered the three digits "911" as a universal emergency number for use by public safety agencies in communities throughout the United States. By dialing "911" an individual (in a community served by this number) gains direct access to a switchboard operated by public safety agencies organized to handle emergencies on a community-wide basis. This basic "911" system is currently in operation in over 250 communities in the United States.

In March, 1972, AT&T, Pacific Telephone Company, the President's Law Enforcement Assistance Administration (LEAA), the communities in Alameda County, California, and the California Council of Criminal Justice agreed to use the communities within Alameda County as a test area to experiment with a sophisticated version of the "911" system. This system would, among other things, provide for automatic identification at the answering point of the telephone number and address from which an emergency call is being made. This automatic identification would be accomplished in one of two ways: either 1) the telephone company would release in advance the telephone numbers and addresses of all of its customers to the public safety agency answering the calls, for storage in their confidential computer files until a "911" call was received; or 2) the telephone company would maintain the computer file, releasing the telephone number and address information to the public service agency only at such time as a "911" call was made.

The automatic identification feature of the sophisticated "911" system caused two questions to be raised. First of all, how would people feel about having their telephone number and address automatically identified at the time of a call to "911"? Secondly, how would customers, particularly those with non-published service, feel about the Telephone Company releasing their number and address to the public safety agency for storage in their computer files? To attempt to gain some insights concerning these two points, Surveys & Statistics was requested to conduct a survey among residents of Alameda County.

In October, 1973, telephone interviews were conducted with 206 residence customers with non-published service, and 105 customers who had published service in Alameda County. Customers interviewed were selected randomly from current billing records.

First, respondents were asked if they had ever heard about the "911" emergency number. This was followed by a general question concerning their reaction to the idea of automatic identification of the caller's telephone number and address at the time of an emergency call to "911". Then, a specific question regarding the acceptability of the Telephone Company's releasing their telephone number and address in advance to the governmental agency answering "911" calls, was asked. It was explained that their telephone number and address would be stored in the answering agency's confidential computer files and could be used only if and when a call to "911" was placed from their

number. If this arrangement was not acceptable to the respondent or if he expressed uncertainty about it (said he "didn't know" if it was acceptable or not), he was asked if it would be acceptable if the TelCo retained custody of the number and address, but made it known to the answering agency at the time of a "911" call from his telephone number.

MAJOR FINDINGS

- Despite the fact that "911" is operative in the City of Alameda, awareness of the system is quite low in the County as a whole. Three out of four of the subscribers interviewed said they had not heard of "911".

- There is no significant difference in the responses of non-published and published customers with respect to the advance release to the public safety agency, or retention in Company computer files, of telephone number and address information.

- Overall, reaction of respondents to the idea of "911" with automatic identification of the calling number and address is very favorable. Further,

  - More than eight out of ten of those interviewed say they would be willing to have their telephone number and address released in advance to the public safety agency answering "911" calls.

  - Nearly nine out of ten respondents indicate that automatic identification

of their number and address w ..ld be acceptable to them if the Telephone Company maintained the information in their computer file, releasing it only at the time of a call to "911".

DETAILED FINDINGS

Awareness of "911"

About one-quarter of those interviewed indicated familiarity with the basic "911" concept. The remaining three-quarters said they had not heard of the "911" emergency number service.

FAMILIARITY WITH "911"

Heard about "911"?	Non-Published Customers	Published Customers
Yes	26%	22%
No	74	77
Don't Recall	-	1
Total Respondents	(206)	(105)

Higher awareness might have been expected due to the fact that basic "911" is in operation in the City of Alameda.

General Reaction to "911" with Automatic Identification Feature

After "911" with automatic number and address identification was described, respondents reactions to this service were very favorable:

GENERAL REACTION TO "911"
WITH AUTOMATIC IDENTIFICATION

	Non-Published Customers	Published Customers
Favorable	88%	89%
Unfavorable	6	3
Don't Know	6	8

Nearly nine out of ten respondents have a favorable reaction to the automatic identification of their telephone number and address at the time of a call to "911", not considering who maintains the number and address file.

Specific comments about the concept of "911" with the automatic identification feature are summarized in the following table. It should be noted that, although the great majority of responses are favorable, there does appear to be some concern about the confidentiality of the information, as witnessed by those who said the system would be OK only in an emergency, or OK if only the right people get the number.

SPECIFIC COMMENTS ON HAVING TELEPHONE NUMBER AND ADDRESS AUTOMATICALLY IDENTIFIED AT THE TIME OF CALL TO "911"

	Non-Published Customers	Published Customers
Favorable Responses*		
Good Idea	36%	47%
OK only in emergency	20	14
Mentioned personal situation or incident where "911" would have been or would be helpful	18	11
Would speed service/save time	13	11
Good idea because people get excited in emergency	13	6
Very good for people with children	9	5
Have no objections/alright/ok	8	10
OK if only the right people get your #	2	9
Excellent idea for the elderly	1	7
All other	**	3
Unfavorable Responses*		
Wouldn't like it/911 OK, but not with automatic identification	6	3
Don't think we need it; wouldn't save time	2	1
Don't Know*	6	8
Total Respondents	(206)	(105)

* Percentages are based on total respondents; totals add up to more than 100% due to multiple responses.

** Less than .5%.

Custody of Telephone Number and Address

Eight out of ten respondents said it would be acceptable to them to have their telephone number and address released in advance to the governmental agency answering "911" calls. The remaining respondents were nearly evenly divided between those who felt the arrangement was unacceptable and those who did not want to express an opinion one way or the other.

	Non-Published Customers	Published Customers
If Answering Agency Had Custody of Number and Address in Advance, It Would Be:		
Acceptable	82%	80%
Not Acceptable	10	14
Don't Know	8	6
Total Respondents	(206)	(105)

Examination of the comments made by those who did not express an opinion reveals that over half of the non-published customers and nearly all of the published customers probably lean more toward acceptance than non-acceptance. This could mean that the level of acceptability of advance release of telephone number and address to the "911" answering agency might go over 85% if people were sold on the benefits

of the system and their fears (primarily about confidentiality of the information) were allayed.

Among non-published customers, greatest resistance to the release of telephone number and address information in advance comes from those under 30, men, and those who are self-employed. Among published respondents, men, and those retired and/or pensioned, showed greatest opposition.

Respondents who said it was unacceptable for the government agency to have their number and address or didn't know whether or not they would find it acceptable were asked a further question. They were queried about the acceptability of the TelCo retaining the information until such time as a call was made to "911" from their number. Combining the acceptable responses to this question with those who said release of the information in advance would be acceptable, we find that nearly 90% of the respondents would be favorably disposed toward the TelCo retaining the information, but making it known to the agency at the time of a call to "911".

	Non-Published Customers	Published Customers
If TelCo Retains Custody, Releasing # and Address Only at Time of "911" Call, It Would Be:		
Acceptable	89%	87%
Not Acceptable	6	7
Don't Know	5	6
Total Respondents	(206)	(105)

Other Customer Concerns

Another concern which became apparent from customers' volunteered comments was that about the cost of the service. Sixteen percent of the published respondents and 1% of the non-published respondents asked who would pay for "911" service and/or how much it would cost.

Two percent of the non-published and 3% of the published respondents said the arrangement sounded like "big brother", there are too many government files already, or it would be an invasion of their privacy. Finally, 3% of the published and 1% of the non-published expressed anxiety about being held responsible for accidental false alarms or wondered how prank calls would be handled.

CONCLUSIONS

Nearly nine out of ten of our customers, both those with non-published and those with published service, think that "911" with automatic identification of calling number and address is a good idea. About eight out of ten are willing to let the Telephone Company release their telephone number and address in advance to the governmental agency in their community answering "911" calls.

Results of the study, however, indicate that additional acceptance would be garnered if the TelCo retained the numbers and addresses in their Company files and released them only at the time a call is made to "911". Even then, about one in ten people would object. However, it seems

reasonable to assume that such objections could be minimized by public education programs designed to emphasize the benefits of automatic identification of the calling location in time of an emergency, and stressing facts which would allay some of the fears expressed by respondents in the survey, especially the concern about confidentiality of the information.

"911" EMERGENCY NUMBER STUDY

SELECTED VERBATIM COMMENTS

NON-PUBLISHED CUSTOMERS

Favorable Comments:

- Fantastic, absolutely needed, tremendous, spectacular, completely necessary to eliminate human error. From the standpoint of the medical profession, from my experience in the medical profession, great.

