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APPLICATION OF COMPUTER-AIDED DISPATCH IN LAW ENFORCEMENT

—an introductory planning guide

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National Criminal Justice Information and Statistics Service
UNITED STATES DEPARTMENT OF JUSTICE

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PREFACE

This document presents results of work supported by the Law Enforcement Assistance Administration, U. S. Department of Justice, under the Omnibus Crime Control and Safe Streets Act of 1968, as amended. It was sponsored under an inter-agency agreement with the National Aeronautics and Space Administration through Contract NAS 7-100. Points of view or opinions stated in this document are those of the authors and do not necessarily represent the official position of the U. S. Department of Justice.

FOREWORD

This book has been prepared and distributed to provide public safety planning personnel with a compact source of information on one of the most important aspects of police command and control automation, namely computer-aided dispatch (CAD) systems. A CAD system is valuable in itself for the improvements it provides in the critical dispatching function, and can be the nucleus for a completely automated police command and control operation.

This volume is one of a series prepared under the sponsorship of the Law Enforcement Assistance Administration (LEAA) to provide planning guidelines on the various aspects of police command and control automation. The complete series consists of the following documents:

Title	Document No.
Application of Mobile Digital Communications in Law Enforcement	JPL SP43-6 Rev. 1
Application of Computer-Aided Dispatch in Law Enforcement	JPL 5040-16
Application of Automatic Vehicle Location in Law Enforcement	JPL 5040-17
Patrol Force Allocation in Law Enforcement	JPL 5040-18
Advanced Command and Control Systems in Law Enforcement	JPL 5040-19

The series was prepared by the Jet Propulsion Laboratory of the California Institute of Technology, using the results of studies sponsored by LEAA at JPL as well as at other institutions. The documents are being distributed as part of LEAA's mission of giving technical assistance to state and local law enforcement agencies. They are addressed to the local law enforcement planner who must face practical working problems in deciding what degree and kind of automation best suits his department. Our intention has been to give him the basic understanding he needs to make such a decision, and procedures for making the associated analyses or having them made. The manuals are developed within the framework of the overall command and control system so that potential benefits of individual innovations can be evaluated in terms of improved system performance.

The technologies that are available to law enforcement agencies today have the promise of making their operations more efficient as well as more effective. Our hope is that this series of documents will provide a clear and concise picture of what that promise is and what is involved in making it a reality.

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Systems Development Division
National Criminal Justice
Information and Statistics Service
Law Enforcement Assistance Administration
United States Department of Justice

CONTENTS

CONTENTS (Continued)

TABLES

FIGURES

ABSTRACT

A set of planning guidelines for the application of computer-aided dispatching (CAD) to law enforcement is presented. Some essential characteristics and applications of CAD are outlined; the results of a survey of systems in the operational or planning phases are summarized. Requirements analysis, system concept design, implementation planning, and performance and cost modeling are described and demonstrated with numerous examples. Detailed descriptions of typical law enforcement CAD systems, and a list of vendor sources, are given in appendixes.

This document is one of a series of five guideline manuals on mobile digital communications, CAD, automatic vehicle location, patrol force allocation, and multiagency command and control systems for law enforcement applications.

1. INTRODUCTION

Increasing the degree of automation of police command and control operations has been a topic of growing interest over the past five years. The Law Enforcement Assistance Administration has a strong interest in the field and has supported several departments in their implementation of computer-aided dispatch (CAD) systems. Such systems are the basic step in the automation of police command and control; a few law enforcement agencies have implemented CAD systems, more are planning to do so, and nearly all are interested in following developments in the field.

There are two major reasons for the growing interest in CAD. The first is that departments want to improve the management of their resources in one or more of the following ways:

- Decrease response time to citizen calls for service.
- Increase productivity by enabling a patrol unit to respond to more calls per shift, or
- Match patrol assignments better to hours and locations of expected need.
- Reduce dispatching errors.
- Reduce hand preparation of reports.
- Have instant access to activity statistics, and use such statistics in formulating budgets and deployment strategies.

The second reason is that CAD provides a framework for bringing together the many new tools for command, control, and communications that are computerized or computer-compatible. In addition to computers themselves, these include:

- Mobile and portable digital terminals.
- Dynamic channel assignment.
- Automatic vehicle location systems.
- Remote data base inquiry.
- Management reporting systems.
- 911 emergency telephone number service.
- Regional cooperative dispatch among adjacent jurisdictions.

The interest in CAD systems reflects their potential for improving operations in the ways mentioned, but there are also potential drawbacks that should be recognized when plans are being made. One obvious drawback is that departments will grow more dependent on technology and on specialists such as computer system engineers, programmers, and data processing managers; this limits the autonomy and in some ways the flexibility of the department. The cost of installing a CAD system and converting operations to it is still high, especially for software, and will remain so until enough systems have been installed to permit some degree of standardization. The sophisticated hardware will need specialized maintenance over its lifetime, and the cost may be a burden. Finally, all automated systems can be expected to have failures and there must be a backup mode of operation for such times. The backup mode must be kept exercised and ready for use at any time.

The purpose of this document is to provide some background and guidelines that will assist law enforcement agencies in selecting and evaluating CAD systems and in developing operational plans for their use. The next chapter is a brief review of the current status of implementation of CAD systems around the country; since the situation is changing very rapidly, the survey does not include all agencies that are planning for or are in the process of implementing CAD systems. Chapter 3 represents a summary description of what a CAD system is and how it operates, as background for the rest of the document. Chapter 4 outlines the process of planning for a CAD system, followed by planning guidelines in Chapters 5, 6, and 7. Chapter 5 covers the analysis of requirements, while Chapter 6 describes the hardware and software components of a CAD system and gives an example of how a proposed system can be sized. It also discusses some principal trade-offs that are available to the CAD system planner. Chapter 7 gives some guidelines for preparing an implementation plan, and finally Chapter 8 discusses briefly the cost versus benefit analysis of a CAD system.

2. STATUS OF COMPUTER-AIDED DISPATCH

In the course of preparing material for this manual, we contacted several law enforcement agencies that have installed CAD systems and discussed their experiences in designing and implementing the systems as well as the impact on their operations. Actual experience with CAD is still very limited, since with one exception the systems became operational in 1973 and are still in the shakedown stage. Some of the major characteristics of these existing systems are summarized in Table 1.

An important observation about CAD systems is that the trend to their use is just beginning; as of mid-1975, only about 10 percent of the 135 police departments in jurisdictions of more than 100,000 population had a CAD program, and as noted above these were still new. As the table shows, there is a range of capabilities in the existing systems, since they necessarily reflect different requirements in the form of rate of calls for service, size of patrol force deployed at a given time, and extent of other automated files that can interface with CAD. The basic functions performed by the CAD systems are quite similar and, as the state of the art matures, an increasing degree of standardization should be anticipated.

The feasibility of computer-aided terminals for complaint taking and dispatching is well established. Most of the recent installations have gone into operation without major problems or subsequent modifications, although start-up problems or subsequent modifications, although computer-aided dispatch systems have by no means reached any degree of standardization. Several design trends can be identified, however. All but the relatively small agencies employ two-stage configurations, one station for complaint taking, and a second station for dispatching; Glendale and Palm Beach County receive calls and dispatch from the same stations. San Diego and New York City further subdivide the complaint-taking function into primary and secondary stations, with longer calls and report-taking handed off to the latter operators.

Most agencies have dedicated computer processing units, all of which are of the minicomputer class, although report generation is usually performed by the municipal data processing agency. The two shared computer installations have not experienced difficulties with this arrangement, although priority is given to the CAD operation in order to deliver near real-time support.

The area of greatest concern is that of display size and format; many agencies have spent several months designing and testing displays and supporting software prior to installation, or have experienced costly redesigns if development testing was omitted. One "lesson learned" to date is the value of testing work station designs in near-operational environments prior to hardware development; it is nearly impossible to establish good display formats from drawings alone, or from static mock-ups.

Early dispatch display formats were designed for single CRT screens, usually with the top portion of the screen used for incident-related information and the lower half for field unit status. This approach was (and is) adequate for relatively small agencies, but has proved unworkable for large, heavily loaded agencies, which have resorted to dual screen arrangements, one for incident data and the second for field unit status. This allows more information to be shown at one time, reduces the "busy" activity of a single screen, and reduces the number of manipulations required of the dispatcher.

Also noted in Table 1 is the lack of experience with address verification and prior history files. Geofiles developed by municipalities for other purposes, such as tax or utilities functions, oftentimes are too cumbersome for dispatch purposes and must be reworked for these applications. Updating these files can be an expensive proposition. No agency has a prior history file in operation at the present time.

In view of the early stage of development of CAD systems, it will be extremely important over the next few years for any planner considering the implementation of a new system or the upgrading of an existing one to observe at first hand as many other systems as he can, and to learn as much as possible from the experience of others.

	Dallas PD	Glendale PD	Huntington Beach PD	Las Vegas Metro PD
Population (000's)	844	133	116	200
Calls for service (dispatches) per year (000's)	420	50	57	NA
Complaint and dispatch - separate stations	Yes	No	Yes	Yes
Number of switchboard operators	15	2	1	6
Number of dispatchers	5	2	2	6
Number of displays:				
Complaint board	1	1	1	1
Dispatcher	1		2	2
Number of patrol units[4]	46	19	22	45
Computer files:				
Incident status record	Yes	Yes	Yes	Yes
Patrol unit status record	Yes	Yes	Yes	Yes
Address verification and cross street ID	No	No	Yes	No
Incident history	No	No	Yes	No
Automated reports generated:				
Data log	Yes	Yes	Yes	Yes
Crime statistics	Yes	Yes	No	No
Field unit activity	Yes	Yes	No	No
Crime patterns	Yes	Yes	No	No

NOTES:

[1]Electronic conveyor belt only; dispatcher does not use CRT/keyboard.

[2]Used for backup mode dispatching only.

[3]Converting to dual CRT display.

[4]Number of units deployed during peak period.

Table 1. Summary of Characteristics of Some Existing CAD Systems

NYC PD[1] (Sprint)	Oakland PD[2]	Palm Beach County Sheriff	San Diego PD	Seattle PD	Shreveport PD
7868	362	160	607	631	182
3000	266	35	1022	626	NA
Yes	Yes	No	Yes	Yes	Yes
48	10	2	16	6	4
17	2	2	3	4	4
1	1	1	1	1	1
–	1		2	1[3]	2
700 (est.)	46	36	130	200	130 (est.)
Yes	Yes	Yes	Yes	Yes	Yes
Yes	Yes	Yes	Yes	Yes	Yes
Yes	No	No	No	No	No
No	No	No	No	No	No
Yes	Yes	Yes	Yes	Yes	Yes
No	No	No	No	No	No
No	No	No	No	No	No
No	No	No	No	No	No

3. DESCRIPTION OF COMPUTER-AIDED DISPATCH SYSTEMS

Computer-aided dispatch is just what its name suggests: a system that permits the normal operations of handling service calls from the public to be assisted by making use of the special capabilities of the computer. These capabilities are, for this application, those of performing simple, repetitive, routine tasks tirelessly and without error, storing and retrieving information almost instantly, and creating CRT displays from stored data and keyboard inputs. The computer does not replace the uniquely human capabilities required for law enforcement command and control, and can only assist the human operator.

The dispatching operation consists of a flow of complaints or incidents, originating with public calls to the complant board and moving on to the dispatcher (who assigns patrol units and coordinates any required support), to the patrol units (who investigate the incidents), and back to the dispatcher with information on status changes of patrol units and information on closed incidents. (Unusual situations such as disasters or civil disorders naturally fall outside this simple framework.) This dispatching operation is under the control of one or more supervisors (depending on the size of the department), and must be planned and managed along with all the other functions and resources of the department. A CAD system supports all these elements of the department, in the ways listed in Table 2.

As shown in Figure 1, a typical computer-aided dispatch system is comprised of a central processor, a data base system, and keyboard-display terminals for complaint board operators, dispatcher, and support personnel. The data base system contains several files, including:

- *Incident records*, a log for each incident from initial call to log off or final disposition.
- *Status of field units*, a summary of the status, assignments, and availability of vehicles.
- *Geo- or address file*, a listing of all addresses (to the block level) within the jurisdiction, including the corresponding beat number and reporting area.
- *Personnel*, a log of personnel status and assignments.
- *Dangerous situation*, a file of addresses of dangerous persons or places.
- *Vehicle and crime information*, local files of stolen vehicles and wants and warrants. There may also be access to remote files such as DMV, NCIC, etc.

The flow of information through the system is as follows: The complaint board operator enters information received from a citizen directly into the data files through the keyboard terminal and central processor. No hand-written or key-punched data are required; all information about the complaint (informant's name, address, telephone number, and nature of complaint) is typed directly into the file, through the terminal. Once the information has been entered into the system, the incident is passed to the dispatch terminal (calls not requiring a dispatch can be referred to the proper bureau or agency). When the incident is first entered into the computer files several processes begin to operate concurrently: the computer assigns a case number and time tags the incident, verifies that the address does in fact exist and is within the agency's jurisdiction, determines the beat number and available units assigned to that beat, and lists any history at that location (e.g., prior incidents, registered guns, etc.). A one-line summary of the incident is then brought up on the dispatcher's display screen. A key element in the process is the assignment of a priority level to the incident; normally, the priority is assigned by the complaint board operator in accordance with agency procedures when the call is received. The dispatcher then calls up the complete incident record on the display screen so that a field unit can be assigned and necessary information relayed to it by voice or digital communication links. The dispatcher types in the ID of the unit dispatched, and the computer updates the unit status and incident files and logs the time. Activity logs and statistical reports are prepared for each shift, each day, each week, each month, and as required for internal management as well as for reporting to state and federal agencies.

The department chief and his watch commanders use one set of reports for the deployment of personnel and mobile units, based on computer summaries of incidents by reporting district, type of crime, and time of day, as well as averages for corresponding prior time periods by reporting district and type of crime. The computer also prepares summaries of activities of the personnel and mobile units to indicate how each officer and each unit have spent their time: on assignment, on patrol, in court, special assignment, on leave, etc. Some agencies provide terminals through which operations managers can access the data base and retrieve statistics for near real-time application of resources.

One final comment about field reports. Patrol officers report some information before clearing for a new assignment. This information is entered by the dispatcher prior to log off, and is retained within the computer file until final disposition, which could occur many months after the incident took place. The field officers may prepare disposition reports at shift

Table 2. Computer Functions in CAD

Command and Control Function	What the Computer Does
Complaint board	Displays the format of the complaint record on the operator's console screen. As operator enters the complaint data on the keyboard, displays the input data in the appropriate spaces on the format (this lets the operator check on what he has entered). Automatically enters case number, date, time, and beat number. Checks input data for validity (duplicate cases, invalid addresses, etc.). Maintains backlog status of dispatchers and assigns complaint to dispatcher handling that beat.
Dispatch console	Displays all complaint records assigned to the position (or holds in memory those that overflow the screen, allowing operator to page through the memory as desired). Displays status of all patrol units under dispatcher's control. Maintains status records automatically as units are assigned, cases cleared, or status changes comes in from units. Automatically enters case number, date, and time case assigned to patrol unit. Checks data for validity. Accesses external files to determine nearest cross street, history of incidents, etc. at the address. Accesses remote files (warrants, DMV, NCIC, etc.) as required. Stores all records of cases cleared.
Patrol units	Updates status of patrol units. Accesses remote files (DMV, NCIC, etc.) directly upon request of officer, if equipped with digital terminal, or operator. Generates case reports for routine cases from officer inputs.
Supervisor	Allows supervisor to call up on his display any incidents in progress. Provides direct, immediate access to complaint/incident files. Generates activity reports for each shift. Maintains activity log.
Management	Maintains complete records of all activities. Generates statistical reports as needed, sorting incidents by type, area, patrol unit, time of day, date, or other classification.

termination to comply with legal requirements. These would constitute the only manually generated documents. One agency uses a technique in which the officer at shift termination telephones in the information to a keyboard operator who enters the data into the computer files; the officer need not make a written report.

In summary, the kinds of improvement in the dispatching operation that can be expected from implementation of a CAD system are:

Accuracy. CAD eliminates many errors due to repeated handling of cards, slips, time stamps, etc. and copying of in-

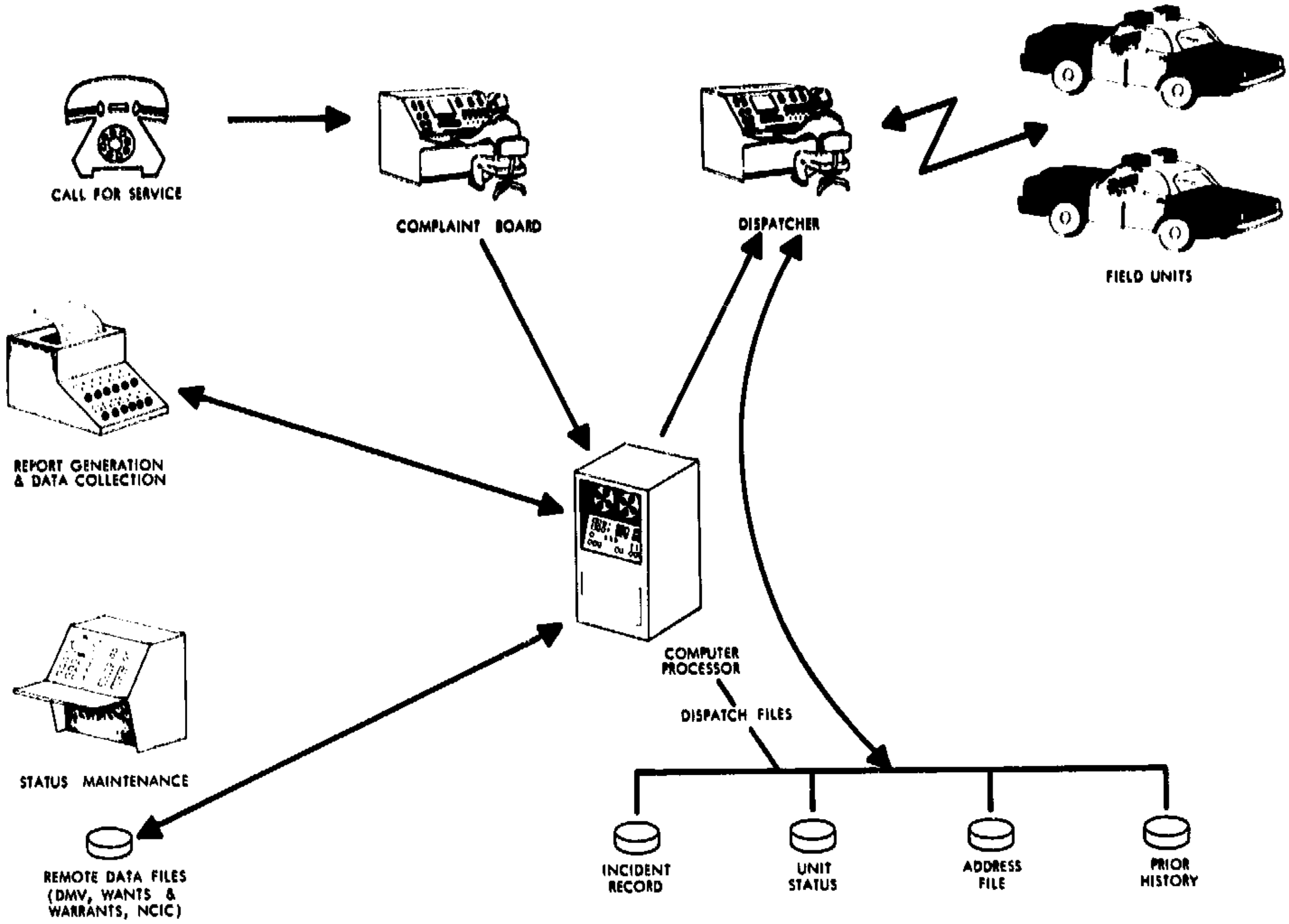


Fig. 1. Computer-aided dispatch functional diagram

formation from one form to another. It automatically edits human inputs for such errors as invalid codes, improper case number assignments or patrol unit designations, and in more sophisticated systems can compare an input address with files of valid addresses.

Operator Performance. CAD relieves the operator of many tedious mechanical tasks, thus improving operator performance by allowing concentration on the essentials of decision-making and supporting field units.

Speed. A CAD system can carry out some tasks, such as file updating or file look-up, much faster than is possible in manual systems. The speed of the computer also makes possible some tasks (such as checking for previous incidents at the address) that would not be possible in a manual system because of the time required. CAD cannot, however, reduce the time it takes an operator to listen to a verbal message or talk to a caller or patrol unit, or to decide what should be done next. Thus it should not be expected that a CAD system will necessarily increase the number of calls per hour that can be handled by a complaint board operator or dispatcher.

Span of Control. Similarly, a CAD system does not necessarily enable a dispatcher to control more patrol units even though it does provide a more efficient way of keeping track of incidents, resources, and assignments. One dispatcher for 30 to 50 patrol units is still a heavy load during hours of peak activity.

Paperwork Reduction. Since all the information about an incident is entered into the computer files in real time, it is available for generating reports that are needed. These include case reports, which for the most part can be produced by the computer directly based upon information provided by the officer. This saves considerable time of officers and clerks, and even where a report must be prepared by an officer the computer can prepare the routine portions of it. The same information on incidents can be used in the preparation of shift activity reports or management reports of various types (special computer programs must be written to select and organize the information from the data base for each type of report.

Expansion of Capabilites. A CAD system can serve as the nucleus for the addition of other capabilities making use of or building on the automated command and control equipment and procedures. The computer, consoles, peripheral equipment, and software that are needed for a CAD system provide the basis for adding such other capabilities as:

- Automatic vehicle location.
- Automatic generation and receipt of digital messages.
- Joint dispatching with fire and emergency medical services.
- Joint dispatching of adjacent jurisdictions.

While all the above kinds of improvement are significant, the planner must keep in mind the inherent drawbacks mentioned in Chapter 1 as well as some additional cautions:

Man/Machine Interaction. The optimum way for a dispatcher to interact with the computer has not yet been determined. Even in the best CAD system the dispatcher must page through several formats to find the right one, and then enter the information, while additional messages are arriving and events occurring in rapid succession. The workload imposed on a dispatcher is still stressful, and we are not providing the kinds of formats, displays, and data entry devices that would reduce this stress appreciably.

File Construction. While one of the major advantages of a CAD system is the capability of accessing any number or size of files in fractions of a second, there is still the problem of creating files in machine-readable form. The conversion of large amounts of data into machine-readable form requires human labor and is expensive; an example is the geographic data file that is used to verify addresses and identify the nearest cross street. This file also requires labor to update, although it does not change rapidly and the task may not be very large. The essential files, such as those for maintaining vehicle status, are relatively easy to assemble. Several of the remote files that would be assessed by the CAD system, such as auto registration data and the NCIC, are already in machine-readable form and only the interface needs to be provided.

System Effects. When a CAD system has been implemented, it becomes the core of the command and control system. For this reason, it is likely to affect many other operations and procedures. Those effects extending beyond the dispatching operation itself must be identified by the planner and taken into account in the planning; otherwise the CAD system may not fulfill the objectives he has set for it. For example, if the agency adds an automatic vehicle location system at some later date, computer software modifications will be required to perform the location-finding calculations, to determine the unit closest to an incident, and to drive displays, all of which have an impact on the digital equipments and work station layouts.

4. PLANNING FOR COMPUTER-AIDED DISPATCH

The planning process consists of the following basic steps:

(1) Analysis of requirements.

(2) Selection of system configuration and preparation of specifications.

(3) Preparation of implementation plan with cost estimates.

(4) Evaluation of expected benefits versus cost.

The following chapters suggest guidelines for these steps: This chapter discusses the overall planning process.

It must be kept in mind that the process does not consist of simply going through the steps defined above and coming out with a definitive plan. Planning should always be an iterative process, which means that one goes through some or all of the steps several times. For example, once the requirements have been defined and the process of defining the system configuration has been started, it may turn out that the available resources will not cover a system that meets the requirements. If more resources cannot be found, the requirements will have to be scaled down to fit the budget. Another possibility is that no single off-the-shelf system will meet all the requirements; one way of solving this problem is to modify the requirements to fit what is available. The implementation plan is developed in collaboration with user personnel, and during this step it may be determined that the requirements already defined do not meet the needs of the operational personnel. Requirements may have to be added or modified, and the process must then be repeated on the basis of the new set of requirements. The cost benefit evaluation in turn may reveal that certain features do not appear to justify their cost, or that others that have not been included in the plan will actually yield a large benefit for a relatively small additional cost. In this case too, the process is started again from the beginning.

The difficult step in the planning process is the first: analysis of requirements. This step attempts to answer the question; "What is needed in the way of computer-aided dispatch functions?" Answers are likely to cover the range from "We're doing all right with what we have" or "Our citizens deserve the best service we can give them, and we can afford to give it to them."

It was mentioned above that operational personnel will necessarily be involved in the preparation of an implementation plan; in fact, they should be involved from the very beginning when requirements are being defined. They have one very useful view of what is needed, and in any case they will accept a new system much more readily if they have had a hand in the process of defining and selecting it. Where a large department makes it feasible, it is often a good idea to try out CAD on a small scale, say one complaint operator console and and one dispatcher console, to see whether the requirements as defined are realistic and whether the new system is likely to be accepted readily. This trial may well lead to a revision in the definition of requirements.

Since it is never possible to have everything, every requirements analysis must include some trade-offs of one desirable feature against some other desirable feature. It is always desirable to save money, and trade-offs frequently involve determining how much capability has to be sacrificed to stay within available resources. Typical trade-offs for a CAD system might be:

- Number and size of computer files to be created and maintained.
- Simple incident log printouts versus computer-processed statistical reports for management.
- A self-contained CAD system versus one with a built-in capability for future expansion.
- Single versus dual CRT displays (see Chapter 6).
- Dedicated versus shared computer (see Chapter 6).

These are fairly straightforward trade-offs, mostly involving money. Other, more intangible trade-offs will come up during the analysis of requirements; for example, how much will a given CAD system decrease the stress on dispatchers, and how much is such a decrease worth? Chapter 8 contains more discussion of the evaluation of benefits, which necessarily enter into trade-off analyses.

Even when all the steps in the planning process have been repeated as many times as necessary to produce a final, realistic plan, it should not be expected that the plan will remain unchanged up to and through the implementation of the system. Such implementation normally takes considerable time, and many things can happen during that time to require changes in the plan. Conditions can change, resources can change, technology can change, and even personnel can change to the point where the plan will need to be revised. The planner must always be ready to revise his plan when circumstances make it advisable.

Chapter 5 provides some information and guidelines that may be helpful in analyzing requirements for a CAD system. Chapter 6 describes some of the hardware currently available for CAD systems and describes some system concepts. This is a rapidly changing technology, however, and the planner should not rely on the data presented here but contact the various suppliers directly. A partial list of such suppliers is included in Appendix A.

Preparation of an implementation plan is discussed in Chapter 7, including procedures for estimating system costs. Chapter 8 takes up the question of cost versus benefit analysis, which is made difficult by the many intangibles on the benefit side of the equation. Some of the factors that should be weighed are discussed, and examples are presented based on CAD evaluation reports from the Huntington Beach and Oak Park Police Departments.

5. PLANNING GUIDELINES: ANALYSIS OF REQUIREMENTS

The general requirement to be met by a CAD system is to improve command and control, which is a real-time decision-making process where humans and machines monitor the status of field units, receive information on incidents, and assign and control units as incidents are worked. The results are both reported immediately and stored for later recall.

Any command and control operation is a decision-making process, but a police command and control center is an especially busy one. Without taking part in such an operation during a busy period, it is hard to appreciate the pace at which vital decisions must be made. On a typical busy Friday or Saturday night, a dispatcher is making decisions at the rate of two or three a minute for periods up to an hour at a time. We want to be sure that CAD does not make this very demanding job *more* difficult.

