An Evaluation Plan for the Philadelphia Computer-Assisted Dispatching System

by

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SCOPE OF THE PLAN

This evaluation plan has been developed expressly for the use of the Philadelphia Police Department (PPD) in evaluating the computer assisted dispatching (CAD) system presently being installed by ADL Systems, Inc. The plan has been tailored to specifically address the areas of primary concern identified by the PPD in its original request for proposals for CAD system designs. Further, the plan includes consideration of the CAD system's usefulness and effect on police department procedures, which we at Public Systems Evaluations, Inc. (PSE) have identified based on extensive knowledge of current police dispatching methods, problems, and technological tools. This plan is not intended to be a complete evaluation in itself, but a clear and understandable guidebook for the PPD to use on a periodic basis to measure the effect of the new CAD system as compared to the pre-existing paper-based dispatching system. Usability and simplicity of approach have been important considerations.

Following this introductory section are three chapters designed to highlight the process of comparing "during CAD" performance to "pre-CAD" performance:

- operational analysis
- technological analysis
- attitudinal analysis

A final chapter will explain the conclusions to be drawn from the comparisons made in the three central chapters.

Operational analysis is concerned with the effect of CAD on PPD operations -- the complaint taking process and the dispatching process in particular. This section has received the greatest emphasis because it covers the primary concerns of both the PPD (response time and workloads) and PSE (the match of CAD system capabilities to PPD operating policies). The effects of CAD on communications support tasks and on supervisory and management tasks, which are also considered under the operational analysis, present major opportunities for productivity improvement.

Technological analysis contains the evaluation of the CAD system hardware and software. The major concern here is with performance rather than with intricate engineering details. Design performance, as indicated by reliability, maintainability, and the safeguards for privacy, is one key element of technological analysis. Flexibility is the other -- the allowance for modification of departmental operating procedures or reporting requirements, for future growth, and for future additional technological developments such as an automatic vehicle locating system or automatic caller identification system.

Attitudinal analysis is the third major evaluation area. Attitudes can reveal the degree to which a system enhances human judgmental and memory abilities rather than simply replaces them. Opinions about specific aspects of the system's functioning can help to pinpoint where its greatest advantages lie. Further, the effect of CAD installation on worker job attitudes and morale will reveal its influence on the basic productivity of the radio room work force.

Data gathering. In each of the three central chapters data organization exhibits present information about the pre-CAD system for important areas of comparison. Where the changes due to CAD have been clearly established in the system's Functional Specifications, the "during CAD" comparison information has been noted next to the "pre-CAD" information. A thorough evaluation by the Department should verify that these changes have been accomplished as planned. For many basic comparisons, especially in the operational and attitudinal analysis chapters, data must still be obtained. This should be gathered after allowing an appropriate amount of time for all system users to become acquainted with proper operation of the system and thoroughly accustomed to the level of workload they will experience under the system.

An appropriate schedule of evaluation activites is shown in Exhibit 1. It is important to read and understand the evaluation plan at an early stage, while the system is still being installed. Six to ten weeks of normal operations should be allowed for the radio room personnel to adjust to CAD operations as routine, during which time the Department should be checking the basic system functions and outputs to make sure that there are no glaring hardware defects. Step by step progress can then be made in evaluating how well the CAD system performs when fully integrated into the Department's operations. Allow workers to establish a comfortable pace which is fully adequate to CAD imposed workloads. Scheduling these types of activities should be coordinated with the progress of system implementation, as shown in Exhibit 1.

The purpose of this evaluation plan is to serve as a framework for

Exhibit 1

Example Schedule of Activities

Approximate Dates	June 1978	July/August 1978	September 1978	October 1978	Nov./Dec. 1978	January 1979	February 1979
Implementation Progress	Installation and training	Initial operations	Use of system should become second-nature to personnel				
Evaluation Activities	Read and understand evaluation plan	Allow personnel to become adjusted to routine use of the system Observe to verify that basic system characteristics (formats, function keys, outputs) perform as planned	Observe to verify ease of system operation	Administer Questionnaire (Appendix 2) and compile results	Make observations for quantified performance measures in the operations chapter	Summarize technological performance Complete any remaining data gathering and performance verification	Review overall evaluated performan
Important Related Exhibits in Text	1		2*,3,5,6* 7,8,9,10	15,16,17,18		11,12,13,14	20,21,22

* Portions of this Exhibit will be completed at different times.

organizing and structuring the Department's analysis of what CAD has done for the PPD and how the CAD system can be best integrated into their operations. To accomplish this we have provided a global structure of CAD information, disagregated into specific categories for which the Department can easily obtain data. The results of these detailed comparisons are brought together in a summary form in order to flag problem areas and to suggest further needs for attention to training, for organizing the Department's use of the system, or for requesting the assistance of the system contractor.

Chapter I

OPERATIONAL ANALYSIS

The major portion of evaluation effort should be focussed on the impact of CAD on police operations. Accordingly, this plan examines in detail the four primary areas of police operations affected by CAD installation:

- Receiving calls-for-service from citizens
- Dispatching field units to handle calls-for-service
- Communications room support tasks
- Supervisory and management information reporting

For the most part, the information relevant to this analysis is clearly addressed in the Functional Specifications. Thus, many of the exhibits for organizing the data are already partially completed for the "during CAD" system of operations in addition to the "before CAD" data. The items which should be of greatest concern to the Department, the quantitative performance indicators, are those which require further data. The simplest ways to obtain these data items are listed in italics in the exhibits. In general the information will be available from reports which the Department already prepares, or from new reports to be prepared by the CAD system, or through examination of a small sample of CAD incident information printouts. Assembling conclusions from the data organization exhibits is a straightfoward process covered step-by-step in the final chapter of this evaluation plan.

1. Receiving Calls-for-Serivce

The objectives of CAD in Philadelphia relevant to the handling of incoming calls-for-service are the computerization of the complaint-taking function and the relocation of the complaint taking positions within the radio room to increase peak volumes. Computerized complaint-taking objectives include:

- Providing for appropriate data collection
- Minimizing complaint transfer problems
- Allowing direct inquiry from district stations

In addition, the PPD elected to increase its peak incoming complaint handling capacity by pooling nine teams of 4 complaint operators into one team of up to 23 operators. The specific objectives included:

- Increasing the overall maximum capacity to receive calls
- Increasing the capacity to receive calls from each division
- Reducing telephone delays at peak loads

Since telephone complaint handling is the point of initial citizen contact with the police for most calls-for-service, the effect of CAD on the quality of this service is particularly important to consider.

a. Computerized complaint taking

Many of the benefits of computerized complaint taking can be forseen from the design stage, so evaluation of this CAD function is centered on verifying system performance and examining the use of the system by its human operators.

Data collection should be checked for the extent of information entry, the ease of entry, accuracy, and the time required for entry. The relevant comparisons are carefully laid out in Exhibit 2. When the

Exhibit 2

Initial Complaint Data Collection Comparison

Item	Before CAD	During CAD
Extent of Information Entry: *Compare how much information is entered into the CAD system with the level of information obtained by the paper card system. Each percentage value indicates the percent of time that a particular information item is recorded from a telephone complaint.*		
Location	100%	100%
Type of call	47.5% (58.3% including meet complaint)	____% *Compare a sample of about 200 incidents in the hard copy printouts to see what proportions contain entries in each of these categories.*
Written comments	65.4% (of which more than 1/3 will be replaced by type of incident codes)	____%
Verbal comments	Estimated to cover 20% of all calls, including those with written comments and often those without type of call entries.	____%
Source of complaint	67.1% (of which 84.6% come from civilians)	____%
Time call received	89.1%	____%
Ease of Information Entry: *Compare convenience of use of CAD verses the paper card system.*		
Mode of entry	Handwritten directly from telephone call	Typed--either directly from call or from handwritten notes. *Observe complaint-taker uses.*
Intersections permitted	Yes	Yes *Check GBF misspelling list for problem cases.*
Special locations permitted	Yes	Some if entered into memory *Check GBF misspelling list for problem cases.*

Exhibit 2

(*continued*)

Item	Before CAD	During CAD
Abbreviations permitted	Yes (Roughly 20 to 25% of calls use abbreviated addresses.)	Some, if entered into memory *Check GBF misspelling list for problem cases.*
Misspellings allowed	Yes (Only about 3% of calls are misspelled)	Some, if entered into memory *Check GBF misspelling list for problem cases.*
Type of call codes	Check boxes and free-form supplemented field	Structured code list and free-form supplemented field *Ask complaint takers if codes are well matched to needs.*
Accuracy of Information Entry: *Compare the accuracy of the information stored by the CAD system with that of the information on paper cards.*		
Verification of locations	1.3%, but many locations are known to human operators	100%
Type of incident	Often too vague or misspelling altogether (see extent of entry)	Specific list improves communication, but important items like thefts and auto accidents are still not identified. *Seek feedback from complaint-takers, dispatchers, and managers as to the adequacy of the categories.*
Duplicate complaints	Roughly 8.2% of incoming calls, but some are screened before a card is written due to complaint operator interaction.	____% *Check the number of extra versions of a sample of a few hundred complaints on the printout.*

Exhibit 2

(*continued*)

Item	Before CAD	During CAD	
Time to Enter Information: *Compare the workload per incident of using CAD to that of the paper card system.*			
Telephone conversation time	33.6 seconds	____%	*Have an observer use a watch to time a sample at 200 complaint handling times. Try not to make this activity obvious to the operator being observed. Use at least 10 different complaint operators.*
Additional complaint writing time	29.1 seconds	____%	
Total processing time	62.1 seconds	____%	

remaining entries for the "during CAD" period are filled in, an administrator can quickly and easily judge whether call-for-service information is more or less complete, whether it is noticeably more difficult to enter, more accurate, or entered more quickly. Important aspects of data collection are considered separately and in detail because it is the central function of complaint taking.

Complaint transfer and remote inquiries should be considered along with data collection in a full assessment of computerized complaint taking. The important comparisons are listed in Exhibit 3.

b. Configurations of complaint operators

Increasing maximum capacities required a rearrangement of complaint operator positions. The mechanism of designing the telephone queue is discussed in detail in Appendix 1 and will not be repeated here. The net effect of the changes is to provide improved capacities to the extent indicated in Exhibit 4. The most pronounced difference is the lower number of complaint-takers required. Note that actual performance does not always equal maximum possible performance. Observed peak loads during July 1-14, 1977 exceeded the acceptable maximum capacity of the system for 6 (of 336) hours. This occurs because during extreme peak periods, delays in answering phones become longer and complaint clerks keep conversation times to an extreme minimum level. The indicated maximum capacities in Exhibit 4 are the largest number of calls which can be handled and written up within 62 seconds without delaying more than 5% of the calls for 12 seconds before answering. (Overrings are counted after 12 seconds.) For example, if the 62-second service time

Exhibit 3

Computerized Complaint Taking Comparison

Item	Before CAD	During CAD	
Complaint Transfers: *Compare the handling of complaints being transferred between consoles under CAD to that under the paper card system.*			
Extent of complaint transfers	Less than 5% of calls at test console, reported to be higher at certain other consoles.	____%	*Have dispatchers report complaint transfers to their supervisors. This problem should be discussed with the system contractor.*
Ease of complaint transfers	Move paper card to proper console.		Use computer to readdress incident.
Time to transfer complaints	5 to 30 seconds.		Instantaneous.
Remote Inquiry: *Compare the handling of inquiries from outside the radio room under the CAD to that under the paper card system.*			
Extent of remote inquiry (from Districts)	Infrequent, perhaps 3 consoles per shift. (less than 100 per day)	____ *time per day*	*The "Radio Unit Statistics" report should record the activity, by user number, originating at the district consoles.*
Ease of remote inquiry	Telephone call to complaint operators.		Direct query of CAD system.

Exhibit 4

Peak Call-for-Service Capacity Comparison

Item	Before CAD	During CAD
Overall maximum capacity*	1080 calls/hour including MUNicipal calls.	1080 calls/hour not including MUNicipal calls. *Check this with data from line counters.*
Maximum capacity* per console	120 calls/hour	not relevant
Probability of a delay of 12 seconds or more at peak load	0.31	*Determine from charts at end of Appendix 1.*
Percentage of calls delayed 12 seconds or more at peak load	16.2%	*Check the percentage of overrings.*
Number of complaint operators at normal maximum capacity	36	23

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* The largest number of calls that can be handled without delaying more than 5% of the calls for more than 5 rings of the telephone, assuming a service time of 62.1 seconds.

remains unchanged, the probability of overrings at peak loads should decrease from 0.31 to 0.05 under CAD.*

Additional changes occurring along with CAD will help to improve performance. The automatic call director system will reduce telephone answering delays, especially during non-peak periods. The use of remote inquiry terminals and the cutback in MUNicipal lines would reduce incoming call rates by up to 32.5% if MUNicipal calls were completely eliminated. The diversion of some of these calls to 911 will mean a reduction more in the neighborhood of 10% to 20%, implying improved performance. Appendix 1 allows an administrator to assess the relationship between performance and incoming call volume. Careful reading reveals that the new system will be particularly sensitive to the length of time it takes to enter an incoming call, with performance improving greatly if service time can be reduced.

2. Dispatching Capabilites

There are three important sets of CAD objectives related to dispatching capabilites:

- Provide for dispatch data collection
- Display data needed for dispatching and control
- Limit workload levels and peak load delays

All three of these areas present particularly important opportunities to making dispatching more efficient and more effective.

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* Larson, R.C., "Improving the Effectiveness of New York City's 911," Drake, Keeney, and Morse, eds. Analysis of Public Systems. Cambridge, MIT Press, 1972.

The data display should reduce confusion and enhance the dispatcher's decision-making abilities. Exhibit 5 indicates the important characteristics affected by the CAD information display. In order to determine how much of an improvement has resulted from installing CAD, it is appropriate to ask the dispatchers who use the system in a working environment. Routine dispatching and specialized command and control situations such as Operation Find should both be considered. Relevant inquiries have been included in questions 5 and 7 of the questionnaire to be distributed after the dispatchers have become adjusted to the new system (see Appendix 2).

Data collection. During dispatching it is important to keep track of the dispatcher's progress in handling calls-for-service and maintain a record of departmental activities. The data collection process must be able to keep up with the inflow of information over the radio channel and must not cause undue interference in tracking the many incidents which may be active at the same console at the same time. Important aspects of dispatch collection affected by CAD are shown in Exhibit 6.

Limiting the dispatcher workloads and delays at peak volumes was an expressed objective of CAD. The most critical factor determining both of these limits is the number of cars per console. The number of cars is in turn limited by a high level of radio air-time occupancy.* Within these constraints, the only contributions CAD could fairly and realistically be asked to make are:

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* This problem will be aggravated by the reporting of vehicle arrival times.

Exhibit 5

Dispatch Data Display Comparison

Item	Before CAD	After CAD
Data accessibility: *Compare the difficulty for dispatchers to find a piece of information under CAD with that under the old system.*	Glance to card in rack, or pull card from rack, or search through stack of waiting jobs. System is felt to be convenient.	Glance to terminal, or call up new display. *Observe dispatcher activities and note any unusual patterns.*
Data organization: *Compare how information is categorized and presented by CAD with the same properties of the paper based system.*	Data organized in order received or in order of perceived priority before dispatching, and by car number thereafter.	Separate displays for vehicle status, waiting complaints, and working jobs.
Data useability: *Compare the usefulness of CAD information with that of information on the paper-based system.*	Raw data were felt to be sufficient for making judgments by experienced dispatchers. Inexperienced people need considerable help from their back-ups. Much of the experience is not transferable from console to console.	Recommended dispatches and priority ranking of complaints added to display. CAD display shows time on assignment. Data display limits the number of simultaneous dispatching activities that can be undertaken. *Ask dispatchers about CAD's usefulness. See Questionnaire, Appendix 2.*

Exhibit 6

Dispatch Data Collection Comparison

Item	Before CAD	During CAD	
Extent of Information Entry: *Compare how much information is entered into the CAD system with the level of information that is obtained by the paper card system. An analysis of these data elements is presented in Appendix 3. These percentage values indicate the percent of time that a particular information item is recorded by the dispatch cards.*			
Time dispatched	98.8%	____%	*Compare a sample of about 200 incidents in the hard copy print-outs to see what porportion contain entries in each of these catagories.*
Time arrived	Not collected. (31.6% during special test)	____%	
Time cleared	95.0%	____%	
Car number(s)	99.4%	____%	
Reports assigned	99.1%	____%	
Disposition	Not collected	____%	
Ease of Information Entry: *Compare the convenience of use of CAD versus the paper card system.*			
Mode of entry	Handwritten directly from radio.		Typed--either directly from radio or from handwritten notes. *Observe dispatcher uses.*
Time entries	Time stamp		Function keys
Car(s) assigned	Handwritten		Typed
Location 8 type of call for patrol-initiated activites	Handwritten		Typed from radio or handwritten notes. *Observe dispatcher uses.*

Exhibit 6

(*continued*)

Item	Before CAD	During CAD	
Time to Enter Information: *Compare the workload per indicident of using CAD to that of the paper card system.*			
Car numbers	2 to 4 seconds (mostly to file card in slot)	____%	*Have an observer use a watch to time a sample of 50 information entry times. Try not to make this activity obvious to the dispatcher being observed. Use at least 10 different dispatchers.*
Time stamps	4 to 8 seconds (locating and refiling card)	____%	

- To reduce the total amount of dispatcher activity time necessary to process a call
- To minimize any confusion associated with peak volume conditions

A list of possible factors affecting performance in these areas is shown in Exhibit 7. The best indication of progress in this area is the subjective perception of the dispatchers. While they are likely to perceive workload as increased (because of new activities brought about by the change to CAD), they should tend to describe it on the questionnaire as "less hectic" (due to old activities not required under CAD.)