- I think it's wonderful because it would be a lot easier to dial just a few numbers instead of a whole lot in an emergency. It would also be good for children. They could remember just 911 much easier than remembering a whole phone number.

- I think it would be fantastic. Really good that something like this could happen. People get hysterical and don't know what they are doing. I think it would be just great and I'm very enthused about it.

- Excellent idea. If I was having a heart attack, you remember three digit numbers. It should be nationwide -- everyone should be protected by this service. I live alone and depend solely on my telephone. I like the idea of number and address being automatic.

- It's a wonderful idea. Ten years ago someone broke into our house and I called the Police but I was so scared I couldn't say anything and if they hadn't been on the ball and told me what to do, I might never have been able to tell them who I was, or the guy might have gotten to me before I could tell them.

- Wonderful.

- I'd be all in favor of it. From what I've seen of emergency facilities, it isn't very good. It would be good to organize and have a central location for people to call so help could get there faster.

- That would be wonderful. That way you'd eliminate all the trouble of having to call through the operator and wait for your call to go through a switchboard. This positive identification would be a big boon.

- I would have no objection. If they have to know where I am, they could find me. As long as that's as far as it went, because I have an unlisted number. Very good idea and I like it.

NON-PUBLISHED CUSTOMERS

Favorable Comments (Continued):

- Well, if it wouldn't be made public I think it would be marvelous. Fantastic to have three digits instead of so many numbers and it would be good for small children to just have three numbers to dial. I just think it would be wonderful.

- As long as they knew they wouldn't be using for anything except an emergency I guess it would be alright. It sounds like a good idea.

Unfavorable Comments:

- I don't know...I think I'd be likely to object. We've seen recently how the telephone can be misused and there might be a way this system could be misused. I'd have to have more time to think about it.

- Well, if it's basically honest people, my objections are none. But, as it is too many people are into your private affairs now. I'll tell them if I want them to know. No, I'd have to say no -- too many ways we're identified, too many tabs on now. I think the 911 is great, but it wouldn't be good to have identification by a government agency.

- I don't think I'd like the idea at all. It's too personal. I have my list of emergency numbers and I'll take care of it. Why is the government getting into this at all?

- With all this stuff about bugging and taping, it's just more invasion of my privacy and I don't want anything to do with the government. I don't like it. I don't want anything connected with my phone to be in the hands of anybody. If you can be sure, it's a fine thing, but just look at this Richardson guy, how they just let him go. It's all crazy now. You can't be sure about anything.

- I don't know. I could see situations where that would be valuable. But there might be some people who wouldn't want to get help for someone at another address if they knew their own address would be identified. I can see that there would be some value, but I don't think it outweighs the value of maintaining anonymity. Because we are reaching the point with increased technological capacities where big brother and 1984 is just around the corner.

NON-PUBLISHED CUSTOMERS

Undecided:

- I don't know. I'd have to ask my husband. It might be a good idea.

- I'd have to give a little thought. It might be a good thing, but I would have to investigate it further.

- I don't know. It seems odd, but I guess it's alright. Their always saying things like the government already knows too much about us. I just don't know if this would be a good idea or not.

- I don't know. I'd have to think that one over. I just don't have any specific reactions on this.

- Well, gee, I don't know. I would wonder if our telephone number and address would be given out for mailing lists. Wouldn't want it unless it were confidential.

PUBLISHED CUSTOMERS

Favorable Comments:

- I'm for it. If it really was an emergency, I would only use 911. Suppose someone was breaking into your house, you might not want to speak. Most people might think it was an invasion of privacy, but I'd have no objection to it. They have your number and address anyway.

- I think that would be fine because I'm elderly. I'm in my late 70's. I think that would be <u>wonderful</u> - especially for people like me.

- For this particular household, it'd be excellent, because I don't have a good heart, and even though my wife is quite level-headed, when under duress, she's subject to the same pressure as anyone else. It should be instrumental in getting help right away.

- Well, I'm sure it would be of great value if it were a true emergency. I know if I had a bad emergency I'd be so nervous I couldn't even remember my address.

- It's an excellent idea. It is not an invasion of privacy but quite the opposite. If I ask for help, I would <u>want</u> that information known.

PUBLISHED CUSTOMERS

Favorable Comments (Continued):

- It is a good idea. Chances are that nine times out of ten when you call for an emergency, by the time you get done answering all the questions the place could be burned down. I think your proposal is a good idea.

- Well, I'd certainly go along with it. It's a wonderful idea. For the one reason that I've already had a heart attack and there's always that fear in the back of your mind -- you know, what if I needed help?

- Fine for my wife because of her language problem. Convenient to just dial 911 and you get assistance like Police, Fire and Ambulance.

- As long as I knew that it was a bona fide location like the Police Department I wouldn't mind it at all. I wouldn't want the names and addresses to fall into the wrong hands, though.

- If it's just used in case of emergency. If that's the only way they could use 911 for emergency, then I guess it would be alright, but I don't like the idea of my address and number given out.

Unfavorable Comments:

- To tell the truth, I don't want that. It is kinda nice, but I don't know. I don't think I would really like it. I like to do it myself. I don't want nothin' flashed around. I do it if I call.

Undecided:

- Well that would mean you would have to have some kind of set-up to handle it. Would the government pay for it? I don't know how I feel about another somebody having tabs on me with all the stuff that goes on already -- the telephone bugging and things like that.

- Well, I don't know. I always got help when I needed it. I honestly don't know and I'd like to think it over.

- I don't know. I'd have to think about it. Offhand, I'd say you should put me in an undecided category. My telephone can be traced now so I don't see that it would make any difference to me.

(PUBLISHED CUSTOMERS) TEL. # _____ _____ 1-10

11

A SURVEY OF CUSTOMER ATTITUDES TOWARD A UNIFORM EMERGENCY NUMBER

Good morning (afternoon/evening), I'm _____ from the Pacific Telephone Company. We're conducting a survey among our customers concerning a proposed new service. I'd like to ask you a few questions about it.

It has been proposed that the three-digit number "911" be established in your community as the number to dial for emergency help. For example, this number might be used to contact the police, the fire department, or summon an ambulance.

12-20 BLANK

1. Have you seen or heard anything about this proposed plan? Yes ☐1 No ☐2 21

EXPLAIN TO RESPONDENT:

If this number were established in your community, emergency calls would be answered at a central point by a government agency, say the police department. They would either send help or immediately give the information to the agency who could help in that type of emergency.

One of the features suggested for the proposed "911" emergency number service is automatic identification of the telephone number and the address from which the call is being made. This would mean that the agency answering the call would know the exact location of the caller. Thus, they could send help even if the caller were unable, say due to injury or excitement, to identify himself or explain where he was.

2. What would your reaction be to having your telephone number and address identified automatically at the time you made an emergency call to "911"?

_____ 22

_____ 23

_____ 24

3. If this emergency number proposal were implemented, the Telephone Company would release your number and address to the governmental agency in your community answering "911" calls. This information would be kept in the agency's confidential computer files and could be used only if and when you placed a call to "911." Would this procedure be acceptable or not acceptable to you?

Acceptable ☐1 → TO Q.4
Not acceptable ☐2 25
Don't know ☐3

Comments _____ 26
_____ 27
_____

(IF "NOT ACCEPTABLE" OR "DON'T KNOW," ASK:)

3a. If the Telephone Company did not release your telephone number and address to the governmental agency in advance but kept it in Company files and made it available to the agency only when and if you made a call to "911," would that be acceptable or not acceptable to you?

Acceptable ☐1
Not acceptable ☐2 28
Don't know ☐3

4. Now I'd like to ask you some optional questions in order to help us analyze the results of this survey. Would you please tell us if the head of your household is self-employed or employed by someone else?

Self-employed ☐1
Employed by someone else ☐2 29
Presently unemployed ☐3
Retired or pensioned ☐4
Other (write-in) _____
_____

4a. In what profession, industry or line of work is the head of your household employed?

30
_____ 31
_____ 32

5. What is the age of the head of this household? (READ LIST)

Under 30 ☐1
30 - 44 ☐2 33
45 - 64 ☐3
65 or over ☐4

VERIFY AND RECORD THE FOLLOWING INFORMATION:

Respondent's Name:_____

Street Address:_____

City or Town:_____

Telephone Number:_____

Those are all the questions I have. Thank you for your time.