We have already pointed out that CAD does not necessarily enable a dispatcher to handle more units or more incidents. The objective of a good command and control system is to enable the dispatcher to make better decisions, and for management to have a clear, concise, and up-to-date picture of field activities. It does this by helping the dispatcher keep track of current incidents and their status and of units available and their status, and by providing fast access to other information files. A CAD system does these things more efficiently and faster than they could be done in a manual system.

The requirements analysis process for a given agency follows this sequence:

(1) *Functional Requirements Analysis.* Those functions that can be performed by a CAD system are defined, enabling the planner to select a set of them for preliminary assessment. Section 5.1 lists these functions and summarizes the results of our survey of several departments.

(2) *Work Station Load Analysis.* In most cases the development of a plan will require a brief survey of the volume of calls for service and the patterns of incidents. Section 5.2 discusses techniques for making such surveys.

(3) *System Design Decisions.* These are determinations of major system parameters such as numbers of positions and files, and how the people manning the work stations are to interact with their equipment. Section 5.3 presents our findings on how to arrive at these decisions.

5.1 Functional Requirements

The first step in determining functional requirements is to identify those functions that the agency will want the CAD system to perform. Since these cover a range from basic to highly sophisticated, it may be advisable to list separately the functions that are considered essential and those that are desirable but not essential. Then when the system specifications are being developed they can include the desirable features to the extent that resources permit. It should be expected that this initial step of defining functional requirements will have to be repeated at least once after a system has been defined and cost estimates developed.

As a basis for arriving at a reasonably complete list of functions that might be performed by CAD systems, we made a survey of 11 police departments which have CAD systems in operation.

Table 3 lists the range of functional requirements for a CAD system that we found in our survey. Table 4 summarizes how these requirements are met for each of the departments surveyed. Some of the significant points to be noted are:

- All of the cities except Palm Beach County and Glendale have a two-stage command and control system in which a complaint board operator takes the calls and a dispatcher assigns them to patrol units. In those cases the dispatcher takes the calls directly.

- Although it is not noted in the table, three of the largest cities (New York, Seattle, and San Diego) had two types of complaint board operators, primary and secondary. The secondary operator handles the longer calls.

- All of the larger cities and some of the smaller ones have automatic call distribution systems (ACDS) that are placed ahead of the complaint board to route the incoming calls evenly among the complaint board operators.

- The job of the complaint board operator is to record the caller's information in a standard format. In all cities surveyed, this is done on the keyboard of a terminal with a CRT display.

- In most cases the complaint board operator is able to route a call to another agency if it is not appro-

Table 3. CAD System Functions

Function	CAD Features
1. Receive calls from public	• Complaint board operator (CBO) handles and enters data into computer. • Computer adds routine data -- serial number, date, time, operator ID. • Computer checks data for validity. • Some systems have address verification and listing of nearest cross streets by computer. • Some systems have computer check of prior history file for previous incidents or other data on the address. • Large systems may have a backup CBO to handle long calls.
2. Route calls to fire, police ambulance, other agencies when appropriate	• CBO has computerized files of most-used telephone numbers to speed referrals plus other functions (ambulance, tow, queries to remote data bases).
3. Route police incidents to dispatcher	• Computer reformats incident data from CBO into dispatcher incident format, adds routine data, and displays on screen of dispatcher for the given area. • Computer also prepares incident summary (one-line) and adds to incident summary file displayed on dispatcher's screen to indicate his backlog.
4. Dispatch incident (assign patrol unit)	• CAD automatically maintains status file on all patrol units under dispatcher's control and displays file on dispatcher's screen. • Some systems use half screen for status file, others use separate screen. • Some systems have computer display list of patrol units nearest incident address (from last reported position) to help dispatcher select unit.
5. Provide support to patrol unit in real time	• Address verification, nearest cross streets, and prior history checks as noted under (1) above (some systems). • Relay queries to remote data bases (wants and warrants, DMV, NCIC) and relay responses to patrol unit. • In some systems with mobile digital terminals in vehicles, patrol units can send queries and receive responses directly. • Where queries are relayed in control center, some systems use separate information operator for this function rather than dispatcher. • Some systems maintain temporary situation files (traffic, street repairs) and display automatically the situations related to the incident address. • Dispatcher is able to locate and assign additional support rapidly. • Dispatcher can contact other agencies rapidly as needed. Some systems handle such contacts through watch commander, dispatch supervisor, or information operator.
6. Monitor patrol unit fleet activities	• CAD provides for real-time monitoring of vehicle status, assignments, time on call, breaks, vehicle location. • Dispatch supervisor or watch commander can monitor entire fleet by calling up displays of all dispatchers.
7. Monitor status of all incidents	• CAD maintains continuously updated files of all incidents -- assigned, unassigned, cases cleared. • Dispatch supervisor or watch commander can monitor status of all incidents by calling up incident displays from dispatcher's consoles or from computer files.

Table 3 (Continued)

Function	CAD Features
8. Maintain communications with patrol units	• Dispatch by voice or digital; system maintains radio and telephone activity statistics. • Systems with mobile digital terminals can have CAD automatically update patrol unit status files from digital messages by patrol units.
9. Log off incidents	• CAD system handles all routine operations of log off: date and time of log off, removal of incident from active file, storage in closed incident file.
10. Emergency command and control	• CAD system supports coordination of multiple unit and/or multiple agency assignments to one event. Resource availability is always updated and visible to supervisory personnel.
11. Officer field reports	• Some systems use the CAD facilities to simplify end-of-shift reports. For routine cases, officer telephones data and records clerk enters data via keyboard using standardized entries.
12. Routine statistical reports	• Periodic reports on crime statistics required by state level (BCS) are generated by the CAD system from the incident logs. • Reports are generated off-line at convenient times, using computer and line printer. • Statistics can be broken down by any desired set of categories (type of crime, area, time of day, day of week, etc.) and computer will sort by these categories.
13. Department management reports	• Department management reports are also generated from CAD computer files (incident logs, activity logs for CBOs, dispatchers, patrol units, officers). • Any desired breakdown can be used. • Computer can be programmed to flag deviations or trends automatically.
14. Special reports	• One-time reports or studies of particular crime activity patterns are easily generated by the computer from the CAD system data available. • Studies of officer or patrol unit activity are easily produced from the CAD logs.

priate for the police department. Most call distribution systems do not disconnect the caller unless he hangs up.

- All departments dispatched by voice, but some also have the capability for digital dispatch (a digital message to the printer or screen in the mobile digital terminal in the patrol unit).

- In all cities except Dallas and Toronto, a complaint, once entered by the complaint board operator, is assigned a priority and routed to the dispatcher handling the zone where the incident is located.

- In all of the systems, dispatchers cleared cases on the basis of a voice report from the patrol unit.

- Dallas, Jacksonville, and Glendale have programmed their systems to produce management reports as well as the standard logs. The Jacksonville system prints out patrol unit activity, manpower allocations, and response time. The Dallas system prints out activity reports by beat, car, man, and crime type.

- Dallas maintains a backup system of cards in slots in parallel with the CRT display for monitoring the status of calls for service and the status of units.

- For split-screen CRT displays, only one display screen is provided for the dispatcher, with the area divided between the displays of patrol units' status and incident status. Most agencies have dual displays at the dispatch station, one for unit status and the other for incident records.

In 1975 most of the departments surveyed were in various stages of providing computerized files to support the dispatcher. Huntington Beach has extensive files giving locations of registered gun owners, wants and warrents, and narcotics and sex offenders. This department is installing a geographic file that verifies an address and indicates the type of premises; the computer also references any microfiche files covering the location (the microfiche files contain, for each reporting district, a map of the streets and alleys, the locations of sites having alarms, layouts of apartment house complexes and banks, plus other pertinent information).

Interagency contacts are all handled, as the table indicates, by voice (except for remote data base queries). Although CAD offers the possibility of computerized cooperative dispatch for adjoining jurisdictions, only limited systems have been worked out as yet. The Palm Beach County (and other counties in Florida) Sheriff's CAD System dispatches for several of the municipalities in the county; three municipalities in Illinois (Oak Park, Forest Park, and River Forest) are now operating a cooperative CAD system.

The table indicates that case log-off is usually done by the dispatcher. In fact, the procedure varies considerably in its details. In Huntington Beach and Glendale, the patrolman dictates a highly formatted case clearance report to the dispatcher and the dispatcher keys in the codes in the appropriate fields on the form displayed on the screen. The Dallas procedure is quite different; the patrol officer simply indicates to the dispatcher the time a case is cleared and then at the end of the shift dictates the details to a clerk, who has recalled the incident report to the screen and enters the required information. In all systems, the computer generates a complete file of case clearance information for use in statistical reports.

A range of different reports are generated by CAD systems (in addition to activity logs). Some systems generate management reports on incident rates by area, beat, time of day, etc., scheduling of patrolmen for duty, analyses of police operations and equipment use, and uniform crime reports (UCR) data. The Glendale and Dallas systems produce an extensive set of reports for use by law enforcement managers, including activities by shift, day, beat, patrolman, vehicle, type of crime, and other variables. Jacksonville produces extensive reports for manpower scheduling and resource allocation.

In no case is a CAD system used for large-scale emergencies. The practice is to assign one or more dispatchers and frequencies to an emergency console, and the assigned units are managed by two-way voice communications.

5.2 Work Station Load Analysis

The second part of the requirements analysis process is a quantitative measurement of the operations taking place at a typical dispatcher console. This will be useful in selecting a particular system on the basis of how well it will help the dispatcher handle the expected load.

In general, conversion to a CAD system may not reduce the number of dispatchers needed at any one time. We noted earlier that a large amount of a dispatcher's time is occupied in talking and listening, neither of which is accelerated by a CAD system in itself, although in combination with mobile digital terminals a CAD system can reduce the average voice message length.

The basis for a work load analysis is a tabulation of message rates and message lengths; together these constitute the load on the dispatcher. We were unable to obtain good numerical data in the course of our survey, and decided that it would be necessary to make some detailed observations and analysis of a real CAD system in operation. The Huntington Beach and San Diego departments kindly allowed us to make the observations we needed. The procedure was slightly different in the two cases:

- *Huntington Beach.* We selected certain periods of high and moderate activity and obtained voice tapes of dispatchers plus the corresponding case logs. From the tapes we timed voice messages with stop watches and elapsed time clocks and established correlations between cases, cars on patrol, message rates, and operator utilization, i.e., "busy time".

- *San Diego.* Here we made videotapes of the dispatcher's incident display and recorded the voice channel. This enabled us to analyze the relationships between the keyboard and screen operations, and the voice messages.

The dispatcher's time is devoted to talking, listening, manipulating the display screen, and reading data; the first three of these functions can be measured, and give a reasonable indication of dispatcher workloads, assuming that adequate allowance is made for reading and assessing data, making decisions, and resting. The work load is affected primarily by the number of field units deployed, by the number of calls for service in progress, i.e., dispatches, and by special duties such as relaying requests for inquiries to crime information files, and arranging for ambulance and tow truck service. In San Diego each dispatcher handles 30 to 50 field units, and makes all dispatches by voice on assigned radio channel. Each dispatches cases, notes status changes, and logs off cases through the keyboard terminal. The console has two CRT displays, one fixed format for status of vehicles, and the other a variable format for working incidents. The keyboard has a standard alphanumeric keyboard with 19 special function keys. All information

Department	Receive Calls	Route to Other Agency	Take Info. for PD	Route to Dispatcher	Dispatch Call	Location Verification	Prior History File	Remote Queries	Recommends Car
Huntington Beach[1]	ACDS[6]	Call director	CBO[6] +keyboard +CRT	Computer	Computer	Computer	Computer	Dispatcher	Dispatcher
Seattle[2]	ACDS	Call director	CBO +keyboard +CRT	Computer	Voice	Computer (beat ID)	None	Dispatcher	Computer
San Diego[1]	ACDS	Call director	CBO +keyboard +CRT	Computer	Voice	Computer (beat ID)	None	Info op	Computer
Palm Beach[2]	Dispatcher	Dispatcher	Dispatcher +keyboard +CRT	Not applicable	Voice + computer	None	None	Patrolman	Computer
Toronto[3]		Complaint operator	CBO + cards	Conveyor	Voice	None	None	Dispatcher	Dispatcher
Glendale[4]	Dispatcher	Dispatcher	Dispatcher +keyboard +CRT	Not applicable	Voice	None	None	Dispatcher	Dispatcher
Las Vegas[2]	ACDS	Call director	CBO +keyboard +CRT	Computer	Voice + computer	Computer	None	Patrolman	Computer
Jacksonville[5]	First available CBO	Call director	CBO +keyboard +CRT	Computer	Voice	None	None	Info op	Computer
Dallas[5]	ACDS	Complaint operator	CBO +keyboard +CRT	Computer + TTY	Voice	None	None	Dispatcher	Computer
Shreveport[3]	ACDS	Complaint operator	CBO +keyboard +CRT	Computer	Voice + computer	None	None	Dispatcher	Computer
New York City	ACDS	911 operator	CBO +keyboard +CRT	Computer + Teletypewriter	Voice		None	Info op	Dispatcher

1 Turnkey Systems by Motorola

2 Turnkey Systems by KUSTOM

3 Turnkey Systems by GE

4 Turnkey System by TRW

5 Systems designed and procured by municipal EDP departments

6 Legend: ACDS — Automatic call distribution system
CBO — Complaint board operator
CRT — Display screen

Table 4. CAD Functional Requirements in Selected Police Departments - June 1976

Department Files	Contact with Agencies	Monitor Unit Status	Monitor Incidents	Communication with Mobile	Log Off Case	Emergency Command	Reports
Computer	Dispatcher	CRT[a]	CRT	Voice + digital text (1-way) status	Dispatcher keyboard	Manual	Log only
Computer	Operator	Split CRT	Split CRT	Voice	Dispatcher keyboard	Manual	Log only
Computer	Operator	CRT	CRT	Voice	Dispatcher keyboard	Manual	Log only
Computer	Dispatcher	Split CRT	Split CRT	Voice + digital text	Patrolman + dispatcher keyboard	Manual	Log
	Dispatcher	Split CRT	Split CRT	Voice + digital status	Dispatcher keyboard	Manual	Log
None	Dispatcher	Split CRT	Split CRT	Voice	Dispatcher keyboard	Manual	Log crime statistics, other
Computer	Dispatcher	CRT	CRT	Voice + Digital text (2-way)	Dispatcher keyboard	Manual	Log
None	Operator	Split CRT	Split CRT	Voice	Dispatcher keyboard	Manual	Log, patrolman activity, manpower allocated, response time
None	Dispatcher	Cards + CRT	Cards + CRT	Voice	Dispatcher, records clerk keyboard	Manual	Log, reports by beat, car, man, crime type, response time
Computer	Dispatcher	CRT	CRT	Voice + digital text (1-way) status	Dispatcher keyboard	Manual	Log
None		Manual	Manual	Voice	Dispatcher	Manual	Complaint log

inquiries for wants, warrants, and stolen vehicle and property checks are handled by a special operator over a tactical channel so that the dispatcher is not burdened with this duty.

Figure 2 and Table 5 summarize the work load analysis. During the busy period in San Diego an average of 20 dispatches were in progress, and during one 10-minute period reached a maximum of 25 cases in progress. Thirty calls were dispatched including three priority-1 calls, and 31 logged off. The case load history is shown in Figure 3.

The dispatcher was busy 66.5 percent of the time, talking, listening, and manipulating the terminal; of that 9.8 percent was devoted to terminal manipulations. Busy time during the hour varied from 53 percent to a maximum of 74 percent; on the average, 12 voice and terminal transactions per minute were processed (a maximum of 18 transactions per minute was noted). The average voice message was 3.4 seconds in duration, and the average terminal transaction, 7 seconds. Forty-seven field units were deployed during the hour. The dispatcher performed a total of 799 operations during the hour!

Average transaction times were noted to be:

	(Seconds)
Assign unit to incident	3
Clear incident	2
Review incident	2
Add new data to incident record	7
Send message to another console	10

In general, the station appeared to be approaching saturation under the observed loading conditions, with instances of mobile-to-base voice message interference noted, although good radio discipline was maintained. A heavier work load could have been accommodated for a short period of time, but obviously would have been very stressful to the dispatcher if sustained for long periods. Prioritization of calls was noted to be a very effective means for leveling the work loads, for both the dispatcher and field units.

For the 1-hour period of "normal" activity, with 37 field units deployed, an average of 11 calls for service were in progress with a maximum of 13. Dispatcher utilization ranged from 17 to 41 percent, for an average of 30 percent, of which 10 percent was devoted to terminal manipulations. On the average six transactions per minute (voice and keyboard) were processed.

Data points for the Huntington Beach Police Department, which has a generally similar type of computer-aided dispatch system, are shown for comparison. In all cases, the amount of time spent in manipulating the display terminals varies from 5 to 10 percent, i.e., voice transactions are the primary work load determinants. The Huntington Beach Police Department tends to have a somewhat higher work load average per dispatch than does San Diego, even though Huntington Beach employs mobile digital printers and status indicators; this would indicate that "digital" dispatching may not displace voice dispatching (and voice radio channel loading) to the extent anticipated by some planners, although more operational experience is needed before conclusions can be drawn. The work load does not drop to zero as the case load approaches zero since, as one might expect, the dispatcher spends considerable time making administrative support calls during relatively slack periods.*

*We wish to extend our sincere appreciation to Captain Ken Fortier and staff of the San Diego Police Department, and to Captain M. C. Burkenfield and Sergeant Robert Fickle of the Huntington Beach Police Department for their assistance and cooperation in obtaining these measurements.

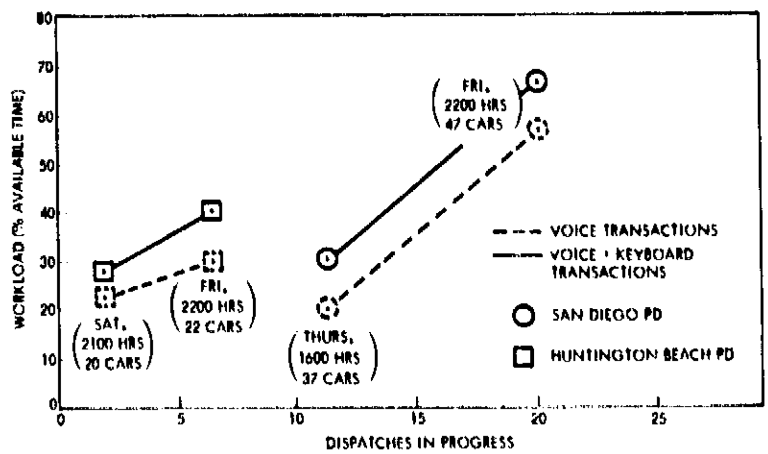


Fig. 2. Computer-aided dispatcher work load measurements

Table 5. Dispatcher Work Load Summary Data

Date, Day	Time	Cars Per Dispatcher	Cases in Progress*	Average Voice Channel Utilization, %	Transactions Per Minute		Dispatcher Busy Time, %
					Ave.	Max.	
HUNTINGTON BEACH POLICE DEPARTMENT							
3/7/75, Fri.	2200-2300	22	7	30	11	18	40
3/7/75, Fri.	2300-0000	22	7	31	10.9	18	37
2/5/75, Sat.	2100-2200	20	2	25	7.6	18	28
SAN DIEGO POLICE DEPARTMENT							
4/10/75, Thurs.	1625-1725	37	11	20	6	19	30
5/9/75, Fri.	2200-2320	47	26	58	12	18	66.5

*Maximum in progress during any 10-minute interval of the hour.

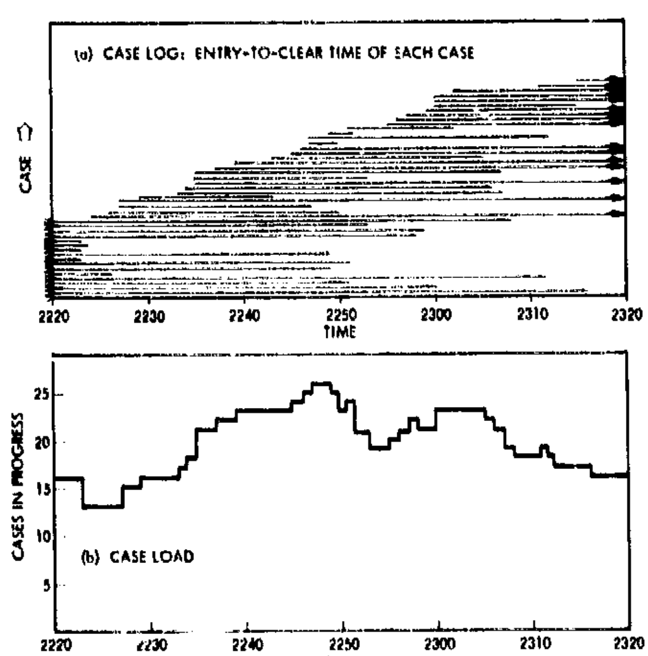


Fig. 3. Measurement of dispatcher case load: San Diego PD, May 9, 1975

Additional studies of key command and control functions (particularly dispatch stations) should be performed in order to provide a better understanding of the impact of technological innovations on these operations. Stressful environments should in no way be aggravated; personnel who lack good typing skills, such as field officers temporarily assigned to dispatch duties, may find it difficult to perform in a "type or perish" environment.

The two departments observed and reported here are representative and provide some basis for estimating work loads at dispatcher consoles. The planner should consider making similar measurements during a typical busy period, which is the load that determines the major requirements of a system. The data given above suggests that a console should be provided for each dispatcher work station in a manual system; some suggestions and recommendations regarding the desirable features of such a console will be found in Chapter 6.

The procedure for making work load measurements in a system without CAD is essentially the same as described above. That is, a typical busy period, or several such periods, should be analyzed. This is most easily done by replaying a tape recording of the traffic to and from a given dispatcher, and using a stopwatch to determine message lengths. Items that should be covered in the analysis include:

- Number of incoming messages and length of each.
- Number of outgoing messages and length of each.
- Case number associated with each incoming and outgoing message (where messages are related to specific cases).
- Type of message (status change, assignment of a patrol unit, data file query, monitoring, and support).
- Number of cases initiated during the observation period.
- Number of cases closed during the observation period.

From such a set of observations, it is possible to determine some of the parameters of interest for a CAD system (as well as for general management purposes):

- Length of messages by type (status change, assignment to incident, requests from patrol unit, etc.).
- Rate of messages (incoming plus outgoing). This is done by dividing the observation period into small segments of 5 or 10 minutes and counting the messages in each such segment.
- Percent utilization of dispatcher's time. For a non-CAD system, this will be the total of all message times plus some allowance that will have to be determined by observation for time spent in writing, handling slips or forms, etc., without simultaneous talking or listening.
- Average number of messages per case.
- Number of incidents being handled at one time for each 5 or 10 minute segment (this gives the peak load within the hour).
- Average and maximum length of time from start of an incident to the time it is closed (by incident priority).
- Number of patrol units assigned to the dispatcher.

A review of the data provided by such an analysis will be useful in evaluating the features offered by different CAD systems and in designing the system itself. Such information, especially that related to message type, is helpful in the selection of keyboard functions and formats for screen displays. The data on dispatcher utilization and number of simultaneous incidents being handled are the principal measures of work load, although the number of patrol units assigned to the dispatcher influences the work load. As noted earlier, a CAD system does not necessarily reduce the work load as measured in these terms, but should make a given load less stressful for the dispatcher to handle.

5.3 System Design Decisions

Once a department has begun considering adoption of a CAD system and has carried out the first two steps of defining functional requirements and analyzing the work load, the next step is to make some of the essential decisions about what the system will look like and how it will operate. The purpose of this section is to review each element of a CAD system and outline some of the considerations that should influence such decisions. Wherever possible, specific data on the system element is presented.

5.3.1 Trunk Line Requirements

A police command and control center, manual or with CAD, will in most cases have a complaint board operator

(CBO), although certain departments combine this position with that of dispatcher (Glendale and Palm Beach County in our survey). In either case, the function of taking calls for service from the public must be performed. If a new CAD system is to be implemented, it may be a good idea to reexamine the CBO position to determine how well it is performing its function and whether any modifications should be made at the time the new equipment is installed.

This section will discuss methods of determining the required number of trunk lines to service the CBO position, and the numbers of primary and secondary operators required to maintain a given level of service.

A major system design decision is that of whether or not to have a secondary operator position. Figure 4 shows the typical flow of calls through a complaint board system having a secondary operator position, although the first part of the flow is the same in either case. Calls from the public are automatically connected to an available trunk line as long as they are not all occupied (in this case the caller receives a busy signal). The incoming calls all go to the automatic call distributor system, which attempts to find an available primary operator. If none is available, the call is placed in a queue until a primary operator is free to receive the call.

Those systems having secondary operators use them to handle the longer calls, generally those a minute or longer in duration. The primary operator receives all calls first, and decides which should be transferred to the secondary operator (or to some other city department). In all cases the incoming call continues to occupy a trunk line until the caller hangs up, even when the call is transferred to the secondary operator or another department.

The procedure for determining the number of trunk lines and operators needed is as follows:

(1) The planner specifies the performance level desired, in terms of what percentage of calls are allowed to receive a busy signal, and what mean waiting time is acceptable.

(2) The planner measures (or estimates) the peak call rate to be handled.

(3) The design curves shown in this section are used to derive the required numbers of trunk lines and operators.

Typical performance specifications are in the following form:

(1) No more than 5 calls out of each 1000 shall receive a busy signal.

(2) The average waiting time for a call placed in the primary operator queue shall not exceed 2.5 seconds.

(3) The average waiting time for the secondary operator shall not exceed 20 seconds.

The numbers entered in the "blanks" above are typical; the planner should establish these for his own system on the basis of his own measurements of peak loads, and his estimates of how frequently a given call rate might be exceeded.

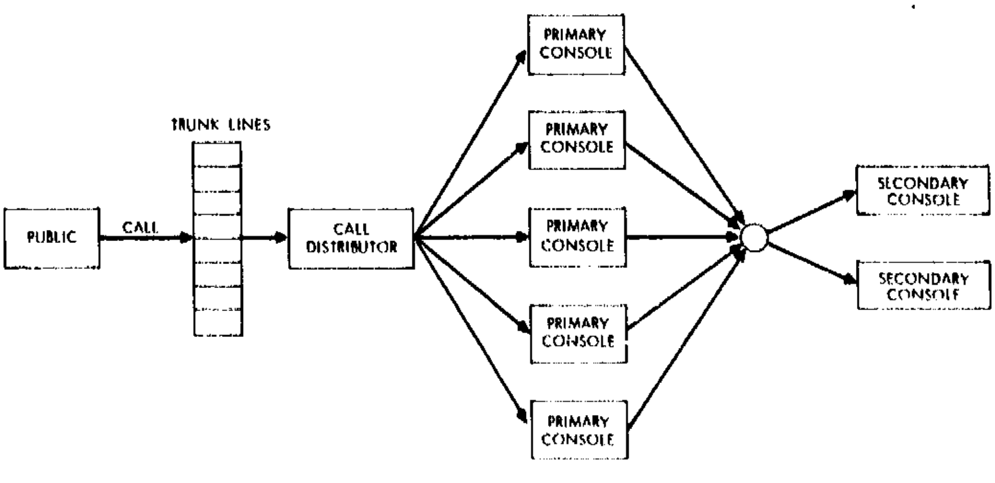


Fig. 4. Complaint board operator call flow

As part of his measurement of call rate, the planner should have collected data on call durations. He is then in a position to determine peak loading on the trunk lines as follows:

$$\text{Trunk work load} = \frac{\text{Peak call rate (calls/hour)} \times \text{call duration (sec)}}{3600}$$

As an example, suppose that on a busy Friday night a police department is receiving 200 calls per hour and the calls are serviced in 150 seconds on the average. Service time includes the total time the call was in the system, including any time spent in queue waiting for either the primary or secondary operator (plus the time spent talking with either operator or with another city department). In this case:

$$\text{Trunk work load} = \frac{200 \times 150}{3600} = 8.33 \text{ load units}$$

Now the curves of Figure 5 can be used to determine the number of trunk lines needed to handle this load with the performance already specified. The value of C (the number on each curve) is the number of trunk lines.