While peak volumes will still result in substantial delays due to lack of available cars, these peak loads should put less of a strain on the dispatchers and thereby improve their concentration.

3. Communication Support Tasks

A number of tasks necessary to maintain coherence and communication within the radio room will be less time consuming and less inconvenient under the CAD system. As shown in Exhibit 8, these include:

- Assignment of report control numbers
- Monitoring time on assignment
- Searching for records of past incidents
- Use of the computer inquiry systems

The reduction in routine paperwork and task interruptions due to the integration of these capabilities into the CAD system should be substantial. The most noticeable factor is likely to be improved functioning of the backup man during computer inquiries. The assignment of reports control numbers will disappear completely and is likely to be

Exhibit 7

System Activities Comparison

Item	Before CAD	During CAD
Dispatching activites: *Compare the activities of dispatching under CAD to those required by the paper-based system.*	Reach up for card, write in entries, stamp time sent, file and search for cards, check map for proper cars, decipher handwriting, radio conversation.	Look up at screen, type in entries, recall typing formats, radio conversation, possibly recording conversation on scratch paper. *Observe dispatcher activites, see if inefficient vestiges of the old system of dispatching remain.*
Peak load dispatching: *Compare the activities of dispatching at peak loads under CAD with those used under the paper based system.*	Check for available cars, arrange calls in priority order, periodically review very large stacks of calls.	Possible slow computer response at high volume, finite queue for waiting calls. *Observe peak load performance. Ask dispatchers what they see.*

Exhibit 8

Communications Support Tasks Comparison

Item	Before CAD	After CAD
Compare the support tasks required by the paper-based system with those required by CAD.		
Assignment of reports control numbers.	Done manually, using the telephone to coordinate with district records.	Completely absorbed by CAD system.
Sorting & filing pink and yellow cards.	Manual sort process.	Completely absorbed by CAD system.
Monitoring time on assignments.	Sampled manual review.	Can be easily monitored by dispatcher. *Check to see if effort devoted this task is decreased.*
Searching for records of past incidents.	Time consuming manual.	Computer assisted search. *Talk to personnel assigned to this duty to discover any degree of improvement.*
Use of computer inquiry system.	Required ignoring other activities on console.	Better integrated with normal dispatch activities.
Further support tasks.	-----	New tasks may be created, such as maintaining the computer hard-copy outputs. *Talk to communications supervisors, who are likely to absorb most of these new tasks.*

forgotten in the process of the changeover even though it consumed the greatest amount of manpower of all of these items.

New communications support tasks may be created as a result of the CAD implementation. For example, a new supervisory duty will be to monitor and maintain the list of CAD functions allowed for use by various radio room personnel or at the various consoles. Some checking of the paper printout of the CAD backup system may be assigned from time to time. It is not possible to fully list the new tasks which could be developed to support CAD operations.

4. Supervisory and Management Capabilities

The effect of CAD on PPD's supervisory and management capabilities will depend on careful organization to meet the new operating conditions. Important supervisory tasks which can be affected by CAD include:

- Monitoring of communication operations
- Monitoring of communications personnel
- Identifying needs for training

In addition, the CAD system will gather and organize summary information to facilitate management planning both for the radio room and for patrol allocation, including:

- General management information reports
- Improved information gathering
- Display of console-specific and patrol unit-specific information

Because much of this information is not currently available in a useful form in Philadelphia, CAD presents an opportunity to greatly improve supervisory and management capabilities.

Radio room supervision can be improved by the supervisor's ability to examine the status of units and calls-for-service at each dispatcher's position. Reorganizing the complaint-taking function from nine separate areas into one will reduce the amount of supervison needed for that function. Aspects of supervision affected by CAD have been summarized in Exhibit 9 to facilitate comparison with the pre-CAD system.

Management information provided by the system can be used to allocate both radio room and field manpower by time of day, by function, and by area of city. While exact demand levels are not available to pinpoint manpower requirements, tracking the normal workload levels will provide a better idea of manpower requirements and allow an administrator to use informed judgment to decide what level of staffing should be adequate for up-coming tours of duty. A detailed analysis of how this process can be carried out for determining the number of complaint-taker positions to be manned is given in Appendix 1. Trained field managers can use data on the demand for field services (which CAD will also collect) to decide how to deploy the patrol force for best efficiency.

The CAD system produces a large number of very detailed management information reports, some of which are useful for radio room managers and others of which are useful to patrol managers, as listed in Exhibit 10. The summary portions of these reports which provide data by shift and 24 hour totals contain most of the information required for professional police managers to monitor the Department's performance.*

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* While the distribution of calls-for-service by hour or by nature codes will be interesting to review on an infrequent or casual basis, the information which they provide is (for the most part) too detailed for useful application.

Exhibit 9

Comparison of Radio Room Supervisory Activities

Item	Before CAD	During CAD
Monitoring Operations:	*Compare the activities of supervisors in monitoring the operations of the radio room before and during CAD.*	
Check jobs backed up.	Watch size of pile of cards, possibly review for priorities.	Review information displayed on terminal. *All supervisory activity and effectiveness questions can be addressed by questioning supervisors on the effect of CAD on their activities.*
Check units available.	Look for empty slots in rack.	Review information displayed on terminal.
Check excess time out and other incident characteristics.	Review completed jobs, check some cards in rack.	Review jobs in progress displayed on terminal.
Monitoring Personnel:	*Compare the activities of supervisors in monitoring personnel before and during CAD.*	
Resolve questions for complaint clerks.	Supervisor available at each console.	*Depends upon the allocation of supervisory manpower.*
Resolve questions for dispatchers.	Supervisor available at each console.	*Depends upon the allocation of supervisory manpower.*
Verify complaint clerk performance.	Supervisor attention and peer group pressure enforced at each console.	*Depends upon the allocation of supervisory manpower.*
Verify dispatcher performance.	Continuous demands from radio and check by backup man minimized need for direct supervisor action.	Little change expected in this area.
Identify Training Needs:	*Compare the way in which training needs beyond initial lessons are identified before and during CAD.*	
For complaint clerks	Questions from dispatchers resolved difficulties individually.	
For dispatchers	Backup man supported dispatcher needs.	Backup man will still be available.

Exhibit 10

Management Information Reporting

During CAD

Reports Relevant to the Radio Room:

All of these reports contain new information not compiled prior to CAD. *If they are regularly used by radio room managers, they represent a significant advance in management information reporting.*

- Zero Car Availability Summary
- Zero Car Availability Audit Report
- GBF Maintenance List
- GBF Misspelling List
- Radio Unit Statistics Report
- Distribution of Calls for Service by Division by Day
- Distribution of Calls for Service by Division by Shift

Reports Relevant to Patrol Management:

All of these reports contain new information not compiled before CAD. *If they are regularly used by patrol managers, they represent a significant advance in management information reporting.*

- Distribution of Calls for Service by Division by Shift
- Distribution of Calls for Service by District by Shift
- Distribution of Calls for Service by District by Day
- Distribution of Calls for Service by Nature Code
- Patrol Unit Workloads
- Distribution of Reponse Time by Shift
- Distribution of Response Time by Type of Call

If running totals are kept for several of these statistics on a monthly or quarterly basis, the information will be useful for longer term planning purposes. A detailed assessment of the applications of these reports is beyond the scope of this evaluation plan, but it should be verified that these reports are distributed on a timely basis to the managers who can best use them. For comparison purposes, an analysis of similar management information has been presented in Appendix 3.

Having completed the necessary data gathering and verification for the operational analysis chapter, we turn to the technological analysis.

Chapter II

TECHNOLOGICAL ANALYSIS

The analysis of CAD technology should focus on the performance of the system as installed in Philadelphia. There are two main areas of concern in evaluating technological adequacy:

- Hardware performance
- Flexibility

While many data items in this section of the evaluation can be extracted from the Functional Specifications, the most significant items require data gathered from experience. It is a major advantage to Philadelphia that ADL Systems' technology has already been proven in the Boston installation. Not only does this mean that the contractor's experience can provide a system which is better matched to the operational needs of a big-city police department, but it implies that the repairability and maintainability requirements of the system are designed for such department's abilities. The extent to which the Department's capabilities match the system's requirements will have a strong effect on the levels of the performance data gathered here.

Comparisons in this chapter do not have the advantages of a pre-existing system to provide a baseline. PSE has therefore attempted to indicate a reasonable standard of achievemnt based on our knowledge of other departments' experience with new dispatching technologies.

1. Hardware Performance

The aspects of hardware performance which are of greatest concern to the PPD are:

- Reliability
- Maintainability
- The provision of safeguards for system security

These characteristics of the system are the results of proper engineering design and appropriate maintenance by trained maintenance personnel.

Reliability issues include three general areas:

- How often the system breaks down
- How long it takes to fix it
- How well the system can perform while its components are impaired
- How easily the non-computerized backup system can be implemented if it is needed

Appropriate evaluation measures for reliability are indicated in Exhibit 11. Note that our standards for reliability are not hard and fast quantitative thresholds but simply approximate guidelines to assist the informed professional judgment of communications administrators.

Maintainability includes both routine preventive maintenance and maintenance initiated in response to reduced system performance or component failures. Elements of both aspects of maintainability are clearly set out in Exhibit 12. Information on routine maintenance can usually be gathered quickly and easily by interviewing maintenance personnel. This helps identify problems both with the system itself and with maintenance training. Information on non-routine maintenance can be gathered only by talking to the person or manufacturer who correctly

Exhibit 11

Reliability Information

Check to see that reliability meets reasonable guidlines.

System Reliability	Guidelines
• Downtime percentage	*Should not be more than about 3% for a 6 month interval.*
• Mean Time Between Failures	*System should not fail completely except in rare cases, certainly not more than once every 4 to 10 weeks, but difficult-to-locate problems may cause repetitive failures until properly repaired.*
• Mean Time to Repair	*Should be no more than 1 shift or so except for unusual cases.*

Check to see that component failures will not cause complete system failure.

Impaired Operating Capabilities	*Automatic switchover capabilities in ease of component failure should be verified.*
• CPU	Backup CPU available.
• Main computer peripherals	Backup peripherals available.
• Dispatcher terminals	Broadcaster can share terminal with his backup if necessary.
• Complaint-taker terminals	Number of available positions is reduced, impact depends on number of assigned operators.

Check to verify the functional nature of the backup system.

Ease of Switchover to Backup System	*Performance during switchover to the backup system should be observed for smoothness of operation.*
• Availability of necessary information	Hard copy output is provided by line printer.
• Complaint taking functions	Paper based system functions effectively, but confusion may be a problem.
• Dispatching functions	Confusion may be a major problem.

Exhibit 12

Maintainability Information

Routine Maintenance:	Guidlines
• Minimum impact on operating system.	*Should require very little time except on backup system, and should be scheduled for off-peak hours.*
• Procedures should be clearly identified and clearly understood by maintenance personnel.	*Procedure design and personnel training should seem adequate to maintenance personnel and their supervisor.*
Non-routine Maintenance:	
• System should provide diagnostic reports to aid in locating "soft" failures.	*Reports should seem useful to maintenance personnel and convenient for manufacturer's repair representatives.*
• System components should be sufficiently interchangeable to allow substitutions for major units.	*Repair activities should be clean and simple.*
• Hardware manufacturers should provide prompt response under a service contrast in case of hard failures.	*System should not be down for more than one or two shifts except under unusual circumstances.*

repaired the problem. Non-routine maintenance should be expected to require assistance outside of normal in-house personnel except in cases of fairly simple problems.

System security is necessary to protect against unauthorized uses or misapplication of authorized uses and to provide safeguards for the privacy of individuals. Many of the necessary safeguards were designed into the system by ADL Systems, and the remainder should be provided through Departmental procedures. Assessment of the adequacy of privacy safeguards and authorization restrictions should be made by verifying the designed performance levels indicated in Exhibit 13.

2. Flexibility

Once the CAD system has met the needs and objectives required by the PPD at the present time, there are several dimensions of needs for flexibility to cope with change, including:

- Changes in PPD operating policies
- Future growth in demand
- Future technological developments

It is particularly difficult to assess the flexibility of a new system because what is really to be evaluated is the system's ability to meet challenges that are unforseen at present. The results of our analysis are sketched briefly in the following paragraphs, and summarized in Exhibit 14.

Simple changes in PPD operating policies such as (hypothetically) recording an indication of which sergeant was to review the reports for each incident could be made by making entries in the free-format fields of CAD in currently unforseen ways. More complex changes may be nearly

Exhibit 13

System Security

	The designed performance objectives should be verified by direct observation.
Authorization Restrictions	Designed Performance
• User restrictions	The specific terminals and the functions available to each individual user are restricted.
• Terminal restrictions	The specific functions which can be performed at each terminal are restricted.
• Access limitations	*Physical access to the terminal should be restricted to authorized personnel only.*
Individual Privacy Protections	
• Hard copy printouts should be at least as well protected as dispatch cards.	*Physical access and disposal procedures must be monitored.*
• Access to CAD information should be restricted to those districts and dispatchers with a need to know.	Difficult to enforce. No comprehensive check on inquiries is performed by the system.
• Information about what cars and which officers are in service must be restricted to authorized police personnel.	*This information is currently protected by radio room procedures; similar procedures at the district stations must be enforced.*

Exhibit 14

System Flexibility

	Flexibility must be judged on the basis of changes which can be anticipated reasonably.
Flexibility to:	
Allow changes to operating policies.	Depends upon the severity of proposed changes. Any change which cannot be fitted into current formats, such as re-drawing sector boundaries, will be difficult.
Handle growth in demand.	Adequate to handle present needs, but substantial unforseen growth could create problems, especially since a car is sent to every caller. Shorter service times can help.
Match with new technologies.	Complex systems can be designed to fit with the CAD systems. Simple devices which draw upon CAD processing capacities are limited by those capacities.

impossible to retrofit onto the system. For example, if Operation FIND were not designed into the system in the first place, computer capacities and programming costs might have rendered it impossible to add on later. The intermediate level of change represented for example, by redrawing the response sector boundaries to increase field unit productivity would involve extensive work in reorganizing the geographic base file which would be expensive but not infeasible.

If future growth in demand is pronounced, it will be difficult to expand the CAD system to cope with it. Adding extra complaint-taker or dispatcher terminals will be a major undertaking, and it may prove simpler to quickly screen out unimportant calls. Past patterns indicate that such substantial growth is not expected in the immediate future, so the current design should be adequate until it becomes technologically obsolete. The pronounced effect that shorter service times for handling incoming calls would have on capacities can be determined through the analysis in Appendix 1.

Future technological improvements which might interface with the CAD system could be as simple as adding on a direct-to-microfiche computer output device to facilitate records storage or as complex as adding an AVM-based command and control system. Complex computer-based additions can be required to be self-supporting and generally can be designed to fit CAD in a fashion similar to the way CAD was designed around the pre-existing computer-inquiry network. Simpler improvements that depend upon the CAD system's processing power will be limited by the available computing capacity.

Chapter III

ATTITUDINAL ANALYSIS

The human element is the third link in the chain of implementation. Having examined the hardware and its effect on operations, in this section the evaluation effort is turned towards the attitudes of the system's users to discover:

- Whether the system is thought to be good for the department
- How well, quantitatively, the operational goals have been acheived
- What must the people and the organization of the department do to properly adjust to the presence of the new CAD system

Information about attitudes can only be discovered by asking people. For the period prior to the implementation of CAD, this information was gathered by means of unstructured interviews with radio room personnel and a carefully designed questionnaire. Similar information for the "during CAD" period should be obtained in the same way: through direct discussions with the men and women who use the system on a day-to-day basis, and by means of the structured questionnaire provided in Appendix 2. The results will not be strictly comparable (as in a formal evaluation) to the pre-CAD information already gathered because anonymity of response cannot be assured on the follow-through analysis, and because very little information about CAD had been distributed in the early stages. Nonetheless, such follow through will provide important

evidence about the way in which CAD meshes with the Department's overall communications organization.

1. Perception of CAD as a Good Idea

The degree to which radio room personnel perceive CAD as a good idea is an important indication of how fully the system will be accepted and how fully its total capabilities will be utilized. Important reasons the dispatcher and complaint-taker might be concerned about CAD include:

- The system's effect on job satisfaction
- The system's effect on how difficult their jobs are

Three of the most important factors determining whether radio room personnel will be favorably or unfavorably disposed towards the new system are:

- How well informed the workers feel about the system's goals
- How well informed the workers feel about how they will use the system
- What each worker feels that other workers think of the system (the group effect.)

Quantified measures of worker opinion on all of these important issues were obtained on the pre - CAD questionnaire and are displayed in Exhibit 15 to facilitate comparisons. Based on the low level of understanding of the system's goals and use beforehand, the Department should expect significant increases in the level of posititve opinions about the system for every one of the questions that appear in this exhibit. Comparison questions have been included in the "after-CAD" questionnaire provided in Appendix 2.

Exhibit 15

Overall Opinions from Dispatcher Survey

Compare the opinions of radio room personnel regarding CAD with the same opinions after they have had a full chance to learn the system.