Respondent was: Male☐1
Female☐2 34

PLEASE FILL IN THE FOLLOWING:

Interviewer's Name:_____ 35

Date Interview Completed:_____ 36

Verified By:_____ 37

A STUDY OF ANONYMOUS PHONE CALLS TO THREE POLICE DEPARTMENTS IN ALAMEDA COUNTY

LOUIS RADNER

Background

The proposal for an advanced 911 system in Alameda County includes provision for the automatic display of calling number and street address at the answering point. These features introduce the possibility that individuals willing to call anonymously might refrain from calling if the calling number and street address become available to the public service agency receiving the call. Such a reduction in anonymous calls might impose a penalty on the operations of police departments. (Because of the nature of the complaints, anonymous calls are of less significance to fire departments and, frequently, are not specifically tagged in their records.)

The purpose of this study was to estimate the magnitude of this potential penalty by examining the characteristics of anonymous complaints currently being received by three representative Alameda County police departments. Collateral information on this problem was obtained by contacting public service agencies operating existing 911 systems which include called-party-hold. The called-party-hold feature, which permits a call to be traced after the caller has hung up, might have had a similar dampening effect on anonymous calls.

Method

Data on anonymous complaints was obtained by examining the complaint-dispatch cards of police departments in Oakland, Berkeley and Fremont. These three cities contain over one-half of the total population of the County (See Appendix) and therefore provide an adequate basis for a representative sample of phone complaints to police departments. At the same time, the three cities show some variation in regard to population characteristics, geographical location within the County and details of police procedure.

The complaint-dispatch cards constitute a record of all incoming phone calls received by the respective police communication centers which result in a dispatch message to a field unit. A typical card contains fields for the date/time of the receipt of the complaint, the nature of the incident, location of the incident, the name, address and phone number of the complainant, the identification of the responding field unit and remarks. Cards are filled out by hand upon receipt of a call by an operator.

For each department, cards were examined for the 24-hour periods of Wednesday, August 15 and Friday August 17. This was done to include both a relatively quiet mid-week period and a busy weekend evening in the time sample. To provide further background data on the nature of the complaints and police procedures, several hours of tape recordings of incoming calls

on August 15 and 17 were monitored both in Oakland and Berkeley.

Results

Table 1 shows a breakdown of the type of complaints reaching the police communication centers. "Citizen Calls" are complaints originating from citizens via telephone. The "Police Originated" category refers to incidents reported by police units in the field, usually via radio. (In Oakland, this category includes a large number of requests for a patrol wagon or a tow truck.) The "Alarm Systems" category refers to activation reports from automatic alarm systems. The lower percentage of alarm activations in Fremont is probably due to the more residential nature of this community.

TABLE 1

TYPES OF INCOMING COMPLAINTS FOR AUGUST 15 AND 17, 1973

Type of Complaint	Oakland		Berkeley		Fremont	
	No.	%	No.	%	No.	%
Citizen Calls	1167	71.8	285	79.9	219	85.6
Police Originated	338	20.8	43	12.0	32	12.5
Alarm Systems	120	7.4	29	8.1	5	2.0
TOTAL COMPLAINTS	1625	100.0	357	100.0	256	100.0

The remainder of this analysis will focus on the citizen complaints. Results of the analysis of incoming calls from citizens are presented in Table 2.

TABLE 2

TYPES OF INCOMING CALLS FROM CITIZENS
FOR AUGUST 15 and 17, 1973

Type of Incoming Call	Oakland		Berkeley		Fremont	
	No.	%	No.	%	No.	%
Complainant Identified	1005	86.1	268	94.0	204	93.2
Anonymous Complainant	162	13.9	17	6.0	15	6.8
Complainant Refused	41	3.5	1	0.4	4	1.8
Blank Field	37	3.2	16	5.6	2	0.9
Passing Citizen	50	4.3	0	--	9	4.1
Resident	34	2.9	0	--	0	--
TOTAL CITIZEN CALLS	1167	100.0	285	100.0	219	100.0

The "Anonymous Complainant" category includes all calls on which the name of the calling party is not obtained, for whatever reason. Under the overall heading of "Anonymous

Complainant," the "Complainant Refused" category refers to calls on which the calling party is asked for his name and refuses to provide it. A blank field on the complaint-dispatch card or the notation "P/C" for "Passing Citizen" or "res" for "Resident" describe calls on which the police operator does not ask for the calling party's name. The procedures of all three police departments allow the operator to omit the calling party's name for certain types of relatively minor incidents such as traffic accidents. The higher percentage of anonymous calls in Oakland is related to the fact that the Oakland police operators have greater discretion to omit the caller's name on minor incidents.

The complainant refused calls are of most interest to this study because they are the calls which might be discouraged by the anonymity-reducing features of the advanced 911 system. These complainant refused calls constitute only a small percentage of all incoming calls from citizens, varying from 3.5% in Oakland to 1.8% in Fremont and 0.4% in Berkeley. This difference among the three cities is strongly influenced by differences in police call-handling procedures: Berkeley and Fremont will attempt to obtain the name of a reluctant caller; Oakland will not. Variability among the characteristics of the three communities served may also contribute to the difference in percentage of complainant refused.

Table 3 shows a breakdown of Oakland's complainant refused calls by type of complaint. Twenty-one of the 41 complainant refused calls (51.2%) involved the relatively routine complaints of disturbing the peace or animal incidents. For most of the more serious complaints the percentage of complainant refused calls was low and not significantly different from the 3.5% proportion of complainant refused calls to all citizen complaints. A relatively high percentage of complainant refused calls was obtained for car prowler, drunk driving, and possible drugs, but the very small number of cases involved in these complaints make the data difficult to interpret. Other than these few cases, there was no evidence that specific types of serious complaints tend to be made anonymously.

Berkeley's only instance of a complainant refused call involved an auto accident; Fremont's four cases included two instances of disturbing the peace, one case of "suspicious circumstances" and one report of a suicide. The suicide indicates that, although most of the complainant refused calls are of a routine nature, occasionally an extremely critical incident may be involved.

An analysis of the calls classified as "Blank Fields," "Passing Citizen" or "Resident" was conducted to see if these categories might contain significant numbers of misclassified calls which more accurately should have been designated as complainant refused. In Oakland, the majority of these anonymous

TABLE 3

OAKLAND COMPLAINANT REFUSED CALLS

CODE	COMPLAINT	TOTAL # OF CITIZEN COMPLAINTS	NUMBER COMPLAINANT REFUSED	% COMPLAINANT REFUSED
415	Disturbing the Peace	78	2	2.6
415J	--Juvenile	52	1	1.9
415C	--Investigate the Trouble	48	5	10.4
415E	--Music Party	29	7	24.1
415F	--Family Row	34	2	5.9
	(Total 415)	(241)	(17)	(7.1)
459	Burglary	165	4	2.4
910	Prowler Outside	32	1	3.1
912	Suspicious Person	33	2	6.1
921	Car Prowler	5	4	80.0
933	Burglary Alarm	10	1	10.0
943	Fight	17	1	5.9
950	Investigate Report from Citizen	50	1	2.0
955	Animals Straying	10	2	20.0
955B	Noisy Animal	14	2	14.3
962	Meet A citizen	84	1	1.2
23101	Felony Drunk Driving	1	1	100.0
23102	Misdemeanor Drunk Driving	3	1	33.3
10851	Auto Theft	26	2	7.7
	Drugs Possible	1	1	100.0

calls (102 out of a total of 121) involved routine complaints such as disturbing the peace or traffic accidents, which, under Oakland procedures, may be recorded as anonymous calls. It is possible that some of the remaining 19 calls should have been classified as complainant refused but this is not a large enough error to disturb any of the previous conclusions. The same result was obtained in Berkeley and Fremont where almost all the anonymous calls in these three categories involved traffic accidents or disturbing the peace.

Cities with Called-Party Hold

Police officials were contacted via phone in Omaha, Nebraska and Worcester, Springfield, Brookline and Quincy, Massachusetts. All these cities heavily publicized the called-party-hold feature and all report no noticeable decrease in complainant refused calls.

Summary of Results

The results of this study indicate that:

A. Only a small percentage of incoming calls are complainant refused calls.

B. At least half of the complainant refused calls involve routine incidents.

C. For the most part, the remaining complainant refused calls are not concentrated on any one type of complaint but are scattered among several types of serious complaints.

Further evidence comes from cities which report no reduction in anonymous calls after 911 with the anonymity-reducing feature of called-party-hold was put into operation and heavily publicized.

