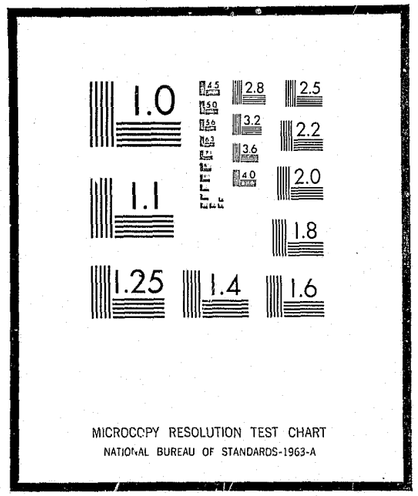

REPORTS, RECORDS AND COMMUNICATIONS IN THE BOSTON POLICE DEPARTMENT

A PROGRESS REPORT

Submitted to

Law Enforcement Assistance Administration
U.S. Department of Justice

by

Boston Police Department
Boston, Massachusetts

and

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Cambridge, Massachusetts

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I. INTRODUCTION

A. BACKGROUND

In the spring and summer of 1967, the Boston Police Department, with the assistance of Arthur D. Little, Inc., and with the support of the Office of Law Enforcement Assistance (grant number 153), made a survey of the Department's capabilities and problems in communications and information systems. This work was reported in reference (a). Some of the recommendations were implemented in the spring of 1968. In the summer of 1968 the Department, again with support from the Federal government and assistance by the same consultant group, began a more detailed examination and elaboration of potential solutions, together with implementation where possible.

This is a progress report on work done under Law Enforcement Assistance Administration (LEAA) grant number 346 to the Boston Police Department. The report summarizes and evaluates work completed, describes work now in progress, and projects future accomplishments.

B. OBJECTIVES

This project resulted from a subjective appraisal that the Department's communications, reporting procedures and records could be improved. The initial project objectives were:

- to determine needs and capabilities in each of these areas;
- to invent and evaluate ways to improve capabilities;
- to assess the impact of these improvements on operations and costs; and,
- to implement and evaluate the changes.

(a) Reports, Records and Communications in the Boston Police Department: A Systems Improvement Study. LEAA Project Report, May 1968.

As that project progressed a further set of objectives arose, based partly on a desire to exploit an existing computer capability and partly on a wish to provide new capabilities to the Department, in addition to improving established ones. Broadly speaking, these objectives are:

- to provide a real-time picture of field operations to allow a more efficient and responsive use of field forces;
- to provide access by field forces to a summary description of information in the central files concerning people, things and events;
- to provide District Stations with real-time information on the activities of forces responsible to them

C. THE APPROACH

Existing capabilities are there to be measured: they have been determined by studying records, watching and participating in activities and by interviewing people. Departmental needs are more difficult to determine and articulate. Personnel throughout the department have been consulted about their problems and the relevance of possible solutions.

A vast amount of data has been collected and examined. Analytic models of police operations have been constructed, as well as models of the flows of information. Detailed descriptions of how police carry out a number of tasks have been prepared. Most of the detailed work has been used to design a computer-controlled information system which will be described in this report.

D. ORGANIZATION OF REPORT

Part II is a very brief statement of the work done for this portion of the project. This part explains succinctly that some of the work accomplished is reported on here, some is available in other documents, and some will not be available. In the latter category are analyses and results peculiar to this department and of minimal interest or usefulness to others.

Part III, A, is concerned with communications. The elements and

means of communication are discussed, together with changes already made and the impact of those changes.

Part III, B, develops the conceptual framework needed to understand the total flow of information within the department, and to understand why the proposed changes are needed. This part examines the paper-borne information in some detail.

Part III, C, justifies the development of a computer-based command and control system which will not only improve the effectiveness of field operations but will eventually be the center for much of the information in the department. This part gives an overall description of the planned system and discusses its problems and requirements.

Several technical appendices are included to back up statements made in the body of the report. The major portion of the work done is reported on in two separate documents. One deals with field reporting, the other with functional specifications for the computer-based command and control system.

II. SUMMARY

The work of this phase of the project has included.

1. Detailed elaboration of the capabilities and needs of the department to collect, transmit, and use information.
2. Implementation and evaluation of certain changes.
3. Justification of a computer-based information system designed initially to control field operations.
4. Creation of a long-term development plan for the computer-based information system.
5. Development of functional specifications for the phases of the system associated with command and control of field operations.
6. Specification of hardware and some of the software required to implement the system.
7. Estimation of requirements for money and people.

This report deals in greatest detail with items 1, 2, and 3. It does not, however, report on an intensive analysis of investigative operations or on specialized studies in personnel matters. Items 4 and 6 are reported on briefly here. The functional specifications are available under separate cover. The estimates of cost and manpower requirements are not given here. They exist in a series of memoranda which are revised periodically as hardware and personnel costs rise inexorably.

The planned new reporting system, which falls under item 2, will be reported on separately.

III. RESULTS

A. COMMUNICATIONS

1. The Elements and the Means of Communication

Figure 1 illustrates the communication links between public and police, and among police units, as they were when this project began. Police units include headquarters, district stations, mobile units (patrol) and roadside call-boxes. Figure 1 also shows the current, or "new", communication links.

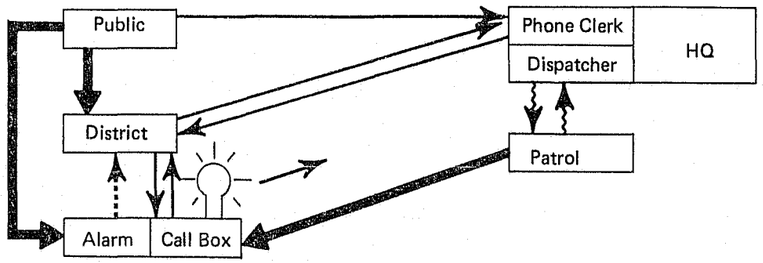
The nature of the police units is generally well understood, with the possible exception of call-boxes. Each call-box is topped by a light which may be flashed to gain the attention of officers who may be within sight. Each call-box also has a "citizens' alarm" which can be actuated by the public. The alarm sends a telegraphic message, coded to identify the location, to the appropriate district station. Someone at the station then calls a phone clerk at headquarters to initiate response by patrol.

In addition to the telegraph link from citizens' alarm to district station, the elements are linked by telephone lines, radio, flashing lights and by face-to-face meetings. Citizens sometimes walk into a district station and occasionally stop a patrol car or officer on the street.

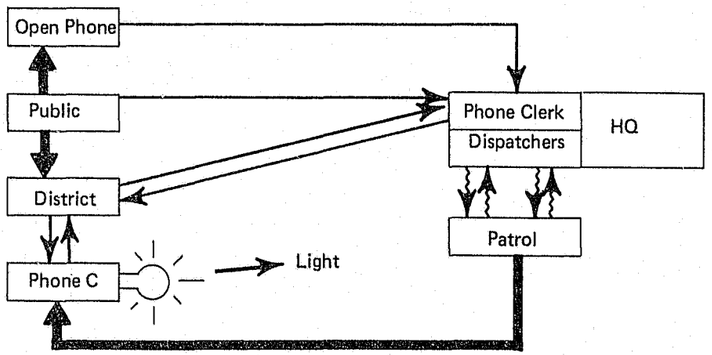
Each of the communications links will be discussed in turn, in terms of its problems and their solutions.

2. Public to Police

The public can contact the police by physically walking into a district station, intercepting a patrolman on foot or in a car, going to a call box and pulling the alarm, or calling police headquarters on the telephone. Most public contact is to headquarters on the police emergency lines. There is a small number of calls directly to district stations on administrative lines, but this is discouraged, both because



a. OLD



b. NEW

Legend:

Physical Proximity
Telephone
Radio
Telegraph

FIGURE 1 CHANGES IN COMMUNICATION LINKS

it wastes time during an emergency and because such calls often fail to get recorded in the log of Department activity.

a. Emergency Telephone Lines

The arrival rate of calls to the Boston Police emergency number has had an upward trend for several years. This seems to be true for most large cities. An increasing fraction of calls results in police response. The effect has been to increase the total work load of the police, in terms of message traffic, incidents investigated and reports generated.

Two important problems are to insure that enough telephone trunks are associated with the emergency number and enough phone clerks are available at times of peak traffic. Appendix A describes the criterion "enough" in technical terms. Here the situation is handled more qualitatively.

There are now eight lines on the emergency number. It is estimated in Appendix A that the present busiest-hour traffic is approximately 90 calls per hour. The average call duration is estimated to be 2 1/2 minutes. If a new call arrived every 40 seconds, and each were 150 seconds long four lines would suffice. However the arrivals are Poisson-distributed and their lengths vary according to some unknown distribution, usually assumed to be negative exponential. These characteristics materially increase the number of trunks required. The number of trunks must be increased to fifteen in order to be adequate for the near future. The criterion of adequacy is discussed further in Appendix A where it is pointed out that both theory and practice indicate that one call in fifty is now "lost". This means that the telephone equipment cannot find an empty line and gives the caller a busy signal under the assumption that he will dial again. There is some question about the suitability of this "loss" rate; perhaps higher standards should be set. The cost of providing more lines is very small. There is the problem, however, of providing people to answer

the calls, and disciplining their use of telephone connect time.