Referring now to Figure 5, we note that our requirement for not more than 5 calls per thousand receiving a busy signal translates to 0.5 percent, which is the lowest horizontal line. Following along this line to the value of 8.33, we take the nearest value of C to the right, which is 17. This is the number of trunk lines needed to meet our specifications under our peak load conditions.

It is of interest to note the effect of changing some of the parameters. For example, if the percentage of calls receiving busy signals were increased from 0.5 to 5 percent, the number of trunk lines needed to meet the same demand becomes 13. And if the average call duration becomes 120 seconds rather than 150 seconds, the number of lines required to handle the message flow to the original 0.5 percent busy signal specification becomes 14 once more. With *both* changes (5 percent busy signals, 120-second calls), the number of trunk lines required becomes only 11.

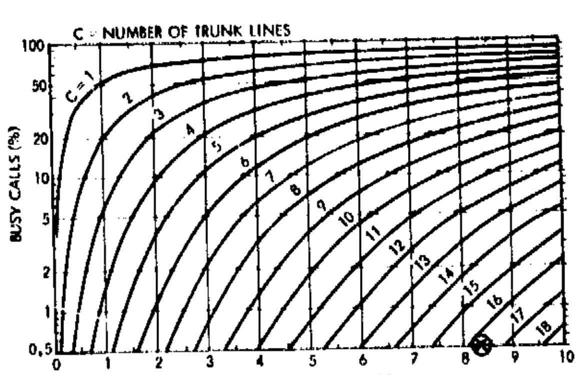


Fig. 5. Trunkline design

5.3.2 Primary Complaint Board Operator Positions

The procedure for determining the number of primary complaint board operators needed is similar, but in this case the performance parameter is the average waiting time before the caller is connected to a primary operator (i.e., the average length of time a call remains in the ACDS queue before the ACDS can find an available primary operator). This delay will naturally be shorter if there are more operators, but more operator time would be spent waiting for calls.

For our purposes, delay units are obtained by dividing the average waiting time by the average measured service time (time the operator takes to handle the call, not including waiting time):

$$\text{Delay} = \frac{\text{mean waiting time in seconds}}{\text{mean operator service time in seconds}}$$

The operator work load is then calculated as:

$$\text{Operator work load} = \frac{\left(\begin{array}{c}\text{peak call rate (calls per hour)} \\ \times \text{ mean service time in} \\ \text{seconds}\end{array}\right)}{3600}$$

Returning to our previous example, we have calls arriving at the rate of 200 per hour and the average service time per call is 100 seconds. We have specified that the average waiting time shall be no more than 2.5 seconds, so that our number of delay units is:

$$\text{Delay unit} = 2.5/100 = 0.025$$

The operator work load, calculated as shown, becomes:

$$\text{Work load} = 200 \times 100/3600 = 5.56 \text{ load units}$$

Now we turn to Figure 6 to find the number of primary operators required to handle this load with no more than the specified average wait. The 0.025-delay-unit line runs horizontally near the bottom of the figure. It intersects the vertical 5.56-load-unit line at the point shown, and we take the nearest curve to the right as before. This is the curve for 10 primary operators, which is the number needed.

Once again, it is interesting to note the effect of changing the parameters. If the specification for average waiting time is changed from 2.5 seconds to 5 seconds, for example, the delay unit value becomes:

$$5/100 = 0.05 \text{ unit}$$

and the intersection of this value with the same work load falls between the curves for 8 and 9 operators, making the required number 9. And if the average operator service time drops from 100 seconds to 60 seconds, the work load becomes:

$$200 \times 60/3600 = 3.33 \text{ units}$$

and only 7 operators are needed to maintain the 2.5 second average waiting time.

5.3.3 Secondary Complaint Board Operator Positions

Not all departments use a secondary complaint board operator to handle the longer calls, but some have found it a good way to improve service to the public and reduce the work load on the primary operators. In calculating the number of secondary operators needed, we note first that all calls going to a secondary operator must first go through a primary operator. If all secondary operators are busy, there is a waiting time that must be added to the waiting time required for the caller to reach the primary operator. The waiting time for the secondary operator will naturally depend on the number of secondary operators.

We calculate the number of secondary operators needed in the same way as for the primary operators, calculating the delay and the work load and finding their intersection point on Figure 6.

First, however, we need to define what kinds of calls are to be handled by the secondary operator. We will define "long" calls as those that require more than 60 seconds to service *and* which do not require dispatch. All other calls (namely those that either require dispatch or take less than 60 seconds) are defined as "short" calls.

In our sample specification, we indicated a maximum average waiting time for a secondary operator as 20 seconds. For our example of a department with calls arriving at the rate of 200 per hour, let us assume that 5 percent, or 10 calls per hour, are "long" calls that are to be transferred to the secondary operator. We will assume further that the mean service time of the secondary operator is 5 minutes (300 seconds). Now our delay calculation is:

$$\text{Delay} = 20/300 = 0.066 \text{ unit}$$

and our work load calculation is:

$$\text{Work load} = 10 \times 300/3600 = 0.83 \text{ unit}$$

On Figure 6, we find the intersection of these two values in the area between the curves for 2 and 3 operators, meaning that we

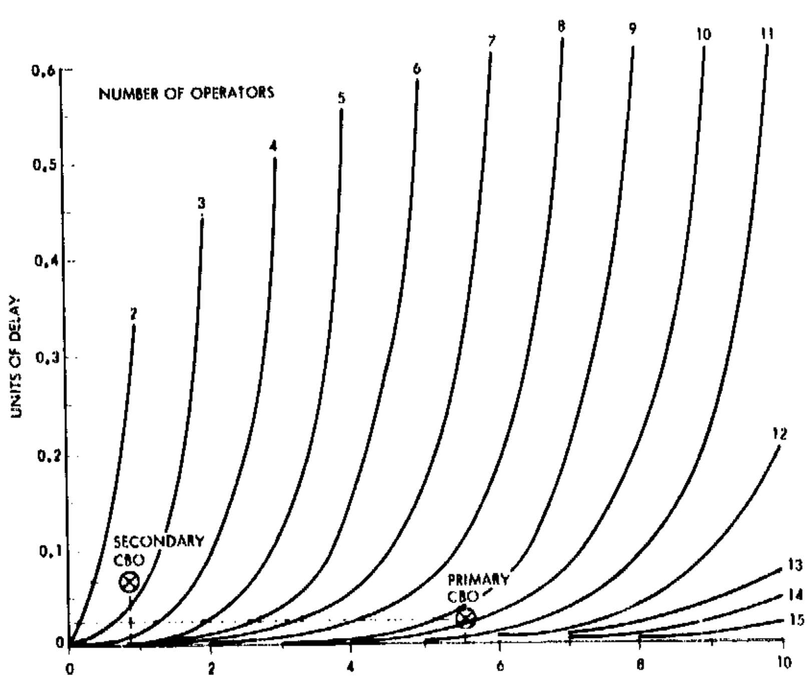


Fig. 6. Complaint board operator position design

will need 3 secondary operators to handle this load without letting the average waiting time exceed 20 seconds. Because the curve for 2 operators is so steep, increasing the allowable waiting time does not change the result dramatically; even for a waiting time of 60 seconds, 3 operators are still needed. Similarly, reducing the percentage of "long" calls to, say 3 percent, does not reduce the requirement for 3 secondary operators. Reducing the average length of a "long" call to 2.5 minutes, however, makes 2 secondary operators adequate for nearly any specification of average waiting time.

5.3.4 Decision on Use of Secondary Complaint Board Operators

The determination of whether secondary operators should be included in the command and control system can be made whether or not a CAD system is to be installed. Since all positions, primary and secondary, must be equipped with CRT/keyboard consoles in a CAD system, the additional cost of procuring and installing the additional consoles may be a special consideration for CAD systems.

In order to make a quantitative comparison of a system with and without secondary operators, the following parameters must be measured or estimated:

(1) Average arrival rate of "short" calls.

(2) Average arrival rate of "long" calls.

(3) Average service time of "short" calls.

(4) Average service time of "long" calls.

The maximum average waiting times must also be specified for both types of calls, as in the previous calculations. In the 1-operator case, only one average waiting time can be specified, since in this case there is no distinction between "long" and "short" calls.

The comparison is made by calculating the loads on the two types of operators in the 2-operator case, and on the one type of operator in the 1-operator case. The curves of Figure 6 are used once more to determine the numbers of operators needed in both cases.

We can use the same figures for message rates and types as in the previous examples:

Call rate	200 per hour
Percent "long" calls	5
Service times	
"Short" calls	100 seconds
"Long" calls	300 seconds

For the 1-operator case we need an average service time for all calls, which is 95 percent at 100 seconds plus 5 percent at 300 seconds, or 110 seconds. Now we compute the work loads:

$$\text{Work load on primary operator} = \frac{200 \times 100}{3600} = 5.56 \text{ units}$$

$$\text{Work load on secondary operator} = \frac{10 \times 300}{3600} = 0.83 \text{ unit}$$

$$\text{Work load on single operator} = \frac{200 \times 110}{3600} = 6.11 \text{ units}$$

The delay units will be the same as previously for the primary and secondary operators (0.025 for the primary operator and 0.066 for the secondary operator), assuming the same specifications of 2.5 and 20 seconds for maximum average waiting time. For the single operator the 2.5 second specification is the same, and the delay unit value is 0.023. Now from Figure 6 we find the following requirements for the two cases:

Operators	2-Operator System	1-Operator System
Primary	10	11
Secondary	3	--
TOTAL	13	11

This means that two additional operator positions are needed, but the number of primary operators is reduced by one. Whether this trade-off favors the 2-operator system or not will depend on the costs involved for the two types of operators and on the anticipated improved service with secondary operators in the system.

5.3.5 Dispatcher Position

Functions

The dispatcher is at the core of the police command and control operation, responsible for coordinating the patrol forces to meet the rapidly changing demands for police service. This coordination primarily takes the form of receiving and transmitting messages that fall into five basic categories:

- Messages involving initial assignments of cases.
- Messages supporting cases in progress.
- Messages supporting units on patrol.
- Messages involving case dispositions.

- Messages relaying queries to remote data banks and the answers to these queries.

The first category of messages covers the activities of the dispatcher when a case first arrives at the dispatching position: finding an available patrol unit, giving that unit the address and details of the case, assigning the unit to the case, and entering this data into the computer through the console keyboard.

The second category, supporting cases in progress, includes messages from assigned patrol units such as status changes, requests for verification of address or location of informant, request for backup unit, or additional case information to be entered into the computer file.

The third category, support of units on patrol, includes status messages, handling requests to talk to other patrol units, clearing requests for meals, and general administrative functions not related to specific incidents.

Those messages related to case disposition include the case clearance messages from patrol units, any comments on the case, and status changes for units involved in the case.

The last category of messages has to do with requests from patrol units, both on patrol and on assignment, for information from remote files; most such queries are for license plate checks or wants and warrants checks.

The data we obtained during our observations of the San Diego Police Department were analyzed with respect to these categories. For busy hours, the distribution was as follows:

	Percent of Total
Initial assignment	26
In-progress case support	44
Patrol support	15
Case dispositions	15

In addition to these messages, queries to data bases were added in proportion to the number of patrol units deployed, an average of 1 query per 2 hours per patrol unit.

The data on dispatcher activity collected from the Huntington Beach and San Diego observations, presented graphically in Figure 2, was given in slightly different form and with some additional measures in Table 5. This data, plus the above message classification, served as the basis for our simulation of a dispatcher work station. Before we describe the simulation and its results, however, some general comments are in order on our observations of dispatcher activity.

Table 5 indicates that the Hungtinton Beach dispatchers were busier on a per car or per case basis than the San Diego dispatchers; this results in part from the fact that they handle data base queries. In the busiest hour for both departments the Huntington Beach dispatcher was handling 22 cars and 11 cases while the San Diego dispatcher was handling 47 cars and 25 cases. The consequence can be seen in the "busy time" column, where the San Diego dispatcher was busy almost 67 percent of the time while the Huntington Beach dispatcher was busy only 40 percent of the time.

We were able to observe that when the dispatcher "busy time" reaches a value of around 60 percent, the stress on the dispatcher becomes severe and the result is that the dispatcher begins to defer action on calls that are perceived to be of lower priority (whether from patrol units or from the complaint board) and to shorten messages. Field units are also observed to reduce their demands on the dispatcher during peak load periods. Nevertheless, the dispatcher is faced with simultaneous demands that cannot all be met, and must decide among conflicting demands. This can place the dispatcher under great stress. We feel that 65 percent "busy time" reaches or exceeds the peak limit that should be allowed for the design of a system. Sufficient stations should be installed to keep "busy time" to approximately 30 to 50 percent during peak periods such as Friday evenings.

Simulation

On the basis of our observations at Huntington Beach and San Diego, and using the statistical data we collected at those departments, we were able to construct a computer simulation of a dispatcher work station. The purpose of the simulation was to permit us to determine the effect on dispatch output parameters of varying the work load. The parameters handled by the simulator are:

Input Parameters	Output Parameters
Operational procedures	Dispatcher busy time in percent
Message types	Communication channel utilization in percent
Distribution of message types	Waiting time for dispatcher
Call arrival rates and time distribution	Waiting time for communication channel
Service times and distribution of service times	
Number of cars per dispatcher	

The variations in operational procedure that were considered were:

- Queries to remote data banks handled by dispatcher or by separate information operator.
- Complaint board operator and dispatcher positions are combined or separated; dispatcher takes calls from public and performs dispatcher functions as well, or calls first go through complaint board operator.

The three variations of these procedures that we selected for simulation were:

System A	Separate CBO and dispatcher; dispatcher does not handle queries to remote data banks.
System B	Separate CBO and dispatcher; dispatcher handles queries to remote data banks.
System C	Dispatcher takes calls from public, but does not handle queries to remote data bases.

The load on the system was in the form of varying case arrival rates. Since our analysis of message types showed that only 15 percent of messages are not case-related, this seemed the most effective way of loading the system. We used the distributions of case durations that we had observed.

Figure 7 shows the effects on dispatcher busy time and on channel utilization of varying the case arrival rate from low to high demand, for the three systems analyzed. Both the dispatcher busy time in percent and the channel utilization rate in percent are shown.

We have already noted that a 50 percent busy time is all that should be expected of a dispatcher (recognizing that there will always be short-duration peaks well above this value) even during a peak load period. The shaded line across the chart at this point serves to identify the points at which the load curves cross this limit. Likewise, a 30 percent channel utilization rate is about the maximum that should be allowed because above this value waiting times for a channel become too high (as will be shown in the next figure). A shaded line across the graph at this value again helps to identify the points where the different load curves exceed this value.

The major points to be noted from this figure are:

- The load curves cross the two limits at approximately the same points (cases per hour):

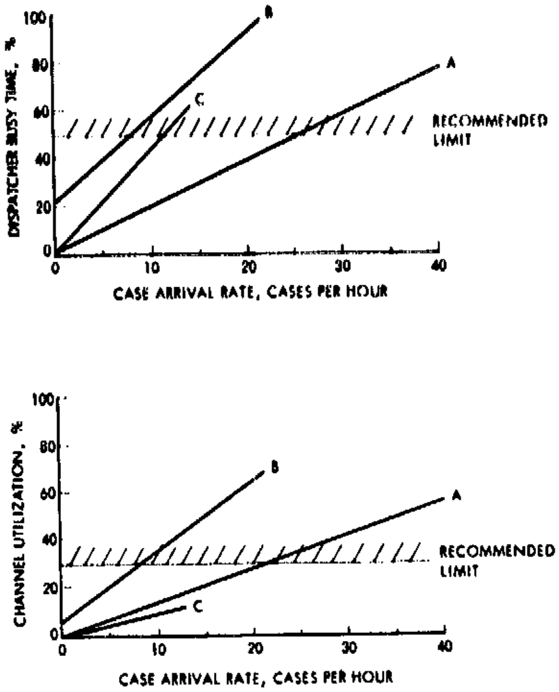


Fig. 7. Dispatcher and channel utilization vs system load

	Busy Time Limit	Channel Limit
System A	26	23
System B	8	8
System C	11	----

- The slight differences are toward the channel limit; that is, this limit is reached before the busy time limit is reached.
- System A (dispatcher handles no citizen calls or queries) can tolerate a much larger load before exceeding design limits.
- System B (dispatcher handles data base queries) leads to more rapid rise in load as case arrival rate increases than either of the other systems.
- The relationship is linear in both cases; the increase in busy time or channel utilization is proportional to the increase in case arrival rate.

Figure 8 shows the results of the simulation in terms of how waiting time varies as the case arrival rate increases. The most obvious difference from the previous figure is that the relationship is no longer linear; in all cases the waiting time begins to rise more rapidly as the load increases. This is most dramatic in the case of System C; at about 8 cases per hour the

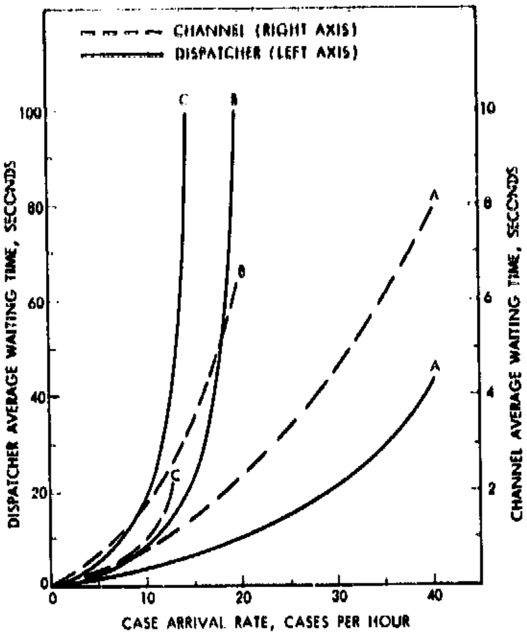


Fig. 8. Waiting times vs. case arrival rates

waiting time begins to rise so rapidly that this is obviously the limiting rate for this system (note that it is lower than limit imposed by a 50 percent dispatcher busy time limit from Figure 7).

System B also shows the start of a very rapid rise at about 11 cases per hour. This is the point at which the curve for System B crosses the 10-second waiting time line; 10 seconds is the maximum average waiting time specified for the proposed nationwide 911 emergency network, and is about the maximum that a patrolman should be expected to wait to reach a dispatcher.

System A reaches a much higher load rate before the 10-second line is crossed, but the rate is again somewhat lower than the point where the dispatcher busy time limit is reached (about 21 cases per hour).

System C is above the 10-second line even for low load rates because the dispatcher is taking calls from the public and these tend to be much longer than communications with patrol units. Nevertheless, the rise in waiting time is steep when the case arrival rate reaches the critical point, about 8 cases per hour.

From the point of view of the system planner, the important result of this simulation is that with any of the systems simulated there is a critical point in the case arrival rate beyond which performance degrades seriously either because: (a) the dispatcher is unable to handle the increased load without being subjected to undesirable stress and reducing the level of service and (b) waiting times become excessive, which degrades system performance because patrol units cannot communicate with the dispatcher satisfactorily. Channel utilization could also become a limiting factor at slightly higher rates if these other factors did not impose their own limits.

To summarize, there is a critical case load value that should not be exceeded. Taking into account both the dispatcher busy time limit and the waiting time limit, these critical case loads as shown by the simulation are approximately;

	Cases per Hour
System A	21
System B	11
System C	8

These figures alone would suggest that System B and System C are about equal, but there are significant differences. It was shown in Figure 8 that the channel utilization remained very low for System C at all points; this is due to the fact that the dispatcher is taking calls from the public; these are relatively long calls and use no channel time at all. Note also that in our simulated System C the dispatcher does not handle remote data base queries, as is the case in System B. If the dispatcher had this added load, System C would be out of the question except for very low case loads.

The conclusion is that the first step to be taken to increase the capacity of a dispatcher position is to separate the CBO function from the dispatcher function. This not only frees a large amount of dispatcher time, but reduces the stress on the dispatcher because he is no longer required to deal with the public as well as manage his patrol units. He can concentrate on the dispatching job, which has enough stresses of its own in a large command center without the added stresses involved in taking calls from the public.

Another important function of a separate CBO is to filter calls from the public; some fraction of these calls do not require a response from police or other emergency vehicles, but if the dispatcher takes a call directly he must do the filtering at the expense of his other functions. The separate CBO can also improve public relations if a busy dispatcher is unable to give as much time to a caller as the caller would like.

There are two ways in which the handling of remote data base queries can be separated from the dispatcher function. One is to have a separate position for this funciton, as in San Diego. This is a relatively simple change to make, and the information operator can keep track of other situations such as tow requests and ambulance requests.

The other possibility becomes available when the patrol units are equipped with mobile digital terminals. With suitable software and equipment in the command and control center, queries to remote data bases (normally Department of Motor Vehicles and NCIC, which are already computerized) can be relayed automatically from patrol unit to remote data base and back, with no load on the center personnel.

In either case, the simulation results indicate that the capacity of a dispatcher position can be increased substantially by removing this function from it.

It is relatively simple to determine the number of dispatchers needed for a given center. Since the system should be sized to handle the heaviest expected load, the number of cases in progress during one or more of the busiest hours should be counted. This becomes the load to be handled. Now the maximum allowable case load per dispatcher is determined; the figures given above from the simulation are good starting points for this determination. The planner can modify these if he feels it is appropriate in light of conditions in his department, or he may have some combination of functions that does not correspond exactly to one of the three systems modeled.

As an example, let us assume the planner expects to have a System A configuration where the dispatcher handles neither calls from the public nor remote data base queries. Our simulations (and our observations) indicate that with this system one dispatcher should not be expected to handle more than 25 cases per hour. We will assume that the case load during several busy hours has been counted, with the maximum load to be planned for amounting to 80 cases per hour. The number of dispatchers is then:

$$\frac{\text{Case load}}{\text{Cases per dispatcher}} = \frac{80}{25} = 3.2$$

which means 4 dispatcher stations will be needed.

The above analysis of dispatcher work loads can be summarized as follows:

- Only in a small department with low maximum case loads is it practical to combine the CBO and dispatcher functions.
- Relieving the dispatcher of the task of handling data base queries makes a significant increase in dispatcher capacity for managing patrol units and monitoring incidents.
- Dispatcher loads should be sized to keep the average maximum busy time to about 50 percent (with this average, there will be short-term peaks when the dispatcher is well above this figure).

5.4 Human Factors Considerations in the Design of CAD Systems

In selecting a system design, the planner must consider a number of factors in addition to the matter of sizing the system. In the course of our observation of police command and control centers, particularly those operating under peak loads, we noted several ways in which the details of the console hardware and software affected the efficiency with which the dispatcher operates. Since a major concern in connection with dispatchers is the stress under which they necessarily operate, any efficiency improvements that can lessen this stress should be carefully examined.

We have already seen that a 50 percent average busy time is the most that should be expected of a dispatcher even during peak hours. In planning for a new CAD system, it is probably advisable to design for an average of 30 to 40 percent, or perhaps a corresponding figure of not more than 20 cases per dispatcher (including both backlog and assigned cases).

5.4.1 Configuration of Displays

In the design of the console itself, it is important to avoid overloading the human capacity for accepting and processing information. A dispatcher in a CAD system is handling information in four different ways, more or less simultaneously or in very rapid shifts from one to the other: listen, talk, read the display, use the keyboard.

In the conventional manual dispatch system, the dispatcher normally performs in a listen-talk mode, with a minimum of manual-visual tasks. Hence, the CAD environment imposes additional manipulative functions on the dispatcher, which can add to the stress level if not carefully engineered. In fact, the dispatcher is in a "type or perish" environment, which can be particularly stressful to field personnel who are rotated into the dispatch center occasionally and do not have a high level of typing skill. The console must be designed to help him perform the manipulative kinds of processing in the most efficient and least stressful manner. The voice communications with the patrol units can be made more efficient by digital communications, but appear to be indispensable. CAD may help reduce the length of some voice messages, but the total talk-listen time is not changed significantly. The displays and the display formats, however, can influence the efficiency of the console-related functions.

The major design decision to be made is that regarding the number of screens on each console. The data in Table 1 on existing CAD systems indicates that several of them make use of split-screen displays, where half of the screen is used for displaying patrol unit status and the other half for the current incidents or other displays. One department that began with a split-screen CRT display has since changed to a two-screen display, having found that a single screen does not provide the dispatcher with enough room to display the information needed for rapid, efficient decision making.

Even two screens may not be optimum. With a two-screen console, there will typically be four sets of data displayed:

(1) Status of up to 40 or 50 patrol units (a separate screen on a two-screen console).

(2) One case in full detail (6 to 10 lines of a display).

(3) Summaries of the cases in progress, giving at least the case number, type, and the patrol unit assigned to it; there may be as many as 30 or 40 of these summaries.

(4) A one-line summary of the highest priority incidents in the dispatcher's backlog, giving for each the time of the call, the priority, case type, and address. There usually is room for as many as five of these backlog cases.

The dispatcher can call up to the screen any information that is in the computer's memory; in particular, he can display the complete backlog or any part of it, and he can call up the complete 10-line format for any case in progress if he needs to determine (for example) what patrol unit is assigned or to add or change data on the basis of a report from a patrol unit. This is a convenience, but at times of heavy work load it takes time to key in the necessary instructions to the computer, and the information that is called up has to displace some other information on the screen. The dispatcher's task is easier if the most frequently used data remains continually displayed, with room left for calling up other data from the memory. Three and even four screens can be used effectively to make the dispatcher's task easier by cutting down on the manipulations he must perform to display the information he needs for decision making.

This is not the same as providing the dispatcher with more information; it simply makes the information more readily available. Care should be taken not to flood the dispatcher with more information than he can use, or that he can use under peak load conditions. Some designers of automatic vehicle location (AVL) systems have proposed a display showing continuously the locations of patrol units on a map of the city. This is a very sophisticated design and would be useful for some purposes, but it would place an additional burden on the dispatcher by confronting him with an overly busy display. If AVL is available, the computer should determine the patrol unit closest to an incident, and display only the unit number(s), which is all the dispatcher needs or want to know.

In some command and control centers, a separate terminal is used for transmitting queries to remote data bases. Such an arrangement may be the result of separate procurements of this capability and a CAD system, but the planner considering a new CAD system should avoid it. It is relatively simple to incorporate the remote data base query capability into the display/keyboard terminal used for the CBO and dispatch positions. If the dispatcher (or CBO) makes data base queries, his job is simplified if he can simply push a key instead of turning to a different console.

5.4.2 Display Formats

There are many possible ways to display the information a dispatcher needs, and no single set of displays and display formats will be the best for all departments using CAD systems. From the human factors point of view, formats are very important; the way the information is presented can make a very large difference in the efficiency with which a dispatcher works and the amount of stress imposed on him.

The ideal way to develop a set of display formats for a planned CAD system would be to design a set of formats and experiment with them, making modifications until most of the people who will be using them are satisfied. If this can be done on some kind of a simulation facility before the system is installed, the system startup will be easier. Even in this case, however, it should be expected that there will be some changes in format after the new CAD system is implemented. Such changes require modification of the software and tend to be expensive, but they should be planned for because they are almost certain to be needed.

A simulation facility would be too expensive for any but the largest departments, but it would be possible for a number of departments in the same area to develop such a facility jointly. This would permit dispatchers to try out different formats under simulated high-load conditions, to see which were best for their particular situations.

As CAD systems become more numerous and more widespread, it is possible that vendors will offer standard software packages that include standardized formats for displays. In this case, the planner will need to consider the trade-off between the lower cost of standardized display formats and the advantage of having formats specifically tailored to the needs and/or wishes of his dispatchers.

One way out of this possibly difficult choice is the use of so-called "smart" terminals. These are consoles with a built-in microprocessor (a very small computer), and they permit changes in display software, particularly special functions and displays, much more easily than is the case with the usual type of displays, which have fixed display formats and function keys. The Shreveport Police Department has used "smart" terminals to great advantage, and they can be expected to become increasingly available for new CAD systems.