The weight of evidence indicates that the installation of an advanced 911 system will cause little or no penalty to police operations in terms of the number and variety of incoming calls.

LR:sc

APPENDIX

RELATIONSHIP BETWEEN POPULATION, CRIME RATE AND CITIZEN CALLS TO POLICE DEPARTMENTS

MEASURE	OAKLAND	BERKELEY	FREMONT
Estimated 1972 population	362,000	116,500	119,500
Crime rate per 100,000 population	6,852	5,962	4,137
Average citizen calls per 24 hours per 100,000 population	161	123	92

The 1972 population estimates were obtained from the Alameda County Planning Departments. Crime rates were derived from the Total Crime Index reported in the 1972 Uniform Crime Reports of the Federal Bureau of Investigation. The Total Crime Index includes murder and non-negligent manslaughter, forcible rape, robbery, aggravated assault, burglary-breaking or entering, larceny $50 and over and auto theft.

The averages for citizen calls per 24 hours include only those calls which resulted in the filling out of a complaint-dispatch card and are therefore not a measure of the total number of all calls from citizens to the police departments.

On the other hand, these figures do include all citizen complaints which require a response from field units and are, consequently, an important component of police services. As seen in the above table, the average number of citizen calls is closely related to the crime rate and presumably to the population characteristics and socio-economic conditions which underlie crime.

Acknowledgements

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NAME as a Component of the 911 Automatic Location Identification Feature

(Study of its Potential Value to Public Safety Dispatching)

If the A.L.I. display were to incorporate the name of the subscriber along with the calling phone number and its installed address, how reliable would it be in providing the name of the person actually calling?

A sample of 115 complaint cards at the Oakland Police Department for Friday, September 14, 1973 was examined against the 1973 Haines Criss-Cross Directory and the November 1973 Pacific Telephone reverse directory to discover how often the complainant, the phone number and the address on the cards were identical to the same combination in the reverse directories.

EXAMPLE (taken from a complaint card):

Address of Complainant:	4707 Manila
Phone Number:	653-6936
Name of Complainant:	Dykes

APPENDIX C

COMPARISON OF 115 COMPLAINT CARDS AT THE OAKLAND POLICE DEPARTMENT WITH REVERSE DIRECTORIES

I.	CONFIRMING INFORMATION NOT AVAILABLE (40 percent of the sample):		
	A. Known unlisted numbers	7	
	B. Address and phone number not found in reverse directories*	39	
		46	
			% of Confirmable
II.	NAME OF COMPLAINANT IS NAME OF CALLING PHONE SUBSCRIBER:		
	A. All information on cards correlates with reverse directories	36	52.2
	B. Phone number and subscriber correlate; address different	2	2.9
	C. Transcription error in address; otherwise all information correlates**	3	4.3
	D. Call taken from wrong city; otherwise all iformation correlates	1	1.5
	SUB-TOTAL	(42)	(60.9)
III.	NAME OF COMPLAINANT NOT NAME OF CALLING PHONE SUBSCRIBER:		
	A. Address and phone number correlate; subscriber different	12	17.4
	B. Address and subscriber correlate; phone number different	5	7.2
	C. Address listed, phone number and subscriber different	4	5.8
	D. Phone number listed; address and subscriber different	6	8.7
	SUB-TOTAL	(27)	(39.1)

* It may be assumed that his category contains a high number of unlisted subscribers since the percentage of unlisted residential numbers in Oakland as a whole is approximately 23%.

** e.g., card had 419 51st Ave.; phone directory had 419 151st Ave.

A STUDY TO DETERMINE THE POTENTIAL VALUE OF AUTOMATIC LOCATION IDENTIFICATION (A.L.I.) TO PUBLIC SAFETY

I. BACKGROUND

The following are results of a study to determine the potential value of certain advanced features of a 911 system. Such a system might include at one or more answering points in Alameda County the automatic display of the calling phone number and its address during the time of a 911 call. The study is designed particularly to evaluate the Automatic Location Identification (A.L.I.) feature as an aid to public safety dispatching.

II. PURPOSE OF STUDY

A. To document those instances when Automatic Location Identification would be valuable in quickly and correctly obtaining the caller's address (e.g., he is panicked, forced to whisper, or is disconnected).

B. To record from the context of the conversation the caller's proximity to the event. Is the displayed address reliable for dispatch purposes? Is it reliable enough to be tied into a computerized dispatch system (e.g., police beat, fire box, ambulance company)?

III. METHODOLOGY

One 911 staff member listened to a total of 963 tape recorded calls from citizens to 7 public safety agencies in Alameda County:

Oakland Police Department
Oakland Fire Department
Alameda 911
Piedmont Fire Department
San Lorenzo Fire Department
Fremont Police Department
Alameda County Sheriff

The population served by those departments is approximately 65% of the County.

Of the 963 calls monitored, 534 were calls for service; the remainder were requests for information and other routine business requiring no dispatch. Only those calls for service were analyzed for location-related data.

The time periods monitored varied according to the type of tape recorder used and requirements for a dependable sample. Those departments using 24-hour continuous tapes were monitored for 24-48 hour periods (Oakland Police, Oakland Fire, Fremont Police, Alameda 911, Sheriff's Department); the two voice-actuated recorders (San Lorenzo Fire and Piedmont Fire) covered calls for a period of 3-4 months.

The following criterion was used to distinguish EMERGENCY calls to a department from NON-EMERGENCY calls: If the caller was reporting something in progress or was requesting an ambulance or rescue unit, the call was tabulated as an EMERGENCY. If he was asking for police or fire response

for an incident not requiring immediate dispatch (e.g., "cold" burglary, auto blocking driveway, broken water main) it was considered NON-EMERGENCY. This distinction is necessarily arbitrary but remained consistent throughout the study.

IV. SUMMARY OF MAJOR FINDINGS:

(The following statistical table may be referred to for more detailed data.)

1. Calls for service to police departments in the County average a ratio of one EMERGENCY call to three NON-EMERGENCY calls. That ratio is reversed with the fire departments where an average of 77% of the calls require EMERGENCY response.

2. In an average of 53% of the calls from citizens to the four police departments monitored, the caller was at the exact location requiring assistance. In an additional 25% of the calls, he was within a few addresses of the incident. In 12% of the calls, the caller's location was unknown, but it may be assumed that most were either at the scene or nearby since those more than a block away usually declare that fact. Therefore, between 85%-90% of all calls to police would display an address either on the scene or within a few addresses.

3. Callers reporting fires or requesting a rescue unit less often give their own location; therefore the "unknown" category is larger for the three fire departments monitored -- 23%. Callers were on the premises in an average of 40% of the calls; another 30% were within a few addresses. Since it can be assumed that most callers with "unknown" locations know of the fire firsthand and are nearby, a total of 85%-90% of all calls to fire departments would likely display an address useful for dispatch.

4. Callers were not significantly more often on the premises in the case of EMERGENCY calls. There were shifts in both directions -- in Oakland police EMERGENCIES, there was an increase of 5% in the "on the premises" category. In Fremont there was a decrease in that category of 34.4% with most callers shifting to "within a few addresses."

5. There was a wide variety of reasons the caller's address was difficult or impossible to obtain (an average of 16% of all calls for service). A common reason in Oakland but not in other departments was "accent"; a typical reason in all departments was that the caller was excited, talking fast or in a whisper.

sc:December 3, 1973

AN ANALYSIS OF CALL TRAFFIC INTO SEVEN ALAMEDA COUNTY PUBLIC SAFETY AGENCIES
(Study of Potential Value of 911 A.L.I. Feature)

	OAKLAND POLICE		OAKLAND FIRE		SHERIFF'S DEPT.		FREMONT POLICE		ALAMEDA 911		SAN LORENZO FIRE		PIEDMONT FIRE	
	#	%	#	%	#	%	#	%	#	%	#	%	#	%
Emergency														
Police or Fire	42	23.7	43	81.1	7	7.4	12	19.4	5*	22.7	39	46.4	16	39.0
Ambulance or Rescue	12	6.8	3	5.7	4	4.2	4	6.4	2	9.1	32	38.1	4	9.8
SUB-TOTAL	(54)	(30.5)	(46)	(86.8)	(11)	(11.6)	(16)	(25.8)	(7)	(31.8)	(71)	(84.5)	(20)	(48.8)
Non-Emergency														
Police or Fire	123	69.5	7	13.2	84	88.4	46	74.2	15	68.2	13	15.5	21	51.2
TOTAL CALLS	(177)		(53)		(95)		(62)		(22)		(84)		(41)	
Location difficult to understand (emerg. calls only)	14	25.9	11	20.7	1	9.1	2	12.5	0	--	7	9.9	2	10.0
Caller didn't know building address (all calls for service)	5	2.8	0	--	2	2.1	1	1.6	0	--	1	1.2	1	2.4
Caller's proximity to incident (all calls for service) **														
On premises	92	52.0	13	28.8	48	52.7	33	53.2	15	68.2	27	41.5	19	47.5
Within a few addresses	52	29.4	17	37.7	18	19.8	15	24.2	4	18.2	18	27.7	9	22.5
More than a block away	14	7.9	5	11.3	11	12.1	6	9.7	3	13.6	4	6.2	4	10.0
Unknown	19	10.7	10	22.2	14	15.4	8	12.9	0	--	16	24.6	8	20.0
TOTAL CALLS	(177)		(45)	.	(91)		(62)		(22)		(65)		(40)	

*All calls were for police service
*Includes only calls from citizens; dispatch information from operator and other departments omitted.