What the phone clerks do will remain essentially unchanged but how they do it will be modified in the near future. The changes are described in a later section.

b. Citizens' Alarms

Over the past several years there have typically been approximately 10,000 activations of the citizens' alarms each year. Between seven and eight thousand of these have been false alarms. On the basis of measurements each such false alarm takes up 25 minutes of a patrol car's time on the average. It was shown in an earlier report that this time costs eight dollars an hour, on the average. The false alarms thus impose an economic burden of approximately $25,000 per year.

The burden of false alarms is a strong incentive to discontinue the citizens' alarm capability. However, there is strong pressure from the public to continue. Because of a major urban redevelopment project in downtown Boston it was necessary to move a large number of police boxes in the area. This need was used as an opportunity to experiment. It was decided to install open telephone boxes for public use. A citizen may pick up one of these open phones and talk directly to a phone clerk at headquarters.

Open phone boxes have now been installed in most of the downtown district of the city. Analysis of the records indicates that the false alarm rate on these open phones has dropped from the District's former rate of 65% to 45%. Some of the current false alarms result from vandalism. Several specific phones have been vandalized repeatedly, which suggests that a vandal-proof design is needed.

The open boxes were installed late in 1968. The data so far this year indicate that the combined number of bonafide

calls on open boxes and citizens' alarms throughout the city has decreased from past volume. This may indicate that the presence of open boxes has had a deterrent effect on street activities which lead citizens to use the alarm system. This hypothesis doesn't fit the fact that the number of crimes has risen more in the area than for the city as a whole. The effect is being investigated.

It was originally thought that radio boxes would be desirable for the open link to police headquarters on the grounds that battery-operated radio equipment would be independent of potential disasters. This idea was abandoned because of the very high cost of such equipment.

3. Headquarters to Patrol

When a citizen calls the emergency number with a request for service, a phone clerk records the message on a card which is passed to a radio dispatcher. The dispatcher contacts a patrol vehicle by radio. Prior to the spring of 1968, one duplex channel was used to control the operation of up to 90 or 100 vehicles. It was very clear at that time that the outgoing messages from the dispatcher were occupying a high fraction of the available time. What was not so clear was that patrolmen in the vehicles were having to wait very long times in order to get on the channel to talk to the dispatcher.

To remedy this situation two dispatching positions were established, using two duplex channels. The primary dispatching position is an outgoing one. This dispatcher gives orders to patrol vehicles, and receives acknowledgements from them. The secondary dispatcher is primarily a receiver of information from the patrol vehicles. When a vehicle goes out of service for reasons unrelated to incidents or when it becomes available, having finished an incident, it addresses the secondary dispatcher. In periods of low activity a single dispatcher is sufficient.

The use of two duplex channels immediately improved the communication capabilities between headquarters and patrol; however,

over the months since that action was taken the volume of message traffic has continued to rise. This is primarily because the demand for service by the public has been rising at a rate of roughly 9% per year. It will eventually be necessary to go to three dispatching channels. At that time it is planned to divide the city into three zones with a dispatcher for each. There will also be a fourth duplex channel which can be used to contact any vehicle in the city. Each vehicle will then monitor its own zone's channel but be able to switch to the city-wide channel.

4. District Station to Patrol

The radio dispatcher at headquarters gives a patrol vehicle its orders with respect to incidents. A patrol vehicle is also responsible to its district for tasks not necessarily associated with incidents. The district station has two ways to get in contact with a patrol vehicle: One is to call a phone clerk on a "hot line" to headquarters and have the clerk ask the dispatcher to radio the vehicle. An alternative method is to activate the recall lights on a group of police call boxes. When a patrol vehicle sees the light flashing, it is supposed to stop and call into the district, using the phone in the call box. This flashing recall light is obviously not a quick response system and can only be used for messages of very low priority.

In the long term it would be desirable to have radio contact between district and patrol vehicle. The plan is to combine this link with a portable radio capability. Given walkie-talkies, the men in patrol cars can maintain contact when out of their vehicles. This contact will be to the district station to which they are assigned. There should eventually be some way for a headquarter's dispatcher to capture the district transmitter frequency if he needs to reach patrolmen who are not in their vehicles. Such a link from district to patrol is now in operation, informally, in the downtown District. This radio link has not been shown in Figure 1 since it is still in an experimental stage. The expected tendency of calls for service to by-pass headquarters and go directly to the district station via the administrative lines has already become evident. The bad effects of this practice are added response

time and the potential for under-reporting. The matter is being studied, and it is expected that the objectionable characteristics can be cured through proper system discipline and control.

B. INFORMATION FLOW

1. Definitions

The previous section, and Figure 1, dealt with the flow of information over communication links such as telephone, telegraph, radio, and optical signals. This section takes up the flow of information on paper in the form of records and reports.

Each request for service from the public, and most police-initiated actions, generates paper work in the form of reports and records. The distinction which we are making between reports and records is primarily one of time. If a report is retained in the files, we call it a record. Some records are created by abstracting or collecting information from several reports. Other records such as fingerprints and photographs are produced directly, and may or may not have textual records associated with them.

2. The Process

Figure 2 is a very simplified version of the flow of information within the Police Department at the start of this project. The diagram follows the information and activity associated with a citizen request for service. The request is called in by telephone and does not result in an arrest. The figure indicates places, people, and collections of information in rectangular boxes. The arrows indicate the physical movement of people or the movement of pieces of paper. The numbers on the figure are in the order in which events normally happen. The discussion which follows is in the same order.

The process starts when a citizen makes a phone call (1) to the police emergency number. A phone clerk answers the call and asks for information on the nature of the complaint, the location, and the name of the caller. The phone clerk then looks up the location in a file to determine what district and car sector is involved. The city is divided into districts and each of these is subdivided into areas called car sectors. Depending upon the time of day, and the resources available, one or more patrol vehicles may be assigned to a car sector. In periods

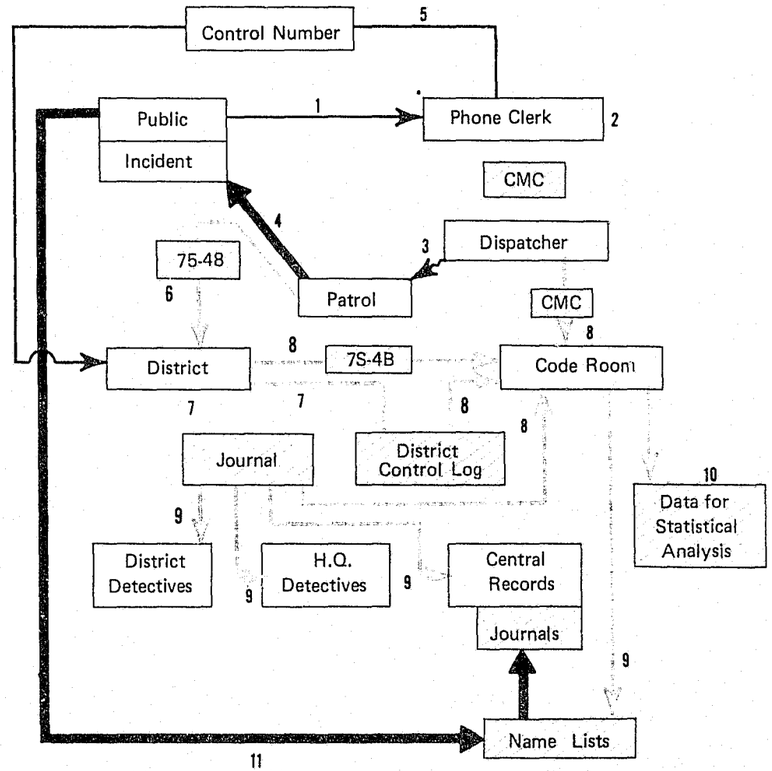


FIGURE 2 SIMPLIFIED DIAGRAM OF INITIAL INFORMATION FLOW, FOR AN INCIDENT NOT LEADING TO AN ARREST

of low activity a single vehicle may cover two or more car sectors.

Normally, the phone clerk writes the required information as he receives it on a form called a complaint message card (CMC). As soon as he has looked up the car sector corresponding to the address, he enters that information on the card. He then time-stamps the card, and sends it on a conveyer belt to the dispatcher (2). Complaint message cards are numbered serially from January 1 through the year. The central complaint number (C.C. No.) is henceforth associated with the incident, whether it be a noisy party or a multiple murder. This number is used to tie together information on the incident which may be produced later.