	Before CAD*	During CAD

Q.13: *In general do you think it is a good idea or not a good idea to have the CAD system in Philadelphia?*

Good Idea:	46.5%	____%
Not a good idea:	40.0%	____%
No opinion:	13.5%	____%

Q. 3: *How do you think the CAD system will affect the way you feel about your job?*

More satisfying:	20.6%	____%
No change:	55.3%	____%
Less satisfying:	20.6%	____%
No opinion:	3.5%	____%

Q.10: *How do you think the CAD system will affect your ability to do your job well?*

Help you:	39.4%	____%
Make no difference:	34.1%	____%
Make it harder:	20.0%	____%
No opinion:	6.5%	____%

Opinions should be gathered on the questionnaire provided in Appendix 2. Percentages are expressed as fractions of the number of responses to each individual question.

Q.2a: *How well informed do you feel about the stated goals of the system?*

Very well informed:	8.8%	____%
Fairly well informed:	54.1%	____%
Not very well informed:	34.7%	____%
No answer:	2.4%	____%

Q.2b: *How well informed do you feel about how broadcasters will operate the system?*

Very well informed:	11.2%	____%
Fairly well informed:	42.4%	____%
Not very well informed:	44.7%	____%
No answer:	1.8%	____%

---

* out of 170 responses

Exhibit 15

(*continued*)

	Before CAD*	During CAD
Q.2c: *How well informed do you feel about how complaint takers will operate the system?*		
Very well informed:	10.6%	____%
Fairly well informed:	55.9%	____%
Not very well informed:	31.8%	____%
No answer:	1.8%	____%
Q. 4: *How do you think dispatchers will feel about the system once they have used it?*		
Most dispatchers for it:	21.8%	____%
About ½ and ½:	55.3%	____%
Most against it:	20.6%	____%
No opinion:	2.4%	____%

* out of 170 responses

2. Qualitative Assessment of System Performance

Many of the goals of the system covered in the Operational Analysis chapter are taken into account by the system's users in developing an overall opinion of performance. It is helpful to elicit these qualitative assessments in order to draw a complete picture of the system's capabilities. Comparisons are shown in Exhibit 16 for the effect of CAD on:

- The time to process a call
- Overall communications capacity
- Individual workloads
- Interactions with the patrol force

As people become more familiar with the system, they should be more likely to see improved performance than they were at the time the survey for Exhibit 16 was taken. At the very least, any substantial perception of worsened performance on the follow-up survey should be a flag for areas requiring special attention.

The major problems and benefits attributed to the CAD system by its users should be checked to reveal how well these factors were planned for in the design stage. Any problems which show a significant increase in worker concern or benefits which show a significant decrease over the levels shown in Exhibit 17 should be examined further. Such subjective opinions serve as "checks and balances" in verifying the results determined objectively in the Operational Analysis chapter.

3. Organizational Response to CAD

The installation of any new complex technological system will

Exhibit 16

Perceived Effect of CAD on Radio Room Capabilities

Compare the opinions of radio room personnel regarding the effects of CAD with the same opinions after they have had a full chance to learn the system.

	Before CAD*			During CAD		
	Performance will improve	No Effect	Performance will worsen	Performance has improved	No Effect	Performance has worsene
Q.5: *How do you think the CAD system will affect performance in each of these areas?*						
Reducing telephone complaint taking time:	33.7%	39.3	27.0	___%	___	___
Reducing dispatch time:	35.6%	36.3	28.1	___%	___	___
Increasing the overall capacity of the communications unit:	39.2%	41.8	19.0	___%	___	___
Reducing dispatcher workload:	43.1%	36.9	20.0	___%	___	___
Reducing complaint taker workload:	36.6%	44.1	19.3	___%	___	___
Keeping track of the patrol force:	60.9%	28.6	10.6	___%	___	___
Reducing radio congestion:	18.1%	60.6	21.3	___%	___	___
Q.9: *How do you think the CAD system will affect the role of Operation FIND in Philadelphia?*						
Frequency of use of Operation FIND:	18.6%	75.7	5.7	___%	___	___
Frequency of success of Operation FIND:	25.5%	66.4	8.0	___%	___	___
Speed of deploying Operation FIND:	55.8%	29.9	14.3	___%	___	___
Coordination in deploying Operation FIND:	44.2%	43.5	12.3	___%	___	___
Interference of Operation FIND with other dispatching operations:	25.7%	64.6	9.7	___%	___	___

*out of 170 responses

Exhibit 17

Problems and Benefits Attributed to CAD

Compare the opinions of radio room personnel regarding the problems and benefits of CAD with the same opinions after they have had a full chance to learn the system.

	Before CAD*	During CAD
Q. 7: *What do you see as the main potential problem that the CAD system will encounter?*		
Dispatchers only able to perform one dispatching task at a time:	23.9%	____ %
Need to type instead of write:	39.9%	____ %
Reliability of equipment and computers:	36.2%	____ %
Capacity of system to hold backed up jobs:	25.8%	____ %
Complexity of operating the system:	16.6%	____ %
Lack of support from dispatchers:	11.0%	____ %
Other:	9.2%	____ %
Q. 8: *What do you see as the main potential benefit of the CAD system?*		
Reduced paperwork:	49.7%	____ %
Faster response times:	18.9%	____ %
Computer recommends which cars to dispatch:	23.9%	____ %
Quieter dispatch room:	25.2%	____ %
Computer verifies addresses as legitimate addresses:	18.9%	____ %
Computer indicates which cars are at which assignments and how long they have been there:	25.2%	____ %
Other:	5.0%	____ %
Q.11: *How do you think the CAD system will influence your relationship with you co-workers? Do you think it will?*		
Make it better:	7.9%	____ %
Make no difference:	79.4%	____ %
Make it worse:	12.7%	____ %

Opinions should be gathered on the questionnaire provided in Appendix 2. Percentages are expressed as fractions of the number of responses to each individual question. If the same question is answered more than once, count both answers. Totals will add to more than 100% because of this.

Exhibit 17
(*continued*)

	Before CAD*	During CAD
Q. 12: *How do you think the CAD system will influence the way the public feels about the police? Will the public feel:*		
More favorably toward the police:	4.3%	___%
No different than now:	87.0%	___%
Less favorably toward the police	8.6%	___%

* out of 170 responses

require a police organization to change its policies in several areas, to accommodate:

- New training needs
- New manpower assignment opportunities
- Needs for management support

Evaluation of the quality of these kinds of programs is a difficult undertaking because of the amount of detailed preparation and coordination involved. As a surrogate measure, the amount of structured planning effort devoted to each of these areas will indicate whether appropriate attention has been provided. Much of the effort (besides the initial training) can only be provided from within the Department. A checklist of the basic areas requiring attention is shown in Exhibit 18. A proper organizational response will show some progress in each of the listed areas.

Exhibit 18

Organizational Response to CAD

This list should be used as a checklist to verify that necessary organization responses have been implemented.

Training programs needed for:

- New dispatchers
- New complaint takers
- New supervisors
- New trainers

Manpower assignment:

- Specialization between dispatchers and complaint takers, *or*
- Formation of teams which rotate complaint taking duties with the dispatching duties of one console,
- Flexible assignment of complaint taker manpower to match the fluctuation in demand over time,
- Assignment of special duties such as taking care of the hard-copy printouts to personnel whose duties are reduced, such as the supervisor responsible for tracking excess time outs.

Management support:

- Completion of this formal program evaluation for CAD
- Regular meetings of managers whose functions are affected by CAD to assure smooth running and facilitate the flow of ideas
- Circulation of CAD-produced reports to those managers who can use such reports to better plan their operations.

Chapter IV

DRAWING CONCLUSIONS

By completing the exhibits in the first three chapters of this evaluation plan, much of the effort in obtaining sound conclusions has been completed. All of the important aspects of CAD as a total system, including hardware, appropriateness of software design to user needs, and the support required from within the PPD, have been addressed. Conclusions need to be drawn by answering four important questions:

- What are the essential features of the Philadelphia CAD system?
- How well does the system function in each of these areas?
- Is this performance adequate?
- What opportunities exist for further improvements?

The answers to all of these questions can be determined through the information gathered in the previous chapters. The framework does not provide all the answers by itself, of course, and professional inference on the part of an experienced police administrator or an evaluation professional will be needed to gather the data from those three chapters into a meaningful set of conclusions.

1. Identifying the Central Features of CAD

The framework does provide a checklist which ensures that the relevant system requirements are properly considered in arriving at

conclusions. The relative importance of these requirements cannot be completely determined before the system is fully operational, and this factor of relative importance is the "missing link" here. If all items are smoothly implemented, the varying emphasis this evaluation plan has placed upon system characteristics, with most of the effort devoted to the Operation Analysis section, will reduce the amount of deliberate effort required in determining emphasis. If implementation is not so smooth, the areas of shortcomings will properly receive additional emphasis in determining importance. A summary list of the important areas reviewed in the last three chapters is shown in Exhibit 19.

2. Determining How Well the System Functions

The process of judging the overall functioning of the system is simply the building of an overall conclusion from discrete, individually observable performance measures. A good set of individually observable performance measures is developed by using this evaluation plan. When the entries describing performance during CAD in the exhibits in the text of this report have been completed, they will provide a useful and detailed description of how well the system functions. This description will communicate the information about CAD to persons who need to learn about it, including new management in the communications unit, any city and state agencies which may be curious about what CAD does for the PPD, or other departments who may wish to know about Philadelphia experience before they decide on the purchase of a CAD system. To facilitate such communication, areas of particularly good performance, or perhaps of

Exhibit 19

Summary List of Important System Characteristics

Characteristics Related to Police Operations:

When receiving calls for service:

- provide for appropriate data collection
- minimize complaint transfer problems
- allow direct inquiry from district stations
- increase maximum capacity to receive calls overall
- increase maximum capacity to receive calls from each Division

When making dispatch assignments:

- display data needed for dispatching and control
- provide for dispatch data collection
- limit workload levels
- limit peak load delays

Effect on communication support tasks:

- automated reports control number assignments
- elapsed time on assignment indication
- computer-assisted incident search capability
- integrated records inquiry system

Effect on supervisory and management tasks:

- changes in the monitoring of communications operations
- changes in the monitoring of communications personnel
- identifying needs for training

Characteristics Related to CAD Technology

Hardware performance characteristics:

- reliability
- maintainability
- system security safeguards

Flexibility characteristics:

- to meet changes in PPD operating policies
- to meet future growth in demand
- to meet future technological developments

Exhibit 19

(*continued*)

Characteristics Related to Attitudes:

Perception of CAD as a good idea:

- overall reaction to CAD
- perceived effect on people's jobs
- how well informed personnel are about the system
- perceived reactions of co-workers

Qualitative assessment of system performance:

- time to process a call
- overall communications capacity
- individual workloads
- interaction with the patrol force

Organization response to CAD:

- new training needs
- new manpower assignment opportunities
- needs for management support

particular importance to watch out for, could be circled on Exhibit 19 which could then be used as a cover sheet.

3. Judging the Adequacy of Performance

In each of the three major areas -- operations, technology, and attitudes -- the CAD system should show adequate performance. Adequacy is defined in terms of the degree to which the system's goals are attained in each area. It is not likely that all of the individual data elements in each area will demonstrate improved performance over the previous dispatching system, but many areas should show improved performance and no significant pattern of performance reductions should be evident. In some areas it will be desirable for performance to be largely the same as the previous system.

Working from existing conditions and the Functional Specifications, many of the individual data elements could be determined before the system was installed. The general conclusions which can be built from this available information are presented in Exhibits 20, 21 and 22 for the operational, technological and attitudinal areas separately. The exhibits further indicate the important conclusions to be drawn from the further data which must be obtained after the system has reached stable operating performance. Such conclusions are straightforward for the informed professional to make once the data elements on which such conclusions are based are properly organized. The exhibits in the first three chapters provided that organizing structure.

Exhibit 20

Operational Conclusions

For CAD Effectiveness In:	Preliminary Anticipated Outcomes	Observed Evaluation Findings
Receiving Calls for Service: (Exhibit 2, Exhibit 3, and Exhibit 4)	Information entry will be more complete and specific, although some effectiveness will be lost due to lack of verbal contact between dispatchers and telephone clerks. Information entry will be slightly less convenient, but slightly more accurate. Workloads per incident should be about the same. Complaint transfers and remote inquiry problems will be almost completely eliminated. Peak volume will be about the same as before, but the elimination of MUNicipal calls will reduce incoming volumes. Delay problems will be substantially reduced. Peak load performance depends heavily on the amount of time it takes to process a call.	*Review the data which were collected in earlier Exhibits to confirm or modify the preliminary anticipated outcomes in determining the observed evaluation findings.*
Making Dispatch Assignments: (Exhibit 5, Exhibit 6, and Exhibit 7)	Dispatch data will be much more accessible, substantially better organized and somewhat more useful than under the paper-based system. The extent of information collected by the dispatchers, the convenience of entering it, and the workload per incident should remain about the same. Coordinating the dispatching system will be much easier, especially at peak loads.	

Exhibit 20, continued

For CAD Effectiveness In:	Preliminary Anticipated Outcomes	Observed Evaluation Findings
Communications Support Tasks: (Exhibit 8)	CAD will eliminate many of the manual paper-shuffling support tasks which currently exist, and will not create extensive new support task requirements in the radio room.	
Supervisory and Management Tasks: (Exhibit 9 and Exhibit 10)	Depending upon the new allocation of supervisory manpower, a considerable increase in the efficiency of supervisors can be obtained through reduced supervisory requirements (especially for complaint takers) under CAD. New management reports can considerably increase management capabilites if they are distributed on a timely basis to the managers who can use them.	

Exhibit 21

Technological Conclusions

For CAD Effectiveness In:

	Preliminary Anticipated Outcomes	Observed Evaluation Findings
Hardware Performance Characteristics: (Exhibit 11, Exhibit 12 and Exhibit 13)	Reliability is likely to be better than the initial performance of other police information systems. Use of the backup system is likely to cause considerable confusion when there are problems, however. Maintainability will be adequate. System security will require restrictions on physical access and system use procedures to achieve full protection.	*Review the data which were collected in earlier Exhibits to confirm or modify the preliminary anticipated outcomes in determining the observed evaluation findings.*
System Flexibility: (Exhibit 14)	Flexibility should be adequate to the current needs of the PPD, and to handle new growth. Substantial changes in operating policies which affect CAD may cause considerable trouble. New technological improvements can be retrofitted, depending upon their own design improvements.	

Exhibit 22

Attitudinal Conclusions

For Responses to CAD:	Preliminary Anticipated Outcomes	Observed Evaluation Findings
Perception of CAD as a Good Idea: (Exhibit 15)	Once they've had a chance to use the system, the majority of dispatchers will feel it is a good idea and that it helps them in their jobs. They will feel quite well informed about the system. The effect on job satisfaction will be fairly neutral.	*Review the data which was collected in earlier Exhibits to confirm or modify the preliminary anticipated outcomes in determining the observed evaluation findings.*
Qualitative Assessment of System Performance: (Exhibit 16 and Exhibit 17)	People will feel that the system makes a substantial contribution to keeping track of the patrol force, and thus aids the dispatchers more than the complaint takers. Limited improvements will also be seen in other areas. Operation FIND will be deployed more quickly and with better coordination, but not noticeably better success. The main benefit will be seen to be reduced paperwork and confusion, and the greatest problem will be the need to type instead of write.	
Organization Response to CAD: (Exhibit 18)	More specific training programs will be developed for communications personnel. Improved manpower assignments will be facilitated, and more management support effort will be devoted to the radio room	

4. Identifying Oportunities for Further Improvements

The summarized conclusions in the last three exhibits provide an aid to identifying opportunities for improving the system's performance. The initial key is locating the general conclusions which indicate that performance in a given area is less than what the Department feels it is ultimately capable of achieving. From this initial key, an administrator can look back to the more detailed exhibits in the first three chapters to locate specific quantifiable properties of the system as described by the data elements, which can be targeted for improvements. Further analysis of the detailed data elements, which should be relatively simple for the experienced administrator, can reveal the full range of activities which might be adjusted to obtain improvements.

There are numerous areas in which the Department can adapt to the system by changing the organizational context, including

- Operating policies
- Manpower assignments
- Training
- Worker morale
- Management commitment, and so forth.

The appropriate strategy will depend upon the particular change to be effected and the array of choices for accomplishing that change once it has been identified as an opportunity for improvement.

APPENDICES

APPENDIX 1: The Telephone Queue

APPENDIX 2: Follow-Up Questionnaire

APPENDIX 3: Data from the Two-Week Special Test

APPENDIX I

The Telephone Queue

One activity that PSE has found to be invaluable in its evaluation efforts is a "pre-implementation" analysis. Before fully developing and implementing a CAD system, a pre-implementation analysis of the key features of the system can aid in ascertaining potential system performance, anticipating problems, and avoiding pitfalls. Many programs, such as the Kansas City Preventive Patrol Experiment, have not been successful because such an analysis was absent in their general test plan. This appendix is the result of extensive analysis of the Philadelphia CAD system's capacities. It is intended to present in simple terms the major factors influencing capacity and the extent of the limitations these factors impose.

Several major changes have been made in the way incoming telephone calls are received as the result of CAD implementation. Complaint operators are grouped in one work area rather than divided up by consoles, paper-based information transfer is replaced by electronic information transfer, and computerized complaint routing replaces the routing based on telephone exchange lines.