November, 1973

SUPPLEMENTARY DISPATCH SUPPORT DATA (SDSD)

IN ITS RELATION TO EMERGENCY SERVICES THROUGH "911"

Presented by:

JAMES A. FRANK, Fremont Police Department

911 SDSD Sub-committee
911 Users Task Force

03/04/74

APPENDIX E

INTRODUCTION: Prior to discussing any relative merits to SDSD in the 911 emergency system, it is necessary to have a full understanding of exactly what SDSD is. It is information that could be automatically displayed with the calling party's number and address to assist emergency services in dispatching their field units. Although simplicitic, this definition is accurate and portrays the functional purpose of the SDSD in conjunction with the 911 emergency telephone system.

In viewing the goal of the current project, we must realize that 911 emergency telephone system is designed to enable public safety to dispatch the proper service to the proper location in order to provide the best level of service to the community it serves.. Keeping this basic premise in mind, we now can view SDSD as to its relevant merit in meeting this overall goal. At this time, I hope to convey to you on the Steering Committee the feeling that Public Safety has regarding SDSD and why we, as a group, feel that the inclusion of such data in the 911 emergency telephone system is necessary and valuable to those of us, the users.

BACKGROUND: As you are all aware, numerous surveys have been conducted in conjunction with the 911 study. The results that are most significant to the question of SDSD are the ones regarding percentage of callers actually on the premises of an incident and the percentage of calls that are received by an emergency service over non-911 lines. A review of three (3) fire departments and three (3) police departments along with the City of Alameda's 911 answering system revealed that approximately 60% of all police calls and 50% of all fire calls would originate from the incident's location. It was also determined that approximately 15% of all emergency calls now being received by existing 911 communication centers (Omaha and Seattle) are received on non-911 lines. As you know, a call being received by an emergency service on a non-911 line would offer the agency no information as to telephone number location or supplemental data. As the question of SDSD was of great importance to the entire users task force established by the Steering Committee, a smaller group (SDSD sub-committee), was formed for the purpose of viewing the ultimate value of SDSD and what components should be included. The members of this committee were Chief Mel Dosa from the Piedmont Fire Department, Lieutenant Gordon Miller from the Oakland Police Department, Battalion Chief Anderson from the Oakland Fire Department, Mr. Mark Leh from the City of Oakland (Electronics Division), Mr. Sairanen from the East Bay Regional Parks and myself. The request for allowing my presentation today is a direct result of our sub-committee's meeting, as we felt it would be advantageous for you, the Steering Committee, to receive first hand the feelings and justifications of public safety agency personnel regarding SDSD.

WHY SDSD? Once having identified what SDSD should contain, the natural question is why should it be contained only within the 911 system? This brings me back to my original statement regarding the goal of the 911 emergency telephone system: to provide public safety agencies with that information that will enable them to respond the appropriate service to the proper location and provide the maximum level of service to the community.

In viewing SDSD from a law enforcement aspect, it is important to realize that if we are able to respond to a criminal action in progress within six (6) minutes or less with the appropriate number of units at the correct location, our chance of a successful apprehension is in the area of 70%. After six (6) minutes, this percentage drops down to 11%, thereby graphically demonstrating, in criminal situations, how valuable information that will assist law enforcement in deploying the appropriate

personnel to the appropriate location is to successful protection to life and property in our community.

From an emergency service concept, law enforcement being the primary agency having mobile units at all times operating within the community, we must realize that failure to respond to the site of an individual who has ceased breathing within four (4) minutes will result in irreparable brain damage and possibly death. Therefore, we no longer have the six (6) minute leeway; we are now down to four (4) minutes in order to respond to something such as a medical emergency I have illustrated. This example also shows that time is crucial in providing emergency services to our community.

I would like, at this time, to outline the general procedure used by most law enforcement agencies in dispatching personnel to the scene of an emergency or crime:

(1) A call is received from a citizen advising either a police dispatcher or call answerer of a situation requiring police attention.

(2) A complaint card or dispatch card is completed and dispatched to the field unit. Prior to the actual dispatch, it is incumbent upon either the call answerer or the dispatcher in some cases to identify the reporting area or police beat in which that call belongs, and the appropriate officer(s) necessary to handle thyincident.

(3) Upon receipt of the assignment by the officer in the field, if he is unaware of the exact location of the incident (which is often the case with newer personnel or in growing cities), he will pull to the side of the road, take out a map or map book, look up the street on which the call is located and then proceed to his destination. It goes without saying the amount of time necessary to accomplish this task is substantially greater than would be required if upon receipt of the phone call, this information was displayed to the dispatcher and could be conveyed to the field unit when necessary.

The procedure is not substantially different in the area of fire service and the information listed under "priorities for SDSD" are self-explanatory for both police and fire in their ability to aid the particular emergency service in dispatching field units and insuring their arrival on the scene with the proper personnel and equipment in the shortest amount of time.

SDSD CONTENT: As we know, any time an information system is offered to different people in different disciplines, it will result in a variety of requests for information to be stored and displayed in such a system. We were no exceptions to this and found that representatives from the users task force had many different anticipated needs and desires for SDSD. However, it was found that there were basic requirements of all emergency service agencies that appeared on everyones list. The sub-committee, as a group, unanimously agreed that the consistent information required by all emergency service agencies should form the basis for SDSD and should be available to all agencies involved in the 911 emergency telephone system. No doubt, as time progresses, additional information may be justified for either all or the majority of the user agencies and at that time the value of that information for inclusion in an ultimate SDSD system would be weighed and decided upon.

These common information requests for SDSD have been broken down into priorities of extreme value, middle value and little value. They are as follows:

Extreme Value:
(1) Police Beat or Reporting Sector
(2) Fire Box Area or Fire District
(3) Cross Street Identification (or preferably, relation to major intersections, major parallel streets, etc.)
(4) Type of Building and Contents (with terminal access by the user)

Middle Value:
(1) What side of the street?
(2) Ambulance Zone
(3) Area is in Another Organization's Jurisdiction (army base, small regional park)
(4) One-way Street Direction

Little Value:
(1) Nearest Hospital
(2) Block Face Character (residential, business, etc.)
(3) Proximity to Adjacent Jurisdictions Border

While the aforementioned items have been broken down into three (3) priorities, at this time, I should point out that these are what is felt to be the basic content necessary for SDSD to be of functional assistance to providing emergency services. As the information from the 911 study project office has indicated, there are additional elements of information that had selective value to specific agencies and might be utilized on a local jurisdictional basis, rather than as part of the county-wide 911 system.

SDSD ACCESSIBILITY THROUGH INQUIRY: As I mentioned previously, not all calls requiring emergency service are received from the location of the incident or on a 911 line. Fifty percent (50%) of the calls on fires originate at other locations as do 40% of police calls as well as the 15% of emergency calls that are received over non-911 lines. As conscientious members of public service agencies, we strive to provide the highest level of service to all our residents and therefore believe that accessibility to SDSD files is an intregal necessity to the system. That is to say, a police dispatcher should have the capabilities through his local terminal device of inserting an address into the 911 system and retrieving the phone number location and supplemental data display. Without this capability, those calls coming in from different locations or over non-911 telephone lines would force the emergency service to respond and react with less information than they do for 911 calls, thereby decreasing the effectiveness of the agency as well as increasing the processing and ultimate response time to the proper location. When we talk of six (6) and four (4) minute time segments in order to insure protection of life and property or the saving of a life, we must realize that any system that will assist in decreasing response time, as well as increasing effectiveness of the emergency service is certainly worth consideration in an emergency system.