Upon receipt of the complaint message card the dispatcher checks the car status board or the card rack which controls it. The status board is a wall panel on which all vehicles are listed by identification (radio call) number. Available vehicles are signified by a light. When a complaint or other task makes a vehicle unavailable the related CMC is put into a slot in a rack by the dispatcher. The card activates a microswitch which turns off the "available" light. Because of the nature of the system neither the dispatcher nor anyone else knows why a particular vehicle is unavailable.

If the car for the relevant car sector is available the dispatcher calls that car by radio (3) and makes the assignment. If the desired car is not available the dispatcher chooses some other suitable vehicle by referring to the card rack. In some cases he may issue a general plea for some car to take the incident. Upon acknowledgement by the car, he tells it the nature of the complaint and the address. After a second acknowledgement by the car, he time-stamps the card and puts it in the rack which controls the status board.

The assigned car then goes to the scene (4). In many cases the patrol is able to contact the person who made the initial phone call. In some cases, of course, this is not possible since the complainant did

not give his name or has left the scene. The patrolman or men investigate the situation, do what they feel is necessary and, after filling out a report, call back to the dispatcher to say that they are free for further assignments.

When the assigned patrol car has finished at the incident, the complaint message card (CMC) is removed from the status rack and a phone clerk calls the number to the relevant district station (5).

If the incident to which the patrol car was sent is a relatively minor one, the patrolman fills out a relatively simple form (identified as form 75-48) which he delivers to the district at some time during the shift, preferably at the end (6). If the incident is serious, he will fill other forms depending upon the nature of the occurrence.

The C.C. Number which has been phoned to the district is entered on a district control log (7). The report (75-48) which comes in from the patrolman is collated with the information already on the district control log, and an incident code is entered on the control log. The district also enters a fine-mesh geographical code on the control log.

When the patrolman turns in his brief or lengthy report to the district he may also turn in additional bits of information recorded "on the back of an old envelope." All the information available at that time is compiled in narrative form and typed on the page of a journal (7). This journal, which is kept at each district station, is a log of all important events in their order of occurrence.

A copy of all journal pages for each day is sent to a headquarters unit called the code room. The code room also receives the initial complaint message cards, copies of district control logs and the 75-48 forms. The code room collates these source documents (8) and checks for internal consistency. The code room also extracts all names from the documents and prepares a list of names for each day (9).

A copy of the journal is provided for the district detectives as background material for incidents which require investigation.

Another copy of the journal is sent directly to the central records division. If a citizen wishes to have a record of a particular incident involving himself or a person he represents as legal counsel, he may get a photocopy of the relevant journal entry from central records for a fee. The journal record can be found by entering the name list using the date of the incident as a key (11).

The code room is the assembly area for data for statistical analyses of Departmental activities. The basic source documents are the district control logs mentioned above, arrest records, 75-48 reports, and detective follow-up reports.

3. Shortcomings

The preceding section provides an overview of the flow of information within the Department at the start of this project. This description would have been essentially correct over a long period of the past. Since the information system has functioned successfully in the past, why change it?

The reasons for change can be expressed in terms of economics and effectiveness. To explain and justify the needed changes it is useful to make a list of shortcomings. The deficiencies can be divided into those related to reporting and recording information and those related to the command and control of field operations.

The problems with respect to reporting and recording information include the following:

- The level of detail of field reporting of incidents is not matched to the incident. Many incidents are over-reported, a few are under-reported.
- The district journal is largely a waste of time and effort, except as a record of housekeeping activities at the district station. It does not provide adequate documentation of serious incidents, for either police or public.

- Name lists are prepared in a very laborious, costly fashion. When a citizen comes in to obtain information about an incident, entry to a file is made through a name list. The name list is prepared by going through the journals, pulling out each name, and connecting with that name the page and item of the relevant journal. This is all done by laborious reading and involves key punching, sorting, and printing.
- Data for statistical analysis are prepared in a similar fashion. The burden of such preparation is so heavy that a large amount of useful, important information is never examined.

Problems with respect to the command and control of field operations include the following:

- From the field patrolman's point of view the 75-48 forms are a waste of his time, for a large fraction of all incidents. The availability of patrol would be improved by not reporting minor incidents on paper.
- The phone clerks, because they can't know what is happening in the field, can take only a passive role with respect to inquiries and requests from the public. They cannot tell a citizen how soon, or late, to expect response by a field unit. They cannot tell a citizen who calls back what the status of police action may be.
- The dispatchers can't get a picture of what is happening in the city. When cars are unavailable they can't easily tell why.
- Field operations, including both patrol and district stations, have essentially no access to the store of information in Central Records. Information comes in, but little can be retrieved without special effort.

- Roughly two thirds of the work load of patrol vehicles consists of activities which are recorded but not analyzed because of the work involved. It is this "hidden work" which is largely responsible for lack of available cars.
- There is no straightforward way to connect the identity of the man (or men) in a patrol car with the activity of the car. This is important because it is clear that some patrol vehicles are unavailable in patterns which are not by chance.
- For those incidents which require detective follow-up there is no easy way to check on whether district or headquarters detectives have or have taken responsibility.

In the following sections some of the above shortcomings will be discussed in detail, together with solutions which have been implemented or are planned. It is rather difficult to isolate the topics, however, since they are interlocked, as was shown in Figure 2. The next section considers field reports. All the other topics are taken up in the next major portion (III C), on Command and Control.

4. Field Reporting

At the start of this project field reports on an incident came in only two types: simple and complex. A complex report has been used for felonies and those cases in which an arrest is made. In most cases the arrest reporting form is adequate to record the necessary information. When no arrest was made non-felonies were treated as essentially equivalent and were reported on form 75-48 mentioned above. For many incidents this has meant a report where none was really needed. For many others the report was often inadequate to the needs of future users.

The initial inadequate reports (in non-arrest incidents) are transcribed with little embellishment, and sometimes reduction, onto the district journal. Neither the journal entry nor the initial reports supply adequate information for detective use, and consequently detectives

start their investigations essentially from scratch. It is difficult to estimate the penalty of this inadequate reporting. However the human tendency to restructure experience in memory, means that the detectives often will hear a story different from that obtained by the initial investigator.

A further shortcoming of the reporting system is that neither the initial reports, which are unavailable to the public, nor the journal transcription of the same information is really adequate for the needs of lawyers, insurance firms, or victims in general. In fact, the information available to the public about incidents of concern is very limited.

a. The "Miscel" System

In order to ameliorate the reporting problems two actions are desirable: to make the simple reports even simpler and to report more adequately those incidents which should be reported. The first action has been taken.

The disposition of approximately 60% of all incidents can be recorded adequately in a very brief statement. A list of applicable incidents and the code by which their disposition may be reported is given in Appendix C.

When an investigating patrolman calls in to say that he has completed his investigation of a miscellaneous incident he gives the secondary dispatcher a letter and number indicating disposition. The secondary dispatcher writes this code on the complaint message card, time-stamps the card, and the incident is closed. The additional burden on the radio dispatcher is a second or two for each miscellaneous incident.

The major impact of the "Miscel" system is the time it saves for patrolmen in the field. Careful measurements were made before and after the introduction of this reporting system to determine how much time is required to deal with various types of incidents. The data were collected in two

periods a year apart, in connection with a patrol experiment. The experiment, reported in Appendix D, was inconclusive but it did generate a number of useful results for other work.

The measured results indicate that introduction of the "Miscel" system reduced the average time spent on incidents to which it is applicable by 20 minutes. This reduction seems very high, but so do the incident durations both before and after introduction of the "Miscel" system. In fact most of the durations are nearly twice what had been measured earlier when the force knew it was under observation. In neither of the periods of this experiment did the force know it was being measured.

To be conservative we assume that a "Miscel" report by radio saves ten minutes over the form 75-48 report, rather than the measured 20 minutes. The time saved in 1968 was thus about 28,000 hours, or more than the total available time of three patrol cars. In terms of money the time saved was worth approximately $220,000.

The one bad feature of this reporting system is the tendency of some patrolmen to downgrade an incident in order to report by radio and avoid the trouble of filing a report. Such cases show up occasionally but they are hard to discover unless a citizen makes an inquiry. This problem could get worse when the present 75-48 forms are replaced by a set of adequate field reporting forms.

b. Field Reporting Manual

It is necessary to report many kinds of incidents in some detail Sometimes the need is legal. In other cases the report is a service to the citizens involved: a record for insurance purposes of things stolen, for example. More often the report is of use to the police either in further investigation of an

incident or in turning up coincidences of time, place, or operating techniques.

The information which should be reported depends both upon the nature of the incident and upon the use to which the report will be put. One major use is in investigation. It is impossible, however, to say exactly which bits of information will be of value. There must be a compromise between the tendency to report as much detail as possible and constraints of time and energy on the reporter.

A number of sets of detailed reporting forms are available as a starting point. We have found it difficult to state criteria with which to decide which content is most appropriate for various types of incident. The question of format is equally vexing and can probably best be settled by field test of forms.