To evaluate the impact of these changes an administrator must focus primarily on the effects of CAD upon service levels* and workloads. Important performance measures include:

- Total system workload
- Maximum system capcity
- Expected average delays
- Probability of excessive delays
- Average worker utilization
- Average time to handle a call

These measures can be addressed most easily by means of queuing theory, which describes the relationships between all of those variables mathematically. To enhance usefulness, the relationships will be shown in a graph form which anyone can use with a ruler, avoiding the need for mathematical abstration. This straightforward approach will allow decision makers to clearly see the existing alternatives for productivity improvement which are available under the CAD configuration.

1. The Pre-CAD Complaint System

A complete description of the pre-existing system begins by examining workload and service time for incoming calls. Utilization and service levels can then be described for the relevant levels of workloads and service times. For convenience it has been assumed that four clerks were available to answer incoming calls. This describes

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* The term "service levels" includes all measures of service quality, including the probability that a call will not be answered immediately, the expected length of any answering delays, the amount of time the conversation consumes, and so forth.

the situation at peak loads fairly well, since dispatchers and their backups were usually too busy to answer phones at such times.*

Workload. Before the installation of CAD incoming workload for complaint clerks included both emergency calls and MUNicipal calls. The city received an average of 399.5 calls per hour for 1977 (44.4 per console per hour), with peak workloads of up to 120 calls per console per hour during normal months and over 200 calls per console per hour during peak load months, as shown in the distributions of incoming call rates in Figure 1-1.

Under the CAD system calls will be received by one large team of operators rather than nine smaller ones, and MUNicipal calls will be removed from the normal complaint-taking workload. The workload distributions of the sample normal and peak demand periods are shifted to those shown in figure 1-2.

Maximum Capacity. When the call rate exceeded 200 calls per hour per console, the answering delays under the pre-CAD system became quite long and an increasing number of complainants hung up before their calls were answered. Because calls remained in the system until answered even if the complainant hung up earlier, many of the calls counted at these high workload levels did not represent real work for the complaint taker.

Two *service standards* define a measurable capacity--the maximum acceptable delay, and the probability that calls will be delayed longer than this allowed maximum. In Philadelphia the maximum allowable delay

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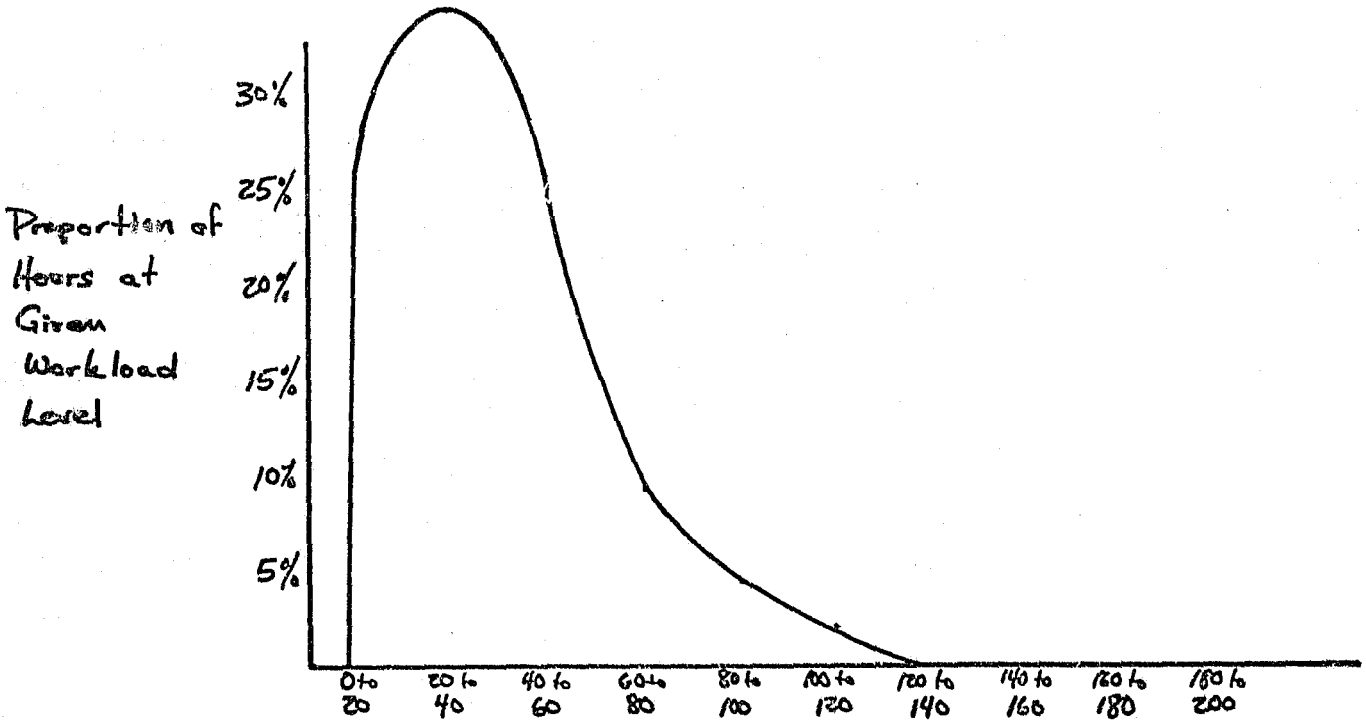
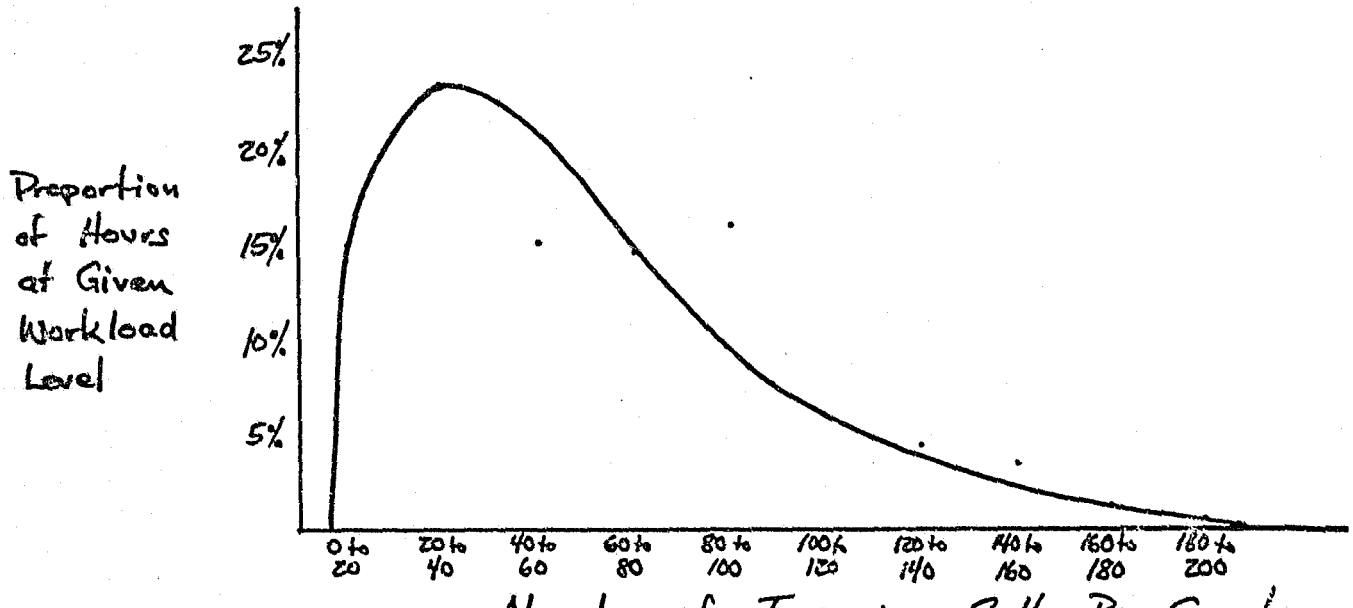
* During off-peak hours there were sometimes only 2 or 3 clerks available, even counting the backup man. Lower manning levels meant increased manpower utilization, and they were generally accompanied by reduced service levels in terms of delays and lost calls.

Figure 1-1

Distribution of Hourly Workload

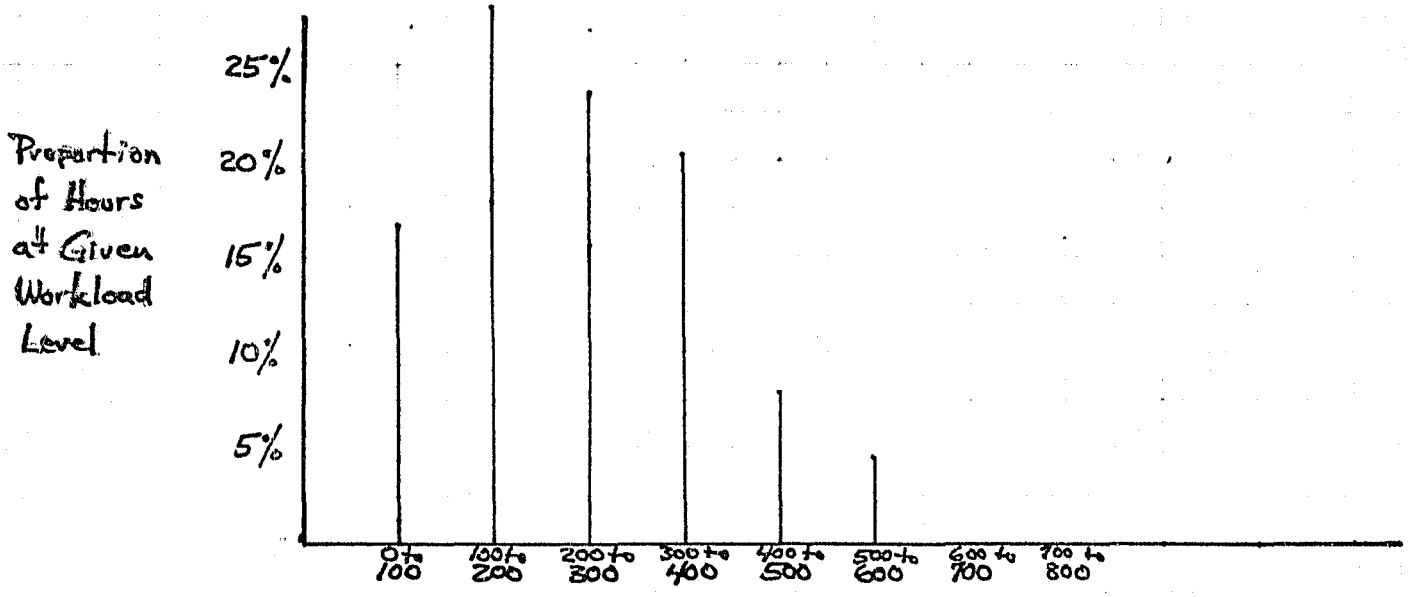


(a) Normal Workload (Oct. 4, 1977)

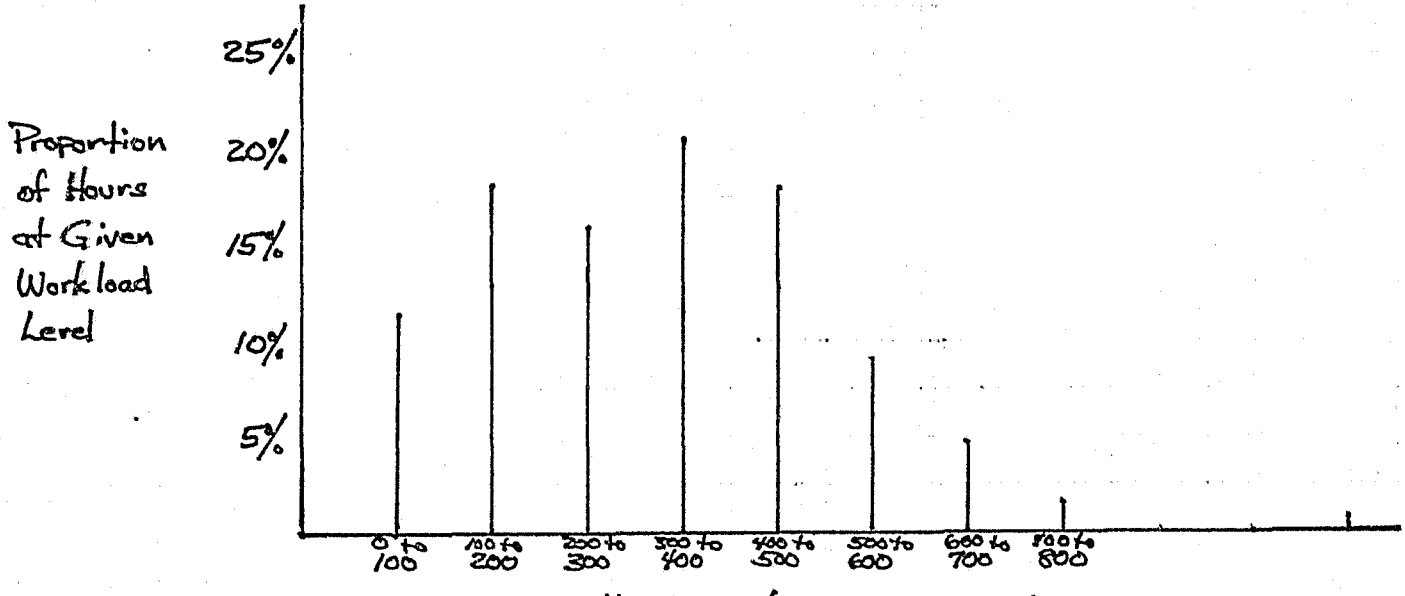


(b) Peak Workload (July 19, 1977)

Figure 1-2
Distribution of Hourly Workload
(Emergency Calls Only)



(a) Normal Workload (October 3-9, 1977)



(b) Peak Workload (July 1-14, 1977)

has been 3 rings of the phone (about 12 seconds), and if possible no calls were to exceed this delay. Obviously this goal is more easily reached at lower workload levels.

Expected Delay Patterns. The Philadelphia Police Department has kept a careful record of the pattern of delays greater than the 12 second target level. Delays were more frequent on heavy workload days than on normal volume days, as illustrated in Figure 1-3. This may have occurred because the backup man could help to answer calls more easily on slower days. Interestingly, the probability of a delay does not increase much beyond the 30% level even at very high levels of workload. This is largely the result of the *busy server effect*, the natural tendency of complaint takers to reduce the time spent with each individual caller as the number of incoming calls increases.

The Four-Person Telephone Answering Team. Focusing on peak demand, the four-person complaint taking team has been the norm. At peak demand the dispatcher and his backup are too busy to be able to assist in telephone answering. For the four-person team, the fraction of the time they are taking complaints depends upon the amount of time spent on an average call and the rate at which calls come in. Figure 1-4 shows this relationship. For example, if the rate of incoming calls is 100 per hour at a given console, then if it takes an average of 60 seconds to handle a call, the complaint taking staff will have to devote 41.7% of its time to answering complaints.

A utilization of 41.7% may appear to offer a lot of opportunity for slack so it is important to see what effect increases in utilization have on service levels. Figure 1-5 shows that the probability that all of the

Figure 1-3

OBSERVED PATTERN OF TELEPHONE ANSWERING DELAYS

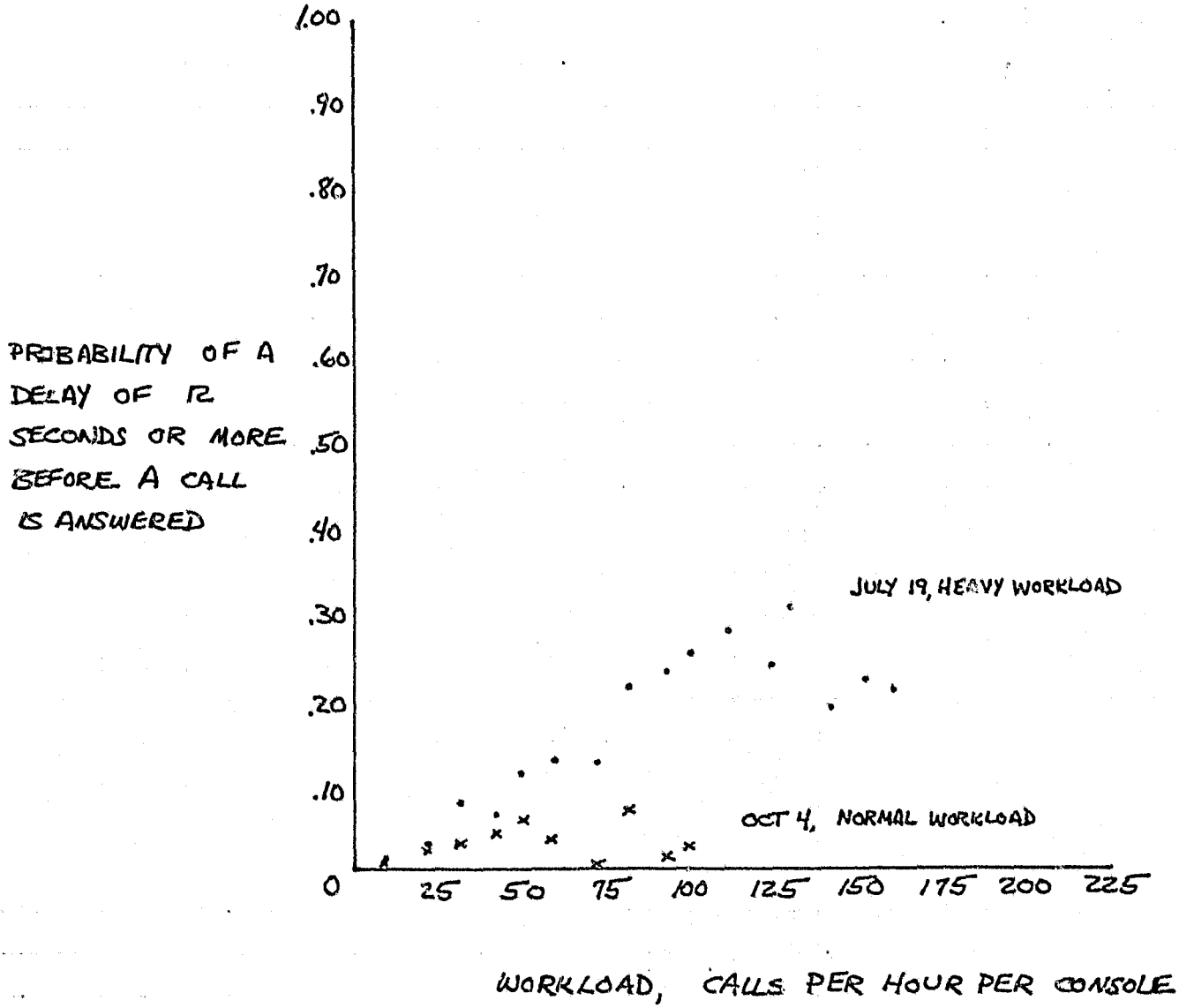


Figure 1-4

RELATIONSHIP OF UTILIZATION, WORKLOAD, AND SERVICE TIME FOR A 4 SERVER QUEUE.