SUMMARY: Alameda County has the unique fortune of being in a position to design and implement a 911 emergency telephone system that will provide its residents with the ultimate in emergency service response. In order to attain this goal, we must carefully evaluate the system and its components. We of the users task force have done this and I think have done this with objectivity and conscientiousness. As a result, we believe that the inclusion of SDSD in the 911 project is important in complementing the highly valuable automated location identification.

We, in public service agencies, are not attempting to establish a "big brother" file on the residents of the communities we serve. On the contrary, we wish only to develop and display that information that will assist us in performing the job we were hired to do: protect and serve the people of Alameda County. We have evaluated SDSD from this light and have determined the necessary minimum requirements for SDSD, consciously aware of the privacy issue and feel that the information requested is not for investigatory or curiosity sake, but is for being able to provide service to the community.

Report No. ATR-74(7912)-1

QUEUEING ANALYSIS OF 911 EMERGENCY CALL ANSWERING

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14 December 1973

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APPENDIX F

I. INTRODUCTION

Queueing theory is the study of systems in which certain entities desire to obtain service for which they may be forced to wait. In this report, the application of queueing analysis to the answering of 911 calls is discussed. In a 911 system, calls are placed to a 911 answering center where one or more answerers are stationed. If an answerer is free, an incoming call can be handled immediately; if all answerers are busy, a caller must wait for an answerer to become free or else hang up and try again. Some of the questions of interest are:

1. How many answerers are needed to maintain the probability of delay below an accepted limit?
2. How long must delayed calls wait to be answered?
3. How much of the time are answerers idle (or busy)?
4. What is the effect of various answering disciplines?

In the sections to follow, some of the basic concepts of queueing theory are discussed, and techniques of solution using both analysis and simulation are described.

II. BASIC CONCEPTS

Some of the basic properties of queueing systems are the pattern of demand for service, the rate at which it can be provided, the order in which waiting entities are served, and the behavior of entities in the queue(s). Many of these properties are described probabilistically.

A. PATTERN OF ARRIVAL

The entities which require service are called customers or arrivals. Arrivals can occur on a regular basis or randomly according to some probability distribution, and can occur singly or in bulk. The average number of arrivals occurring per unit time, called the arrival rate, is an important parameter because it describes the load on the system. Also important is the interarrival time or the average time between arrivals. One of the fundamental facts used in queueing theory is the following:

> If the distribution of the number of arrivals per unit time is Poisson with parameter λ (the arrival rate), then the distribution of the lengths of the time intervals between arrivals is exponential with parameter λ.

Poisson arrivals are the simplest to handle analytically. An intuitive description of the Poisson distribution is that the probability of an arrival in a particular time interval depends only on the length of the interval and not on its beginning point. In a 911 system, the arrival rate is simply the average number of calls received per unit time. Since telephone calls have been observed to adhere to the Poisson distribution, it is reasonable to assume a Poisson distribution for the arrival of 911 calls, although the arrival rate will certainly vary with the time of day, day of the week, etc.

B. SERVICE TIME

Whatever provides the service is called a server, and the average time to complete service, often denoted by $1/\mu$, is called the service time. In a 911 system, a call answerer is a server, and the service time is the time to

complete a call, that is, the time elapsed from the moment the call is answered to the moment when the answerer is ready to accept another call.

An exponential distribution of service times is easiest to handle analytically. Also fairly simple are the Erlang distributions E_n, n=1,2,..... which can often approximate other distributions. One or more servers may be provided, and each server may have its own queue or there may be a common queue. The multiple server case is more difficult to handle analytically. Finally, there may be more than one stage of service; for example, if calls are transferred by the original answerer to a secondary answerer. Note that in telephony the service time (i.e., length of a call) is called the holding time.

C. QUEUEING DISCIPLINE

The order in which waiting customers are served is called the queueing discipline. Some examples of queueing disciplines are first come, first served (FIFO), at random, and according to priority of the customers. The queueing discipline affects the results except in certain special cases.

D. BEHAVIOR OF WAITING CUSTOMERS

Waiting customers may wait until served, depart after a certain amount of time, or not be allowed to wait at all. These correspond, in a 911 setting, to staying on hold until answered, staying on hold until hanging up due to discouragement or some other reason, and to receiving a busy signal. These three cases are the normal cases of interest in telephony. In a 911 system, busy signals are not desirable, and it is likely that callers will be encouraged by recordings or other means to hold until answered.

III. ANALYTICAL RESULTS

The only readily available analytical results in the multi-server case are for Poisson arrivals and exponential service time. Some limited results for constant service are given in Ref. 1. The most likely candidate for the 911 situation appears to be the Erlang C equation which applies under the assumptions that calls are handled on a first come, first served basis and that delayed callers wait until answered.

The usual parameters of interest are the following:

λ = arrival rate (number of calls per unit time)

μ = service rate (number of calls answered per unit time per man)

s = number of servers (answerers)

$\rho = \lambda/s\mu$

For stability, ρ must be less than 1; otherwise, the queue will grow without bound. This says simply that the arrivals do not exceed the capacity of the servers. The quantity ρ is called the servers occupancy ratio and gives the fraction of time each server is busy, on the average.

The Erlang C equation makes it possible to solve for the percentage of calls delayed, usually denoted by $P(>0)$, in terms of the arrival rate, the service rate, and the number of answerers. The equation is not reproduced here (see Ref. 2, p. 116) since a number of tables and graphs are readily available (e.g., Refs. 1,3). The equation for $P(>0)$ also applies to service of waiting customers in random order.

The probability of waiting for a time period greater than t is also of interest and is given by

$$P(>t) = \exp\left[-s\mu t\,(1-\rho)\right] P(>0)$$

where "exp" indicates the exponential function. Thus $P(>t)$ can be computed easily for various values of t if $P(>0)$ is known. The conditional probability

that delayed calls wait for a time period greater than t is given by the exponential term in the equation for P(>t). For service in random order, the probability P(>t) is larger than for FIFO service, whereas there is no difference in P(>0). Graphs for service in random order are given in Ref. 4.

If delayed calls are lost (i.e., receive a busy signal instead of hold), then Erlang's loss formula applies (Ref. 2, p. 303).

In Figs. 1 and 2 graphs of Erlang's C equation are presented as a function of the traffic intensity and the servers occupancy ratio for different numbers of servers. Several curves for constant service time, based on Ref. 1, are also shown. The simple relationship

[(traffic intensity) = (no. of servers) (servers occupancy ratio)]

applies. The curves are plotted only for the probability of delay up to 0.10 since 10 percent of the calls delayed appears to be a reasonable upper bound for a 911 system. Although these curves apply only for exponential and constant service times, results for other service distributions with standard deviation less than or equal to the mean can be expected to fall between these bounds. Thus, analytical results can give a reasonable approximation for the small delays being considered.

The following examples illustrate the use of these curves:

Example 1: Suppose the average time to answer a call is 1 minute and an average of 4 calls per minute is received. How many answerers are required to ensure only 5 percent delayed calls? For this example, $\lambda = 4$, $\mu = 1$, and $\lambda/\mu = 4$. Construct the following table:

No. of Servers	Servers Occupancy Ratio	Probability of Delay (Exponential Service)	Probability of Delay (Constant Service)
7	0.57	>0.10	>0.10
8	0.50	0.059	0.055
9	0.44	0.024	0.022
10	0.40	0.009	0.007