In the previous discussion of display configurations, we mentioned the desirability of having two or three separate screens on each console, so that certain kinds of information can remain on view at all times. When the dispatcher must use one screen, or part of a screen, to look at any one of several different displays he can call up from the computer memory, it is called "paging", in the sense that he pages through the memory much as one would page through a book.

In a manual system, a dispatcher normally has more information permanently on view of front of him than is the case in a CAD system. When the CAD dispatcher calls up a new display on the screen, or portion of a screen, the information that was already there disappears and can no longer be consulted at a glance. Therefore, the selection of those categories of information that are to remain continuously on view and those that must be paged through (called up one at a time) is quite important, and the number of keys that must be pushed to call up a given display is also important in system design. Specific examples of display formats will be given in later sections. In the previous section we saw that the four categories of information usually visible to a dispatcher, either on multiple screens or a split screen, are:

- Patrol unit status.
- One-line summaries of cases in progress.
- One-line summaries of cases in the backlog (or as many of them as the screen can hold).
- One case in full detail.

We also noted that the dispatcher can call up the full detail of any case if he needs to consult it for information or add information to it, as when the case is cleared. Other displays he may be able to call up include:

- Remainder of backlog not shown on screen (if any).
- Vehicle stop.
- Remote query.
- Request tow or ambulance service.
- Message file.
- Personnel file.
- Assigned duty roster.
- Display map of sector (if there is an automatic vehicle location system).

Some additional data on how display formats and paging can affect the dispatching operation is given in Appendix B, which is a scenario for an armed robbery in progress as it would be handled by the Huntington Beach CAD system. Display formats are shown in detail in Chapter 6.

5.4.3 Keyboards

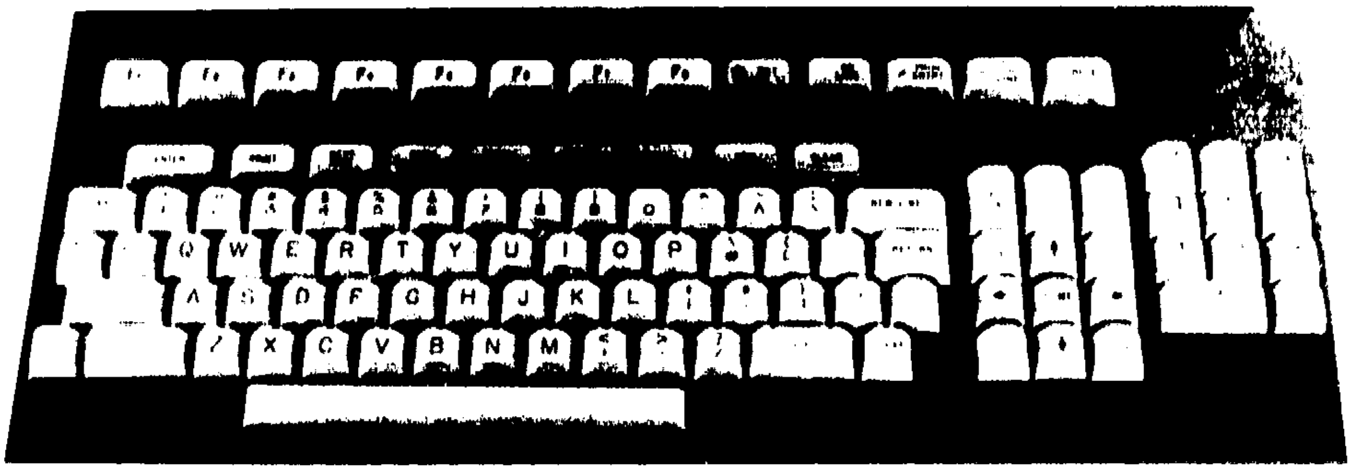
The keyboard is the means by which the dispatcher enters data into the system, controls his displays, searches files, or gives other commands to the computer. He also uses it to send messages to patrol units if they are equipped with mobile digital terminals, or to transmit messages to other computerized systems (e.g., query messages to remote data bases).

A typical keyboard is shown in Figure 9. A console keyboard has a nucleus of keys that are much the same as a normal typewriter keyboard, plus a number of special function keys that can vary (normally) from 12 to 20.

The design decision to be made is primarily how many special function keys should be provided. The trade-off involved is roughly the following:

- One special function key replaces a coded sequence of letters and/or numbers that would have to be entered on the regular keyboard. For example, a touch on the LOG OFF special function key, plus the number of the case to be logged off, tells the computer to locate and display the record of that case number, with the cursor automatically positioned in the "case clearance" field on the format. The dispatcher then simply enters the clearance code and the job is done. This saves the valuable time of a busy dispatcher, *provided* the dispatcher does not spend time hunting for the special function key. Dispatchers with good typing skills normally can command displays using either regular or special function keys with equal speed.

- The more special function keys there are, the more of them the dispatcher has to remember and be able to locate quickly. Unless a special function key is used often, it may not be advantageous to have it. Large numbers of special function keys are expensive to build into the console and both difficult and expensive to change later.



FUNCTION KEY DESCRIPTION:

F1	ENTER MESSAGE	F5	ASSIGN UNIT
F2	DISPLAY MESSAGE	F6	ASSIGN STATUS
F3	ENTER COMPLAINT	F7	REASSIGN
F4	DISPLAY COMPLAINT	F8	DISPLAY STATUS

Fig. 9. Shreveport PD dispatcher keyboard

It should be understood that the computer is doing the same thing whether the command is entered by means of one special function key or a sequence of symbols typed on the regular keyboard. In the log-off case, the alternative to the special function key is to have the dispatcher type L O on the keyboard, plus the case number. Then when the computer locates and displays the case record, the dispatcher positions the cursor himself to the proper place on the format and enters the clearance code. In both cases the computer is finding and displaying the record and entering the clearance code in response to the keyboard input of the dispatcher, and filing the record away again.

5.5 Other Personnel Requirements

We have already considered the determination of numbers of complaint board operators, secondary operators (if used) and dispatcher positions. This section considers the requirements for supervisors and information operators, and presents a brief discussion of the types of personnel to be used for dispatching.

5.5.1 Supervisory Stations

A police command and control center of any size (i.e., one with three or more dispatchers on duty simultaneously) usually has supervisors to monitor the operations and provide overall management of the operation. In large departments there may be separate supervisors for the complaint board operators, the dispatchers, and the overall command and control center. Smaller departments frequently combine these functions and need only one or two supervisors per shift.

The number of supervisors of each type is a management decision outside the scope of this document. From the point of view of the planner, the important aspect of this determination is that each supervisory position must be equipped with a console.

A supervisor of complaint board operators will require a console equipped like those of the operators, and with the capability of displaying the data on any operator console. He may also need to have call director equipment for monitoring and patching calls, plus registers to record telephone activity rates.

The dispatch supervisor needs a standard dispatcher terminal, with the capability of observing the screens of all dispatchers on demand as well as access to all dispatch frequencies. He may also need auxiliary radio and telephone terminals for communication with other agencies. His console will have the same capability for creating incident records, monitoring incidents, and entering data in the files as the other dispatcher consoles.

5.5.2 Information Operator

Many larger police departments have a special position for an information operator to handle such non-dispatching tasks as queries to remote data bases, requests to ambulances or tow vehicles, contacts with other departments, or calls to citizens. This reduces the load on the dispatcher, as the simulation results indicated.

The information operator requires a console similar to a dispatcher console, with telephone facilities plus radio terminals for communications with other agencies.

The information operator uses a separate channel from the dispatching channel; usually one such frequency for the information operator is sufficient for cities of up to one million population.

5.5.3 Types of Dispatcher Personnel

Dispatchers may be either professional, full-time dispatchers, or field personnel who are assigned to this duty in rotation with other police duties. For a CAD system, some moderate degree of typing skill is more important than for a manual system; typing skills are on the average not high among field personnel, which tends to slow down their performance at a CAD console. Also, the fact that dispatching is not their full-time assignment nor an important aspect of their careers makes them tend to be less proficient at the specialized tasks of dispatching. Field personnel without good typing skills who are brought in for dispatcher assignments generally will find the "type or perish" environment of CAD more stressful than the conventional manual systems.

For these reasons, planners in departments now using field personnel for dispatching may wish to review this policy in the light of the different requirements of a CAD system with respect to dispatching skills.

If the decision is made to use field personnel, some special provisions may be made. One department, in the effort to reduce to a minimum the amount of typing required of dispatchers, used consoles with large numbers of function keys. It is not certain that this improved dispatching speed, since considerable time would be needed to locate the desired function key among such a large number.

Having a skilled typist at the dispatcher console also makes it easier for patrol units to dictate information to the dispatcher, particularly case clearance reports. Officers in one department must dictate these reports to a clerk at the end of the shift, and may need up to half an hour for this task.

Our observations have not included measurements of the differences in service to patrol units between professional dispatchers and part-time field personnel dispatchers; subjectively, our view is that service is better with professional, full-time dispatchers.

5.6 Management Reports

Previous sections have indicated briefly the kinds of management reports that can be generated by a CAD system. Although no department would install a CAD system simply to produce better reports, the planner should take full advantage of the remarkable capability of a computerized system to generate all kinds of reports accurately, rapidly, and at low cost.

There are in general four kinds of management reports that a police department needs, and that can be readily produced by a CAD system. The planner's task is to make certain that the required data is available in the computer files, and that software is provided with the system to extract the data and format the reports. The four categories of management reports are:

- *Routine statistical* reports that are prepared regularly for department administration or for transmittal to state and federal (UCR) criminal statistics collecting agencies. Some of these reports may include summary analyses such as moving averages or comparisons with previous periods; such data can be prepared by the computer.

- *Activity* reports that typically cover data on patrol officer activity, changes in volume or type of incident for specific parts of the city, response times to citizen calls, and length of time spent on calls broken down by area or type of call. Since it requires relatively little computer time to prepare such logs, it is possible for department management to have reports more often than would be feasible in a manual system.

- *Incident or case logs* are generated by the computer at the end of each shift, and contain most of the data needed for preparation of the others.

- *Daily field activity* reports are prepared by field officers and submitted at the end of their shifts. Normally DFARs are prepared manually, but one department (Dallas) has a transcriber service in which the field officer telephones in information to a clerk who calls up the appropriate case records on the display, and adds the officer's comments and case disposition code; no other written reports are required except for certain types of incidents. This technique has considerable potential for reducing the paperwork load on field personnel.

A management report generation routine can be provided to flag changes or trends that could indicate problems (call-rate changes in particular beats, sharp changes in officer productivity or crime types, etc.).

Table 6 is a list of monthly reports generated by the San Diego CAD system for internal management purposes. It can be seen that these are organized in such a way as to reveal trends that may require management attention. Table 7 is a list of all the reports generated by the Glendale CAD system. These are typical of the external and internal reports required for a police department. Examination of the list indicates that there are some items of data required that are not on the normal incident record from the dispatching system. Procedures must be established to assure that these items of information are entered into the computerized files (e.g., traffic violation records, juvenile case follow-ups).

Table 8 is a comparable list for the Dallas CAD system. This department has a data section set up specifically to generate reports and to analyze the data collected in the CAD system. The system has on-line printers, permitting any of the reports to be generated on demand at any time.

5.7 Files

The computerized files are the basis for all CAD operations, since it is the immediately available and instantly updated files that aid the dispatcher in his work. The ability of the computer to search a file and retrieve or alter any information in it within a fraction of a second provides powerful support to the dispatching function as well as to the complaint board function.

As noted in previous chapters, there are degrees of sophistication in CAD systems, and the more sophisticated systems use more files than the simpler systems. All CAD systems, however, require a basic set of files dynamically updated by the computer, plus a log of all activity. It is from the activity log and incident files that nearly all of the management reports described in the preceding section are derived.

CAD systems normally store files on random access disc storage devices, which are modular and any number needed can be provided in the system. Storage capacity is not usually a problem for the system planner or designer.

Typical files required or optionally included in CAD systems are listed in Table 9 with the contents of each record in the file indicated.

The availability of some of these files may enable the police department to render valuable service to the community. For example, in an emergency the personnel file can be

Table 6. Internal Management Reports Generated by San Diego Police Department CAD System

Item Reported	Breakdown	Comments
Calls for service work load (in hours)	1. Beat 2. [illegible] of week	Ranks beats in descending order; identifies beats in upper and lower quartile.
Calls for service work load (in hours)	1. Time of day 2. Day of week	Also gives percent of total man-hours spent on assignment to calls for service.
Number of dispatched calls Time spent per call Reaction time	1. Priority (high or low) 2. Beat	Average and standard deviation.
Beat work load: Total incidents Total work load hours On-beat incidents and hours Off-beat incidents and hours	1. Beat	Also shows percent of incidents and hours handled by beat car.
Final disposition of calls for service	1. Disposition code (14 plus no disposition)	Also shows total of all calls for service.
Case log		Hard copy printout of incident records.

Table 7. CAD-Generated Reports – Glendale Police Department

Report	Frequency
Crime and Incident Analysis Reports	
Monthly summary of incidents by reporting district by day of week	Monthly
Recap of major activity in specified reporting district(s)	Request
Summary of incidents and/or case reports	Monthly
Police activity summary update report	Semimonthly
Juvenile Activity Reports	
Juveniles detained and dispositions	Monthly
Weekly follow-up report of juvenile cases referred to county probation department	Weekly
Quarterly report of detained juveniles resident by reporting district	Quarterly
Special Reports for Record Bureau	
Monthly arrest and citation register for BCS*	Monthly
Adult misdemeanor arrests and dispositions	Monthly
BCS monthly crime and clearance report	Monthly
BCS monthly value of property stolen and recovered by offense	Monthly
BCS year-to-date summary schedules of stolen property	Monthly
Quarterly follow-up of arrests pending disposition	Quarterly
Preliminary Editing Reports	
Incident	Daily
Property value update	Daily
Case status update	Daily
Arrest report update	Daily
Nonhazardous traffic violation update	Daily
Team status update	Daily
General Use Reports	
Daily activity log	Daily
Work Status and Employee Evaluation Reports	
Status report of active cases	Weekly
Report of investigative assignments	Daily
Employee/team/bureau/section activity and evaluation report	Monthly
Recovered property retained by officer	Monthly
Traffic enforcement activity (by each employee)	Weekly

*Bureau of Criminal Statistics

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Table 8. CAD-Generated Reports – Dallas Police Department

Item Reported	Breakdown	Comments
Crime Statistics	1. Beat	Beats ranked by number of crimes
Total crimes		
Number per day		
Average per day		
Standard deviation		
30-day average		
Residential Burglaries	1. Beat	
Time, date, day of week		
Location		
One-word property description		
M.O. entry		
Case status		
Case number		
Number of suspects		
Number of vehicles		
Suspect Persons	1. Beat	
Crime		
Date		
Case number		
Description (sex, age, eyes, etc.)		
Weapon		
Vehicle description and license		
Suspect Vehicles of Suspects	1. Beat	Ordered by vehicle
Same as above		
Suspect Vehicles for All Crimes in Period		
Vehicle description and license		
Crime		
Location of crime		
Date and beat		
Case number and status		
Morning Report of Index Offenses		
Last 24 hours		
Month-to-date and last month-to-date		
Last year month-to-date		
This year and last year-to-date		

Table 6 (Continued)

Item Reported	Breakdown	Comments
Morning Report of Actual Offenses	1. Division	
Last 24 hours		
Month-to-date		
Last month-to-date		
Calls - Number of calls	1. Beat	
Total time on call	2. Watch	
Average time on call		
Response Time Average for Year		
Total		
Time received to time dispatched		
Time dispatched to time on scene		
Time at scene		
Calls for the Month	1. Beat	
	2. Hour of day	
Calls for Holdup and Burglary Alarms	1. Alarm location	
Complainant		
Time and date		
Time dispatched		
Comments		
Officer Activity Report	1. Officer ID	
Arrests		
Jail arrests		
Dispositions		
Parking citations		
Accident investigations		

searched rapidly to locate officers with special skills such as dismantling bomb devices or speaking certain foreign languages.

The address file listed in Table 9 is only one version of geographic files that may be created and maintained. A department may choose to maintain complete records of all items of interest associated with a given address, such as:

- Description of the structure.
- Alarms
- Indicator of data such as detailed floor plans, maps, photos, available on microfiche.
- Gun registration at the address.
- Prior incidents at the address.
- Personnel on parole or probation at the address.

This information can be automatically displayed when the address is entered at the console, or can be displayed only on request. This is a useful capability, but the creation and maintenance of such files involves a large amount of clerical work.

5.8 Failure and Backup Mode Operation

In planning for a new CAD system, a department must also plan for carrying on operations in the event of a failure in the CAD hardware or software. Such plans should include detailed procedures for making the transition from normal automated operation to manual operation and back again to automated operation when the problem has been solved.

It may be desirable to provide for an intermediate mode of operation, in which the console keyboards and displays are still working, but do not access the computer files. In this mode the complaint board operators can still use their keyboards to enter incident data, and can then cause it to be printed out on the printers at the dispatcher consoles.

The transition procedures can be exercised on the occasion of routine maintenance procedures or shifting of the computer to perform periodic batch processing of the data base (as in preparing management reports). It may also be advisable to hold unscheduled "fire drills" to verify the transition procedures. Supervisors normally play an active role in coordinating the transitions.

Detailed procedures and their effects on hardware and software are presented in Chapter 6.

Table 9. CAD Files

File Name	Function	Content
Address	1. Determines whether or not address given by complainant exists. 2. Locates address by cross streets, beat, and reporting district. 3. Reports finding to operator.	1. Street name. 2. Number range. 3. Number range of each block face. 4. Name of street at each intersection. 5. Beat. 6. Reporting district.
Incidents	1. Conveys information from complainant to dispatcher. 2. Conveys information from dispatcher to patrol officer. 3. Summary for case log and data base for management reports. 4. Reaction time and delays.	1. Name of complainant, his address and phone number. 2. Type of incident. 3. Priority. 4. Officers and cars assigned. 5. Time and date initiated, assigned and disposed of. 6. Time and status changes for each vehicle in case. 7. Incident number. 8. Precinct number, beat number, reporting district. 9. Operator receiving call position. 10. Dispatcher assigning call and position. 11. Frequency. 12. Silent alarm number. 13. Disposition.
Vehicle Status	1. Display resources to dispatcher and their availability. 2. Display case numbers and vehicles currently assigned.	1. Unit number. 2. Terminal number. 3. Number of personnel in car. 4. Beat assignment. 5. Temporary assignment. 6. Radio channel. 7. Shift. 8. Time assigned on shift. 9. Updated by operator number and time. 10. PIN numbers of officers assigned to vehicle. 11. Status. 12. Time-entered status. 13. Incident number. 14. Type of incident. 15. Priority. 16. Number of unit covered or being covered. 17. Status changes times and case numbers for that shift. 18. Comment.
Incident Summary	1. Provides 1-line summary of incidents assigned but not yet cleared. 2. Provides 1-line summary of incidents in backlog to be assigned.	1. Incident number. 2. Start time. 3. Priority. 4. Time received. 5. Type. 6. Location. 7. Number of assigned unit. 8. Frequency, dispatcher.

Table 9 (Continued)

File Name	Functions	Content
Department Personnel	1. Roster of sworn and non-sworn staff.	1. Name. 2. Rank. 3. D.O.B. 4. Date joined P.D. 5. Home address. 6. Phone number. 7. Next of kin, address, phone number. 8. PIN number. 9. SS number. 10. Special capabilities. 11. Blood type.
Department Vehicles	1. Inventory of patrol vehicles; shows special equipment on each (communications, mobile lab, etc.) whether or not they are in shop, time to bring out of shop.	1. Vehicle number. 2. Model, year. 3. Communications, e.g., types. 4. Lab equipment. 5. Other features (ambulance, tractor, van, bus, etc.). 6. In shop for repair of ___ (part). 7. Estimated return to active status ___ (date, time).

6. PLANNING GUIDELINES: ELEMENTS OF THE SYSTEM

We have seen in Chapter 3 how a CAD system works in general, and what its components are. This chapter provides more detailed information on those components. Section 6.1 describes the hardware elements of the system, and Section 6.2 covers the computer programs and computerized files that are needed for a CAD system.

Before we describe the components of the system, however, it will be useful to present an overall picture of the physical layout of a command and control center with computer-aided dispatch. Figure 10 is a drawing of a typical center. Some of the points to be noted here that have not been mentioned previously are:

- The computer and its related equipment (tape and disc units and interface devices) do not occupy much physical space; the equipment generally does not require specially conditioned facility space.
- There is a position, with a separate console, for a watch commander. The watch commander is in overall charge of the center and of the patrol units. His console enables him to observe the screens of any of the other consoles, and his radio panel permits him to communicate with patrol units on any of the frequencies being used by the dispatchers. He provides overall monitoring of the entire operation as well as high-level decision making for emergency or unusual situations.
- There is a position for a records clerk. This position has a console with a display screen, but has no radio panel and does not communicate with patrol units. Its function is to handle all off-line functions such as preparing personnel rosters, updating the permanent files, transferring logs from disc to tape for permanent storage, generating computerized management reports, etc.
- There is a spare console for training. This is identical to a dispatcher console, and can be used as an active console to handle overflow loads or in case of failure of an active console. Its nominal purpose is to provide practice for new operators.
- A microfiche file is available to the dispatchers. This is a means of storing permanent reference information that the dispatchers may need occasionally for tactical situations. This microfiche file is equipped with a system for rapidly retriev-

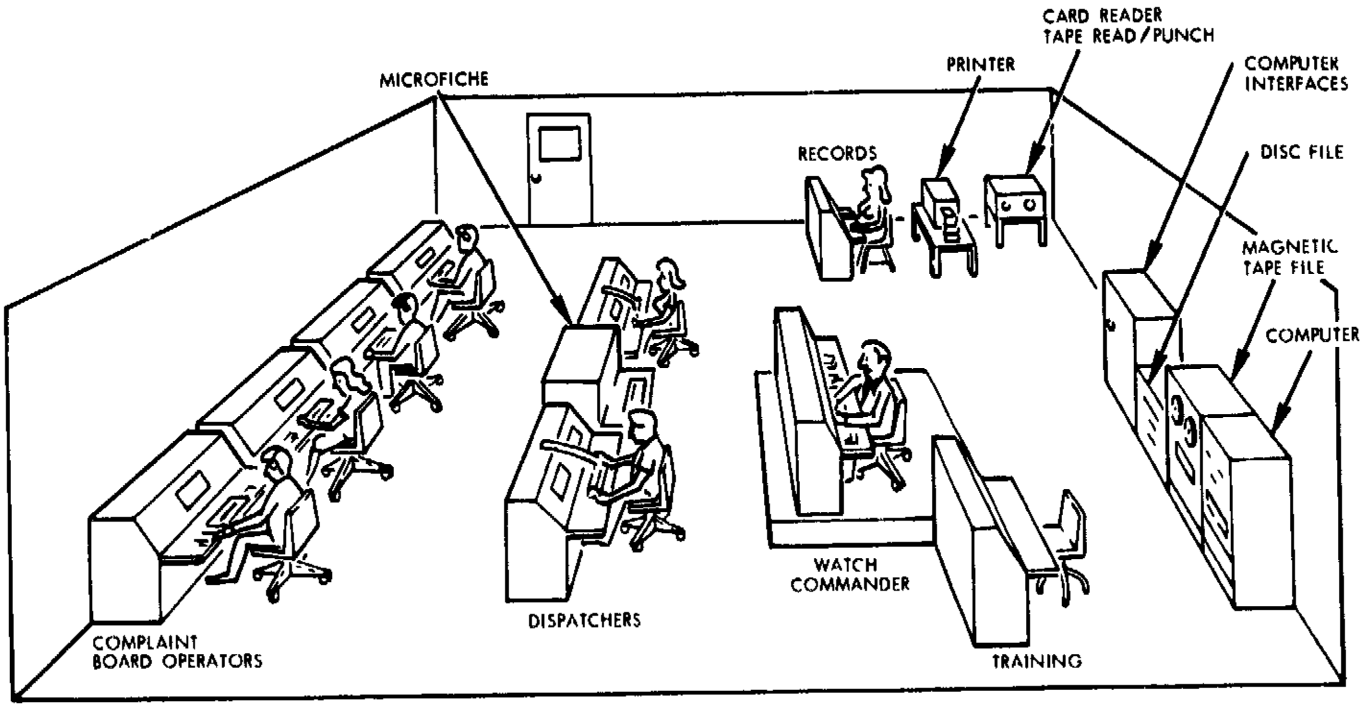
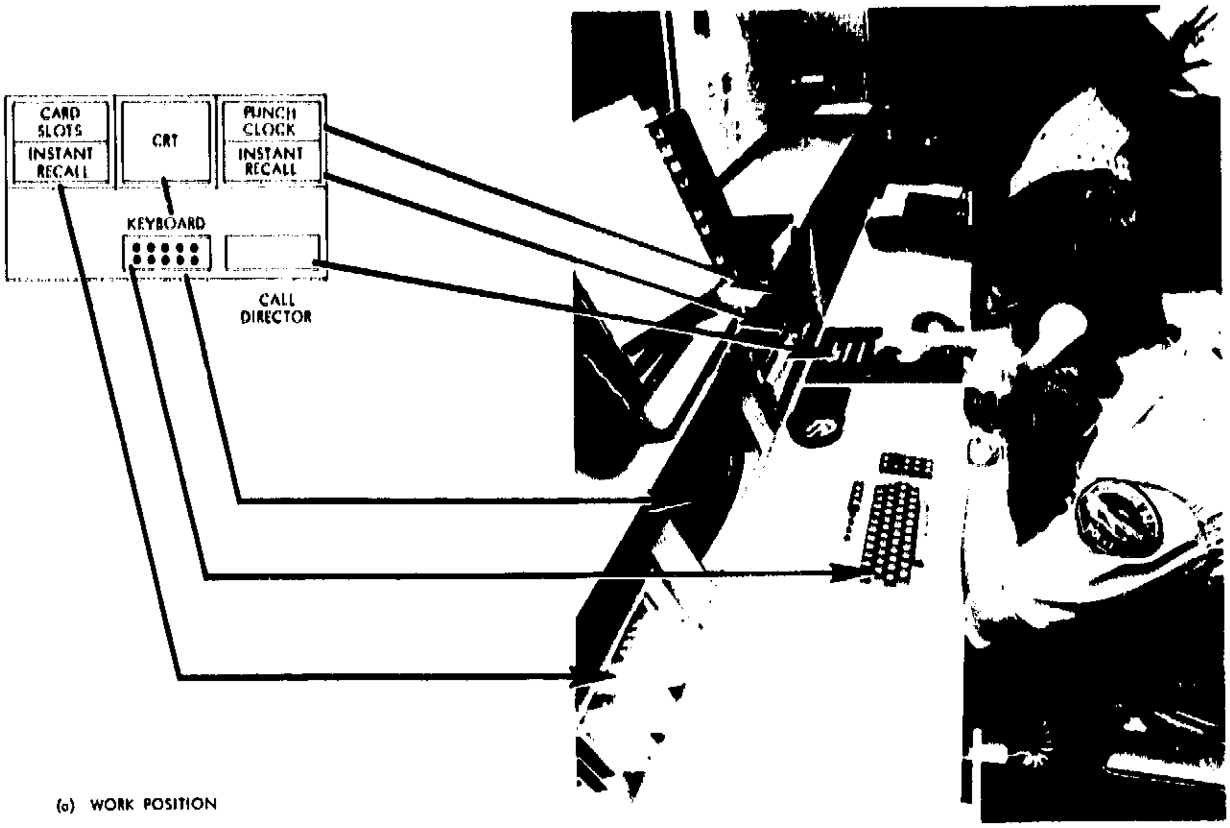
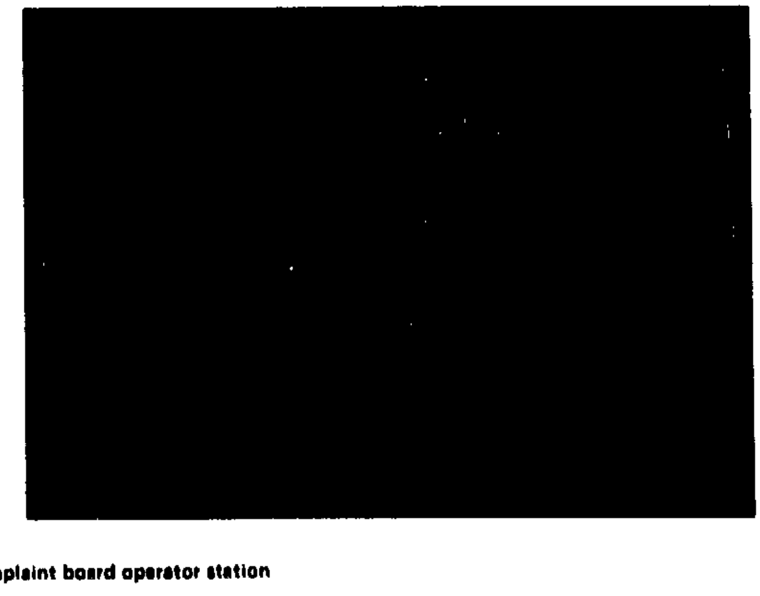


Fig. 10. A CAD dispatch center



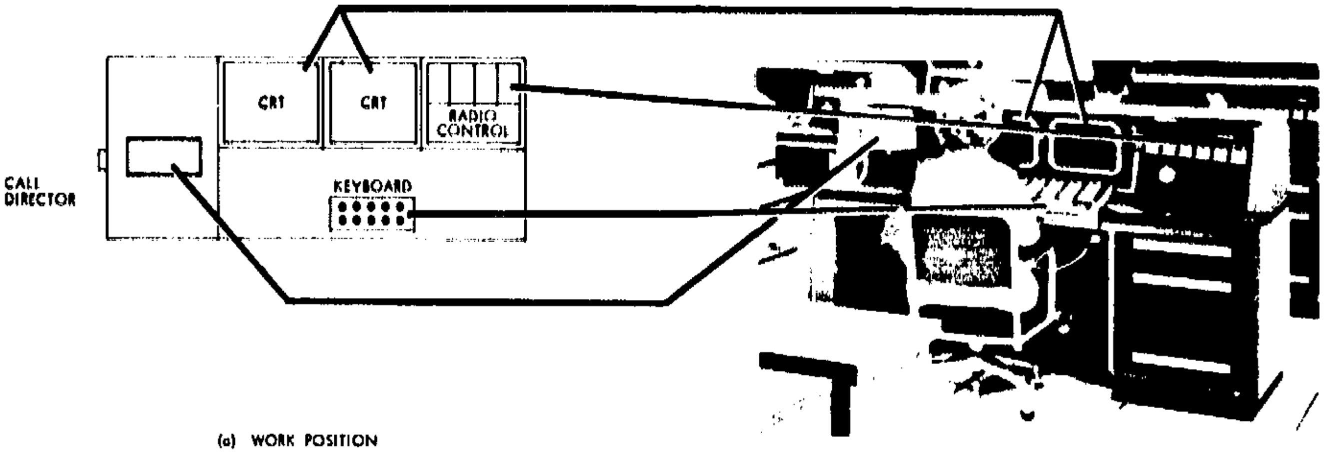
(a) WORK POSITION

Lines 2-5 are used for detailed information fill-in by the operator and become part of the permanent computer record, which is automatically transmitted to and displayed on the dispatcher's incident CRT. Lines 6-9 and 10-13 are duplicate complaint entry formats. Lines 14-24 indicate the complaints, in order received, entered into the system. This information is duplicated at the dispatcher's incident CRT.