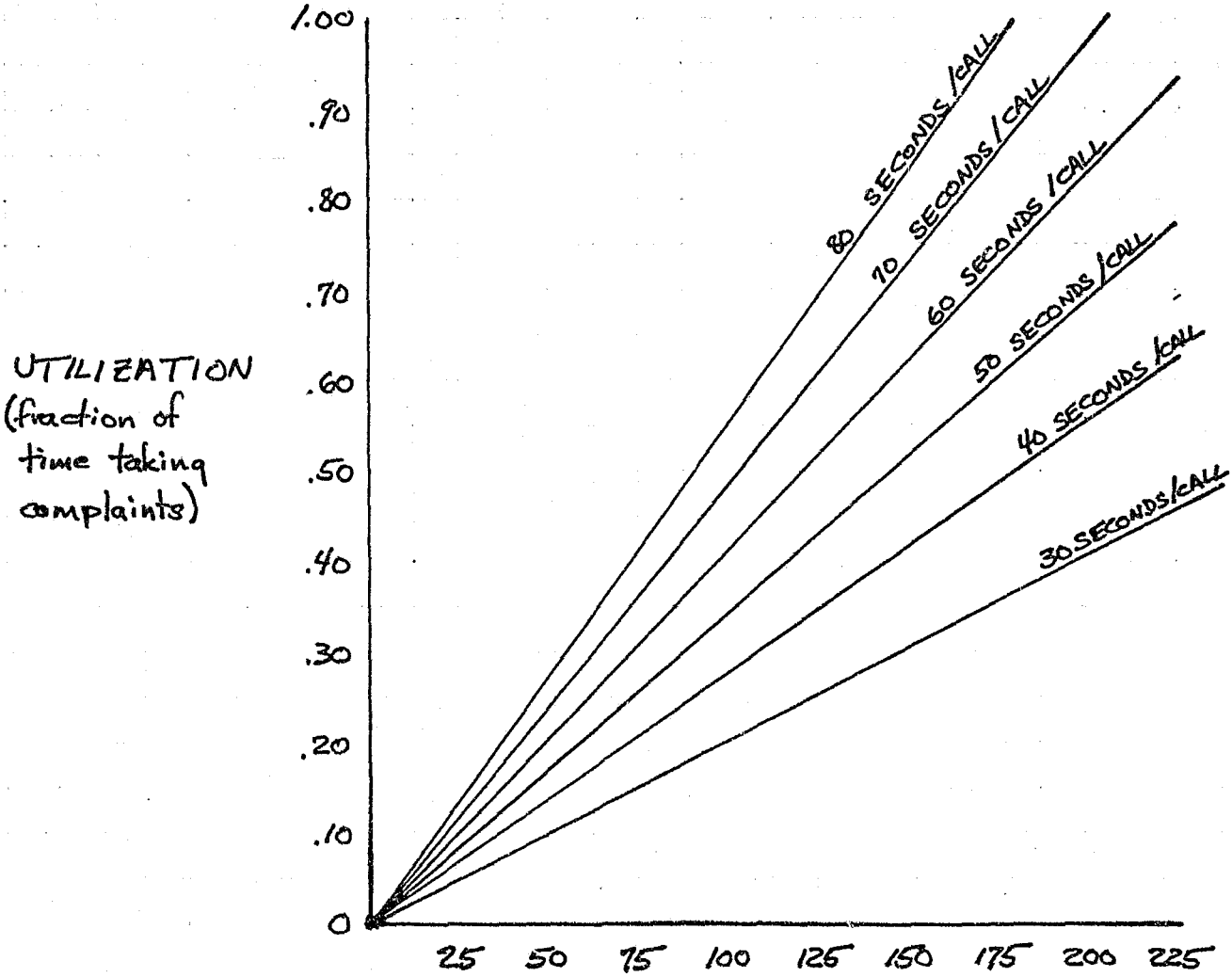
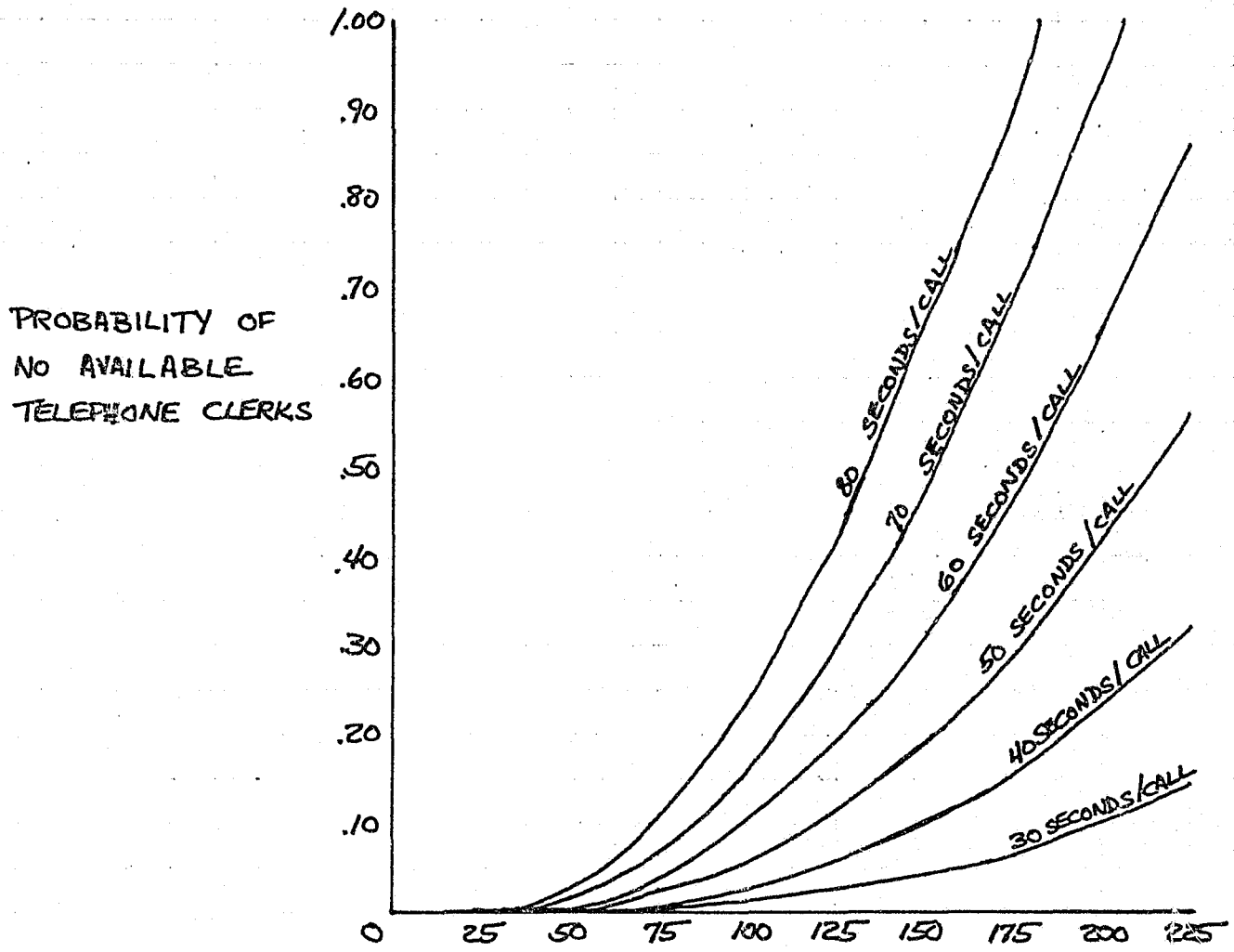


Figure 1-5

RELATIONSHIP OF WORKLOAD, SERVICE TIME, AND SATURATION PROBABILITY FOR A 4 SERVER QUEUE.



telephone clerks will be busy when someone calls increases rapidly at higher call rates, especially when the amount of time per call is long. For example, if it takes 80 seconds to handle a call, then the chance that all operators will be busy *more than doubles* when the incoming call rate increases from 75 calls per hour to 100. Even more startling is the rapid increase in the length of time a delayed caller has to wait, as seen in Figure 1-6.

The levels of overrings (calls delayed more than 12 seconds) and lost calls (estimated by the number of calls delayed more than 30 seconds) show similar patterns of dramatic increases at higher workload levels. as shown in Figure 1-7 and Figure 1-8, respectively.

The importance of examining the service levels of the four-person telephone answering team is to provide a baseline to evaluate the improvements the new 23-person team can bring about.

The 23-Person Telephone Answering Team. It is important to remember that the new system handles many more calls than an individual console under the old system, although peak capacity under the new system is less than 9 times peak capacity under the old system. The nature of the change can best be seen by turning back a few pages and comparing Figure 1-1 and Figure 1-2. The median number of calls increases by a factor of roughly 6 or 8. Importantly, the peak call rate only increases by about a factor of 5 when all 9 consoles are consolidated. To facilitate comparison of peak load patterns, the scales on the figures for 23-person team are 5 times those we have just seen on the figures for the four-person team.

Figure 1-6

RELATIONSHIP OF WORKLOAD, SERVICE TIME, AND AVERAGE WAIT OF DELAYED CALLS IN A 4-SERVER QUEUE

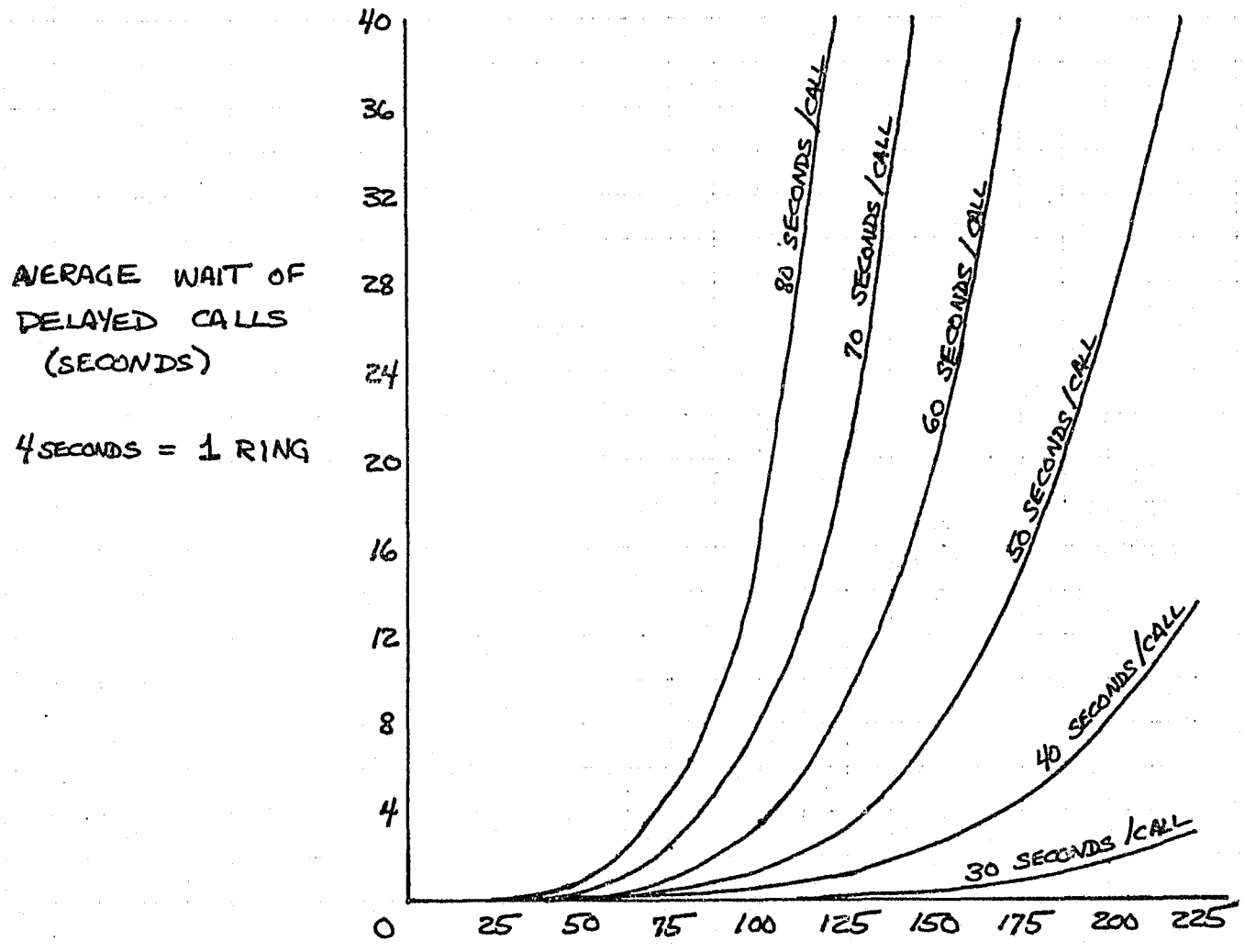
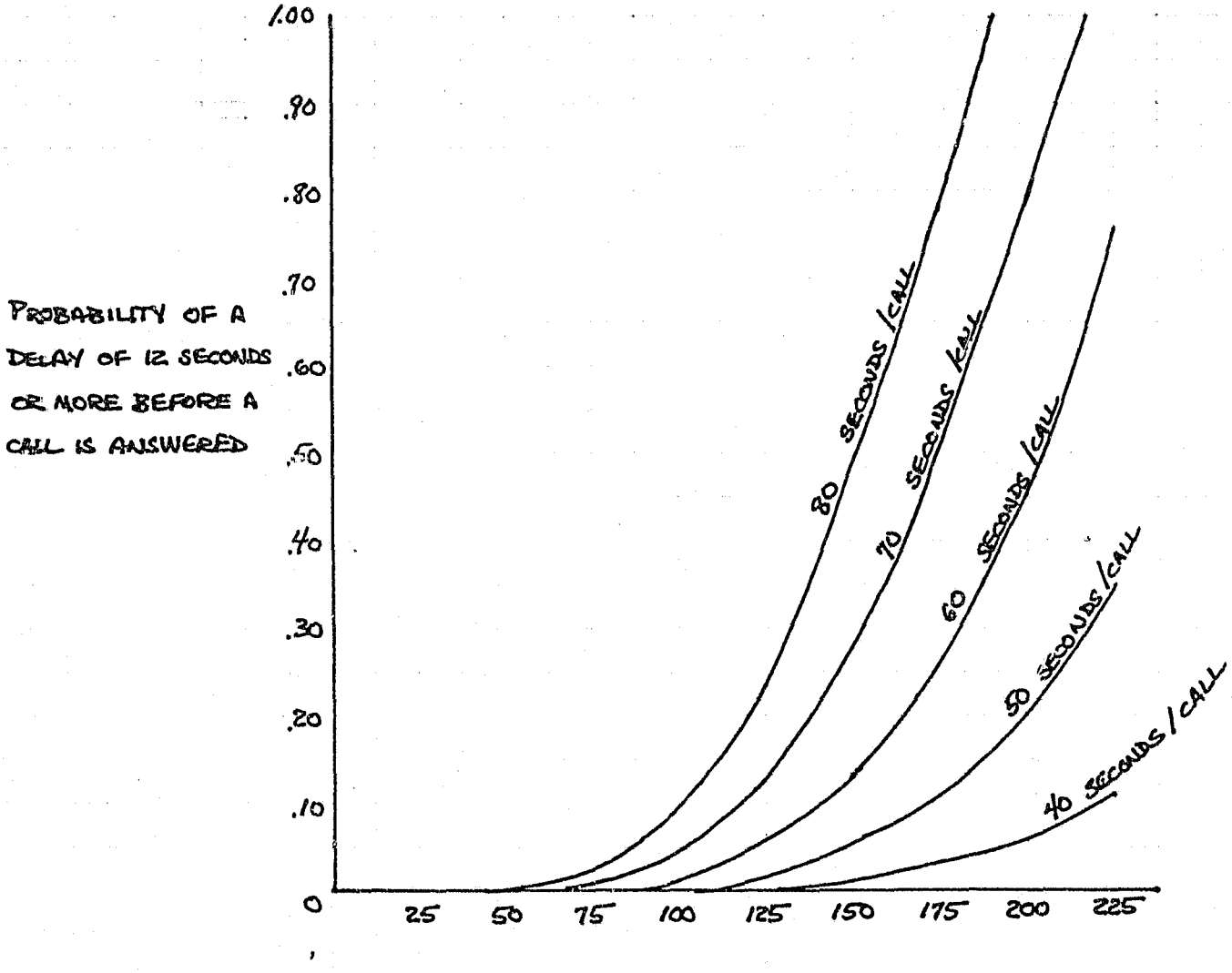