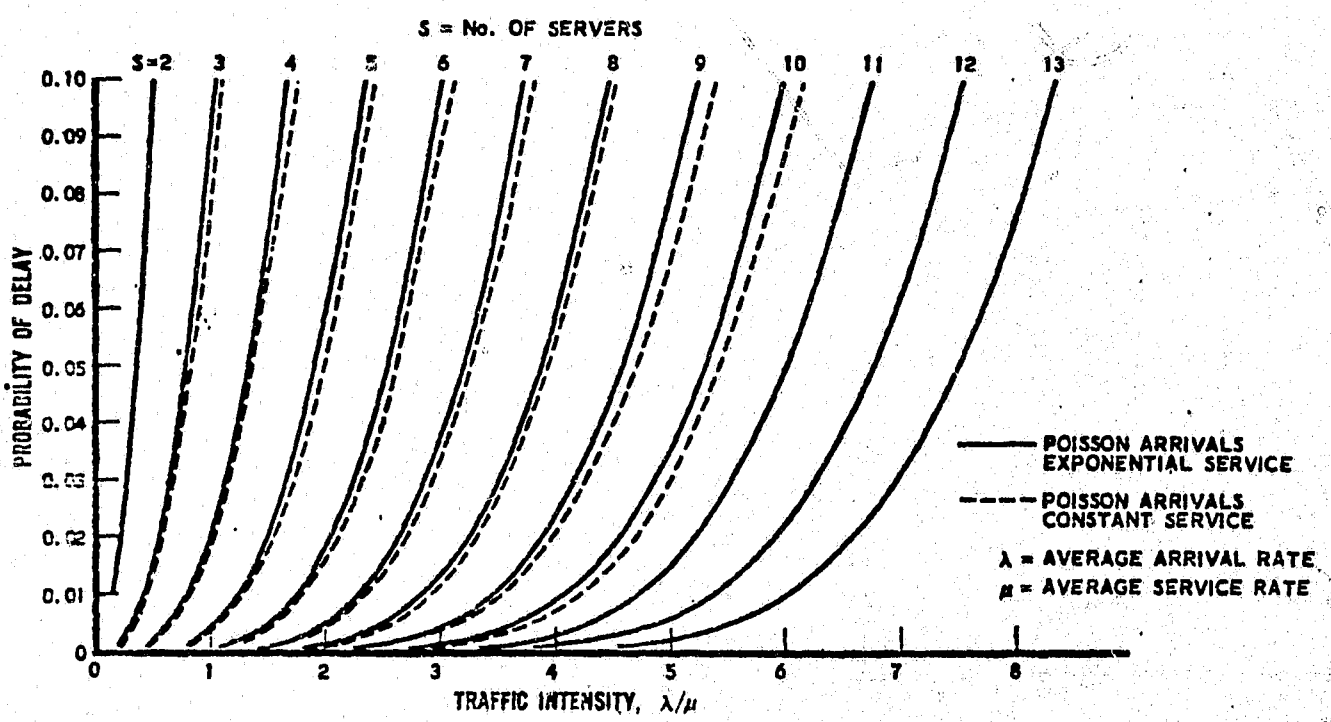

Fig. 1. Erlang C Equation as a Function of Traffic Intensity

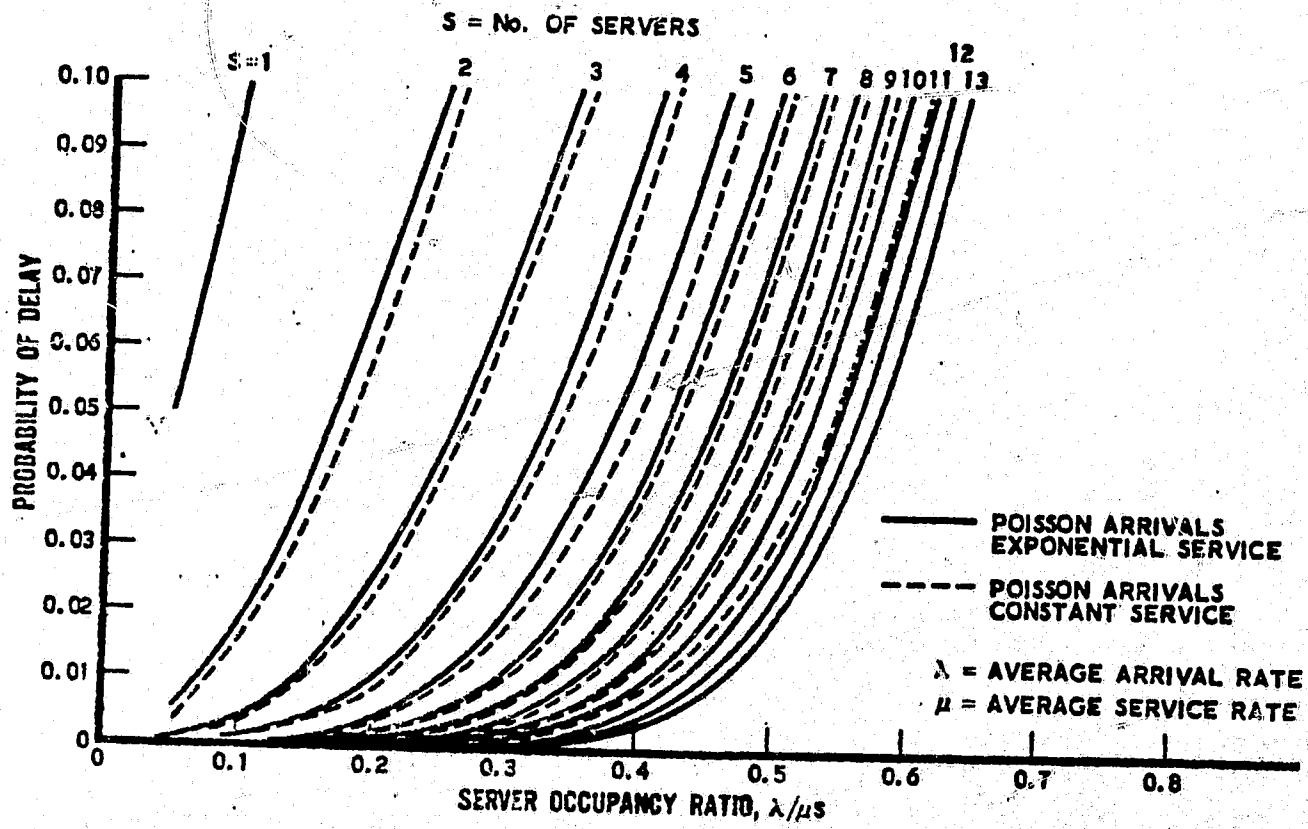

Fig. 2. Erlang C Equation as a Function of Servers Occupancy Ratio

Therefore, 9 answerers are the minimum number required to ensure that only 5 percent of the cells are delayed.

Example 2: Assume the same parameter values as Example 1 and assume the existence of 9 answerers. What is the effect of adding an additional answerer?

With exponential service, the probability of delay is reduced from 0.024 to 0.009; with constant service it is reduced from 0.022 to 0.007. The range of reductions is from 2 1/2 to 3 times. In either case, the servers occupancy ratio is decreased from 0.44 to 0.40. Therefore, the average percent of time that the answerers are idle increases from 56 percent to 60 percent.

IV. SIMULATION

Analytical results for multi-server queueing problems are, for practical purposes, limited to cases with Poisson input and exponential service times. One approach to problems not satisfying these assumptions is to use the analytical results as an approximation. If this approach is inadequate, simulation provides a useful alternative. Several possible uses of simulation in the analysis of 911 answering are suggested in this section.

Simulation can be of use when the arrival or service distributions are not exponential. It is, in fact, possible to use empirical distributions based on actual data. In the 911 setting, the exponential distribution of service time may be suspect since most calls require a minimum time to process and provision will likely be made to transfer long calls to a secondary answerer. Since the placing of telephone calls has generally been found to be Poisson, the assumption of Poisson input is likely to hold, although this should be tested.

Another use of simulation is for analysis and comparison of different answering procedures. There may be, for example, secondary answerers who take over nonemergency calls, or separate dispatchers. These comparisons would be difficult to make using analytical methods.

Finally, simulation can be of use in studying transient properties of the system. This refers to periods when the rates of various stochastic processes are varying, for example, when a sudden influx of calls is received. It is also possible to study various alternatives for dealing with changes in load, etc.

Simulation may be fairly costly since it requires the development of a computer program and a large amount of computer time. Also, attention to experimental design and statistical analysis of results is necessary since simulation is basically a statistical method of generating results.

One major problem with simulation is the determination of how long computer runs should be. When the simulation begins, it will experience transient conditions until the model stabilizes. It is necessary, in order to avoid distortions, to discard the results from this part of the run. It is, however, sometimes difficult to determine when the system has stabilized.

In Fig. 3, a conceptual flowchart for a multi-server queueing model of a 911 answering center is shown. The logic at certain indicated points would vary depending upon the specific situation being investigated. Such a program could be implemented fairly easily in one of the standard programming languages such as FORTRAN or one of the simulation languages such as GPSS or SIMSCRIPT.