Final choice of a set of forms has been delayed by another problem: that of providing field forces ready access to knowledge that certain information exists in the Central Record files. It is planned to generate a computer-based file of what may be called "pointer" information. This will be described in a later section. Some of this file input will be from the phone-clerk and dispatcher positions, but some will come from the field reports. The recommended forms will be issued in a self-contained report.

It is clear that when adequate field reporting forms are in use, the district journals will not be needed as records available to the public. Some sort of journal will probably be maintained for or by the districts but maintenance of these will certainly require less manpower.

C. COMMAND AND CONTROL

In the preceding section the "Miscel" system for reporting minor incidents was described. A field reporting system was discussed as a way to improve the quality of information about incidents and to obviate the need for district journals. The remaining shortcomings of the information flow within the department -- associated with information available to phone clerks, dispatchers, and field forces; with name lists and "pointer" files; and with measurement of the "hidden work load" -- will all be discussed with reference to a computer-operated information system to be described here. The earliest functions of this system to be activated will center on command and control of field forces: hence the title of this section.

1. Motivation

Before describing the planned command and control system, it may be valuable to explain the motivation for it in more detail than has been given so far. The motivation arises from operating needs in the radio-room (which includes terminals for incoming telephone lines), from the need to supply data for management purposes, and from information requirements of field forces.

a. Radio-Room Needs

At any instant the information on what police are doing throughout the city is either in the radio-room, or it can be obtained by persons therein. The information cannot be used to best advantage, however, because it cannot be seen either in its overall shape or in detail. It cannot be recovered or surveyed except in terms of the number of vehicles available to be assigned at any instant.

Incoming calls are distributed by the telephone equipment so that they are answered by clerks in a random order. Consequently, if a citizen makes a second call he is very unlikely to reach the phone clerk to whom he spoke initially. The second clerk has no easy way to find out what happened to the first call. If a second citizen calls about an incident

already responded to, the same difficulty holds. A second response is unlikely if the first one was fairly recent: the dispatcher will probably remember. A real-time status display of events in progress would solve these problems.

When the dispatcher needs a vehicle for assignment to an incident he often has to ask for volunteers during busy periods. In part this is because the dispatcher cannot readily tell the relative importance of reasons which may make a vehicle unavailable. In part the problem of unavailability occurs because there is no way to supervise the amount of time cars spend on incidents. The dispatcher can tell at a glance that a vehicle is unavailable but not very readily why or since when. It is not the dispatcher's responsibility to supervise the time of field men, of course, and if it were he couldn't exercise it. However, under the present arrangement, no one is able to supervise easily the time taken for various patrol tasks. A real-time status display of car activity and its priority would solve these problems.

Real-time displays of incident and vehicle status would also provide information for supervisory personnel. This would be particularly valuable in times of disorder or disaster. Such happenings now require supervisors to go into the streets to get a picture of events.

The data used to generate vehicle status displays can be used to produce an event log for each. If to this were added an input listing men in each vehicle, the question of responsibility would always be clear without tedious manual check up.

b. Data Needs

Data for statistical analyses of Department operations are now collected from complaint message cards, District Control Logs and the field reporting form 75-48 and other sources.

Data is keypunched and analysis is done by computer after the punched cards are read in. Transcription errors and the cost of keypunching would be decreased or made unnecessary by putting data directly into the computer in some fashion which allowed a simple visual check before actually transmitting the data.

More importantly, with direct input of data to a computer system, a large amount of information not now examined will become available for analysis. The importance of this possibility will be shown below. The computer can prepare name lists for public and police use without the tedious reading and keypunching now required.

c. Access by Field Forces

Neither the patrol forces nor the district stations take the trouble very often of obtaining information from Central Records. Patrol cars can now call in a vehicle registration number and have a check made on the stolen car file. This stolen car file is now on computer disc storage and can be interrogated by a video input-output display in the radio-room. The patrol forces could use more of the available information, however, such as histories of places, people, the identity and status of things. What would be desirable, for example, would be an accessible name and information file which would tell what information was held on a person by Central Records. This pointer file would not give the actual information in most cases, merely the fact of its existence. For example: John Doe has an arrest record and convictions, we hold his prints but no recent photograph.

The existence of a pointer file, if coupled to a facsimile or other data transmission device, would also allow district detectives to use Central Records and stop the

present expensive partial duplication of records at each district. Further, if detectives at each district could get information from headquarters easily, they might more readily put information into Central Records to the benefit of all.

d. Patrol Allocation and the Hidden Work Load

A major incentive for creating a new information system is the need to reformulate the process by which patrol vehicles are allocated over time and geography. At present the allocation of patrol over the three shifts is made primarily in terms of the distribution of the initiation of "white card" incidents as shown in Figure 3, for example. The data from which Figure 3 was prepared are discussed in Appendix B.

The distribution of "white card" incident-starts per half hour has a low in the early morning hours, rises steadily to a peak in the early evening and decreases again. The time spent per incident varies with time of day, being longer on the midnight to morning shift. The maximum number of "white card" incidents in progress in any half hour is shown in Figure 4. This number is more relevant than "starts" for describing the incident work load.

Figure 4 also shows the number of "white card" and "pink card" incidents in progress in each half hour period. The "pink card" work load, indicated by the difference between the two plots, is clearly very high during the day shift. In fact, the number of cars unavailable because of being out on "pink card" incidents is roughly one and one-half times the number out on "white card" events. This is in part because there are more "pink card" events per unit time, in part because their average duration is greater (51 minutes versus 40 minutes for this sample of more than 1000 events).