Figure 1-7

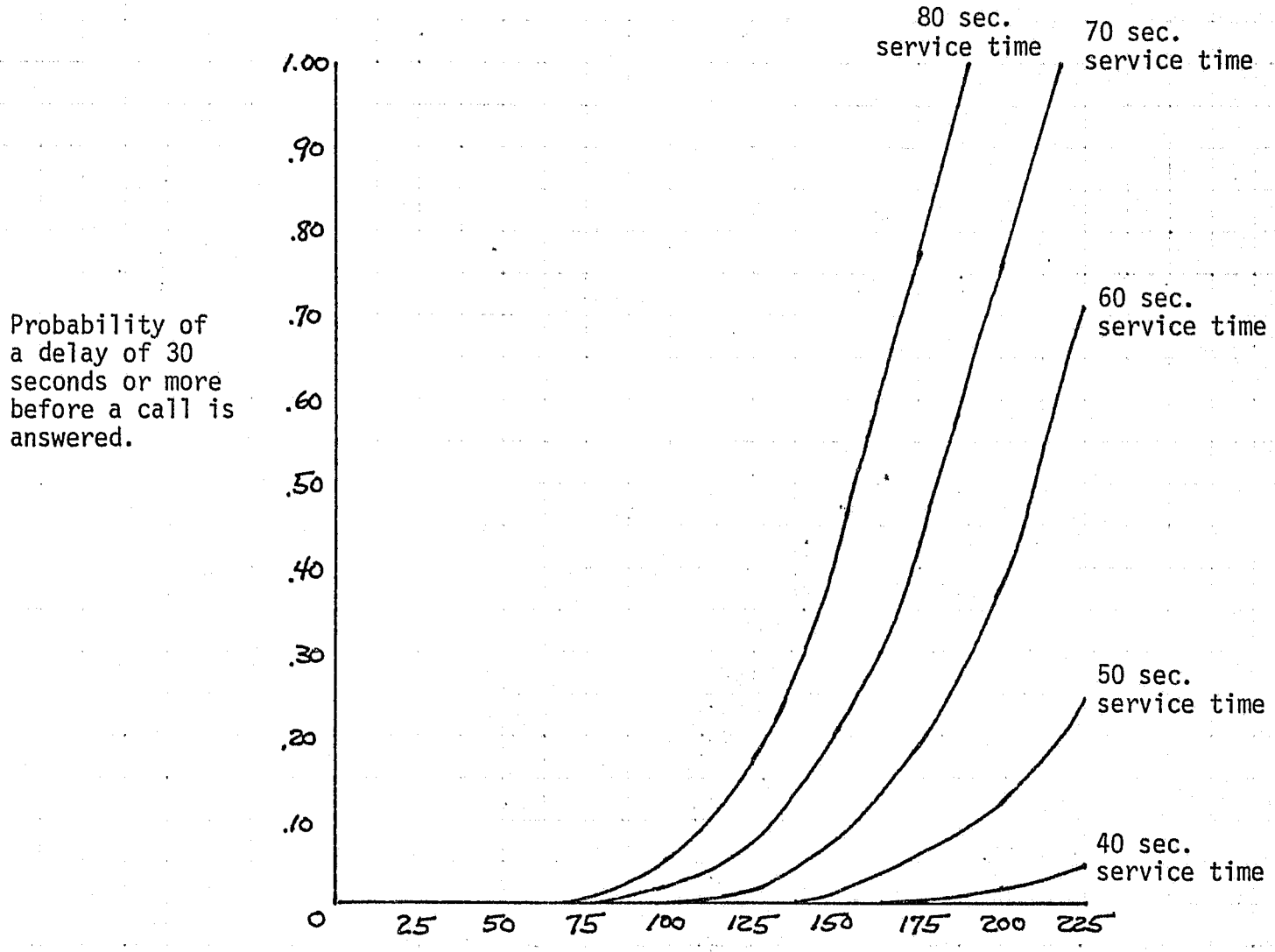
PROBABILITY OF OVERRINGS FOR A 4-SERVER QUEUE



FOR VARIOUS SERVICE TIMES

Figure 1-8

Estimated Probability of Lost Calls
for a 4-Server Queue

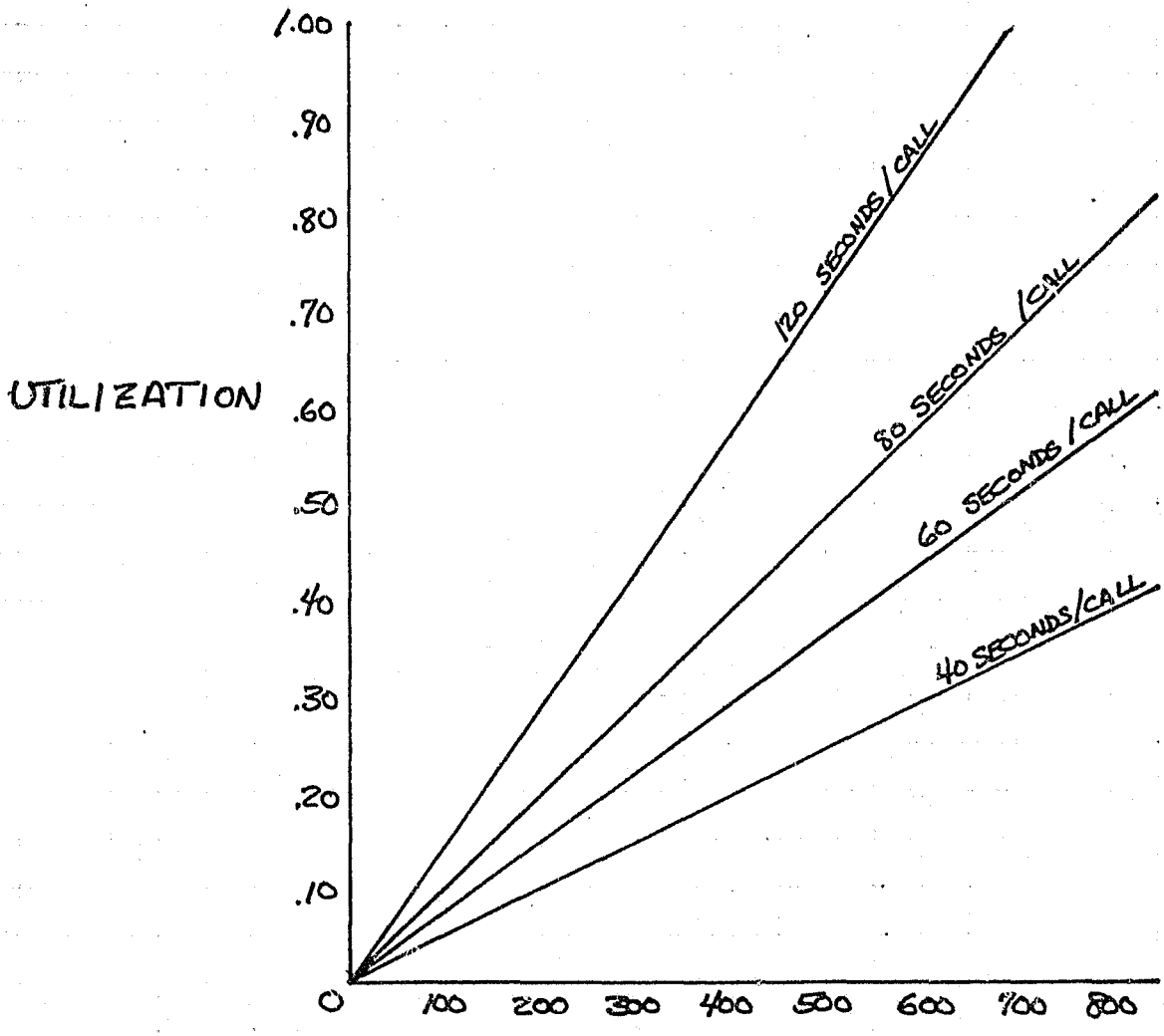


The relationship of utilization (the percent of time spent answering calls) to the incoming call rate and the average time to handle a call is shown in Figure 1-9. Utilizations are somewhat lower for the peak workload range than they were at peak workloads under the old system. But since the peak workload is now fewer times the size of the normal workload, complaint operators will be handling calls for a larger portion of the time at normal workloads. This is an increase in efficiency which is made possible by the new configuration.

The effect of the change on delay patterns if all 23 positions are filled is shown in Figure 1-10: the probability of no available operators when a complainant first calls, the average wait of delayed calls, the probability of delays longer than the PPD's 3-ring (12 second) service standard, and the probability of delays longer than 30 seconds, (which are likely to result in lost calls). In each case, performance is substantially improved relative to the pre-CAD case, if the time to handle a call remains the same. Actually, increase in this service time is likely, especially during the stages of acclimation to the typing and function keys involved in the new CAD system.

Variations in Manpower During CAD. Changing the number of complaint operators assigned to the CAD telephone queue affects all of the performance measures we have been examining. By means of a ruler, communications room commanders can estimate performance levels based on the number of complaint operators and two simple statistics: the incoming call rates, and the average amount of time it takes to handle a call. The PPD can also use the reverse procedure: service standards for minimum performance levels can be set, and these graphs can be used to

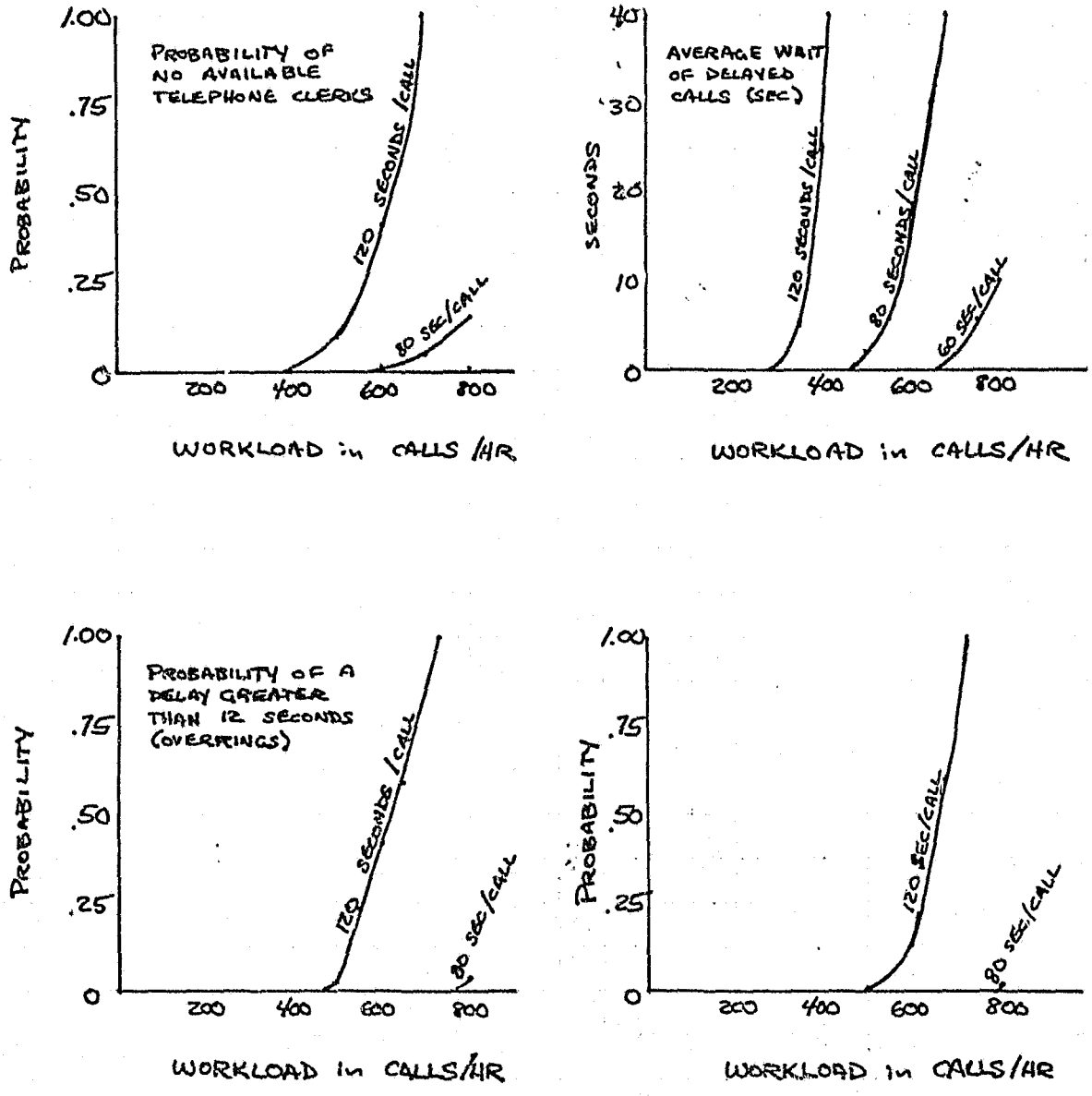
Figure 1-9
RELATIONSHIP OF UTILIZATION, WORKLOAD, AND SERVICE TIME FOR A 23-SERVER QUEUE



WORKLOAD in CALLS/HR
FOR VARIOUS SERVICE TIMES

Figure 1-10

PROPERTIES OF THE 23-SERVER QUEUE

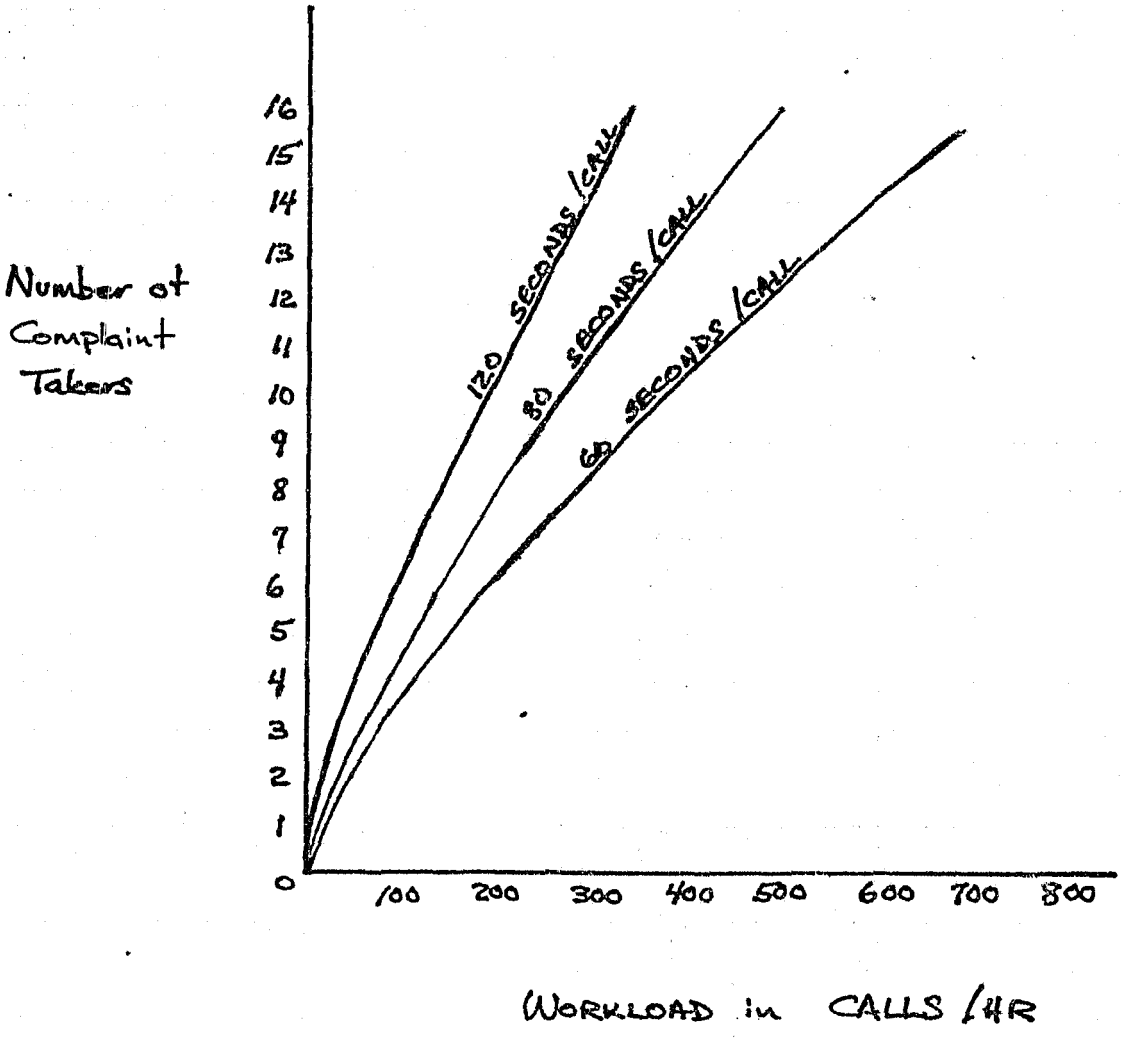


estimate the number of operators required to meet the need. Sufficient documentation of incoming call rates has been kept up by the PPD for some time now. The additional effort required to determine service times can be minimized by using a periodic limited sampling procedure.