(b) COMPLAINT ENTRY DISPLAY

Fig. 11. Complaint board operator station



(a) WORK POSITION

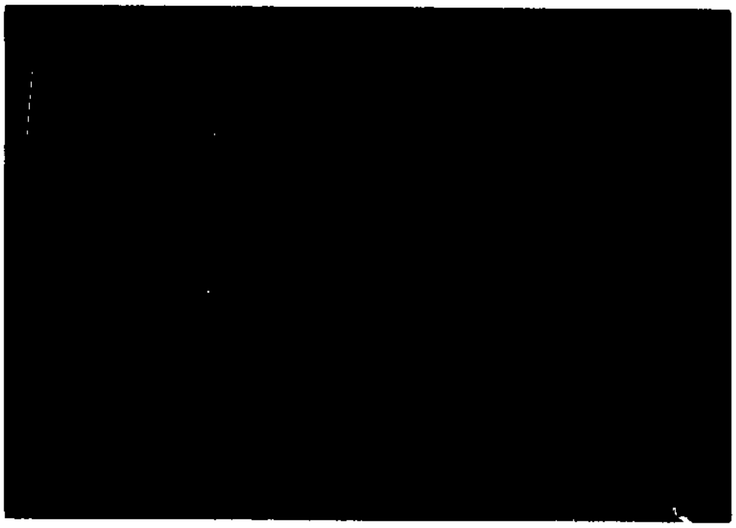
Photo courtesy of Las Vegas Metro Police Department.

Status Display

Car numbers (corresponding to car types) are displayed under appropriate headings of AVAILABLE, ENROUTE, AT SCENE, INVESTIGATING, RETURNING TO STATION, OUT. This information is entered directly from the vehicle via the MODAT mobile data system. Where applicable, the case number to which a vehicle has been assigned is displayed next to the vehicle. The upper right-hand corner displays the backlog of unassigned incidents per beat. Line 2 shows unit 3A2 requesting a car stop check. Line 3 indicates that 314 has not been assigned to a mobile unit in the computer files. Line 4 indicates which mobile units are transmitting emergency messages. Line 5 shows other cars transmitting messages. Line 6 is the automatic ID number which appears whenever a mobile unit uses voice-radio.

Dispatcher Incident Display

A computer-assigned incident number appears on Line 2 as well as time received, nearest street (if applicable), Apt. No., reporting district, Fire Box No., and Beat No. Lines 3-5 indicate the name and phone number of the person reporting the incident, the unit(s) assigned to the incident, and the type, code, priority code, and description of the incident. Lines 10-12 indicate assigned but unresolved incidents, with the incident code on Line 9. The bottom portion of the screen displays an abbreviated version of the top portion of the screen: unassigned incidents, type code, time received, address, intersect street, reporting district.



(b) DISPLAYS

Fig. 12. Dispatcher station

ing any of the stored data and displaying it on a microfiche screen, e.g., street maps, layout of premises such as banks, etc.

The physical arrangement of the equipment is quite flexible. In some cases the complaint board operators are in a different room or a partitioned-off part of the room from the dispatchers. The computer can be in a different room if it is more convenient, and the records clerk can also be in a different location as long as he has a connection to the computer.

For the purpose of filling in a picture of the physical appearance of a CAD system, Figures 11 and 12 show, respectively, a CBO console and a dispatcher console, with typical displays on the screens. Note that in both types of consoles there is a provision for cards so that in the event of a failure in the CAD system the CBO and dispatcher can continue their functions in a manual mode.

6.1 Hardware Description

This section identifies the types of equipment needed in a CAD command and control center. It takes a particular example of such a center and describes in some detail the characteristics of each item of equipment; the center is sized to serve a city of approximately one million population.

The equipment layout of the center we will use as an example is shown in Figure 13. It consists of the communications equipment, the computers and related peripherals, and the set of consoles where the functions of the center are performed. As the figure indicates, the consoles assumed in this center are as follows:

- Eight CBO positions (four dual consoles).
- One complaint supervisor position.

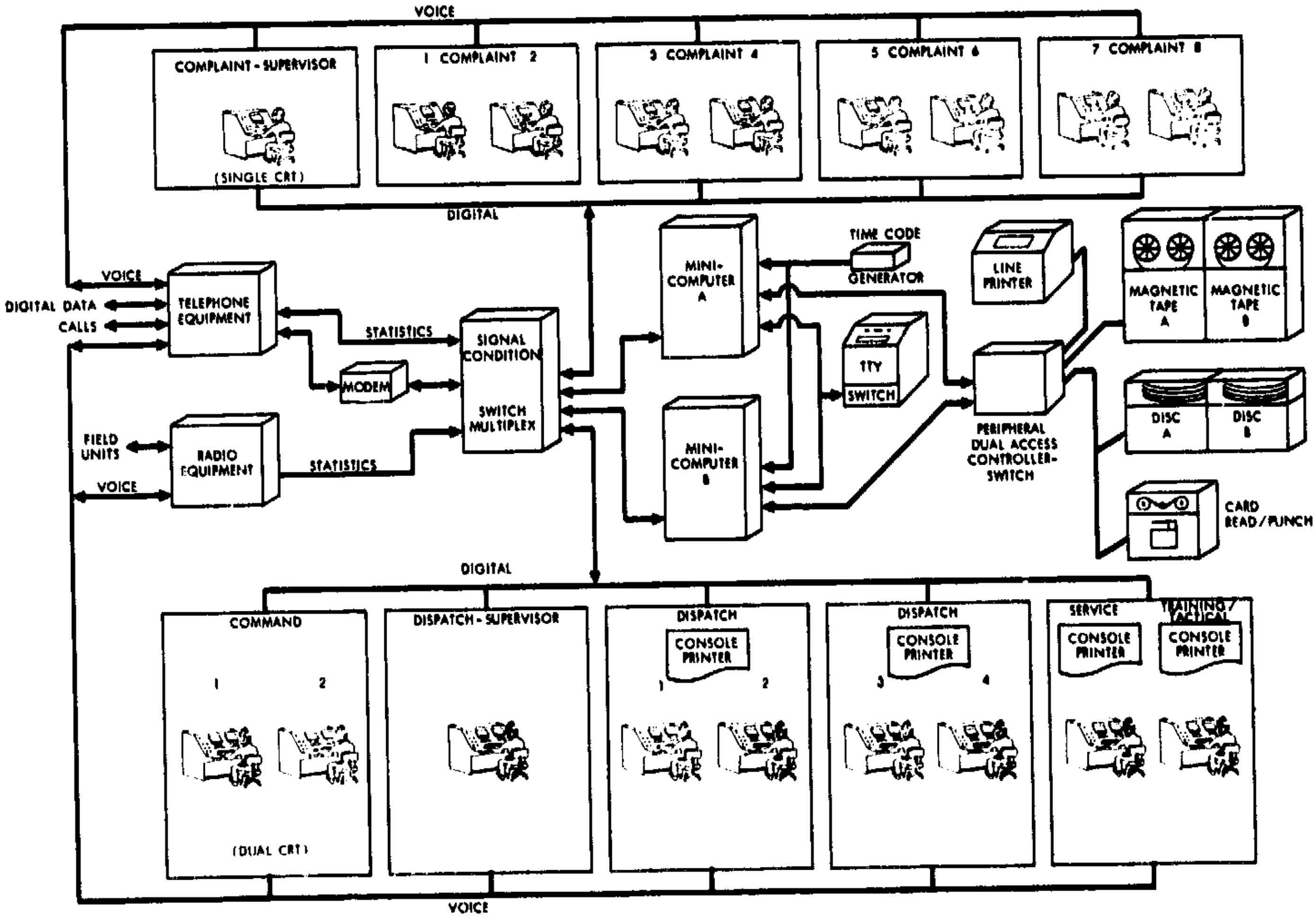


Fig. 13. CAD system block diagram

- Four dispatcher positions (two dual consoles).
- One dispatch supervisor position.
- Two command positions (one dual console).
- One service and training console (two positions).

The dispatch supervisor, command, and service and training consoles are essentially identical to the dispatcher consoles and are able to operate as dispatcher consoles whenever required because of overflow work load or failure of a regular dispatcher console.

The characteristics of the consoles are summarized in Table 10. In the system used here as an example, the command console is used to monitor operations, provide necessary input or feedback, and provide a channel for command decisions in cases requiring them. The service and training console is used to monitor the records channel, serve as a training posi-

Table 10. Summary of Console Characteristics

Position	Components	Function
Complaint board operator	Keyboard	Enters incident data to computer.
	CRT display (single)	Displays format and data as it is entered.
	Call director	Accepts calls from public via multitrunk telephone lines.
	Instant playback recorder	Captures incoming call for quick retrieval of information if necessary to confirm or check data.
	Microfiche files (one set for two positions)	Provides maps and other data such as legal information, other agency referrals.
		Provides for manual taking of complaints if CAD system is not functioning
Complaint board supervisor	Same as CBO, plus:	
	Call director supervision equipment	Monitors incoming call handling.
	Telephone activity registers	Provide historical records of telephone activity.
Dispatcher	Dual CRT display	Displays all formats and data.
	Keyboard	Enters data to computer.
	Instant playback recorder	Captures voice messages for recheck.
	Microfiche files (one set for two positions)	Provides street files and maps, other static reference information.
	Radio dispatch panel	Provides radio communications with patrol units.
	Manual equipment	Permits manual dispatch if CAD system is not functioning.
	Printer (one for two positions)	Provides printed records as needed.
Dispatch supervisor	Same as dispatcher console, except:	
	No manual equipment	
	Auxiliary radio panel	Provides for communication with other agencies.
Command console	Same as dispatcher console except:	
	No instant playback recorder	
	Auxiliary radio panel	Provides for communication with other agencies.

tion for new operators, and handle tow and ambulance dispatches.

As shown in Figure 13, this system used as an example has two processors. They are completelv redundant, with either being capable of handling all the computing required for the CAD system (but note that the multiplexer switch provides for future additions of processors to handle other automated command and control functions). Table 11 summarizes the hardware characteristics of the processors and their peripheral equipment.

No description is provided of the communications equipment shown in Figure 13, since it is standard equipment used for all law enforcement command and control systems, whether or not they have a CAD system.

6.2 SOFTWARE AND FILES

The term "software" is used to refer to the set of instructions executed by the computer to perform its tasks, plus the data in machine-readable form that is used by the computer in carrying out these tasks. The basic instructions enabling a general-purpose computer to accept specific programs are provided by the computer manufacturer; these basic instructions are usually referred to as the operating system. The specific programs that cause the computer to perform particular tasks are called user programs; some widely-used programs (such as a payroll program or an inventory control program) may be supplied by a computer manufacturer or by an independent software house. The files of data are naturally always provided by the user himself, although the file structure may be a standard one.

Table 11. Summary of Computer Hardware

Item	Description and Function
Processors	Each consists of a central processing unit (CPU), memory (usually magnetic cores), and input/output logic. The memory stores program instructions and data; the CPU executes the instructions, using the stored data; the I/O logic interfaces the processor with the input devices (the console keyboards, the disk and tape units) and the output devices (the console displays, the disc and tape units, printers) to move data into and out of the processor.
Disc storage units	There are one or more disc units in the system, depending on the size of the files to be stored. Ordinarily a single disc pack with a capacity of several million bytes is large enough to store all the programs and data for a CAD system. Disc storage provides a means of rapidly accessing a large quantity of data or instructions; those programs and files that are not maintained in the processor's core memory are stored in the disc unit, where they can be brought into core as needed in a matter of milliseconds. Duplicate disc units with duplicate data are sometimes maintained to protect against accidental data loss or disc system failure.
Magnetic tape units	Tapes are normally used for permanent storage of data, and the amount of data that can be stored in this way is virtually unlimited. Tapes are usually easily transferred from one facility to another if they are needed for historical or statistical studies.
Card reader	The normal method of entering programs into the computer for initial development and checkout is through punched cards. A 300-card-per-minute reader should be adequate for a CAD system.
Line printer	Any printed output from the system that has significant volume, such as activity logs and all types of management reports, requires the speed of a line printer. The printer would normally be associated with the records clerk position. It need not be a very high-speed printer, but should be faster than a teletypewriter.
Console teletypewriter	A teletypewriter is provided for each pair of dispatcher positions (one per dual console). This fairly low speed printer is adequate for generating the small amount of hard copy needed from the consoles.
Modems	A modem (modulator/demodulator) is needed for each interface of the CAD system with other digital systems, primarily for purposes of remote data base query (DMV, NCIC, etc.). A modem allows a computer to communicate with another computer over standard telephone lines. A modem is also needed in systems where the patrol units are equipped with mobile digital terminals that can communicate directly with the computer or with remote data bases.

For a CAD system, we assume that the software will be supplied along with the rest of the system by a contractor. He will normally buy the computers together with the operating systems software, but might modify the operating system somewhat to meet the particular requirements of the CAD system. The user programs would be provided by the CAD system contractor. In cities where there is a large and experienced data-processing department, it is possible that the city would act as its own contractor and procure the hardware (including operating system) and write the user programs in the data processing department. Even where the complete system is procured from a contractor, city or police department programmers may take care of software maintenance. Maintenance usually refers to making modifications in the programs to tailor them specifically to the conditions of operation, or adding extra capabilities that improve the overall CAD operation.

Figure 14 shows the strucutre of the software and files that would be needed in a CAD system. There is a basic set of software that would be needed for any CAD capability; this is indicated by an asterisk. The remaining elements of software or files are optional added capabilities.

The following subsections describe the software elements listed in Table 12. The planner may find these useful in that they give a clear idea of what each part of the software is required to do. With this understanding it is easier to evaluate proposals from system or software vendors.

6.2.1 Operating System

It has already been mentioned that the operating system is normally supplied by the computer manufacturer, since its detailed structure is heavily influenced by the design of the computer and the peripherals furnished with it. The separate parts of the operating system are briefly described below.

System Generation Module. This is the set of procedures and instructions that defines the operating system, the system

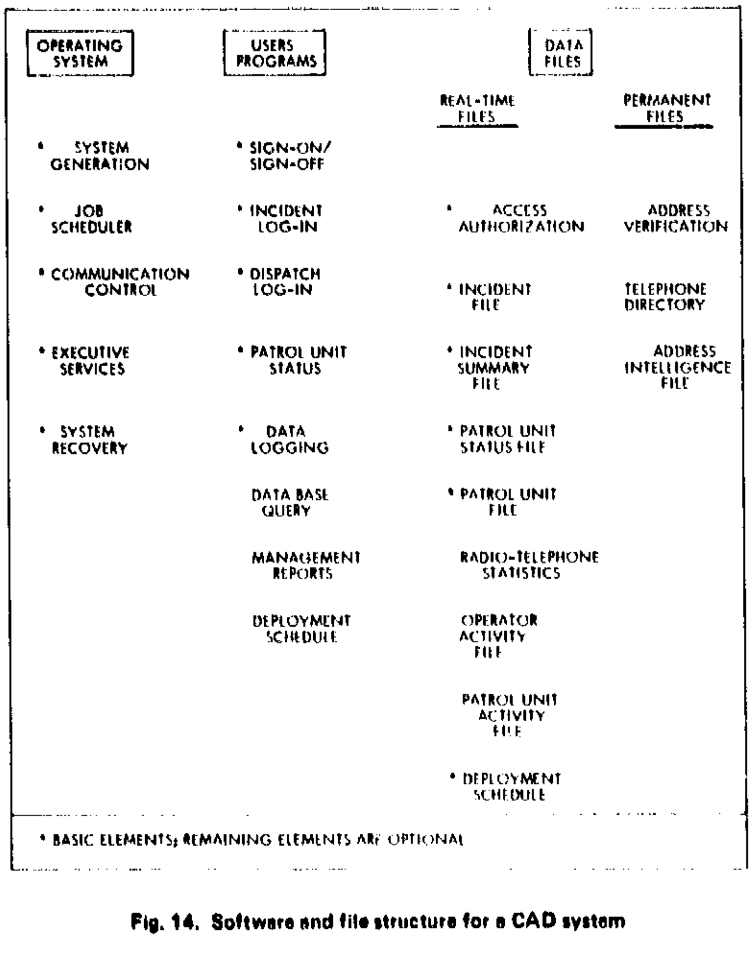


Fig. 14. Software and file structure for a CAD system

Table 12. Record Sizes of Data Files

File Name	Record Size (characters)
REAL TIME FILES	
Access authorization	85 per person
Incident file	850 per incident
Incident summary file	83 per incident
Patrol unit status file	178 per field unit
Radio-telephone statistics	196 per hour
Operator activity file	563 per operator per shift
Patrol unit activity file	928 per unit per shift
Deployment schedule	124 per person
Temporary situation file	176 per address/area
PERMANENT FILES	
Address verification	
Street index	236 per street name
Landmark file	95 per land mark
Master street file	92 per block face
Telephone directory	
Emergency telephones	80 per telephone
Foreign language translation assistance	80 per telephone
Nonemergency telephones	80 per telephone
Address intelligence file	245 per address/area

configuration (i.e., what processors and peripherals are parts of the system), the mode of operation, the disc file catalog identifying programs and file locations, and the software routines that are to be maintained in the core memory.

Job Scheduler Module. Control over the execution of all program elements is exercised by this module. It maintains a priority job queue and executes the high-priority jobs in the foreground with the lower-priority jobs being handled in the background (the background means the intervals of processor time not being occupied by foreground jobs; these intervals are generally on the order of milliseconds or less). There is also a priority interrupt feature allowing a high priority task to take over the processor when it enters the queue. The function of the job scheduler is to schedule and coordinate all the available processor execution time in accordance with the hierarchy of priorities.

Communications Control Mode. This module provides for testing of input data for syntax errors, for message handling in accordance with a given protocol, and for system-level operators to interact with the system as needed during initial system generation and later maintenance, file updating, and program development operations.

Executive Services. This is a set of routines that support user programs in handling data. For a CAD system they would include the special input/output handlers to drive the CRT displays, to sort, edit, and route the input keyboard messages, and to enter data in the designated portion of the display. This module also includes the timer routine that activates time-related tasks for execution, and various utility programs to handle transfers from disc to core or vice versa, or from disc or core to printer. Other utility programs include software compilers and assemblers, routines for generating and updating disc files, etc.

System Recovery. This module provides for automatic transfer of system operation to a redundant slave processor (if one is installed) whenever the master processor error detection routine senses a failure, or whenever the slave processor detects the loss of master-slave communications. In either case the processor that remains operational immediately generates messages to selected terminals and prints out a failure message on the console maintenance teletypewriter.

6.2.2 User Programs

Sign-On/Sign-Off. All operators and field personnel scheduled for active duty are required to sign on and sign off the system. This enables the system to maintain a current file of all personnel on active duty. The sign-on procedure requires the CBO and dispatcher to input his personal ID code; the processor then makes a cursory security check of his eligibility to operate the system and of his authorization to access specified data files (for example, a CBO may not be allowed to change patrol unit status or supervisory data or to modify the address intelligence file).

Once the dispatchers and CBOs have signed on, the dispatchers (or other operators) will sign on the personnel in the partol units under their respective control (unless they can sign on directly through their mobile digital terminals). When the sign-on procedure has been completed, the program will generate a test pattern on the screen to indicate that the procedure is satisfactory, and will also display all pending transactions so that the dispatcher can carry on without interruption from the previous shift.

Each individual person who signs on will have his own activity file in the system, where all transactions executed from his terminal will be logged.

When the person signs off, this procedure causes his activity file to be closed and printed out (on demand). His ID is removed from the file of people on active duty, and the appropriate supervisory terminal is notified of his sign-off.

Incident Log-In. The incident log-in routine is executed whenever a new incident record is to be created. It is used mainly by the CBOs, but when an incident is reported by a partol unit, the dispatcher makes use of this routine to enter the incident into the system. This is an important and frequently-used routine, consisting of the following steps.

When the operator types INC and presses the ENTER key (or presses a special function INC key), the routine displays the incident record format on the screen, as shown in Figure 11. The program automatically enters data in the correct field and displays it on the screen as entered. For example, to enter an address the operator simply types the field identifier (CA in this case) followed by a slash (/) and the data. Names, incident type, etc., can be entered in similar fashion. The advantage of this procedure is that the information can be entered in any order.

When all the available data has been obtained from the caller, the operator depresses the ENTER key and the information is transmitted to the processor. There it is scheduled for execution by the part of the executive service routine that assembles the data, places all entries in the proper field for the dispatcher's display, and hands it over to the incident log-in routine for serial numbering, time-tagging, and address checking (if the system has such a feature). Part of the address check is having the master street file searched to see if previous incidents have been logged in the same block. If there are such incidents, all of them are displayed on the CBO screen along with the current incident to allow for verification that the new incident is not a duplicate of a previous one. If it is a duplicate, the new incident is cancelled. If it is the same as an existing incident but with new data, the original incident is updated and transferred to the dispatcher for action (which may be to cancel it). New incident entries will cause a flag to be set in the master street file to indicate a pending incident in that block and the flag will be removed when the incident is closed.

The next check made by the incident log-in routine is again against the address, but this time against the address intelligence file (if this feature is included in the system). Any information found in the file will be displayed with a special caution marker if the intelligence data contains a caution flag; this is to help the dispatcher make his decisions and to increase officer safety.

One of the fields filled by the CBO is incident priority. The priority may be 1, 2, or 3 (1 for immediate action). The log-in routine automatically notifies the tactical dispatcher console (or other designated supervisor) whenever there is a priority 1 incident.

Finally, if the system has the dispatch recommendation feature, the log-in routine checks the patrol unit status file against the master street file to identify those units that are nearest the incident and available, and displays the list of such units to the dispatcher. This information is added just as the incident log-in routine hands the incident data to the dispatch log-in routine.

Dispatch Log-In. This routine receives the incident data from the incident log-in routine and displays it on the dispatcher console when he calls it up in its turn. Figure 12 shows the format of the display presented to the dispatcher. The dispatcher now decides whether to assign a patrol unit or to defer dispatching until a later time. If he decides to dispatch, he selects a patrol unit or units from his patrol unit status display (or from the list of recommendations presented by the computer, if his system has this feature). He types in the ID's of the unit or units selected, and notifies them. As soon as he receives an acknowledgement of the assignment, the dispatcher presses his ENTER key and the computer time tags the assignment and updates the status display. An incident/dispatch summary task in the dispatch log-in routine takes all the incidents processed by the dispatcher (assigned or deferred) and generates a summary in the format shown in Figure 12. When the dispatcher wishes to recall the full data in an incident listed in the summary, he types in the incident serial number and depresses his ENTER key. The incident summary table is printed out at frequent intervals on the printer at the console, to provide data in case it is needed for manual backup operation.

When an incident is to be closed, the dispatcher enters DC/CLOSED plus any data supplied by the patrol unit to the incident display after he recalls it. The processor confirms the action by showing the time of log-off: the field unit status display is automatically updated, as before.

Patrol Unit Status Routine. This routine maintains the status file for the patrol units assigned to each dispatcher. The format is shown in Figure 12, with the available units listed on the left side and busy units on the right side. The available units are listed by number and beat. Backup units supporting the primary unit are listed immediately after the primary unit regardless of number or area, and show the same incident number as the primary unit.

The routine automatically shifts units from one column to the other in accordance with dispatcher inputs (or direct inputs if the patrol units report status digitally). The time column shows the time the unit made its last status change. If there is a limit on the time a status code should remain unchanged, the processor will cause the time signal to be flashed to alert the dispatcher. Time limits may be automatic for certain status types.

The patrol unit status routine transfers to the activity file for each patrol unit each status change entered for that unit. When an entry indicates that the unit has logged off, the activity file is closed and scheduled for tape logging and printing (on demand).

A special task in the patrol unit status routine is used to update the files during recovery after a period of manual operation. It accepts inputs from the keyboard and updates the files and displays. This task also prints out the status files on the console printer periodically, say every 10 minutes, to provide a starting point for manual backup operation if it should become necessary.

Data Base Query Routine. This is the routine that allows dispatchers to initiate queries to remote data bases at the regional, state, and federal levels. The routine formats the query and response data, maintains a record of the transactions and prints out the query and response for "hits". A typical data base query format is shown in Figure 15.