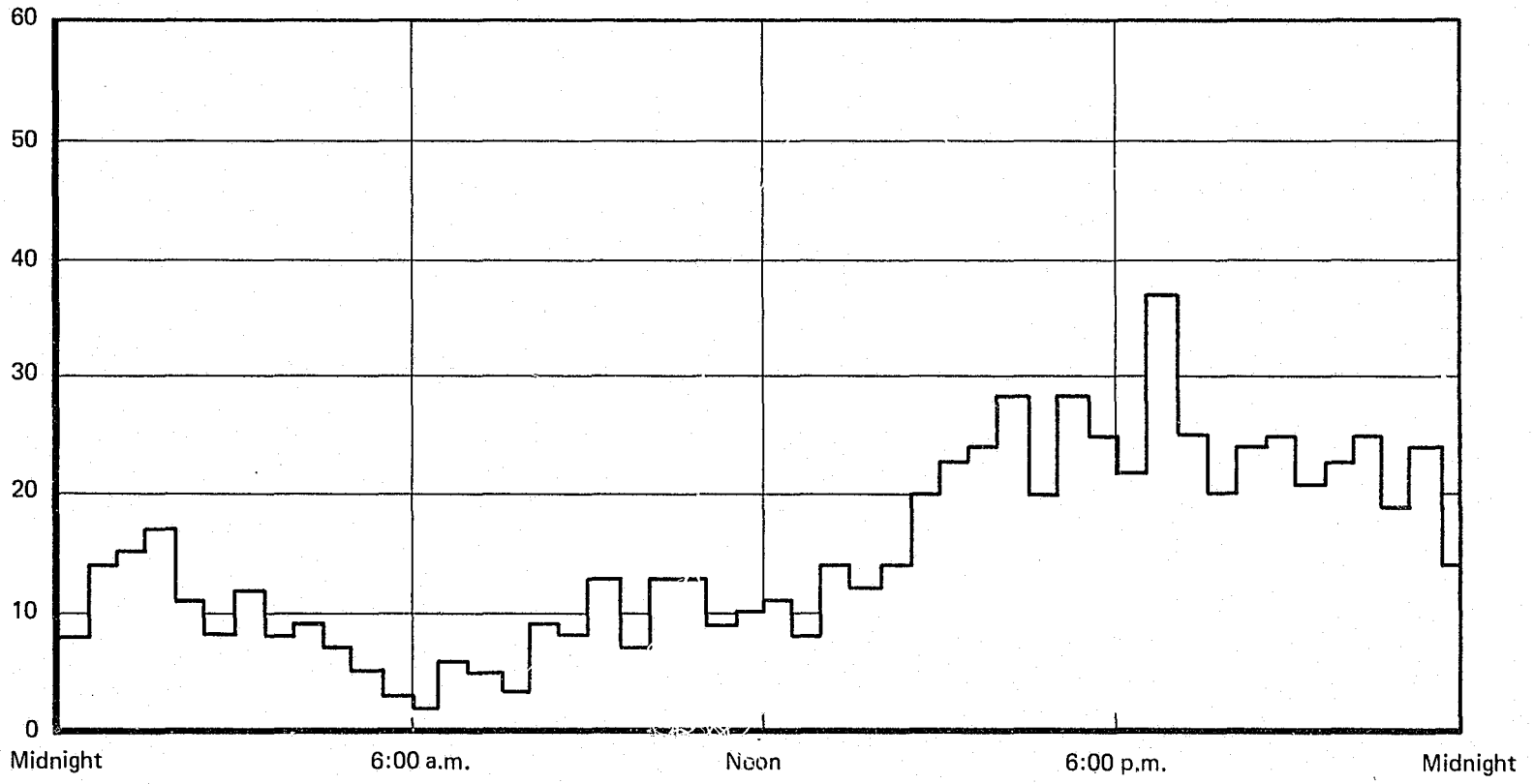


FIGURE 3 "WHITE CARD" INCIDENT STARTS PER HALF HOUR

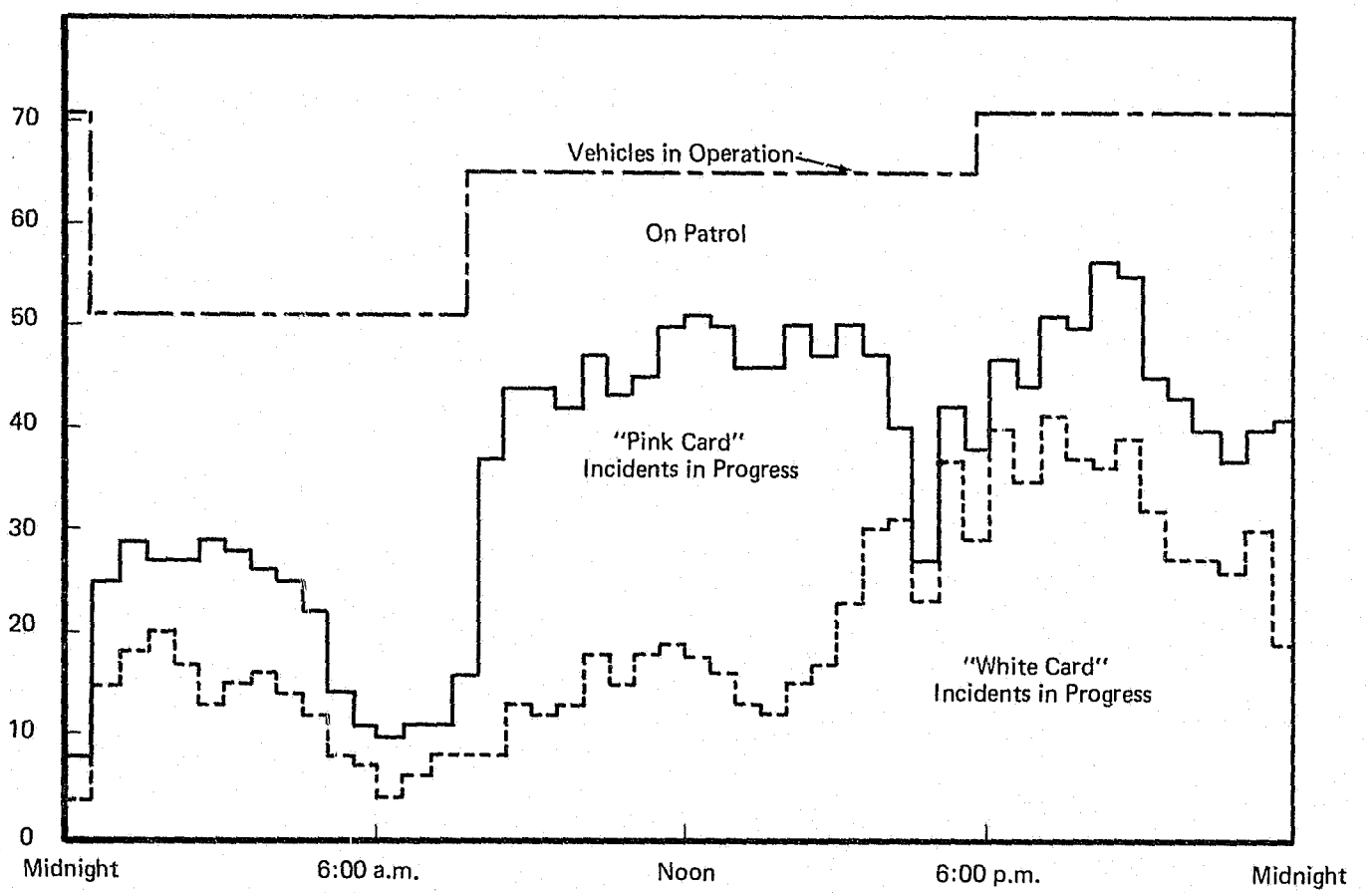


FIGURE 4 INCIDENTS IN PROGRESS IN EACH HALF-HOUR PERIOD

The total number of vehicles out-of-service is very roughly constant between 9:00 a.m. and 9:00 p.m. on the basis of data which includes "pink card" incidents. This differs dramatically from the work load implied by "white card" starts in Figure 3. It is, however, a justification for the roughly equal numbers of cars on the day and evening tours.

From Figure 4 it is apparent that the number of vehicles "on patrol" (meaning available for patrol) is at least 22 during the early morning hours, and averages approximately 25. During the day shift the number of cars available reaches a low 14 and averages 20 between 8:00 a.m. and 4:00 p.m. In other words, during the day shift there are usually only one-plus cars per district, on the average, available for assignment to an emergency. As Appendix B shows, these few available cars are more likely to be in relatively quiet districts than in busy ones.

The data from which Figures 3 and 4 were constructed were taken on a Tuesday. On the busiest night of the week, Friday, the incidents-starts per unit time are up by 10% over Tuesday. This will further reduce the number of cars available for assignment to an emergency. Experience indicates that on a Friday night there are occasionally no cars available in the city.

The fact that occasionally there is not a single vehicle available to assign to an emergency seems to be related to the hidden work load represented by "pink card" activities. The roughly 270 thousand "white card" incidents each year are recorded for later analysis of departmental activities. There is a volume of somewhere between 350,000 to 400,000 "pink card"

incidents a year which are clearly absorbing a major fraction of the time of field forces. Data on these have not been analyzed. The information management system to be described in subsequent sections will allow data on these "pink card" incidents to be captured and analyzed readily. When this hidden work load is brought into the open and examined, ways will be discovered to decrease its volume. It is shown in Appendix B that many of the "pink card" incidents could be handled in ways which would not take a patrol car out of service.

Another reason for obtaining a better picture of the way patrol vehicle time is spent is related to the allocation of vehicles over geography. The present system divides each district into car sectors. On a busy shift one patrol vehicle is assigned to each car sector. The thought is that this patrol vehicle will take care of most of the incidents in that sector. If the vehicle is on assignment when a second incident comes up, a neighboring car sector vehicle will be assigned. What actually happens is that every patrol vehicle spends something like 70% of its time outside of its assigned sector. This 70% is not necessarily spent in adjacent sectors but may be in any sector of its district or even in another district. As a consequence the car sector assignment scheme is of very limited usefulness. This problem is described in detail in Appendix B. The data exists with which a new geographical allocation scheme might be constructed. A possibility would be to have two or three cars assigned to a much larger sector and have the car-to-incident ratio such that one car would be available with very high probability at all times. In any case more data will help in design of a more efficient system and these data, which are now lost, need to be captured.

e. Follow-Up Investigations

An important by-product of the proposed new information system will be the provision of a scheme for follow-up on investigations. At the present time there is very loose control over who has responsibility for follow-up on any incident requiring further work. The system proposed will allow this follow-up to be assigned and monitored by management.

2. General Description

a. Functions

Figure 5 presents a very simplified diagram of the long-term plan for information flow within the department for incidents not leading to arrest. On the left of the Figure it is indicated that patrol response to an incident will be followed by either a "miscellaneous" oral report to the secondary dispatcher, or by a written report, as discussed in section II-B-4. The major difference from the configuration shown in Figure 2, however, is the existence of a computer-controlled information flow. In part this information flow is designed to aid the phone clerk and dispatcher functions. It will also create reference files to indicate what information is held by Central Records; will create the data base for statistical analysis and studies of allocation; and will eventually provide information to the District stations which will obviate the need for the journals.