To determine required manpower levels, first select the service objective (say 95% of the calls to be answered within 12 seconds). Find the chart which corresponds to that service standard (Figure 1-11) and look along the bottom edge to find the expected workload. While it cannot be known in advance exactly, experienced supervisors can probably guess workload levels within 100 calls either way based on patterns earlier in the week. Follow the workload level straight up the chart to the line showing the service time which determines the service standard relationship. Now look to the left and see how many complaint takers would be required. Use the number from the high end of the estimated range in order to allow for fluctuations in demand. Allow extra manpower to compensate for breaks to make sure an appropriate number of complaint operators is always available. There will still be some short term surges, 5 or 10 minute periods in which workloads will be substantially heavier than the hourly rate. Better performance can be maintained by diverting some personnel (first line supervisors, for example) from tasks which can be interrupted for occasional short time periods.

Figure 1-11

SERVICE TIME REQUIRED TO ANSWER 95 % OF CALLS WITHIN 12 SECONDS



APPENDIX 2

DISPATCHERS' SURVEY

The Department is conducting this follow-up survey in order to help evaluate the Computer-Assisted Dispatching System (CAD) and to provide the opportunity for dispatchers to make suggestions on its operation. Listed below are a series of questions. In each case, please indicate your opinions by checking the appropriate box or boxes. Please feel free to make any comments or to speculate on what the results of the system might be.

1. Are you primarily a broadcaster or a complaint taker?

   ☐ broadcaster ☐ complaint taker

2. How well informed do you feel about: (please answer parts a, b, and c.)

	Very well	Fairly well	Not very well
a. The stated goals of the system	☐	☐	☐
b. How broadcasters operate the system	☐	☐	☐
c. How complaint takers operate the system	☐	☐	☐

3. How does the CAD system affect the way you feel about your job?

   ☐ More satisfying
   ☐ No difference
   ☐ Less satisfying

4. How do dispatchers feel about the CAD system now that they have used it? Do you think:

- ☐ Most are for it
- ☐ About half and half
- ☐ Most are against it

5. How do you think the CAD system affects performance in each of these areas? (Please answer parts a-h)

	Performance has improved	No effect	Performance has worsened
a. Reducing telephone complaint taking time	☐	☐	☐
b. Reducing dispatch time	☐	☐	☐
c. Increasing the overall capacity of the communications unit	☐	☐	☐
d. Reducing dispatcher workload	☐	☐	☐
e. Reducing complaint taker workload	☐	☐	☐
f. Keeping track of the patrol force	☐	☐	☐
g. Reducing radio congestion	☐	☐	☐

h. Other. Please state: _____

6. Of the goals listed in question 5, please circle the letter of the one you feel is the most important.

7. What do you see as the main potential problem that the CAD system has encountered?
   - ☐ Dispatchers will only be able to perform one dispatching task at a time
   - ☐ Need to type instead of write
   - ☐ Reliability of equipment and computers
   - ☐ Capacity of system to hold backed-up jobs
   - ☐ Complexity of operating the system
   - ☐ Lack of support from dispatchers
   - ☐ Other. Please state: _____

8. What do you see as the main potential benefit of the CAD system?

- ☐ Reduced paperwork
- ☐ Faster response times
- ☐ Computer recommends which cars to dispatch
- ☐ Quieter dispatch room
- ☐ Computer verifies addresses as legitimate addresses
- ☐ Computer indicates which cars are at which assignments and how long they have been there
- ☐ Other. Please state: _____

9. How do you think the CAD system has affected the role of Operation FIND in Philadelphia? (Please answer parts a-e.)

	Increased	No effect	Decreased
a. Frequency of use of Operation FIND	☐	☐	☐
b. Frequency of success of Operation FIND	☐	☐	☐
c. Speed of deploying Operation FIND	☐	☐	☐
d. Coordination in deploying Operation FIND	☐	☐	☐
e. Interference of Operation FIND with other dispatching operations	☐	☐	☐

10. How do you think the CAD system has affected your ability to do your job well? Has it:

- ☐ Helped you
- ☐ Made no difference
- ☐ Made it harder

11. How do you think the CAD system has influenced your relationship with your co-workers? Has it:

- ☐ Made it better
- ☐ Made no difference
- ☐ Made it worse

12. How do you think the CAD system has influenced the way the public feels about the police? Has the public feel:

- ☐ More favorably toward the police
- ☐ No different than before
- ☐ Less favorably toward the police

13. In general, do you think that it is a good idea or not a good idea to have the CAD system in Philadelphia?

☐ Good idea ☐ Not a good idea

14. Do you have any suggestions or general comments about CAD? (Additional paper will be provided if desired.)

APPENDIX 3

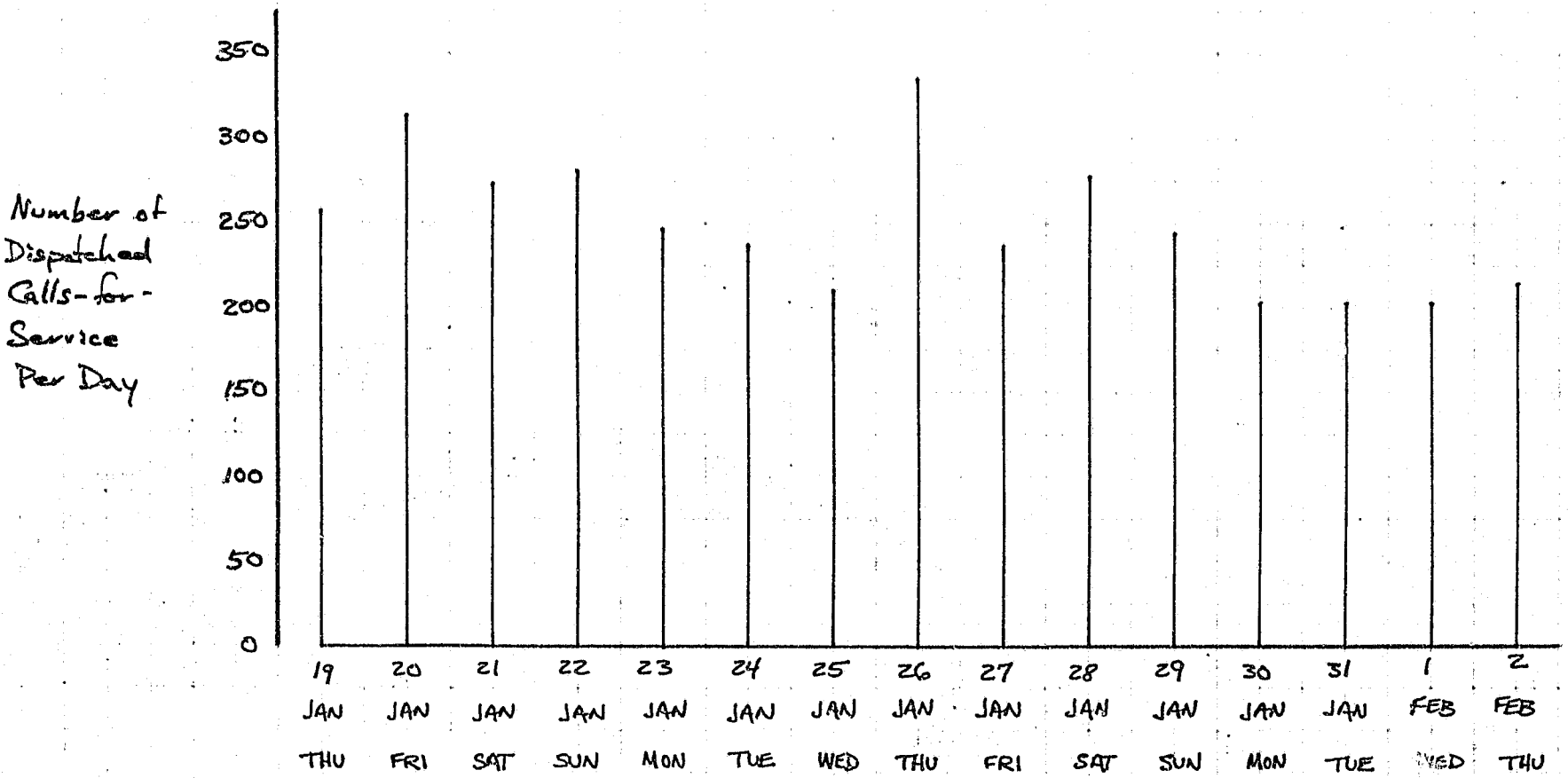
Data from the Two-Week Special Test

During the preparation of this evaluation plan, a special two-week data gathering effort was conducted in order to assess the performance of the pre-existing dispatching system. Dispatch cards from the Northeast Console (Districts 2, 7, and 15) were keypunched and analyzed by computer. Highlights of the results of that two-week test are presented in this Appendix.

The data presented can be used for planning purposes in anticipating the requirements of the CAD system. Also, this information can be used as a baseline to examine the effects of improved supervision obtained through use of either the CAD system or the reports it produces. The data are presented in a series of figures and a brief description of the content of each figure is given at the bottom of each page.

FIGURE 3-1

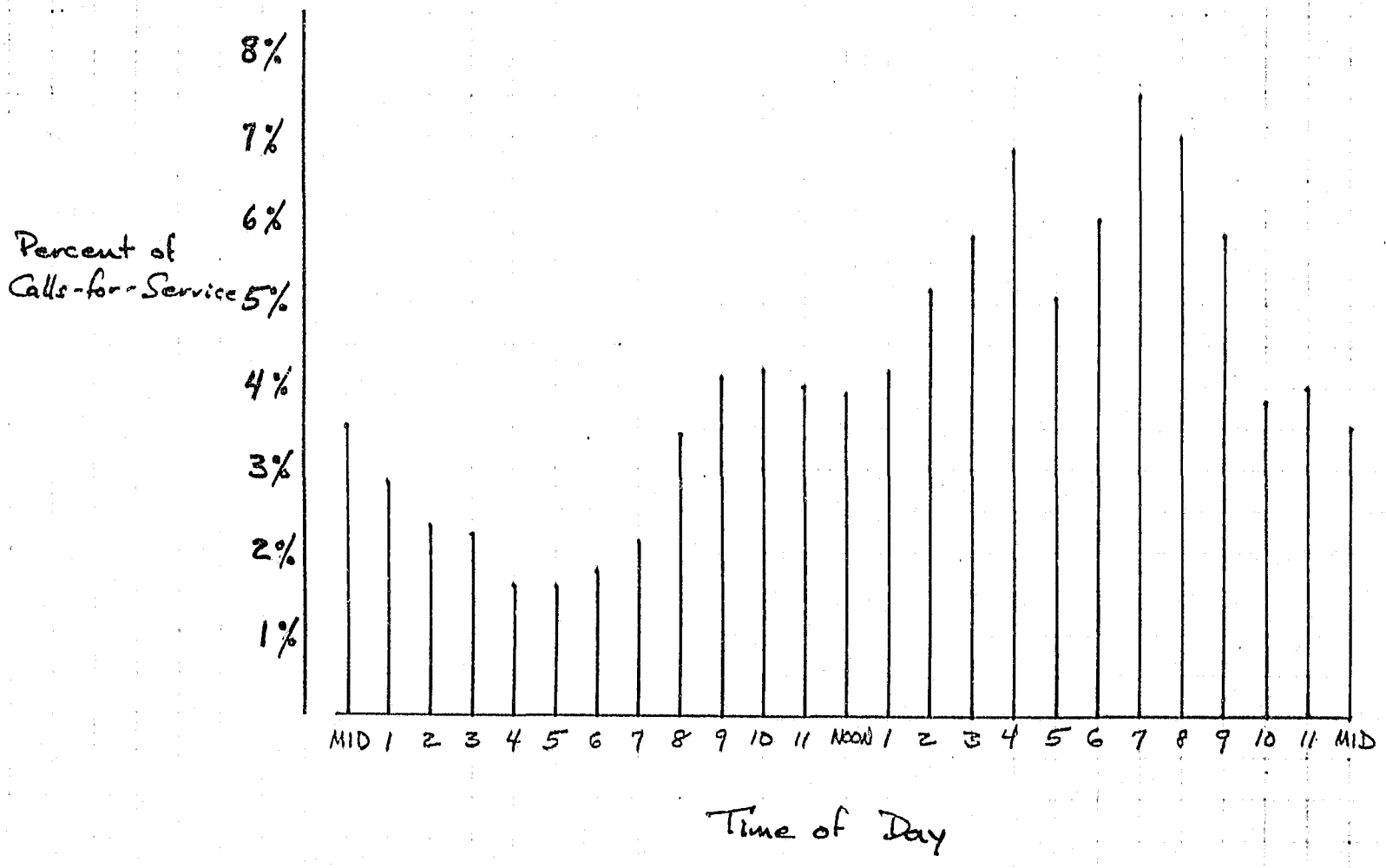
Number of Calls for Service by Date Received



The peaks on January 20th and 26th reflect significant snowstorms, which partially obscured the pattern of peak call rates on the weekends. The Northeast console averaged about 270 white-card dispatches per day during this period. The low total can be attributed to cold and snowy weather.

FIGURE 3-2

Percent of Calls-for-Service by Time of Day Received



Peak call-for-service dispatching loads occurred between 3 and 10 p.m. Volume during the later evening hours was probably low due to the cold and snowy weather.

Figure 3-3

Use of Published Nature Codes

Code	Frequency	Code	Frequency	Code	Frequency
AST-OFF	0	BAR PER	2	HOLNST	1
ROB PRG	0	IN SO SMK	0	ST LIT OU	0
BURG PRG	29	M OFF	2	ST LIT ON	0
RPE PRG	0	M SGT	0	DFT TR SI	1
WMN SCRM	0	M POL	0	RAD SHP	0
M/G	2	TRF CON	2	ABAND AU	25
SOM BRK N	2	IL PKG	1	ILL VEN	0
VAN PROG	5	INV AUTO	10	PSNL	0
SLT ALM	28	ESCT	0		
PRWLRS	2	AU OP RK	2		
DISHSE	143	RPT MS P	9		
HOS KS	104	STLN CR	10		
H K RES	50	DANG HWY	10		
PER VA HS	1	HQTS	0		
M/RIV	0	MT CR GD	0		
M KNIF	0	LNH	0		
HLD PRIS	0	CAWAS	0		
DIS HWY	117	DK	10		
L FIRE	17	TRNS PRI	1		
FR BX	0	TRNS POL	1		
ARPT EM	0	CRT	0		
INV OCC A	7	MECH	0		
PER SUSP	3	SUD DETH	1		
MENT KS	3	RPT	9		
		DIS CRD	188		

The frequency of use of each code indicating the nature of an incident is shown in this figure. Any code used less than 10 times should be reexamined to make sure it conveys useful information. The 16 most frequently used codes on this list account for 97.1% of the use of all codes on this list. The list covered only 32.3% of the codes actually used, however. The most useful codes not included on the list are shown in Figure 3-4.

Figure 3-4

The Most Widely Used Nature Codes

Code	Frequency		Code	Frequency
DISC	188		*BROK*	*13*
DISH	143		*HOLM*	*12*
DIS	117		*COMP*	*11*
HOS	75		DANG	10
INVE	*58*	(investigations)	DK	10
RIR	*41*	(rescue enroute)	INVA	10
MALE	*39*		*OPEN*	*10*
HK R	36		STLN	10
TAPE	*30*	(taped alarm)	*MAN*	*9*
AUTO	*29*	(auto theft or acc.)	*MEET*	*9*
BURG	29		RPT	9
HOSK	29		*S/A*	*9*
LOCA	*28*	(local fire)	*SHOP*	*9*
SLTA	28		*THRO*	*9*
WELL	*27*			
ABAN	25			
LOUD	*24*			
STOL	22			
HKRE	21			
INV	19			
L FI	17			
REF	*17*			
ROBI	*15*	(rob. i.p.)		
DIST	*14*			
BIP	*13*			

Only the first 4 letters of each code were recorded for analysis. The codes on this list accounted for over 50% of all dispatches during the two week test. The italicized codes are the ones not on the published list of nature codes in Figure 3-3. Note the problems with the spacing in the "Hospital Case" codes. Many of the "invented" codes will be useful and should be included on an updated code list.