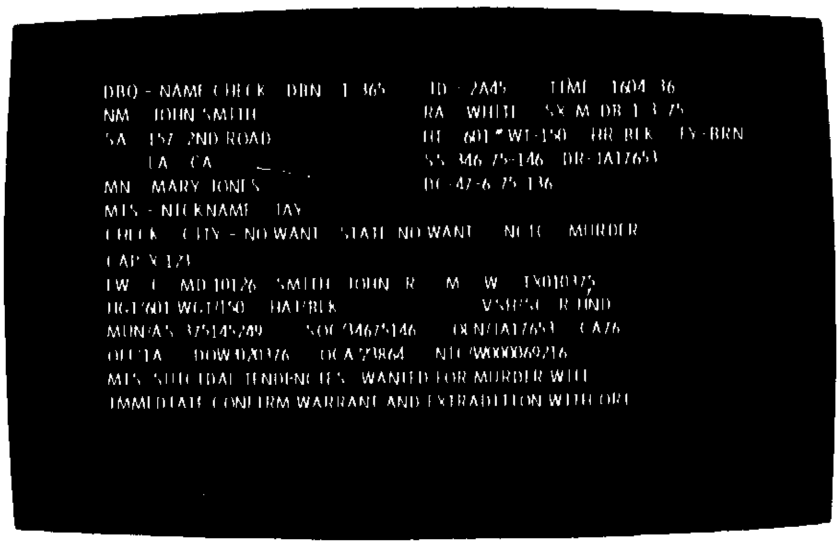


Fig. 15. Typical data base query format

Response messages are screened for positive cautionary characters received as part of the response. Detection of a caution character will create a high-priority response, causing the console that entered the query as well as the supervisory console to be notified immediately. Positive responses are also printed out on a special printer.

Management Reporting. A separate routine is provided to collect from the log tapes the necessary data to generate the set of management reports selected by the department management. Some typical management reports are listed in Section 5.6.

Data Logging Routine. This routine handles the tasks of formatting all the data in the real-time files for permanent storage on magnetic tape. It maintains accountability of all messages into and out of the command and control center and transactions within it.

6.2.3 Data Files

Figure 14 identified two types of files: real-time files and permanent files. The real-time files are those used by the CAD system in its basic functions, and their contents change rapidly all the time the system is operating. The permanent files are those used primarily for reference; they are not completely fixed, but they are updated at relatively long intervals (once a day to once a month) compared to the real-time files.

The contents of the files identified in the figure were listed in Table 9 together with their functions. Table 12 lists the files again, showing the approximate number of characters that could be expected in each record in the file.

6.3 Sizing the System

Determining the quantities of hardware components and their individual capacities is normally done during the detailed system design. Nevertheless it is useful for the planner to know how sizing estimates are made; this section describes a procedure for doing so, based on the needs of a city of one million population.

6.3.1 System Parameters

Those parameters readily available to the planner from the existing police command and control system are:

- Average number of calls for service in peak h. urs.
- Maximum number of patrol units deployed per shift.

From these numbers he can derive some numerical CAD requirements by using some rules of thumb that have proved generally applicable to cities in the 500 thousand to one million population range. These are listed in Table 13. In addition, approximately 40 percent of calls for service generally result in dispatches of patrol units.

Table 13. Estimating Ratios for CAD Systems

Parameter	Number per Patrol Unit
Self-dispatches (patrol unit originated)	4 per shift
Data base queries	2 per hour
Data base query responses (2.5 responses per query)	5 per hour
Partol unit status updates	10 per hour
Miscellaneous supervisory transactions	2 per hour

The final parameters needed for system sizing relate to system performance; for a CAD system these are primarily in the form of required response times. A typical set of requirements is listed in Table 14.

Table 14. Typical CAD Response Time Requirements

Operation	Maximum Time to Perform Operation 95% of the Time
Answer call for service	10 seconds (first ring)
CAD system processing of incident log-in	2 seconds
Update patrol unit status/location	1 second
Display of data maintained in CAD files*	2 seconds

*Time does not include operator type-in time.

Once these parameters and response time requirements have been established, the sizing process proceeds in the following steps:

(1) Determine number of work positions (CBO, dispatcher, supervisory, others if any).

Table 15. Determination of Total Transaction Rate

Transaction Type	Number	Per	(Times)	Number	Units	(Equals)	Transactions Per Hour
Dispatches							130
From calls	0.4	call		200	calls		(80)
From self	0.5	PU*		100	PUs		(50)
Dispatch log-off	1.0	incident		130	incidents		130
Data base queries	2	PU		100	PUs		200
Data base responses	2.5	query		200	queries		500
PU status updates	10	PU		100	PUs		1000
Miscellaneous supervisory messages	2	PU		100	PUs		200
Hard copy print							
Dispatcher records	6	dispatcher		4	dispatchers		(24) 59
Data base query "hits"	0.15	query		200	queries		(30)
Management records	5	total					(5)
Telephone-radio statistics	1	total					1
Total transactions (per hour)							2220

*PU = patrol unit

(2) Determine total system input/output transaction rate.

(3) Determine required CPU capability to handle transaction rate.

(4) Determine core storage requirements.

(5) Determine disc storage requirements.

These steps are outlined in the following sections, using as an example the CAD system described in Sections 6.1 and 6.2. For that system, the curves shown in Chapter 5 indicate a requirement for 8 CBO stations and 4 dispatcher stations, plus 4 additional stations for supervisory and maintenance functions; the additional stations are defined to meet the needs of a particular system and are not derived from the curves of Chapter 5.

6.3.2 Input/Output Transaction Rate

To determine the total I/O transaction rate we identify the types of transactions and estimate the numbers of each from our perviously established system parameters. This process is shown in Table 15.

The number of operations per hour required of the system can now be estimated. We assume the following numbers of operations for each transaction:

2 keyboard messages

2 screen displays

1 magnetic tape log record generation

—

5 operations per transaction X 2220 transactions =
11,100 input/output operations per hour

This translates to 324.3 milliseconds per operation.

Now, making some conservative assumptions about cycle time and allocation of time to operations (averaged over an hour*):

Program execution time	6
Three disc access	120
Data transfer I/O	3.7
Interface multiplexer to console transfer of 1940 bytes (two times)	38.8
	168.5 milliseconds

we see that the system assumed can handle approximately two times the estimated average peak load (i.e., it requires only 168.5 milliseconds to perform tasks for which 324.3 milliseconds are available under the assumed load conditions). This is still a very conservative estimate, however, since of the 168.5 milliseconds shown above, only 6 milliseconds are used by the CPU**; the rest is for data transfers. Thus the CPU can be performing other tasks in parallel, as long as they do not involve the same peripherals (CRTs, keyboards, printers, etc.). It may be possible to trade off the extra capacity for lower cost hardware with less capability, or to keep it available for future expansion of the system to accommodate new capabilities such as mobile digital communications.

The above calculations assumed a typical 16-bit minicomputer with an average instruction execution time of 3 microseconds or less, having direct multiple access (DMA) channels to interface with the consoles and peripheral equipment.

6.3.3 Core Storage Requirements

The core memory in a computer is used to store the operating system software required during real-time operation, the CAD specialized process control user programs, and buffer storage to handle data transfers to and from the consoles and the peripheral devices. Typical minicomputers of the type used for CAD applications are available with core storage modules of 4, 8, and 16K words (each word of 16 bits), generally up to a total of 65K words of directly addressable core storage locations.

*The calculations shown are for operator terminal I/O communications which constitute the majority of transactions and take the longest transfer times from CPU to terminal.

**Central Processing Unit.

For the system outlined in Sections 6.1 and 6.2, the core storage requirements can be estimated as follows:

Real time operating system		16K
CAD user programs		16K
Input buffers*		12K
Output buffers*		9K
	Total	53K

6.3.4 Disc Storage Requirements

Random access storage other than that provided in core is usually provided by disc storage devices. The categories of data to be stored on disc are listed in Table 16, with estimates of the number of bytes (1 byte = 8 bits) of storage required for each category. These estimates are derived from simple calculations based on the previously established system parameters and performance requirements. Note that some of the types of data included in the estimate are for optional files, as defined in Section 6.2, and that the total can be decreased by these amounts if the optional files are not included in the system design.

6.3.5 Sizing Summary

The above calculations indicate that a CAD system does not require very advanced or large-scale data processing equipment. A standard minicomputer is more than adequate for a system of the size assumed in the example, and with added peripherals could handle a considerably larger load. The equipment requirements for the example can be summarized as follows:

Computer	Standard 16-bit minicomputer with 3-microsecond cycle time
Core storage	16K words integral with computer plus three additional 16K modules (64K total)
Disc storage	One 25-megabyte unit

*The sizes of core buffers are determined by the number of terminals, digital communication lines, peripherals, and message/transaction rates estimated for the example system.

Table 16. Estimates of Disc Storage Requirements

Category	Maximum File Requirement (1000 bytes)
Core image programs	64
Operating system	128
*Off-line user programs	32
I/O recovery (6 minutes of data)	1,742
*Master street file (676 street block faces per square mile)	12,844
*Street index (169 street names per square mile)	7,977
*Landmark file (10 landmarks per square mile)	190
*Telephone directory (150 telephones)	12
*Address intelligence (200 records)	49
*Temporary situation file (100 records)	18
Deployment schedule (460 records)	57
System access authorization (460 records)	39
**Incident log (10 hours)	845
**Incident summary (10 hours)	82
Patrol unit status (200 records)	35
*Operator activity (40 records)	23
*Patrol unit activity (200 records)	186
*Radio-telephone statistics (24 hours)	5
Total	24,328
Total with starred files omitted	2,992

*Optional files (see Section 6.2 for contents).

**The number of hours logged on disc for quick access review is optional. The 10-hour capability allows for the second shift to review all incidents processed and deferred by the previous shift.

Peripherals	One card punch (100 per minute)
	One card reader (300 per minute)
	One line printer (600 lines per minute)
	One typewriter-typeprinter per dispatcher console (per two positions)
	One microfiche file and viewer per console (two positions)

This brief list covers only the data processing equipment. A more complete list including communication interface equipment will be found in Table 17 (Chapter 7).

6.4 Planning Trade-Offs

We have already identified certain features of a CAD system that involve trade-offs of one characteristic against another; most often these reduce to a question of performance versus cost, although there are other characteristics that can enter into the selection of a particular system design or configuration. This section discusses some of the trade-offs that a planner may need to consider in addition to those already mentioned.

6.4.1 Dedicated vs. Shared Computers

In a city where the city government already has extensive data processing facilities, it may be feasible to consider having a CAD system become one user of these facilities instead of acquiring its own data processing hardware (it would still need its own consoles and terminals to interface with the central facility). The considerations involved in this trade-off can be summarized as follows:

Advantages

- Potential saving in cost and time of implementing a CAD system.
- Potential saving in maintenance costs (which would be shared).
- Potential saving in cost of developing and maintaining software (if existing DP staff can handle these functions).
- Potential saving in equipment and manpower required for off-line (non-real-time) operations such as generating management reports, tape logging, and record keeping.

Disadvantages

- Department does not have the system under its own control and can influence performance only indirectly.
- The central facility may not be set up to provide support 24 hours a day, 365 days a year at the required level of priority.
- Coordination of CAD hardware and software maintenance is more cumbersome.
- Central facility may not be in compliance with state and federal data security regulations for law enforcement data records.
- The potential cost saving may not be realized because the CAD system vendor does not have full access to the central facility during the development, integration, and test phases of the new system.
- The potential cost saving may prove to be relatively small because of the declining costs of minicomputers suitable for CAD systems.

6.4.2 Minicomputer vs. Large Main Frame Computer

The question of using a large main frame computer for the CAD system may arise in police departments that are planning to implement several automated functions in addition to a CAD system (e.g., automatic vehicle location, digital communications). Only a complete analysis of requirements for all the proposed automated functions in relation to the capabilities of alternative hardware configurations could provide a good basis for making this decision.

It should be noted, however, that the present technical trend is toward distributed computing networks using multiple minicomputers. This trend results from recent improvements in the overall system reliability and performance of minicomputer systems, combined with generally lower costs for a given capability.

6.4.3 Single Processor or Redundant Processor

The systems described in previous chapters have generally been shown with two CAD processors, one of them redundant. The question may arise as to whether there is a firm requirement for this 100 percent backup capability, particularly since the availability factor for typical commercial miniprocessors is in the neighborhood of 0.9986 (about 2 minutes a day or 12 hours a year of down time). Nevertheless, this figure includes an average repair time of 8 hours, which may be more than a department wishes to tolerate. Duplicating the processor brings the figures to 0.99999, which means less than one second per day or 5 minutes a year of down time.

These figures are for the processor alone. For a two-processor system plus the power source and the terminals (assuming some of the terminals can be used to back up the others), the figure is more like 17 seconds a day or just over 1.7 hours a year.

Another consideration is that the redundant processor can be used for off-line functions, such as generating management reports or training operators, without interrupting the regular operation of the system. The redundant processor can also be placed on-line for load sharing of transactions; this mode of operation would require an additional software program at the operating system level to coordinate each processor's activity.

6.4.4 Single vs. Dual (or More) CRTs on Dispatcher Consoles

The advantages of multiple CRTs on dispatcher consoles were discussed in earlier sections; in general, having more information on permanent display reduces the stress level of the dispatcher and simplifies his tasks. Another point to be considered is that if the patrol units have the capability of directly updating the patrol unit status display by digital communications links, the patrol unit status display should be permanently on the screen; otherwise the dispatcher would not be aware of status changes without additional provision for flashing the display. Even with this provision, the stress level would probably be higher than if the patrol unit status display were continuously present on a screen.

6.4.5 "Smart" Terminals vs. Standard Terminals

For our purposes, a "smart" terminal is one that has the following capabilities located in the console:

- At least two full display pages on its local memory.
- Capability for entering and editing display information on the locally stored pages.

A standard terminal has none of these capabilities except that it has the refresh memory for the display on its screen or screens. All display changes are executed by the central processor and transmitted to the terminal.

The advantages of the smart terminal are:

- Makes changes in display or keyboard software easier to implement.
- Reduces the work load and I/O requirements on the central processor.
- Permits a degraded mode of operation if the processor fails; the dispatcher is still able to maintain his patrol unit status display and his incident summary data for local update and terminal-to-terminal message exchange through appropriate patching at the multiplexer assembly.

The cost of smart terminals has decreased steadily as a result of the introduction of microprocessors; their use should be given serious consideration by the planner.

6.4.6 Response Time Trade-Offs

Some of the design decisions to be made for a CAD system involve an increase in response time with a corresponding reduction in equipment size, complexity of software, and costs. A few such trade-offs are briefly discussed below.

Data Transfer Rates. The time required to generate or update a display is affected by the data transfer rates from the processor to the display. A standard serial data interface can transfer a full display of 1920 8-bit characters in 1.6 seconds (9600 bits per second). A more expensive byte parallel buffered direct memory can generate a full display in 3.8 milliseconds.

Core vs. Disc Memory. It is possible to reduce the core storage requirements by having more data stored on disc, with a consequent increase in system response time because the data must be transferred from there instead of from the direct-access core.

Firmware vs. Software. Firmware is the term for frequently-used routines that are programmed in a read-only memory and executed much faster than if programmed in the normal manner under processor control. Examples of routines that are amenable to firmware are communications I/O handlers that always perform exactly the same function.

Programming Language. Higher-level languages such as FORTRAN, Basic and COBOL are advantageous from the cost and convenience standpoints during development and for software maintenance; however, program execution times (and therefore system response times) are improved by programming in assembly language. Object code execution time typically increases by a factor of 1.5 for a routine coded in a higher-level language rather than in assembly language. Run-time executions of higher level coded programs have even greater execution time penalties.

Drum vs. Disc Storage. Response time can be improved by the use of drum storage devices rather than disc storage, but the large increase in cost is not likely to be worthwhile for a CAD system.

6.4.7 Future Additions to the Command and Control System

Future additions to the command and control system that the planner may be considering, and that have a direct effect on the design of the CAD system, are briefly discussed below.

911 ANI/ALI. The nationwide emergency number 911, as it is gradually implemented, can include a feature that may improve incident processing time significantly. This is Automatic Number Identification (ANI) and Automatic Location Identification (ALI). Where this interface is available from the telephone company, it provides automatic identification and display of the calling telephone and its location. This information is displayed on the CBO console and automatically becomes part of the incident data transferred to the dispatcher. This feature is especially attractive for dispatching, since it has been determined that about 80 to 90 percent of incidents reported are at the same location as the telephone used to report them or within a few houses of the telephone. This not only saves the time of entering the data, but simplifies the address and jurisdiction verification by the system.

Automatic Patrol Unit Status Update. Where patrol units are equipped with mobile digital terminals with two-way digital transmission, it is possible to have the patrol units transmit digital status messages directly to the processor (through appropriate logic and switching circuits), which updates the status displays. This reduces the load on the dispatcher, who no longer has to listen to voice status messages and enter the status change on the console keyboard. It also reduces the voice channel loading. If the system is to be implemented at the same time as the CAD system, or if the fleet is already equipped with two-way mobile digital terminals, this reduction in workload can be included in the system sizing calculations.

Direct Data Base Queries. This is another capability that can be provided if the patrol units are equipped with two-way mobile digital terminals. Through appropriate switching circuits in the command and control center, patrol units can transmit queries directly to the remote data base and receive the replies directly on their mobile terminals. This results in a significant reduction in dispatcher work load if the dispatcher is handling these queries, and system sizing calculations should reflect the reduction. Where this capability is provided, however, provision is also made for automatic logging and printout of any "hit" responses; such provisions must be included in the system design.

Automatic Vehicle Location. There are several different techniques for automatically determining the position of all vehicles in the fleet and transmitting this information to the command and control center. Where such a system is implemented, it reduces the work load on the dispatcher by eliminating the task of updating the patrol unit status file. It also helps him locate more quickly and efficiently the nearest unit to an incident.

Most techniques for automatic vehicle location require extensive calculations, which should be handled in a separate processor. The planner should not expect to have the CAD processor handle this additional load.

7. PLANNING GUIDELINES: PREPARING THE IMPLEMENTATION PLAN

The planner considering implementation of a CAD system for his department will need to prepare an implementation plan. This plan is a systematic way of identifying all the things that must be done to make the new system operational, and of evaluating the costs and other effects of each step in the implementation. It may even be desirable to prepare two or more alternative implementation plans as a basis for making a thorough comparison of two or more different systems or configurations of a given system.

The major elements of the implementation plan are an overall schedule and a funding plan. The schedule should have at least the following major activities on it (with sub-elements where appropriate):

(1) Precontract phase.

(2) Procurement of the system.

(3) Facility preparation.

(4) Installation and checkout of equipment.

(5) System demonstration and acceptance.

(6) Personnel training.

(7) Maintenance.

Other items that may be required in some cases are:

(8) Agreements with other local agencies that may be affected.

(9) Connections with remote data bases (local, state, federal).

(10) Time-phased implementation (some optional features or additional capacity to be added at a later date).

(11) Implementation of a CAD as part of a complete automation program for the department or agency.

The funding plan should show complete cost estimates for all items of expense plus a breakdown of anticipated expenditures by fiscal year from the start of funding to completion of system implementation. It should also cover expected maintenance costs. The elements to be identified in the funding plan are in general:

(1) The department (or other local agency) program management office.

(2) Consulting or systems engineering support, if such support is planned.

(3) Procurement of equipment and software.

(4) Facilities acquisition and preparation.

(5) Logistics (training, maintenance).

A sample implementation plan is given below to illustrate the above points. It covers implementation of the CAD system described and sized in Chapter 6. The planner will probably wish to add more detail to the basic plan given here as an example.

A CAD system is most often procured as a turnkey system provided by a single vendor for a stated price. Nevertheless, the procuring agency will want to specify the components of the system.

A private firm may be contracted to perform an analysis of requirements, generate system preliminary designs, and prepare specifications.

Table 17 is an equipment list for the example. Note that monthly maintenance costs are included in the cost estimates. The maintenance cost provides for full-service coverage 24 hours each day and includes replacement parts, scheduled preventive maintenance, and factory updates on the equipment item concerned.

Figure 16 is a top-level schedule for implementing a CAD system, listing the major activities with their start and end dates.

Summary costs for the complete system implementation are given in Table 18. The elements in the table are defined as follows:

Program Management Office. This item covers the cost of setting up and maintaining, within the procuring agency, a program management office of six persons. This staff is responsible for preparing the request for bids, evaluating the bids received, maintaining the interface with the selected vendor, and coordinating the CAD system implementation with the day-to-day police operations and with any local government personnel involved in the implementation.

Travel. This sum is provided to cover the travel required for consultation with departments in cities that have already implemented CAD systems, and any required travel to the vendor's plant.

Table 17. Equipment List

Item	Qty	Unit Cost, $K	Total Cost, $K	Unit Monthly Maintenance Cost, $
1. CAD minicomputer with 16K words of core and standard options (power fail, real time clock, etc.)	2	20.0	40.0	340
2. 16K word memory add-on modules; 3 each/processor	6	6.5	39.0	195
3. Direct memory access unit	2	4.0	8.0	80
4. Dual CPU interface unit	1	3.0	3.0	25
5. Memory protect unit	2	1.0	2.0	10
6. Interrupt expansion chassis	2	1.5	3.0	15
7. Communication multiplexer	2	4.0	8.0	120
8. TTY with paper tape read/punch	1	6.0	6.0	68
9. Dual access 25 megabyte disc controller + 2 25 Mbyte servos	1	41.0	41.0	275
10. Card punch (100 CPM)	1	30.0	30.0	162
11. Card reader (300 CPM)	1	4.0	4.0	24
12. Line printer (600 LPM)	1	18.0	18.0	125
13. Magnetic tape (75 IPS, 800/1600 BPI, 9 track)	2	17.5	35.0	210
14. Time code generator	1	3.5	3.5	25
15. Console printers	4	1.5	6.0	40
16. CRT/KB terminal (single CRT)	18	4.5	81.0	540
17. CRT monitor (for dual CRT consoles)	9	2.5	22.5	135
18. Consoles/radio switching	9	13.3	119.7	1,200
19. Interface signal conditioner/buffer multiplexer (32 channels)	1	64.0	64.00	320
20. Miscellaneous cabling and cabinets	1	10.0	10.0	
21. Uninterruptable power systems (U.P.S. 10 KW)	1	30.0	30.0	1,200
22. Modem 2.4K BPS	2	1.5	3.0	5
23. Microfiche viewers	10	2.5	25.0	470
Equipment Totals			601.7	5,584

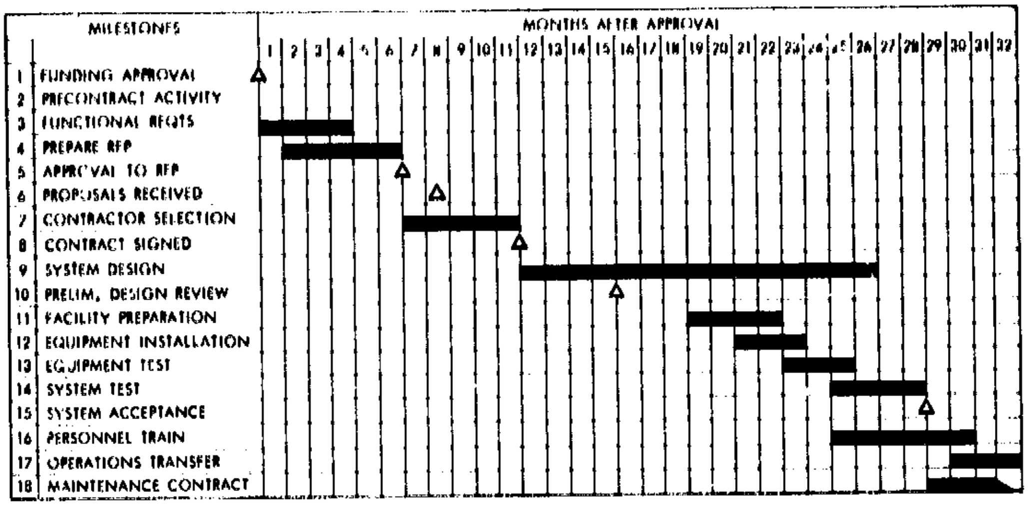


Fig. 16. Overall schedule of activities

Facilities. It is assumed that the command and control center using the new CAD system will be housed in new or remodeled quarters. The cost estimate includes air conditioning, smoke and fire detection system, raised floors to allow cabling between consoles, computers, and other equipment, and the required power supply and grounding system. The changeover from the old to the new system is simplified by having the new system in a separate facility where it can be thoroughly checked out and the personnel trained before the transition is made.

System Contractor/System Procurement. This item covers all the costs of procuring the completely installed and checked out system from the vendor.

Items Not Shown. Some costs that must be allowed for but for which no costs are estimated because of the wide variation in possible costs are:

- Telephone equipment and leased lines required for the new facility over and above those currently used (duplicate costs will be incurred during the period when both old and new facilities are operating).
- Relocation or replacement of office equipment.
- Supplies (tape reels, printer paper and ribbons, spare disc packs, etc.).
- Agency personnel costs in developing data files, training scenarios, etc.

Naturally the equipment and other costs shown here may vary since prices can change quickly and the prices shown are catalog prices that may be subject to discounts. The planner will have to develop his own estimates, and for this purpose will find it indispensible to talk with departments in cities that have implemented CAD systems of their own. It will be most useful to contact cities of comparable size and having systems similar to the one (or ones) he is considering.

Table 18. System Implementation Cost Estimate

		Item		Cost
1.		Program management office		
	(a)	Senior Police Officer	30 months X $2,000	$ 60,000
	(b)	Police Officer	30 months X 1,400	42,000
	(c)	Administrative Analyst	1/2 time 30 months X 1,600	24,000
	(d)	Communications Engineer	30 months X 1,800	54,000
	(e)	Data Processing Engineer	30 months X 1,800	54,000
	(f)	Clerk Typist	30 months X 750	22,500
			Total salaries	$ 256,500
			Employee benefits (30% of salary)	77,000
			Total personnel services	$ 333,500
			Office equipment and supplies	10,000
			Total program management	$ 343,500
2.		Travel		$ 6,000
3.		Facility (upgrade)		$ 100,000
4.		System contractor/system procurement		
	(a)	Hardware development and test (30 MM* @ $3500/MM)		105,000
	(b)	Software development and test (70 MM @ $3500/MM)		245,000
	(c)	Equipment cost (Table 17 + 9-month maintenance)		652,000
	(d)	Equipment procurement and transportation		62,000
	(e)	Engineering services (24 MM @ $3500/MM)		84,000
		Training	6 MM	
		Acceptance test	2 MM	
		Phase over + monitor	5 MM	
		Documentation	7 MM (equivalent)	
		Miscellaneous	4 MM	
	(f)	Travel and subsistence		30,000
	(g)	Program management (20% direct labor cost)		87,000
				$1,265,000
	(h)	Contractor fixed fee (10%)		127,000
		Total System Contractor Cost		$1,392,000
		Total Estimated Cost		$1,841,500
5.		Equipment maintenance (per year)		$ 67,000

*MM = man-month

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8. PLANNING GUIDELINES: COST BENEFITS ANALYSIS

The decision by an agency to purchase a computer-aided dispatch system will be strongly influenced by an overall evaluation of costs vs. benefits, particularly firm or "hard" benefits that are visible to agency managers in the form of reduced costs. We can list a number of benefits that can be expected to follow from the implementation of a CAD system, based on the general goals of computer-aided dispatching, which are:

- Increase the efficiency of command center operations by providing: a real-time capability for entering and updating incident information, dynamic displays of field units available for dispatch, real-time displays of service call backlog, and a faster means of getting supporting information to the field officers.
- Increase the efficiency and safety of the patrol officer by getting him more information in a timely manner and minimizing his paperwork, as well as the paperwork of the entire operational staff.
- Provide near real-time management information on the patterns of crime and other incidents, on the utilization of field forces, and on the general operational effectiveness of resource utilization.

Specific benefits that can be identified from the general goals include:

(1) Improved officer safety.

(2) Reduced crime rate.

(3) Shorter response time to citizen calls.

(4) Reduced paperwork load on field officers.

(5) Reduced paperwork load on command and control center personnel.

(6) Faster and more complete information on crime patterns.

(7) Faster and more complete information on patrol force activities.