When a citizen calls for assistance he will, as before, talk to a phone clerk. The clerk will have before him a video display or small TV-type screen. This display is used both to enter information into a computer-based file and to display selected information on command. To enter data on an incident, the clerk first directs the computer to display a reporting form on the screen. The request and other requests

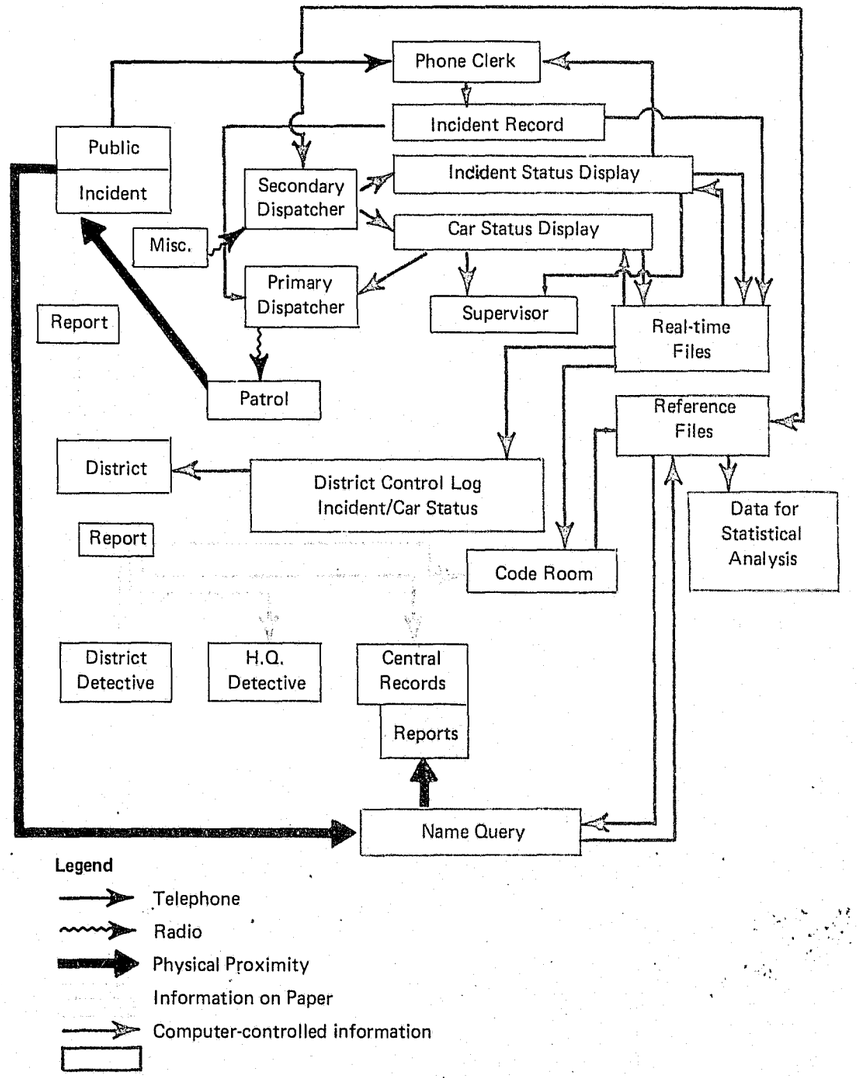


FIGURE 5 SIMPLIFIED DIAGRAM OF THE LONG-TERM PLAN FOR INFORMATION FLOW, FOR INCIDENTS NOT LEADING TO ARREST

for information are sent to the computer by typing a simple alphabetic code on a typewriter keyboard which is integral to the display device.

After the computer delivers the appropriate form to the display, the clerk enters information into the blanks on the form by using the keyboard. For a new incident the clerk would ordinarily record the nature of the incident, location, name and address of the complainant, how reported, priority and a car sector based upon location. In the ultimate system the conversion of location to car sector will be automatic: to begin with, the present manual look-up will continue. The computer will automatically assign an incident number and also enter date and time.

On command, the video unit will send the new incident record to the central computer files. The computer immediately sends this information to a display in front of a primary dispatcher. It will be possible to enter an incident record into the machine at any stage of completion and then call it back for updating. This capability will allow a high priority incident to be placed before a dispatcher as soon as its nature and location are known. The dispatcher will automatically receive other information when the computer receives it from the phone clerk's display.

In Figure 5 the incident record is shown as going simultaneously to the real-time files and to the primary dispatcher. This will appear to be the case because the turn-around time is so short, but actually the message goes to the files and is then sent to a dispatcher's display.

When the incident record is placed before the dispatcher, he will assign a vehicle from the sector where the incident occurred, if that car is available. Otherwise he will assign another vehicle by referring to a vehicle status display for

the district or zone of occurrence. He will record the identification of the vehicle assigned by sending this information to the computer after typing it on his keyboard. The incident record is thus updated in the computer files.

The real-time files of data on incidents and assigned vehicles are used to generate status displays of incidents in progress, one for incidents to which vehicles have not been assigned and one for incidents already handled by the dispatcher. The display of unassigned incidents supplies a one-line summary of each incident requiring investigation: telling when it was reported, where it is, the type of incident, and its priority. A second display tells the status of each vehicle in a given district of the city. It tells for each car when it was assigned to an incident (if it has been) and the sector and type of incident. A higher level display provides condensed vehicle status data for an entire zone. A phone clerk may call up on his video screen either an incident status display or a car status display if he needs to determine the status of an incident in progress.

Displays of vehicle and incident status can both be seen by a supervisor in the radio-room. This capability should be of use in emergency situations.

The real-time files of data on cars and incidents will also be available for use in the code room. When the code room receives field reports on incidents which require them, it will be able to transfer some of the information from the field reports and add it directly to the incident status files. Data on incidents which lead to arrest will enter the files at this point. Normally an arrest is followed by an arrest report, made out at a District Station, and fingerprint and photograph records made at Headquarters.

After the code room enters information into a particular

incident record it will code the file to indicate that the record can be transferred to a reference status out of the real-time file location. These reference files will then be used to produce the statistical reports which describe Department activities.

The reference files also will serve as pointers to information available in central records. For example, when an incident results in an arrest there are usually photographs and fingerprints taken. The reference file will indicate that for a particular person the central records do contain prints and photos.

The incident records in the real-time files will be used to produce a control log for each district as a record of activity and a check-list of incidents requiring further action or reports. This control log will be sent by wire and produced on a print-out device in the District Station. Eventually each District Station will be supplied with displays giving the status of incidents in progress and vehicle activity in its area. Provision of this information, plus adequate field reporting, will allow the district journal to be discontinued for other than housekeeping records.

From this description of functions to be performed, the order of implementation is not readily apparent. The detailed implementation plan is given in Appendix E.

b. Functional Specifications

The previous section describes in very broad terms the functions to be performed by the computer-controlled information system. Current work is concentrated on a computer-assisted dispatch and phone clerk operation. To design such a capability it is necessary to know in very great detail exactly what phone clerks and dispatchers do.

Whenever a computer is used to help people perform seemingly simple operations, it rapidly becomes apparent that these operations are very complex. Things which people can do without much conscious thought can only be duplicated with a computer after exceedingly detailed analysis of the operation. It turns out that the number of specific operations which must be possible with computer help in order that the phone clerk/dispatcher functions can be performed is roughly 30. These transactions, as they are called, are described in great detail in a separate report of some 200 pages. That report also describes the content and arrangement of information in the central files of the computer system, the format of information on the video devices, and the special files needed to support them.

The detailed statement of transactions leads to a set of computer instructions or programs which tell the computer what to do and how to do it. the exact nature of these programs is of course influenced by the hardware chosen to realize the system. The next few sections will describe the hardware and the programs very briefly. The detailed description will be available in independent reports.

c. Message Traffic

On a busy day the hourly average number of incident records initiated is approximately 50. In terms of Figure 2 this means 50 Complaint Message Cards are written per hour, on the average. (Roughly one in seven of these is later voided for one reason or another.) A rule of thumb for such activities is that the rate for the busiest hour in the day will be twice the average rate (see Appendix A), or 100. Each of these incidents will produce at least the following steps: call to the computer for a format message; send incident record to the files; transmit record to the dispatcher; input the car

assignment and send to files; call up of record by secondary dispatcher to close incident, release vehicle; send record to file. There may be subsequent calls for the record by the code room but this will normally be in hours of lower activity.

The message flow to and from the computer files will thus be about 600 per hour in peak periods, due to calls for service which now result in Complaint Message Cards. There will also be messages about changes in vehicle status not related to requests for service. In peak periods these events occur at a rate of approximately 50 per hour. Each such ("pink card") event will result in at least 4 transmissions to or from the computer data files. The estimated peak period message flow is therefore 800 per hour, due to externally generated messages. There will also be a large volume of message traffic generated by the computer to update displays automatically and for various technical reasons. It is difficult to estimate the total traffic ahead of time, or to know whether the initial software package can cope with it.

d. Hardware

The computer-based information system will be built around an IBM 360/40 machine, with data storage on IBM disc files. A large number of highly specialized pieces of equipment will be associated with the control of displays, switching of messages and the control of input and output to the computer. The details will be given in a separate report.

Video displays will be used for input and retrieval of information. They are essential for the speed of response required in the dispatching operation. The slower response of a teletype system would be intolerable. The video displays can be used to full advantage in the local environment at headquarters. The use of such displays at remote locations,

however, is encumbered with technical problems: the bandwidth available on telephone lines will not allow data to be transmitted as fast as it can be produced by the computer. The alternatives are to use costly equipment to capture the data "at speed" and transmit it at a slower speed, or to make a capital investment in high-speed transmission lines. The decision has not yet been made, primarily from lack of information. In order to allow the proper measurements to be taken, a coaxial transmission line has been installed from headquarters to one District Station.