FIGURE 3-5

Number of Calls by District

District	Number of Calls	Percent of Calls
2	858	22.6 %
7	1389	36.6
15	1549	40.8
Total	3796	100.0 %

Response Time Statistics by District

District	Dispatch Time	Service Time*
2	7.25 minutes	24.72 minutes
7	9.00 minutes	23.79 minutes
15	7.93 minutes	23.81 minutes
Total	8.17 minutes	24.01 minutes

Response times were unusually high during this period, perhaps as a result of adverse weather conditions. A smaller sample taken on December 22, 1977, showed the overall dispatch time as 1.39 minutes and service time as 20.48 minutes. In other police departments typical dispatch times are about 3½ minutes and service times are 20-25 minutes.*

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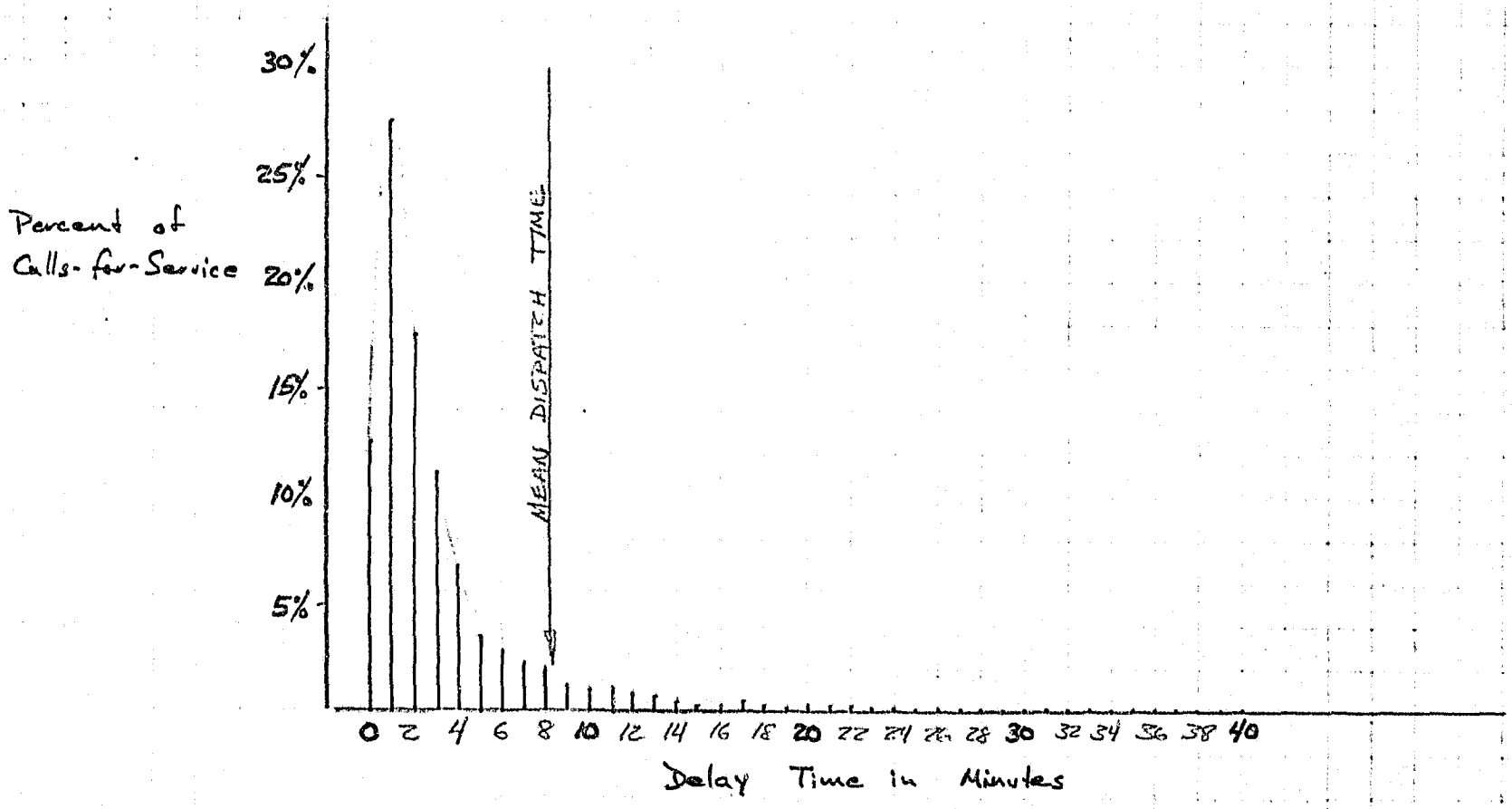
* Includes both travel time and time on-scene.

CONTINUED

1 OF 2

FIGURE 3-6

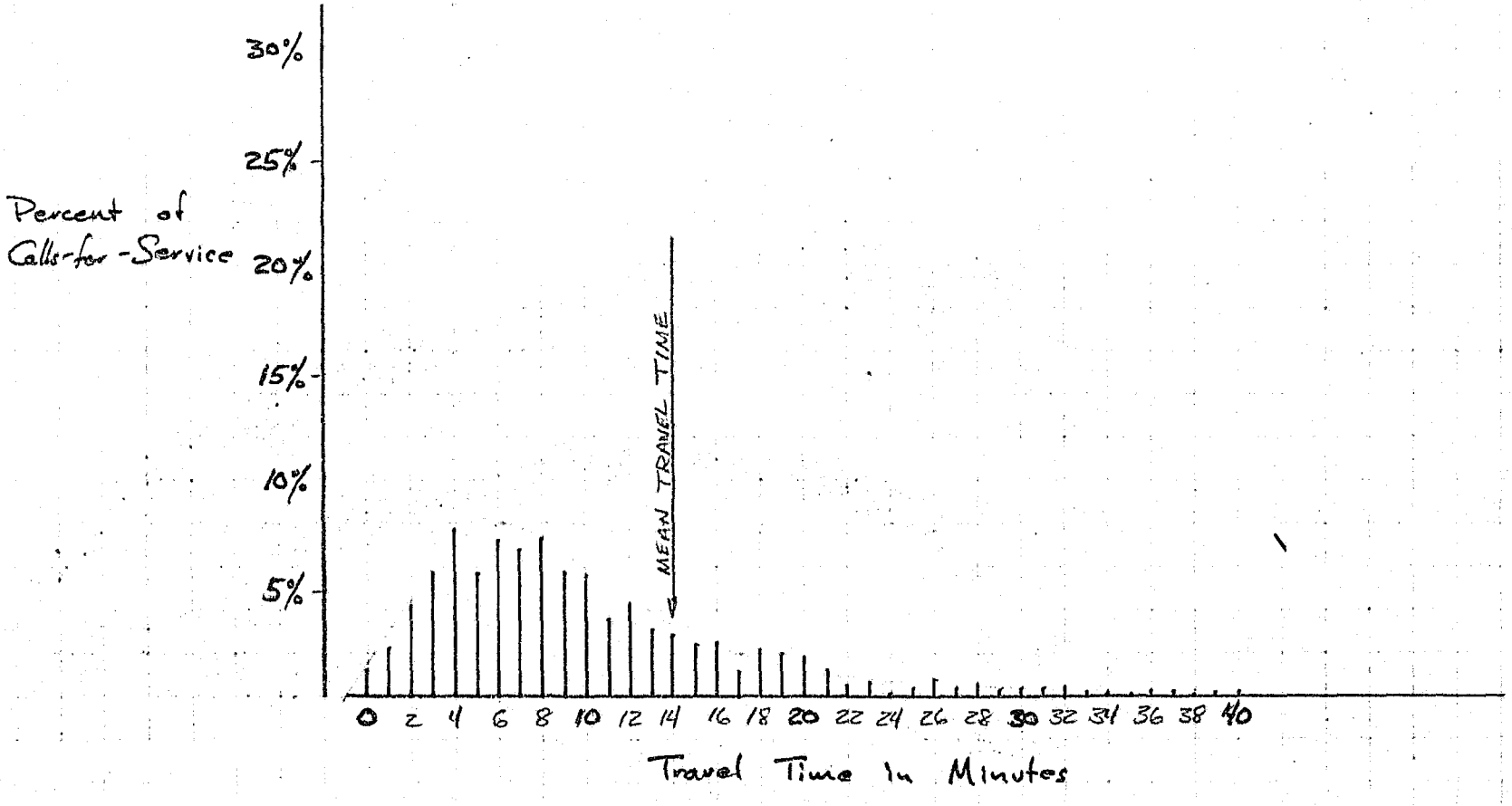
Delay Time Distribution (N=3111)



Even though mean dispatch times were over 8 minutes, the vast majority of the calls were dispatched more promptly. More than half the calls were answered within 3 minutes, and three quarters were answered within 5 minutes.

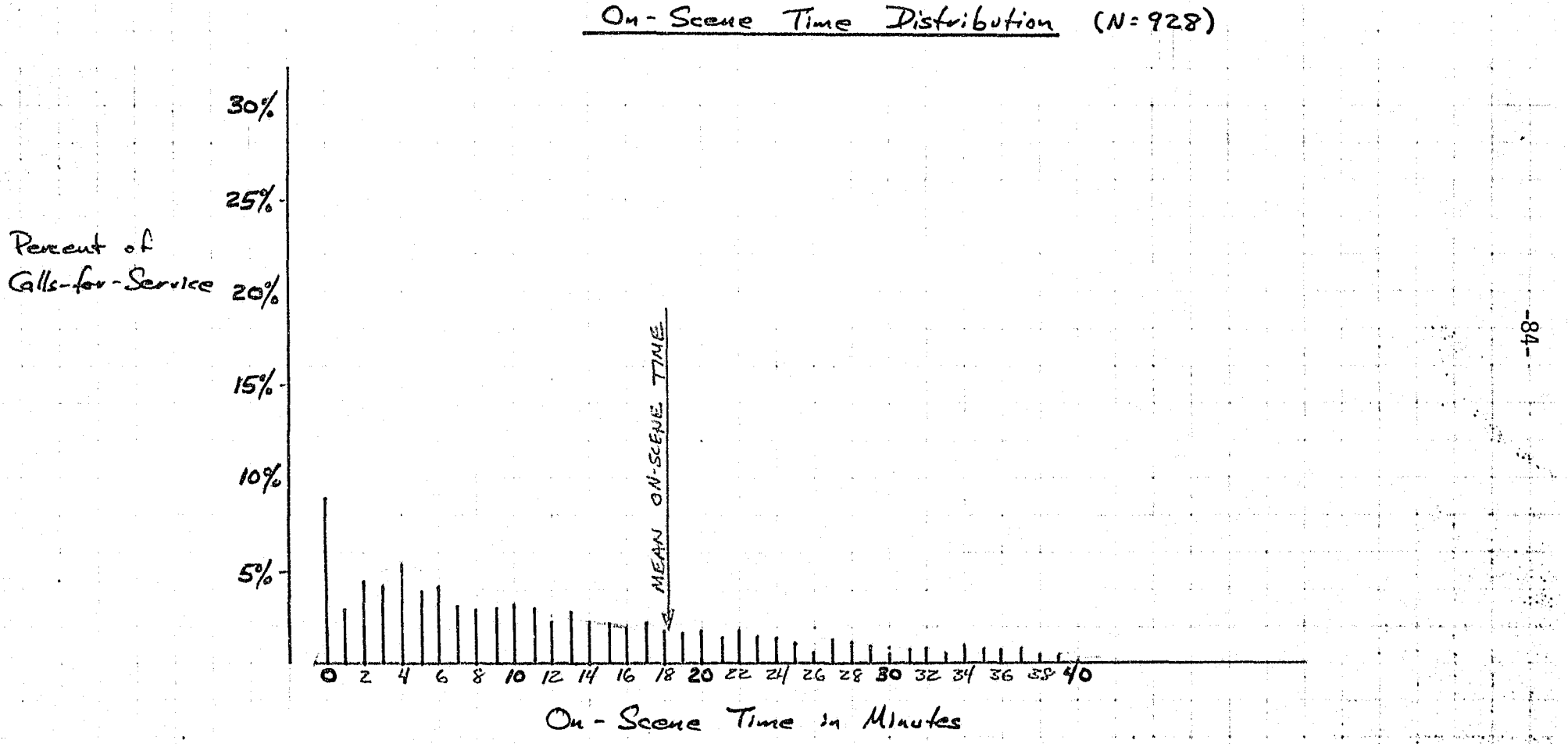
FIGURE 3-7

Travel Time Distribution (N=950)



Most travel times were substantially less than the mean travel time. Half of the calls were answered within 10 minutes.

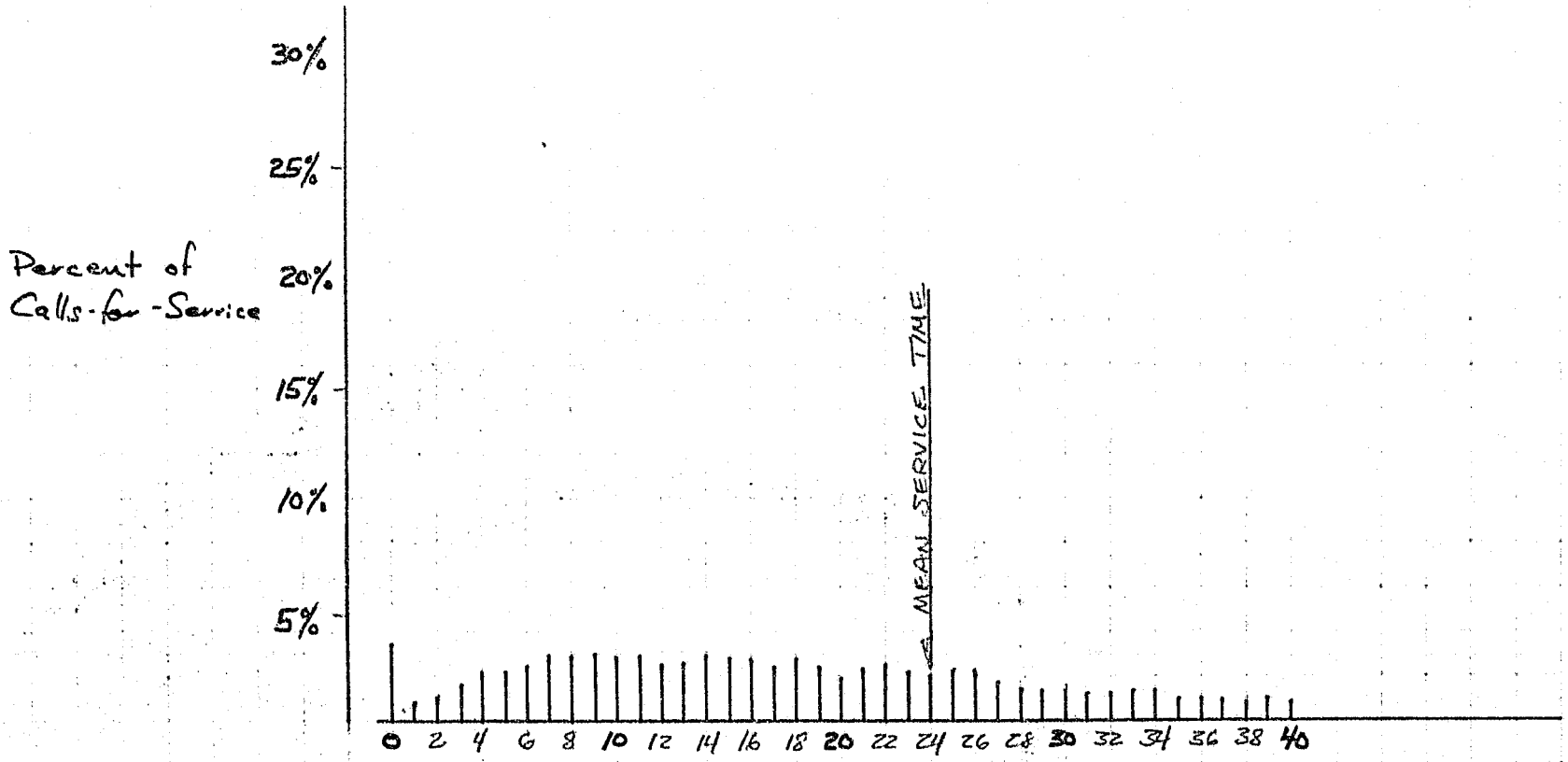
FIGURE 3-8



Most on-scene times were less than the mean on-scene time, with half of the on-scene times less than 12 minutes. There are a substantial number of calls with very long on-scene times.

FIGURE 3-9

Service Time Distribution (N=3395)



Most service times are somewhat less than the mean, with half of the calls answered within 21 minutes. Service times (which include both travel and on-scene times) are sometimes very long due to the complexity of incidents or to traffic problems.

FIGURE 3-10.

Type of Call

SILENT ALARM	119	5.5 %
AUDIBLE ALARM	92	4.3
DISTURBANCE HOUSE	142	6.6
FIRE BOX	19	0.9
DISORDERLY CROWD	315	14.7
FIGHT ON HIGHWAY	50	2.3
HOSPITAL CASE	316	14.7
AUTO ACCIDENT	167	7.8
MEET COMPLAINANT	929	43.3
(missing)	(45.4 %)	

Nearly half of all calls were not designated according to type, and of those that were, almost half were simply marked "meet complainant."

Origin of Call

POLICE	15.4 %
CIVILIAN	84.6 %
(missing)	(32.9 %)

About 15% of calls came as police-initiated activities. In other departments this fraction sometimes runs as high as 25%, possibly reflecting a more thorough screening of the incoming calls from civilians.

END