(8) Improved utilization of field forces.

(9) Improved utilization of command and control center personnel.

(10) Improved interface with the community, and with other agencies.

Not all of these factors, and certainly not the most important of them, can be expressed in dollar terms. Our approach will be to compute dollar values where possible, and to indicate qualitative benefits that are claimed or have been demonstrated for CAD.

Of the benefits listed, items 3, 4, and 5 can be quantified, and give some indication of the improved utilization of field and command and control center personnel, items 8 and 9. Improvements in these items will have a positive effect on the other factors mentioned, but the effects are difficult to quantify or convert to dollar values. The impact of changes in patrol operations on factors such as crime rate and community relations is difficult to measure even in carefully controlled experiments, and too little data exists to form a good basis for developing trade-offs of personnel utilization vs. reduced crime rate, etc.

Two agencies have evaluated their CAD systems and developed estimates of cost savings; these agencies are the Huntington Beach Police Department (HBPD), and a consortium of three departments, including Oak Park, River Forest and Forest Park, Illinois, that operates a cooperative dispatch system (Appendix C). Summaries of their evaluations are presented in Tables 19 and 20. Both summaries apply to CAD systems serving populations of 150,000 (the three-department cooperative CAD system serves an actual population of 92,000, but the results have been adjusted for purposes of comparison). The estimated savings for the three-department system are considerably higher than those for HBPD, $168,840 per year vs. $22,920 per year. The difference lies primarily in the estimated savings for preparation of unit activity reports: it is assumed that activity reports for field units are generated entirely by the computer for the three-department system at a saving of 15 minutes per report (43,800 reports per year), vs. a saving of 2.9 minutes per *incident* for the HBPD (47,000 incident reports per year). The higher estimate may not be realizable in actual practice because field officers must dictate *some* notes to a transcriber in lieu of written reports. The two estimates should represent minimum and maximum cost savings for this function. Both agencies enumerate other areas for potential cost savings, primarily in the preparation of management reports (UCRs, incident patterns by beat, time of day, etc.). Much or all of the data base for these reports is captured by the computer and it is relatively straightforward to implement a report generation capability.

Table 19. Cost Benefits Analysis for Huntington Beach Police Department CAD System*

System: Single agency CAD system serving a population of 150,000	
Man-Hour Reduction:	
1. Dispatch operations	
Transfer complaint	77
Review and sort calls	51
Record response time	230
Enter file number	51
Record status by time	360
	769 hours per year
2. Officer report preparation	
47,000 reports X 0.048 hours per report	2,176 hours per year
Cost Savings:	
1. Dispatch operations	
769 hours X $6.30 per hour	$ 4,840
2. Officer report preparation	
2176 hours X $8.31 per hour	$18,080
	$22,920 per year

*Anon., *Computerized Command and Control, Huntington Beach Police Department.*

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Table 20. Cost Benefits Analysis for a Multiagency CAD System*

System: Multiagency CAD system serving a combined population of 150,000

Cost: $200,000

Savings:

1. *Terminals and telephone lines.* A saving is realized by canceling the lease on the terminal device connected to the state criminal justice information system; connection is made through the AID System. There is also a saving on the leased telephone lines. The lease of the terminal device and telephone lines is estimated at $250 per month per city. The cost of the AIDS telephone line is estimated at $150 per month. The estimated saving is:

   (3 x $250) - $150 = $600 per month

2. *Index cards.* Many of the data items (name, date, time, location, type of incident, incident number, stolen property, etc.) which are indexed from incident reports for entry into a record system are captured by AIDS during the normal dispatch operation. Items not captured during the dispatch operation are added through terminals. Procedures are provided to permit semiautomatic printing of name, incident, location, and property index cards. The estimated saving is:

   (100 incidents per day) X (0.1 hour of clerical time saved per incident) X ($4 per hour) = $40 per day or $1,200 per month.

3. *Unit activity report.* The AID System prints out unit activity reports for each patrol unit per 8-hour shift. This report eliminates the need for officers to submit a handwritten report that a clerk must type and file. Assuming 30% of 360 sworn personnel are required to fill out reports, the cost saving is estimated at:

   360 officers X 30% X (0.25 hour per report) X ($7 per hour) = $189 per day or $5,670 per month.

   The clerical saving is estimated at:

   30% X 360 officers X (0.25 hour per report) X ($4 per hour) = $180 per day or $3,240 per month.

4. *Daily log.* The AID System prints a daily log for all activities. The estimated saving is computed as:

   (3 agencies) X (2 hours per agency per day) X ($4 per hour) = $24 per day or $720 per month.

5. *Ticket listings.* The AID System generates a listing of all dispatch tickets as often as required. Estimated saving = (3 agencies) X (2 hours per agency per day) X ($4 per hour) = $720 per month.

6. *Management report.* The AID System prints out management reports on department activity on a daily, weekly, and monthly basis. Estimated saving = 3 agencies X (160 hours per agency per month) X ($4 per hour) = $1,920 per month.

Total savings for this hypothetical installation are:

Terminals and telephone lines	$ 600
Index cards	1,200
Unit activity reports	8,910
Daily log	720
Ticket listing	720
Management reports	1,920
	$ 14,070 per month
	$168,840 per year

*Based on the Automated Interactive Dispatch System (AIDS) for Oak Park, River Forest, and Forest Park, Illinois. Reference: A.B. Carroll, et al., *Computer-Aided Dispatching for Law Enforcement Agencies*, Community Technology Inc., Champaign, Illinois.

We can estimate the cost savings for our example CAD system designed to serve a population of one million by scaling the values given in Tables 19 and 20. The potential savings are in three main areas:

(1) Dispatch operations.

(2) Preparation of field activity reports.

(3) Preparation of management reports.

The first item accounts for the amount of time saved in processing calls for service and dispatching field units. The estimates for HBPD are used, scaled on the basis of population:

5,122 hours X $5.74 per hour = $29,400 per year*

In addition, a small amount of time is saved for address verification and beat number look-up. An estimate of 8 seconds per call has been made for this function based on studies of the Los Angeles PD operations. For one year of operation:

811 hours X $5.74 per hour = $4,650

The HBPD value of 2.9 minutes per incident reduction in field officer time for incident report generation is used for item 2:

14,120 hours X $9.75 per hour = $137,700

This savings is reduced, however, because of the added cost for transcribers who receive the telephone reports from the field officers:

8,077 hours X $5.74 per hour = $46,400

leaving a net saving of $91,300 per year.

Management reporting at HBPD requires approximately 40 hours per week. It is estimated that one-half this time can be saved by a computer report generator. For our city of one million population the comparable saving is:

6,930 hours X $5.74 per hour = $39,800 per year

This gives total savings for all three items of:

		Savings per year
(1)	Dispatch Operations	$34,050
(2)	Field activity reports	91,300
(3)	Management reports	39,800
	TOTAL	$165,150

Over a 5-year period, these savings amount to:

$165,150 X 5 = $825,750

This saving compares to our implementation cost estimate of 1.84 million dollars. If the higher value of cost savings for item 2 were used, based on the three-department cooperative CAD system, the total 5-year savings would increase from $825,750 to over 3.9 million dollars.

*Labor rates used are based on HBPD.

APPENDIX A

PARTIAL LIST OF COMPUTER-AIDED DISPATCH SYSTEM DESIGN AND EQUIPMENT MANUFACTURING COMPANIES

Kustom Data Communications, Inc.
1010 W. Chestnut
Chanute, Kansas 66720

Motorola, Inc.
1301 E. Algonquin Road
Schaumburg, Illinois 60172

General Electric Co.
Lynchburg, Virginia 24502

PRC Public Management Services, Inc.
7798 Old Springhouse Road
McLean, Virginia 22101

Boeing Computer Services, Inc.
P.O. Box 708
Dover, New Jersey 07801

System Development Corp.
2500 Colorado Avenue
Santa Monica, California 90406

Public Systems, Inc.
1137 Kern Avenue
Sunnyvale, California 94086

E-Systems, Inc.
Garland Division
Box 6118
Dallas, Texas 75222

Sunrise Electronics
P.O. Box 163
Farmingdale, New York 11735

APPENDIX B

HUNTINGTON BEACH POLICE DEPARTMENT COMPUTER-AIDED DISPATCH SYSTEM*

1. Introduction

The HBPD services a rapidly growing city in the Orange County metropolitan area of Southern California. Its population in 1973 was 150,000, approximately 10 times greater than its 1960 population. Huntington Beach has a large daily influx of people during the summer months, so that the population actually served by the Police Department may be double the number of residents. The city covers 27 square miles and has relatively few topographical features that impede communications with its mobile fleet of 22 units (average deployment).

The HBPD received 57,000 calls for service in 1973. Two dispatchers and one complaint board operator are normally on duty to handle these calls and control the mobile units.

2. Computer-Aided Dispatch and Mobile Digital Terminal System

Huntington Beach recently installed and placed in operation an advanced computer-aided dispatch (CAD) and mobile digital terminal system. This system has proved highly satisfactory in operation, and is described in some detail to acquaint the planner with its characteristics and capabilities. A scenario depicting the sequence of events and dispatch and status displays during an incident (in this case, an armed robbery) is presented to better illustrate the operational procedures of a CAD system. A layout of the facility is shown in Figure B-1; Figures B-2 - B-4 present details of the operator stations and microfiche unit.

The computer aided dispatch system consists of a computer and keyboard/CRT terminals which enter, store, and display information relating to the incident, the status of the mobile units, and actions taken by the dispatcher to service calls. Hard copy printers provide permanent records of all transactions.

The mobile units are equipped with Motorola MODAT digital terminals through which the officer can indicate his status: Available, Enroute, At Scene, Investigating, Returning to Station. Mobile teleprinters in the mobile units receive dispatches and other information normally relayed by voice. Patrolmen make all other transactions by voice. The MODAT unit is shown in Figure B-5.

When a citizen phones in a complaint, it is taken by a complaint operator, who types in data at a CRT/keyboard. The data enter the main computer, which creates an incident record for that incident. The address and intersection are sent via phone lines from the police computer to a central computer located at the city's Data Processing Department; the latter computer contains a geographic file, including beat number for the location. These data are sent back to the police department for display on the dispatcher CRT screen. The status of units assigned to the identified beat is displayed on another screen. The dispatcher assigns a unit, types the data into a computer, and notifies the unit by voice-radio. The computer simultaneously sends a digital message to the unit's teleprinter, giving dispatch data about the new incident and historical data obtained from the geographic file.

Each unit has a status terminal which permits the patrolman to send a change in status, via digital radio, to the police department computer. The computer maintains an up-to-date table of the status of each unit.

The HBPD has incorporated silent alarms into the CAD in a unique manner. If a silent alarm sends a signal to the police department, the computer sends a canned message of data and advice to the units assigned by the dispatcher. The Huntington Beach Police Department has linked its silent alarm system to the CAD and to a microfiche file. Alarms show up immediately on dispatcher consoles. In addition, the microfiche file contains location, interior and exterior layouts, aerial photos, locations of protection devices, and highway blockade positions of each alarmed site. A dispatcher can study the fiche display and guide a patrolman via portable radio to a particular location (see Figure B-4).

Requests for data base queries are given by voice-radio to the dispatcher by the mobile unit. The dispatcher enters the request (e.g., vehicle license number) by keyboard, and the police department's computer sends the request to the remote data bases. Responses from the data bases are displayed to the dispatcher, who relays the data to the mobile unit by voice-radio.

Operational data are captured by Huntington Beach for management reporting purposes. Currently, the daily logs of

*We wish to extend our appreciation to the personnel of the Huntington Beach Police Department for their assistance and cooperation in preparing this Appendix on computer-aided dispatch.

incidents are typed out automatically by the computer; however, detailed management reporting will not be placed in operation for about a year.

3. Radio System

The HBPD recently installed a UHF radio system consistent with the county-wide police radio plan (Orange County). The county allocates the frequencies for all police departments in accordance with a master frequency allocation plan. The police channels are in the 455 - 460 MHz range.

The channel assignments for the HBPD are shown in Table B-1. The Orange County communications net provides intra-county links and access to the California Law Enforcement Telecommunications System (CLETS). Through CLETS, data base queries can be directed to person wants and warrants, stolen vehicles and Department of Motor Vehicles files at Sacramento, and to NCIC and NLETS. The Orange County Criminal Justice Information System also can be accessed on this frequency.

One base station transmitter site is connected by land line to the command center. No satellite receivers or microwave links are employed. Five portable radios are used per shift.

4. Example of a Computer-Aided Dispatch

An example of a computer-aided dispatch was conducted by the HBPD to demonstrate the operational procedures they have developed to utilize this new capability, and to illustrate the sequence of CRT displays and formats used by the complaint board operator and dispatcher in handling the incident. The CRT displays are perhaps the most important feature of a computer-aided dispatch system because the operators enter and receive all necessary information from these displays; cards, status boards, conveyor belts, and other traditional dispatching aids are eliminated. All activity now focuses on the CRT displays.

All inputs to the CRTs must be entered via keyboards. Some information is entered by the operators as the incident is being handled; other information has been loaded into the data files prior to the incident and is recalled by the operators, or automatically by the computer if it relates to the current incident. In a sense, this procedure is a "new way to run the railroad," and requires some reorientation on the part of operations personnel.

The process of entering all data into the computer system via keyboards gives the CAD system a major advantage in that data relating to all incidents and field force operations (activities, times, allocations of forces, incident rates, and locational patterns) can be processed automatically by the computer and printed in convenient reports for use by operations and management personnel. Ultimately, CAD should contribute to more efficient use of manpower and mobile forces, enhanced officer safety, reduced workload on operations personnel, and better management reporting because of reduced clerical workload and time involved in statistical report preparation. The degree of the advantages offered by CAD systems has not been established because of the newness of the innovation, but the potential is evident.

The HBPD has identified a number of advantages offered by CAD, primarily relating to the reduced workload for entering and capturing data concerned with operations. These time reductions include:

(1) Recording incident response times

(2) Entering file numbers

(3) Typing radio logs

(4) Updating unit status

(5) Recording unit status

(6) Entering complaint information

(7) Transferring complaint data to dispatcher

(8) Sorting incidents by area and priority

(9) Patrol unit status change (by patrolmen)

(10) Writing dispatch information (by patrolmen)

Table B-1. HBPD Channel Assignments

Channel Name	Number	Use	Base Frequency, MHz
Green	1	Local voice channel (dispatching plus digital status)	Duplex, 460.1
Orange	2	Tactical frequency linking other departments in that part of Orange County	Duplex, 460.4 460.2
Blue	1	County: data file (provides link to state data files through CLETS)	Duplex, 460.5
White	1	Local car-to-car without repeater	Simplex, 465.3
Red	1	County: broadcast	Duplex, 460.025
	1	Digital (to teleprinter)	Simplex, 512.65

For these functions, CAD is estimated to require 550 man hours per year versus nearly 4000 man hours per year for the old manual system.

Before studying the sample incident shown in Figure B-7, the reader should review the CRT format definitions given in Figure B-6. Format (a) is available to the complaint board operator; formats (b) and (c) are displayed to the dispatcher. Each has a keyboard to enter data into the system with the aid of preset formats that are called up on the screen to minimize operator typing workload.

The sample computer-aided dispatch described in Figure B-7 simulates an armed robbery. The scenario focuses on the procedures used by the operations personnel in dispatching and controlling mobile units assigned to the incident.

In the command center, the *complaint operator* has one keyboard and display for entering the citizen's call for service. The *dispatcher* has a keyboard and two displays and operates a radio console. One display shows the *status* of the patrol fleet, the other has *variable formats* for incident summaries, and incident disposition and other special reports.

In Figure B-7, column 1 describes the events in the robbery and column 2 the complaint writer's activities. Column 3 shows the changes in the incident display screen as the event takes place. Column 4 describes the dispatcher's activities, and columns 5 and 6 show the dispatcher's status and incident screens. The manner in which information is entered and retrieved from the display screens by the operations personnel is clearly demonstrated by this scenario.

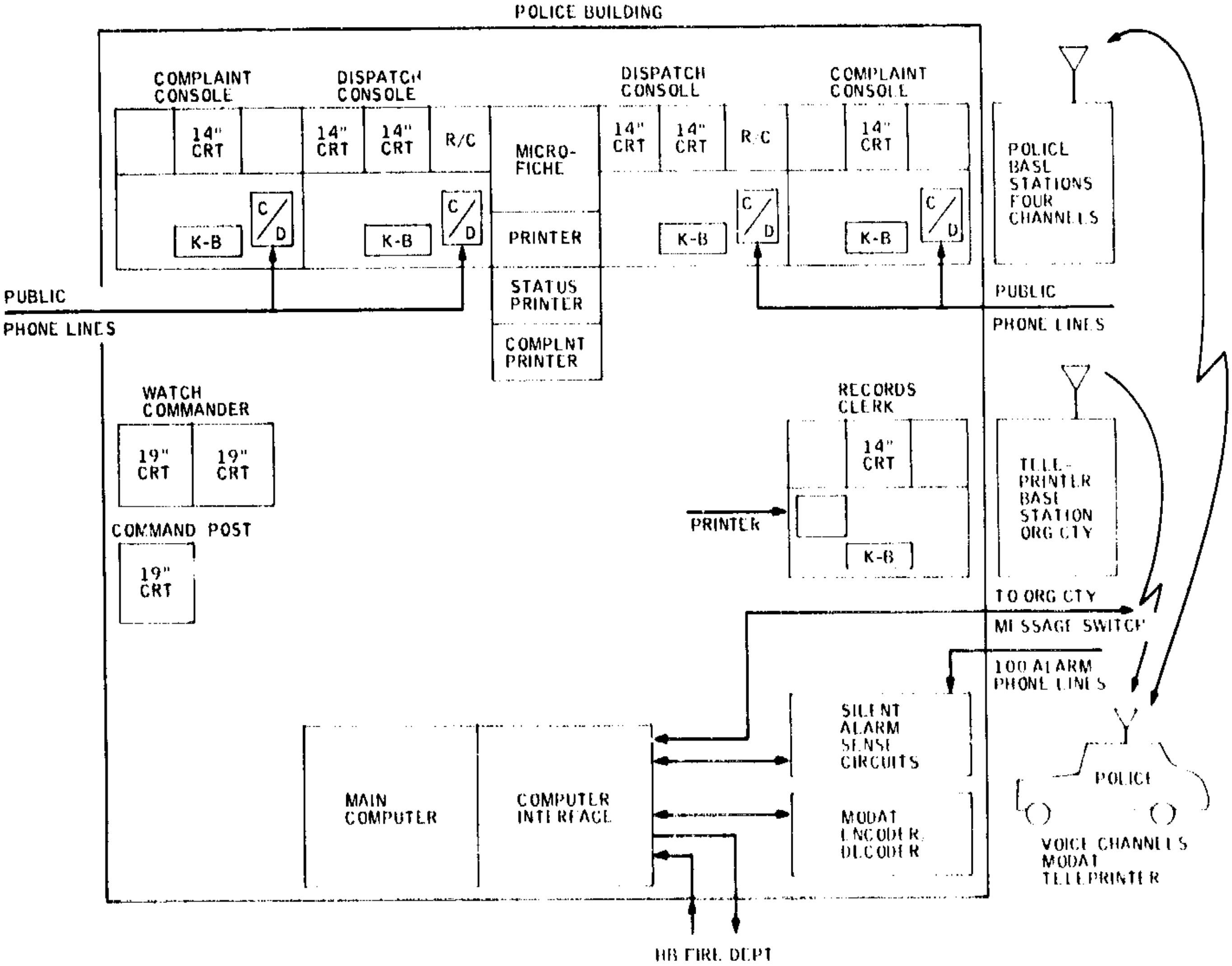


Fig. B-1. Huntington Beach Police radio system

Fig. B-2. The HBPD command and control console

Fig. B-4. Microfiche data file

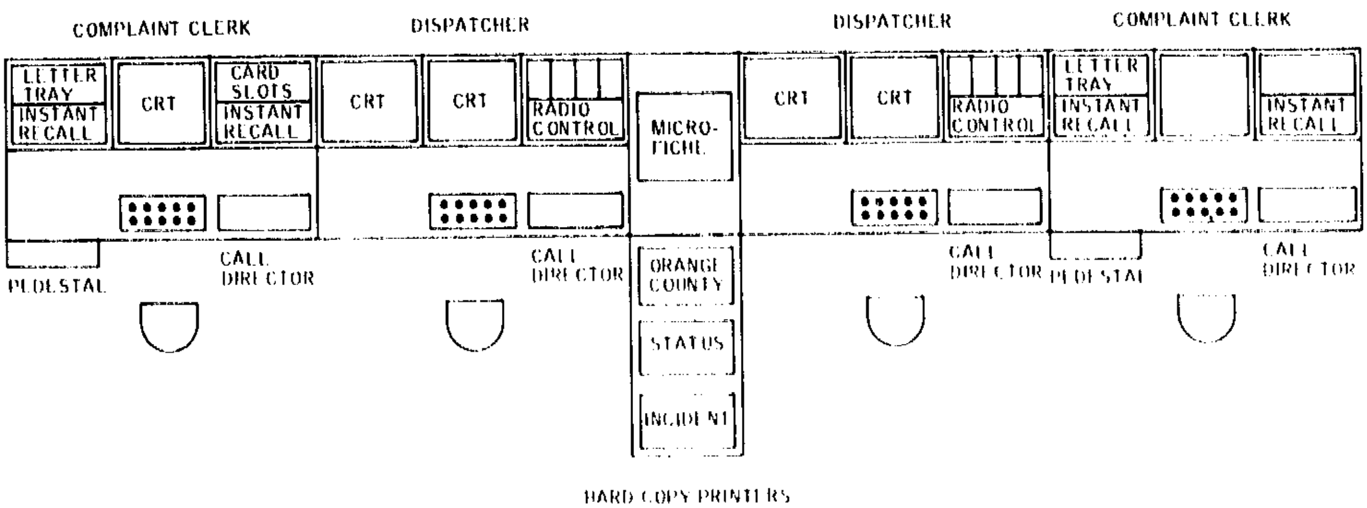


Fig. B-3. Console layout

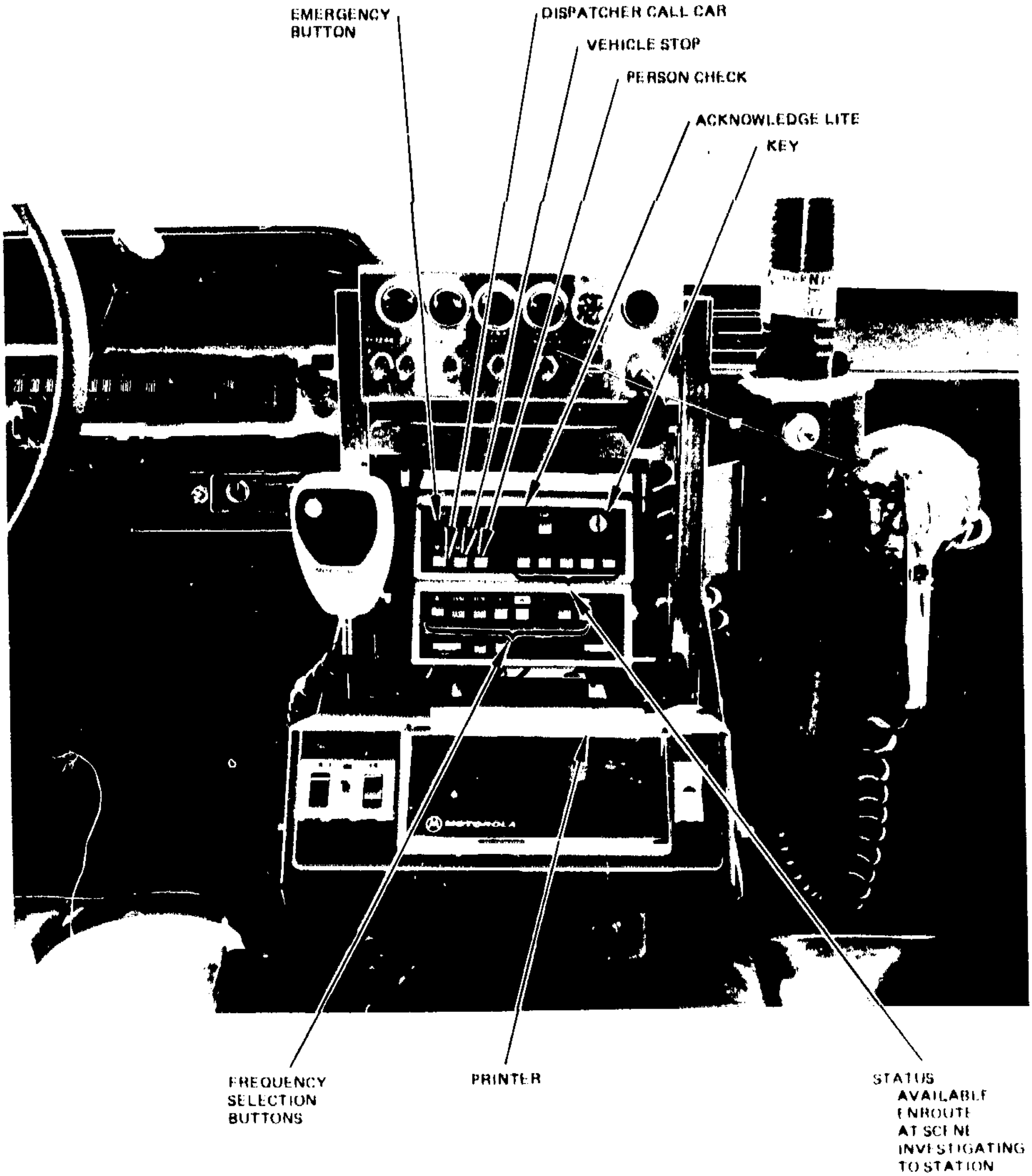
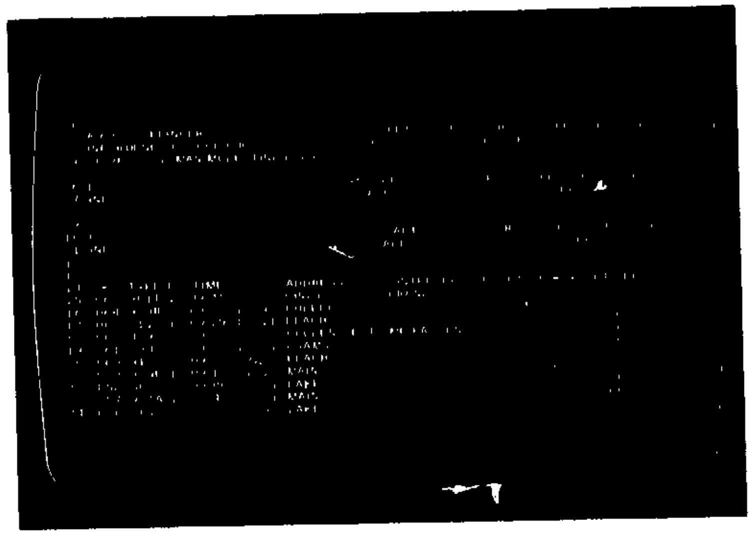


Fig. B-5. MODAT mobile digital terminal installation

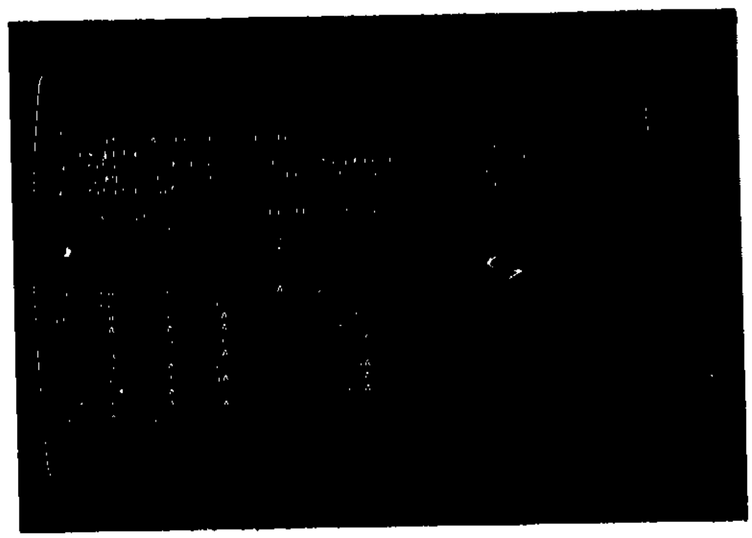
a. Complaint Entry Display

Lines 2-5 are used for detailed information fill-in by the operator and become part of the permanent computer record, which is automatically transmitted to and displayed on the dispatcher's incident CRT. Lines 6-9 and 10-13 are duplicate complaint entry formats. Lines 14-24 indicate the complaints, in order received, entered into the system. This information is duplicated at the dispatcher's incident CRT.



b. Status Display

Car numbers (corresponding to car types) are displayed under appropriate headings of AVAILABLE, ENROUTE, AT SCENE, INVESTIGATING, RETURNING TO STATION, OUT. This information is entered directly from the vehicle via the MODAT mobile data system. Where applicable, the case number to which a vehicle has been assigned is displayed next to the vehicle. The upper right-hand corner displays the backlog of unassigned incidents per beat. Line 2 shows unit 3A2 requesting a car stop check. Line 3 indicates that 314 has not been assigned to a mobile unit in the computer files. Line 4 indicates which mobile units are transmitting emergency messages. Line 5 shows other cars transmitting messages. Line 6 is the automatic ID number which appears whenever a mobile unit uses voice-radio.



c. Dispatcher Incident Display

A computer-assigned incident number appears on Line 2 as well as time received, nearest street (if applicable), Apt. No., reporting district, Fire Box No., and Beat No. Lines 3-5 indicate the name and phone number of the person reporting the incident, the unit(s) assigned to the incident, and the type, code, priority code, and description of the incident. Lines 10-12 indicate assigned but unresolved incidents, with the incident code on Line 9. The bottom portion of the screen displays an abbreviated version of the top portion of the screen: unassigned incidents, type code, time received, address, intersect street, reporting district.