A major problem with hardware is that the IBM video displays, which are of course readily compatible with the IBM computer, are not suitable for the planned functions. As a consequence the final choice of displays is still to be made, based on a combination of cost, ease of programming, and other criteria.

e. Software

The system is designed to operate as a real-time on-line tele-communication processing system. This means that the computer has to do things as the need for them occurs; the computer is running and ready all the time; and, the computer has to receive messages from and send messages to a number of external devices. The information which the computer receives from the display devices has to be filed immediately in the right places. Commands to the computer are essentially instuctions to pick information from these files, combine it appropriately, and send it out to the requesting display and/or other displays. The system will generate displays of the status of incidents and vehicles, based on information in its files. When new information enters the files and changes the status, the system must automatically update the status displays. The alternative of having each display user repeatedly query the central files to make sure that his

display is up to date would be intolerable. As a consequence of having to satisfy all these requirements, the instruction package which controls the computer and the flow of messages must be very sophisticated.

Figure 5 indicates that ultimately the real-time files will be available to displays in District Stations. As has been mentioned, this capability adds such complications in both software and hardware that it will not be attempted at first. In order to achieve a testable capability, the system files and displays in Headquarters will be controlled at first by a software package called FASTER. This computer program is currently in use in several installations on the West Coast. The FASTER software package may not be adequate to operate the system under the work load estimated above without undesirable time delays. It is known that FASTER can cope with more than 1000 messages an hour but the complexity of the transactions is not known. If FASTER proves inadequate, it may be necessary to develop a more sophisticated software package. Alternatively, a newly available IBM program, CICS, is under consideration.

3. Development

a. Hardware

The IBM 360/40 with 128 K bytes of magnetic core storage is planned for installation in February, 1970. Meanwhile, the IBM 360/30 has been upgraded to have 65 K bytes of core memory, in order to permit the operation of a test system before the larger machine is available. The 360/30 can be used to control a few displays so that operators may become familiar with the system.

b. Software

The necessary portions of the FASTER software package

are now running on the 360/30. From the system functional specifications the programming for FASTER is in progress, together with preparation of several special programs. Part of the programming is being done by police personnel who have been specially trained in the use of FASTER.

c. Installation

It is planned to have a prototype system in operation during the current project period. This will consist of two or three displays in a space near the present radio-room. The displays will be operated by the IBM 360/30 now on site. This prototype system will be used for test, training and evaluation but not for the actual control of field forces. It will be run in parallel, with the operators listening to real calls, and entering real information into the system. The dispatcher function will, however, be entirely simulated.

Meanwhile, plans are underway for a new control center which will accommodate the computer-assisted dispatch system and the increased number of phone clerk positions which are going to be necessary in the near future. The specifications for this new room are being prepared in terms of power, space, lighting and other requirements. The choice of location has not been made. It will be necessary to build a new room, primarily because of the need to have continuous operation during the transition from the old system to the new.

It has been decided to defer the inclusion of District Stations as direct users of the real-time files. In part this is to allow data to be collected so that a proper choice of implementation can be made. The principal objective, however, is to limit the scope of the problems to be solved. It is better to have problems on a limited than on a grand scale.

Figure 6 is a simplified diagram of the intermediate plan for information flow, for incidents not leading to arrest.

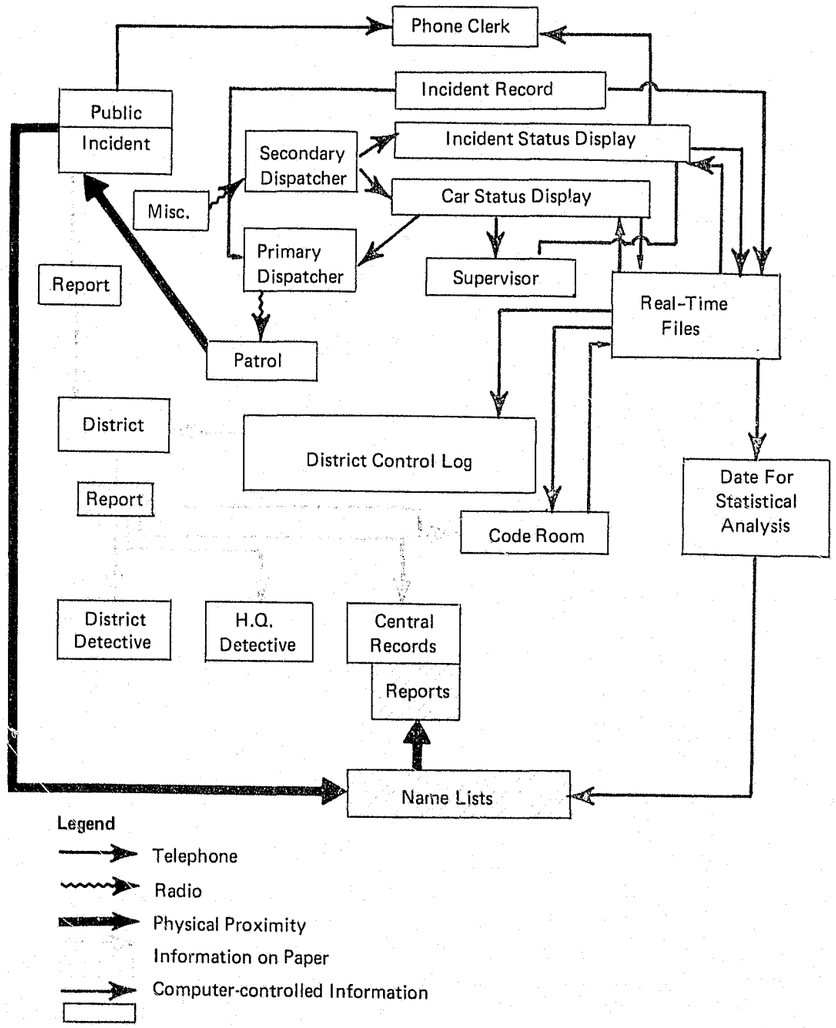


FIGURE 6 SIMPLIFIED DIAGRAM OF THE INTERMEDIATE PLAN FOR INFORMATION FLOW, FOR INCIDENTS NOT LEADING TO ARREST

Here the District Control Log is a piece of paper produced at Headquarters by the computer. The plan shown in Figure 6 is now being implemented.

The phases of the development plan are described in Appendix E, as has been mentioned.

d. Personnel

If the proposed computer-based information system is to become and remain a reality, the department must hire in the near future some person capable of taking charge of the system. The department is fortunate in having a number of patrolmen who have been trained as programmers, and have learned to work with the IBM 360/30. If their skill and training were increased to the level at which they could take charge of the operation, they would undoubtedly leave for more lucrative positions. There is no alternative but to hire someone from outside.

APPENDIX A

EMERGENCY TELEPHONE CALLS: A PRELIMINARY TRAFFIC ANALYSIS

INTRODUCTION

The Boston Police Department has considered a redesign of its emergency telephone calling system from a single-zone system to a three-zone system. The present emergency number, DE 8-1212, would be replaced by another number and, through arrangements with the New England Telephone and Telegraph Company, calls originating from any of the three zones would appear at the answering positions on lines which identify the originating zones.

The motivation for such a change arises from the historical accident that the city was formed as a combination of several formerly independent small towns. Many of these towns had streets with identical names and many of the names have remained unchanged. As a consequence the phone clerks who receive calls for police service often have to question a caller at length to determine which of several Oak Streets is under discussion, for example. It was thought that a division of the city into three zones would cancel most of these ambiguities and would thus shorten the time for police response.

The purpose of this paper is to provide a method for costing a three-zone phone system in terms of the number of lines required, and as a function of the level of service provided. The other side of the problem, to determine the amount of time saved and its value, has not been attempted here.

In considering a redesign of the system, the number of lines serving each zone must be calculated and the expansion capability of the lines serving each zone must be estimated. This paper presents a methodology, based on classic telephone traffic analysis concepts, for performing the calculations and estimates, and shows the results of the methodology when

applied to the inexact parameter values which are currently available.

BACKGROUND

Any telephone traffic analysis depends on the following major parameters:

C = number of calls offered per unit of time,
N = number of paths which a call may take,
H = average length of time a path is held by a call (holding time).

Calls offered are usually combined with holding time to arrive at a dimensionless quantity, traffic offered (A), expressed in Erlangs.

$$A = CH \text{ Erlangs}$$

One Erlang can be thought of as that amount of traffic which would completely occupy one path. Since traffic offered to a switched telephone system has been found to originate in accordance with a Poisson distribution and holding times generally follow a negative exponential distribution, one path can never accommodate one Erlang of traffic. most automatically switched telephone systems are "loss" systems, that is, an offered call which can find no path for completion is lost, or blocked, and cannot be completed without reorigination. The probability that a call will be lost (B) was theoretically calculated by A. K. Erlang and experimentally proven.

$$B = \frac{A^N/N!}{1 + A + \frac{A^2}{2!} + \ldots + \frac{A^N}{N!}}$$

The above terms are used throughout this paper.