The flowchart shown in Fig. 3 is for an event oriented or variable time increment simulation as opposed to a fixed time increment simulation. This means that the clock advances from the time of the current event to the time of the next event in one step. In a fixed time increment simulation, the clock is advanced a constant amount each time, the program checking for the occurrence of an event in that time period. For the queueing model under consideration here, the variable time increment approach is more accurate and uses less computer time.

The first step is to initialize the program and set the clock to the time of the first call arrival. Then, at step A, the program will maintain a list of pending events with time of occurrence. When the clock is advanced to the time of the next pending event, the program checks whether the event is a call arrival or a call completion. If a call arrival is indicated, the program generates the time of the next call arrival, probably using a random number generator, and enters it in the list of pending events. Then, it checks if an answerer is available. If not, the call is queued and the clock advanced to the next pending event. Otherwise, the call is assigned to an answerer according to a specified algorithm, and the time of call completion is determined. After entering the time of completion in the list of pending events, the program advances to the next event.

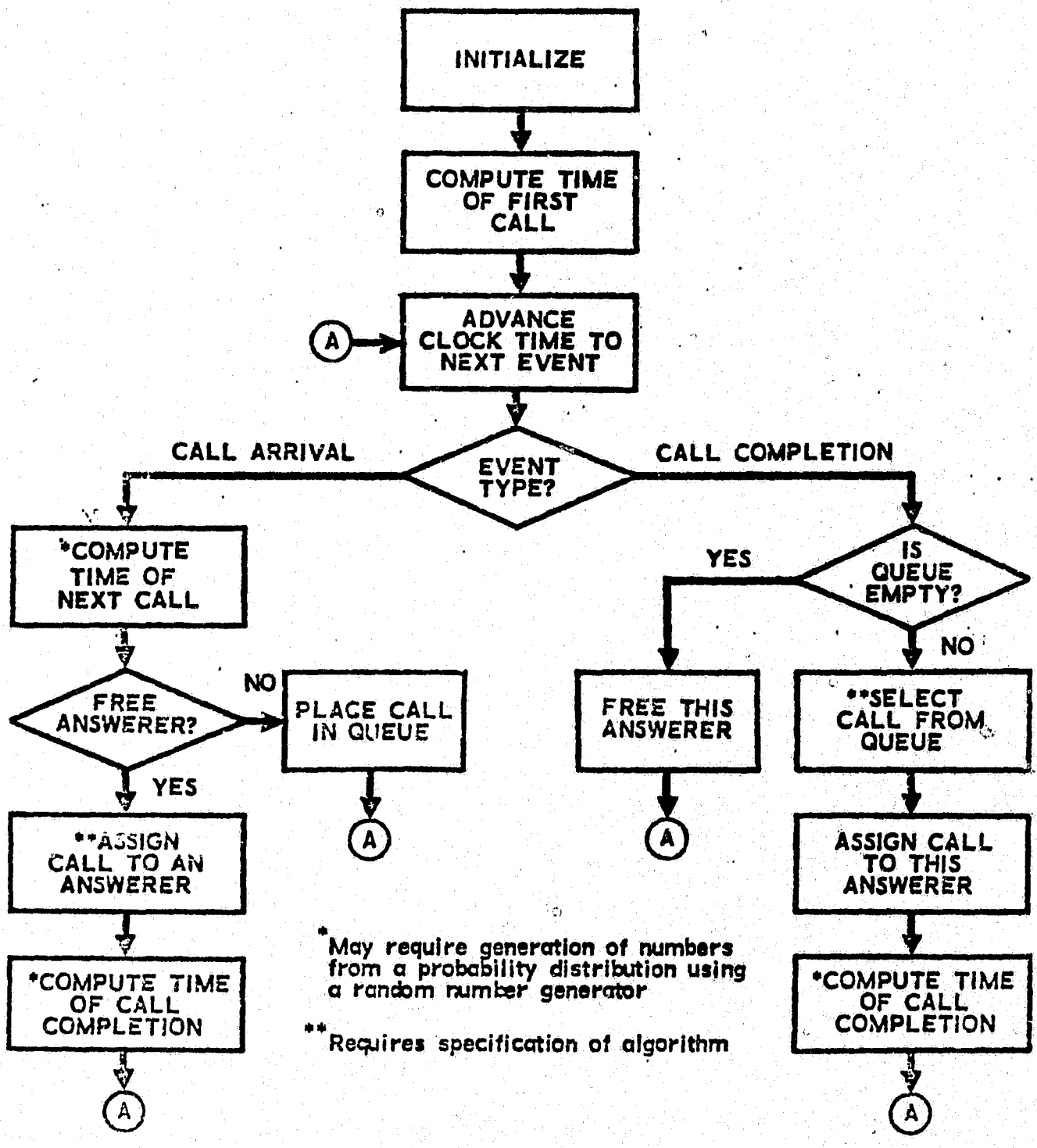

Fig. 3. Conceptual Flowchart for Simulation of Queueing Aspect of 911 Answering

If the current event is a call completion, the program checks whether the queue is empty before freeing the answerer. If calls are waiting, a call is selected for answering according to a specified algorithm and assigned to this answerer. Call completion time is computed as before, and the clock advances to the time of the next event. Although not indicated in the flow chart, data must be collected at various places; a likely time to collect much of the data of interest is at call completion.

This model assumes, in effect, that enough incoming lines are available to hold every call. The model could be adjusted, if desired, to account for occupancy of lines by calls separately from occupancy of primary answerers. Similarly, the call answering could be broken down into several stages, if desired, with event types added for the completion of each stage. Other changes in the details of the model might be necessary in some situations, but the same overall logical flow should apply.

V. METHODOLOGY

This section contains a discussion of some of the important steps in an analysis of 911 queueing problems.

The first requirement is collection of data for the rate and distribution of incoming calls. Sources of these data include existing public safety agencies and other cities where 911 systems are in operation. It is suggested that an attempt be made to relate the rate of incoming calls to the population of the area being served. It is also important to characterize the variability of the rate of incoming calls with the time of day, day of the week, and so on. Whatever convenient checks can be made to determine whether incoming calls are Poisson should be undertaken, although for convenience the Poisson distribution will probably be assumed since telephone calls have been observed to follow this distribution. It should be pointed out that the results of a queueing analysis can be no better than the accuracy of the prediction of the input rate.

A second requirement is analysis of the service time (i.e., the time to complete a call). Here again, experience from other 911 systems should be useful. It is likely that operational standards will be pertinent here so that a comparison of the ability of various configurations of the answering center to meet the standards will be of interest. Several practical considerations should be kept in mind. For example, it is generally observed in queueing studies that the service rate of an individual increases with system load. This is why some tension is often maintained in a 911 answering station through the avoidance of excessive overstaffing. Another consideration is to design the answering procedure so as to minimize the variation in the answering time, especially by avoiding tying up the primary answerers with long calls. This is why secondary answerers are often provided. The amount of queueing is generally governed by the variability in the service time.

Finally, with the incoming calls and service time characterized, it is necessary to specify the operational goals of the 911 center. In some cities, for example Seattle, the goal is stated as an upper limit on the percentage of calls which are delayed.

Once the above steps have been accomplished, solution techniques can be applied to questions of interest. This includes study of the internal structure of a 911 center as well as problems of centralization versus decentralization, etc. The first step, for reasons of simplicity and cost, should be to determine whether analytical techniques provide sufficiently good approximations. One way to do this is to compare the results predicted by an analytical solution with actual experience obtained in other cities with 911. Analytical techniques are often useful approximations even though one or more assumptions upon which they are based are violated.

For the small delays desired in a 911 system, it would be surprising if the results of different models differed by more than one answerer. In addition, nonqueueing factors, such as personnel policy, can prevent the application of results from a detailed queueing study. Therefore, it appears fruitful to explore the use of available analytical results. Then, if these results are inadequate, or if analysis of transient conditions or a detailed comparison of different answering procedures become important, simulation can be considered. The latter situations, however, require a more precise definition of alternatives than appear available at the present time.

VI. SUMMARY

In this report, queueing analysis of 911 call answering has been discussed. The basic concepts of queueing theory were introduced and related to the 911 setting. Both analytical and simulation techniques were discussed. Finally, some recommendations concerning the methodology of a 911 queueing analysis were made.

It is suggested that analytical solutions, although based on some assumptions that may not be entirely valid, can provide useful approximations. It is further suggested that the results of simulation may not be sufficiently more accurate than analytical approximations to justify the cost of model development. Finally, simulation can be of value in examining transient properties of the system or in comparing different 911 answering configurations.

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