Fig. B 6. CRT display formats

EVENTS LOG	COMP
	ACTIONS
0 At 9:00 a.m., January 10, 1976, two men enter a house at 2003 Main St., threaten occupant with a handgun, and take color TV.	
1 At 9:11 a.m., neighbor calls police complaint writer and says robbery in progress.	**2** Immediately puts call on microphone to dispatcher. She keys address of incident into her display, then transmits it to Burroughs 2500 computer for address verification. She continues to key in informant's name, address, phone number, and case description; transmits case to dispatcher. She asks informant to remain on line. Informant provides her with description of suspects (Screen A).
BURROUGHS 2500 TRANSACTIONS **4** Verifies address, provides cross streets, reporting districts, and beat and gives arrest warrant, emergency medical, gun registrant, narcotic registrant, and sex registrant information at that location on complaint writer's screen. The response usually returns within 6 sec, so that the complaint writer can ask the informant for additional data if the computer reports the address as invalid.	**5** Case reappears, showing cross streets. Other files negative. Complaint operator transmits to dispatcher (Screen B).
8 Patrolmen in cars 2C3, 26S3, 2A3 respond to call.	
9 Patrolmen send digital "enroute" messages to dispatcher.	

Fig. B-7. Armed robbery incident handled by computer-aided dispatch

ACTIONS

3 Alerts all cars by voice to robbery in progress at 2003 Main St.

6 Case appears on dispatcher's incident screen (Screen C).

7 Assigns 2C3, 26S3, and 2A3 to this case, Priority 2 (Screen D). She transmits assignment to teleprinters in all cars (see below). The printers retype the case with suspects' descriptions. The incident screen shows that the assignments have been received and acknowledged (Screen E). She also acknowledges the "enroute" message, at which time the PDP 11/20 changes the status screen for these cars from "available" to "enroute," with the case number 030 by each car (Screen F).

CAR TELEPRINTER MESSAGE SENT BY DISPATCHER TO PATROLMAN

[illegible] CS 030 OF [illegible] 75
[illegible]
2003 MAIN

ACT [illegible]

INF SMITH, [illegible]

2005 MAIN [illegible]
UNITS ACT 2A3 [illegible]

[illegible]
REPORTS ARMED ROBBERY [illegible]
NOW [illegible]
[illegible]
[illegible]
[illegible] MAIN

ACT [illegible]

STATUS DISPLAY

EVENTS LOG	COMPLAINT WRIT	
	ACTIONS	
10 At 8:14 a.m., the informant tells the complaint writer that the robbers are leaving the house and entering a car. She says she's going over to help her neighbors and hangs up. Car 2A3 arrives at scene; sees two men leave scene in blue 1972 Chevrolet sedan, with large box in rear seat. Patrolman reports to dispatcher that he a. Arrived at scene (digital message) b. Sees suspects and car leaving scene heading northward (voice message) He decides to pursue vehicle and by voice requests other cars to assist him.	11 Transfers informant's latest information to dispatcher by voice.	
13 Units 2C3, 26S3 arrive at scene to interview victim and send "at scene" digital message.		
15 Units 2A3, 26S3 stop suspects' car at intersection of Beach Blvd. and San Diego Freeway. 2A3 sends digital message "request vehicle stop" to dispatcher and gives vehicle license number to dispatcher.		
17 Patrolman in 2A3 finds TV set in car. He arrests suspects and returns to station to book them.		
18 Patrolman in 26S3 calls dispatcher for a tow truck; makes a Stolen Property Report on TV set, makes Vehicle Impound Report; waits for tow truck; then returns TV to owner.		
20 Tow truck arrives. Patrolman in 26S3 has driver sign Vehicle Impound Report; gives him a copy. 2A3 sends a digital message "to station," when he arrives at station.		
21 2C3, 26S3 complete victim interview and return to patrol. Each sends "available" status message.		

7

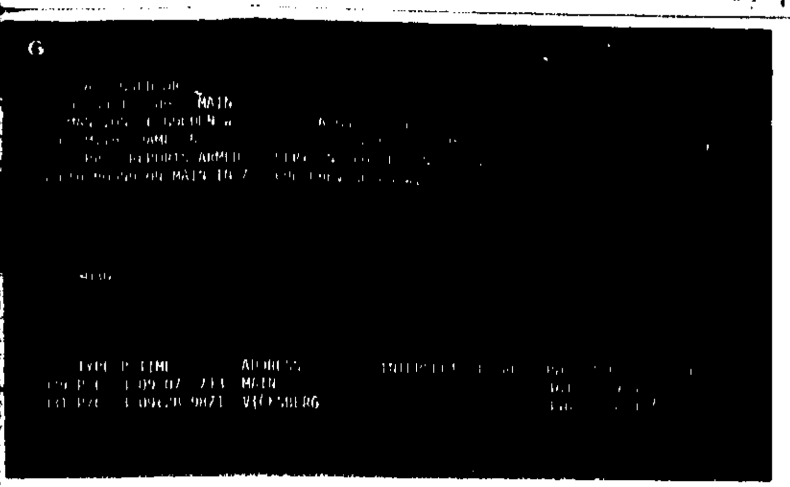
FOLDOUT FRAME

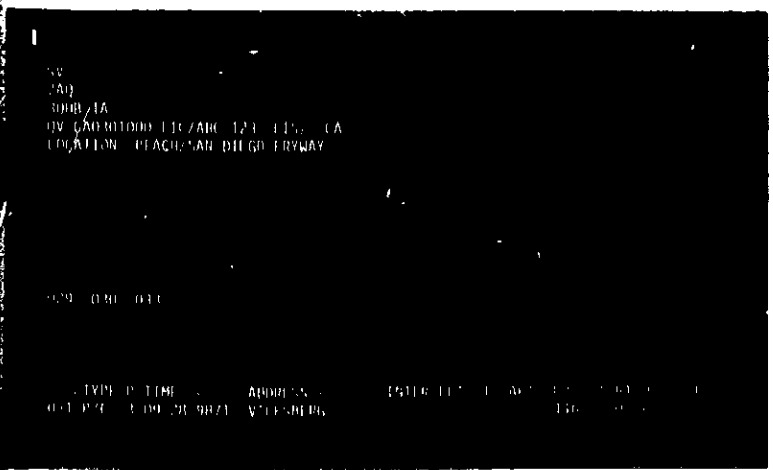
INCIDENT DISPLAY	ACTIONS
	12 Dispatcher enters new information. Sends digital message to all cars: "Two suspects in 1972 blue Chevrolet sedan observed leaving 2003 Main St., north-bound." The dispatcher contacts Orange County Communications by voice land line. The Orange County operator alerts the Sheriff and local police forces in jurisdictions adjacent to Huntington Beach by voice radio (red frequency) (Screen G).
	14 Dispatcher acknowledges "at scene" message. Status display now shows 2A3, 2C3, and 26S3 "at scene" (Screen H).
	16 PDP 11/20 brings up "stolen vehicle system" format. Sends teletype to CLETS. Return shows vehicle not stolen (Screen I).
	19 Dispatcher calls tow truck to meet 26S3 at Beach Blvd. and San Diego Freeway.
	22 "To station" and "available" status messages appear on screen (Screen J).

DISPATCHER

STATUS DISPLAY

INCIDENT DISPLAY





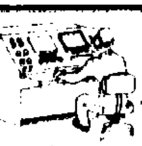
FOLDOUT FRAME

EVENTS LOG	COMPLAINT WRITER	
	ACTIONS	INCIDENT DISPLA
23 2A3 dictates Arrest Report in station house to transcribing section. The transcriber enters report from her keyboard in the format shown on the dispatcher Incident screen.		
25 2A3 returns to street; sends digital "available" message.		

FOLDOUT FRAME /

DISPLAY	ACTIONS
	24 Blank (Screen K) and completed screens for case clearance report for entry into police data file in Burroughs 2500 computer (Screen L).
	26 All three cars assigned to case 30, 2A3, 2C3, and 26S3, again available for assignment as shown on status screen (Screen M).

FRAME



STATUS DISPLAY

KEY TO CASE CLEARANCE REPORT SCREEN

D	7400101	Permanent file case number
C	02100	Classification (first-degree robbery)
T		Theft
O	3 22	Daytime (Wed., 2200 hr)
L	60	Location (code for single-family residence)
E	01	Entry (code for front door)
W	12	Weapon (automatic)
V	27213130	Vehicle (2, suspect vehicle; 72, year of vehicle; 13, code for Chevrolet; 1, code for sedan; 30, code for blue)
P	F300	Property (F, code for TV; 300, approximate value in $)
R	F300	Property recovered
M		Modus operandi
X		Research field
C	2	Clearance (2 indicates case cleared by arrest of adult)

APPENDIX C

A MULTIPLE JURISDICTION COOPERATIVE COMPUTER-AIDED DISPATCH SYSTEM

Three adjacent suburban communities in Illinois, in the vicinity of Chicago, recently installed a cooperative CAD system for use by all three police departments. The cities involved are:

- Oak Park, population 62,500.
- River Forest, population 14,400.
- Forest Park, population 16,000.

The system was designed and installed by a firm in Champaign, Illinois (Community Technology, Inc.) and began daily operation in April 1974. It is known by the trade name of AIDS (Automated Interactive Dispatch System).

Figure C-1 shows the configuration of the system in a simplified form. Note that it interfaces with the Illinois automated law enforcement data base (LEADS, Law Enforcement Agencies Data System) and with the NCIC, through the AIDS computer.

Figure C-2 is a more detailed block diagram of the Oak Park dispatch center, where the CAD computer is located, showing also the interfaces with the River Forest and Forest Park dispatch centers. Note that each of the departments has two dispatch positions with display and keyboard. Only the Oak Park department has a separate complaint operator and a special display position for the chief, enabling him to view any of the other active console displays.

As Figure C-2 indicates, the heart of the system is a Data General Nova minicomputer with 24K words of core storage plus its loader, restart device, and clock. The disk storage is a unit with a capacity of 28 million characters. Magnetic and paper tape drives are included in the system, along with a printer for general-purpose output from the computer. This is not the printer used by the dispatchers; the diagram shows that each department has a printer associated with the dispatching consoles.

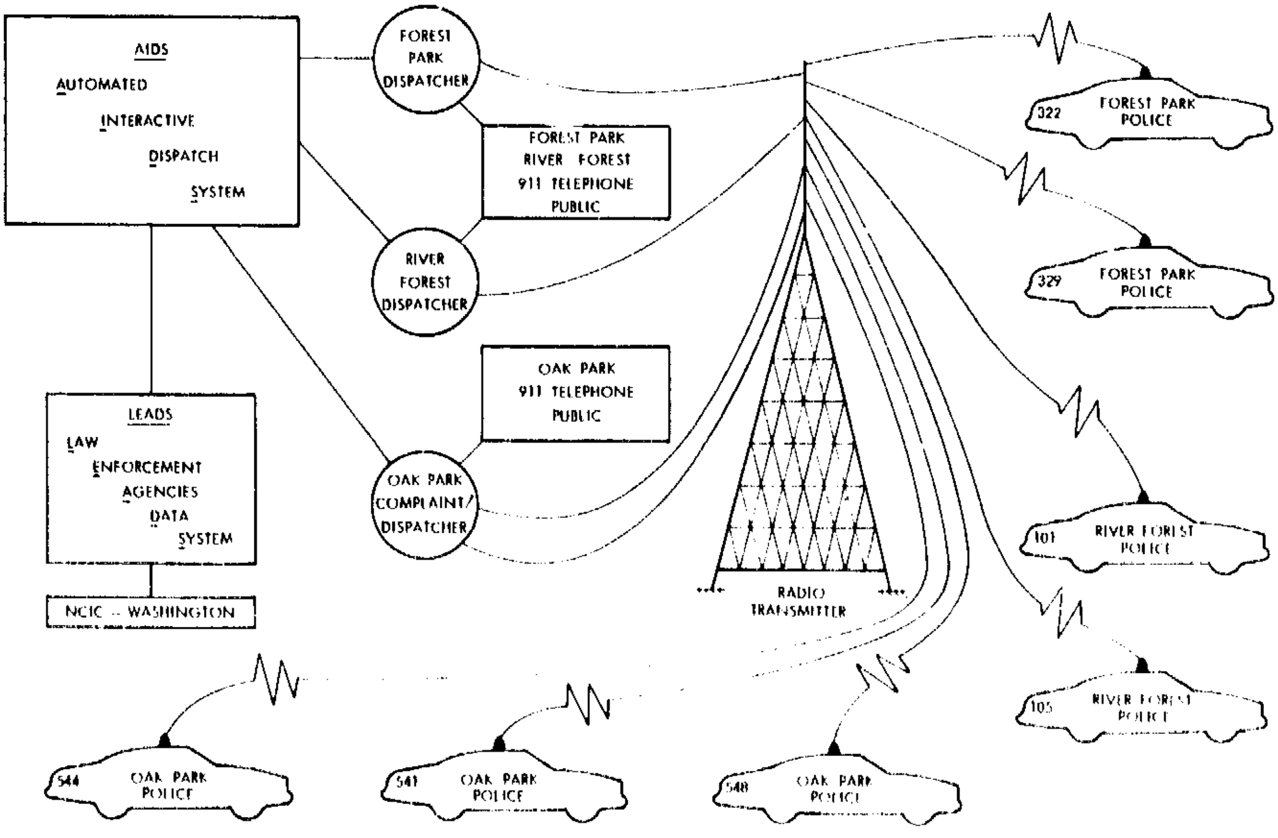


Fig. C-1. Communication system

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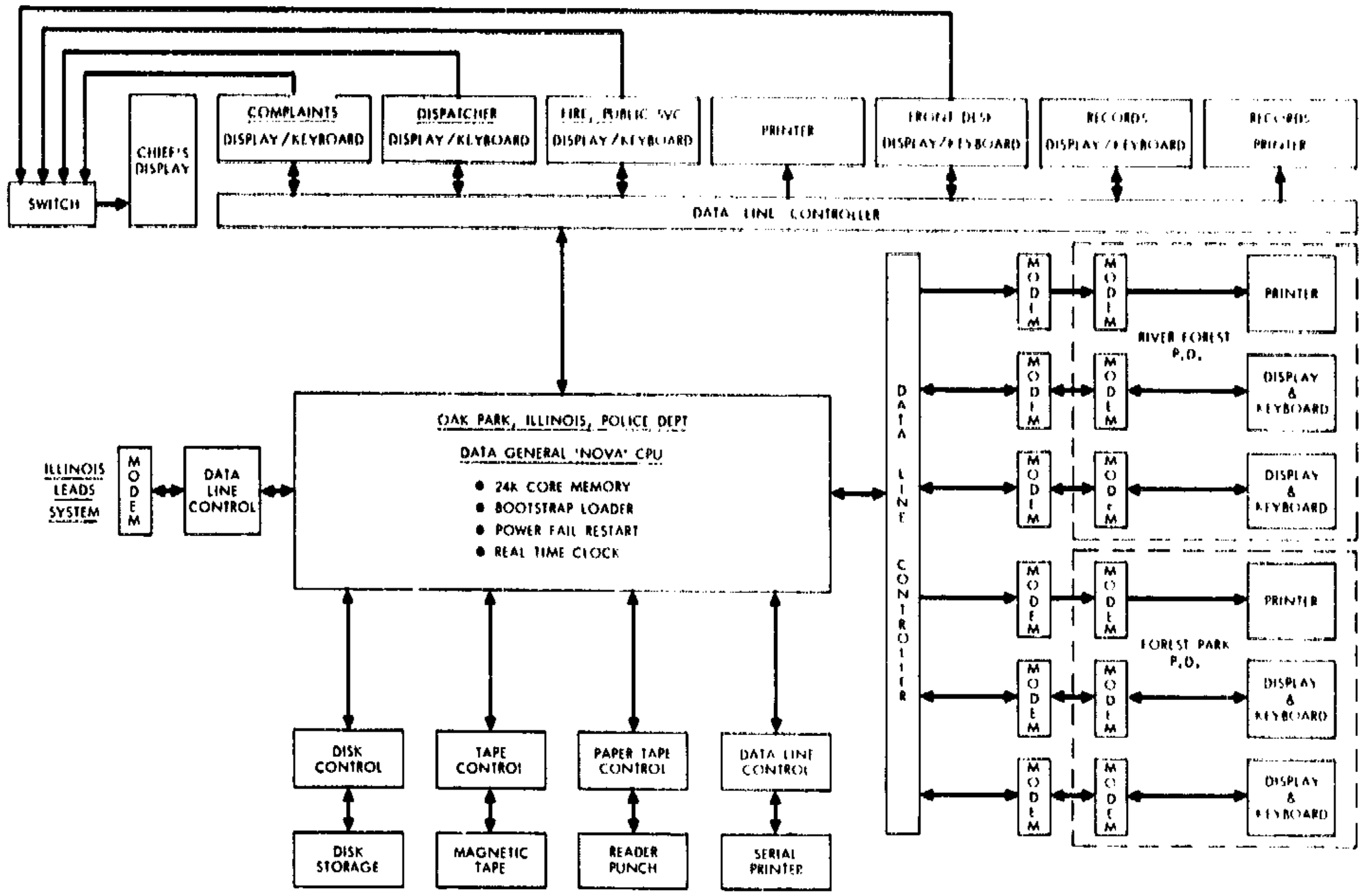


Fig. C-2. Oak park system block diagram

The consoles have single-screen displays. Each screen is divided into four areas. There are 24 lines altogether in the display (with up to 80 characters on each line), allocated as follows:

Line 1 - 11	Incident record* or responses from LEADS or NCIC.
Line 12	Queries to LEADS or patrol unit status update or NCIC.
Line 13 - 21	Unit status table or incident status table.
Line 23 - 24	Messages from the CAD system or from other operators.

*In this system an incident record is called a dispatch ticket.

Figure C-3 shows the alternate forms of the display. The operator can call up either type of information to the display area reserved for it, but with one screen he cannot have on view at the same time, for example, both the incident status table and the patrol unit status table.

The keyboard is illustrated in Figure C-4. It consists of an ordinary typewriter keyboard plus special function keys shown to the left and right. The keys on the left are editing keys for positioning the input and adding or deleting single characters or entries. The keys on the right are dispatch function keys with the functions listed in Table C-1.

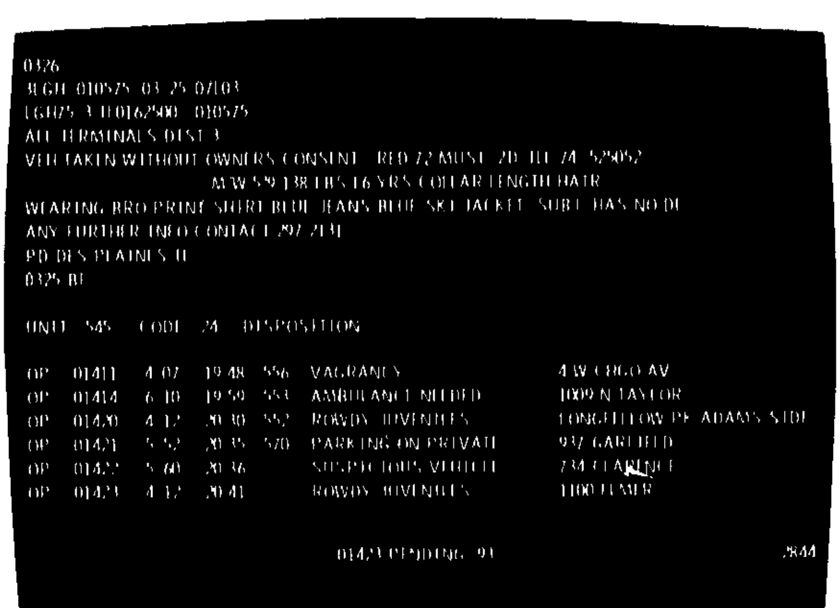
The operation of the system is summarized in Table C-2, which lists all the entries on the incident record (with number of characters alloted to each) and shows the source of the entry in each case. The important point to be noted is that the system itself automatically provides many of the entries with no intervention required by the operator or dispatcher. Serial numbers, dates, and all times are automatically entered by the

Dispatch Tickets

Criminal Justice System Inquiries

Unit Status

Message Area



Criminal Justice System Responses

Unit Status Update

Ticket Status

Message Area

Fig. C-3. Display formats

AUTOMATED INTERACTIVE DISPATCH SYSTEM

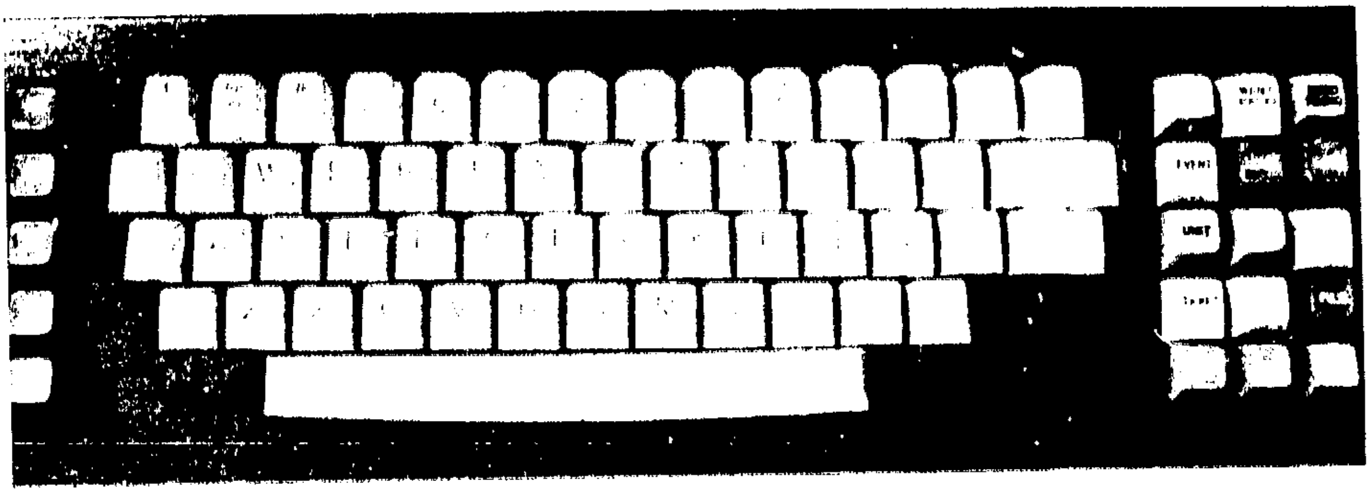


Fig. C-4. Automated interactive dispatch system: Keyboard layout

Table C-1. Function Key Operations

Key	Function
EVENT	Generates a new dispatch ticket for an incident, given a location and (optional) incident code.
TICKET	Recalls and displays a ticket given the ticket number. It is used with the STATUS key to display the ticket status file.
UNIT	Alters the status of a patrol unit, given the patrol unit number, a status code, and possibly some other data depending on the code. Used with the STATUS key to display the unit status file.
STATUS	Used as indicated above to display ticket and unit status tables. Also used with the LEADS key to display recent traffic with the LEADS system.
LEADS	Formats and transmits messages to the LEADS computer. Used with the STATUS key, as noted, to display LEADS messages.
PRINT	Causes dispatch tickets and LEADS messages to be printed out.
FILE	Assigns document control numbers to dispatch tickets.
MEMO	Performs limited message switching between consoles.
CLEAR	Clears the display screen.

Table G-2. Ticket Fields

Field	Size	Information Provided by: AID System	Complaint Operator	Dispatch Operator	Notes
1. Ticket number	5	X			
2. Control number	8	X			
3. Date	7	X			
4. Time	4	X			
5. Incident code	4		X		1
6. Incident	24	X			2
7. Location	24		X		1
8. Zone	4	X			3
9. Department	2	X			
10. Caller	24		X		
11. Victim	24		X		
12. Address	24		X		4
13. Telephone	7		X		4
14. Unit assigned	4			X	1
15. Officers	24	X			
16. Zone responding	4			X	1
17. Time assigned	4	X			
18. Time arrived	4	X			
19. Time completed	4	X			
20. Disposition	3			X	1
21. Assisting units	24			X	1
22. Received by	4	X			
23. Dispatched by	4	X			
24. Notes	216		X	X	

Notes: 1 For convenience, these fields are filled by the system with information obtained from the operator expressly for this purpose.

2 The information for this field is determined from the incident code, if one is supplied. Otherwise, it must be entered manually by the operator.

3 The information in this field is inferred from the location.

4 When Automatic Number Identification (ANI) or Automatic Location Identification (ALI) capability becomes available through the telephone system, these fields may also be automatically filled.

computer. On item 6, the type of incident is entered by the computer on the basis of the incident code entered by the operator. The zone is determined by the computer on the basis of the address given, and the department (city) is also entered automatically. When the dispatcher assigns a patrol unit the unit number is entered in the incident record and at the same time the unit status record is updated. The ID of the person receiving the call (complaint operator or dispatcher) is entered by the computer from its personnel roster, as are the names of the officers (or officer) in the patrol unit assigned. The computer maintains the link between the incident and the unit assigned, and makes the appropriate entries automatically. Thus, when the unit reports arrival on the scene, the time of arrival is automatically entered in the incident record when the dispatcher updates the unit status file. The same occurs when the incident is closed.

The console operator thus makes virtually no entries directly to the incident record once the initial basic information has been entered (whether by the complaint operator or by the dispatcher directly). By updating the status tables, he causes the required information to be entered automatically in the incident record.

Queries to remote data bases (LEADS and NCIC) are entered directly on the dispatcher's console, and the responses can be displayed there as soon as received (although they are printed out on the printer in any case). The computer automatically prepares queries in the correct format for the system being queried; this saves many unsuccessful attempts resulting from trivial format errors in the query.

The system keeps a time-ordered file of all events known to it, and all messages transmitted or received over the law enforcement information network are also recorded. This complete file is used as the source for unit activity reports and all statistical reports including the Uniform Crime Reports.

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