The unit of time most commonly used for determining the number of paths to be provided for calls offered is the "busy-hour". The busy-hour is a representative hour based on regularly recurring hours (usually daily) of heavy traffic intensity. It does not include random peak calling periods or those whose regular interval is comparatively long, such as Mother's Day which occurs once each year. If one provides for a low

probability of lost calls during a busy-hour, then the same probability will apply to all hours exhibiting the traffic intensity of the busy-hours, and greater intensities, usually occurring at random intervals, will carry a higher probability of lost calls. The busy-hour concept is used as a basis for discussions in this paper.

AVAILABLE PARAMETERS

The number of calls to be offered in any time period is seldom known. In practice it is uaually estimated initially and later adjusted on the basis of experience with path occupancy. In the Boston Police Department, and more specifically the behavior of the emergency (DE 8-1212) line group, the experience factor is limited to records of the number of calls received during an 8-hour shift. The evening shift, 4-12 p.m., is the most active shift and as many as 750 calls have been recorded during this shift. The week in which the 750 calls were recorded had an average of 514 calls during the third shift, or an average of 64 calls per third-shift hour during the week.

The busy-hour calls have not been recorded by the Boston Police Department, so the following third shift call distribution from the Detroit Police Department is used as a limited example of hourly distribution (10-25-68).

4-5 P.M.	153 calls
5-6	181
6-7	153
7-8	242
8-9	158
9-10	206
10-11	155
11-12	169
Total	1417 calls
Average	177 calls per hour

Busy/Average hour = 1.37

Using the Busy/Average relationship and applying it to the BPD average

of 64 calls per hour, one can estimate a BPD busy-hour of 88 calls.

A rule-of-thumb estimate for busy-hour traffic is to double the average hourly traffic for a whole day. The hourly average traffic for the week mentioned above was slightly over 44 calls which, when doubled, gives agreement with the 88 call figure derived above. Another check can be made by carrying the busy-hour throughout a shift, as may have occurred during the disturbances, and 704 calls result, giving reasonable agreement with the 750 calls recorded.

For the balance of this paper it is considered that the DE 8-1212 busy-hour demand is 90 Poisson-distributed calls.

The number of paths a DE 8-1212 call may take, considering that all calls are connected to the proper telephone switch outlets, corresponds to the eight outlets or lines in the DE 8-1212 hunting group (1212 through 1219).

The average holding time for these calls, from answer to hang-up, is 2.25 minutes, according to Captain Ahearn of the Department. Allowing an additional .25 minutes for ringing (average of three rings to answer), we will use 2.5 minutes for the average path holding time.

PRESENT SERVICE

Based on the available parameter values the busy-hour traffic offered is:

$$A = CH = 90/60 \times 2.5 = 3.75 \text{ Erlangs}$$

The probability of a lost call for this traffic on eight lines, obtained from the loss formula, is approximately .023. This means that, with a calling rate of 90 per hour at 2.5 minutes average holding time, one could expect 88 of the calls to be completed and 2 of the calls to encounter busy signals. (It is interesting to note that the 88 calls completed for 90 calls offered agrees with the earlier calculation and thus 90 calls offered may be a good assumption.)

The present eight-line group handling 88 calls of 2.5 minutes each during the busy-hour will display an average occupancy for each line

of 88/8 x 2.5 = 27.5 minutes. Lines are allocated to calls from a fixed hunting pattern, always starting with the first line in the group (1212), so the average does not apply to actual line occupancy. The average does apply to answering positions however, since answering, regardless of which line is calling, takes place on a rotational basis among the active answering positions. If all eight answering positions are active, then each position is busy with DE 8-1212 calls for an average of 27.5 minutes during the busy-hour. (Each of these positions is also occupied for an estimated average of 13 minutes with KE 6-6700 calls and 32 minutes with records generated by the calls for a 72 minute busy-hour. When the supervisory position is included as an answering position the busy-hour drops to 57 active minutes. A reasonable explanation exists here for slow answering of complaint calls. At least one more answering position is required now, if the supervisory position is not to be tied up in peak traffic periods.

FUTURE SERVICE-EQUAL LOADS

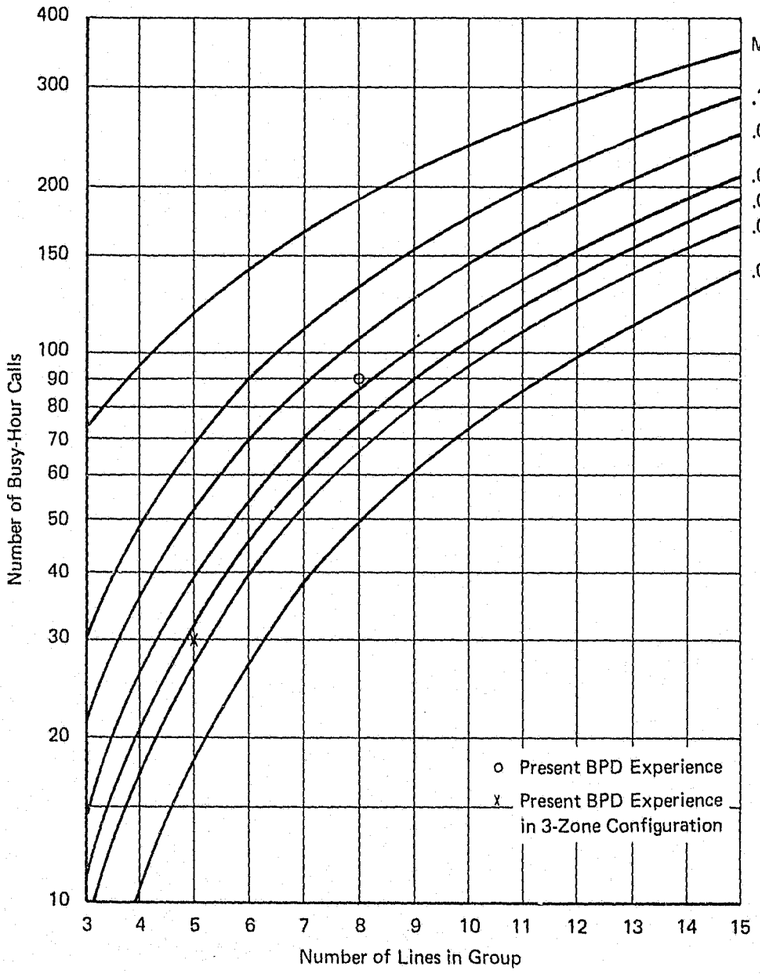
If it is planned to divide the DE 8-1212 calls into three equal calling zones, then each zone will carry an average of one-third of the total calls on a group of lines allocated specifically to calls originating in the zone. Since the data has already set the total load at 3.75 Erlangs, one third of the load will be 1.25 Erlangs. Using this figure and the loss-probability figure mentioned above, one can solve the loss formula to derive the number of lines required for providing a future service in each zone which is equal to the present service. Four lines servicing each zone would give a loss probability of slightly less than .030, somewhat worse than the present service. Five lines servicing each zone would give a loss probability of .007, considerably better than the present service. Looking at this another way, five lines servicing each zone could handle about 1.72 Erlangs of traffic at the present loss probability of .023; translating into busy-hour calls for all zones one gets a capacity for about 126 calls, a 40% increase over the present 90 call figure. One gets only 40% increase in the number

of calls for an 87.5% increase in the number of lines because of dividing the lines into three separate and independent groups rather than using a single group. If the single group were expanded by 87.5%, the number of calls which could be handled would increase by about 145%.

In Figure A-1 is plotted a family of loss probability curves for a busy-hour with 2.5 minute average holding time. The curves are based on the formulas given above. The present BPD experience is shown and one can conclude that if a peak-hour of 135 offered calls occurred during a single hour, that 10% of them would encounter busy signals and 121 of them would be answered. (When the loss probability is high, then reorigination of calls encountering a busy signal increases the normal calling rate artificially. We will neglect this factor because we are concerned with the true calling and answering rates for calls which arrive at the BPD line group.)

Also shown in Figure A-1 is the present BPD experience applied to each of three equally loaded zones served by five lines. (A total of 15 lines in 3 equal groups.) This shows that the number of busy-hour calls per zone could increase to about 42 while still providing service equal to the present arrangement.

The single-zone five-line group handling 30 calls of 2.5 minutes each during the busy-hour will have an average per line occupancy of 30/5 x 2.5 = 15 minutes. However, the five-line group can handle 42 calls with service equal to the present service and the average per line occupancy will be 42/5 x 2.5 = 21 minutes. If three answering positions are provided for the 30-call busy-hour then each position will be busy with DE 8-1212 calls for 30/3 x 2.5 = 25 minutes and with KE 6-6700 calls for an estimated 12 minutes leaving 23 minutes for records. If four answering positions are provided for the 42-call busy-hour then each position will be busy with DE 8-1212 calls for 42/4 x 2.5 = 26 minutes and with KE 6-6700 calls for an estimated 11 minutes leaving, again, 23 minutes for records.



Note: Holding Time 2.5 Minutes

FIGURE A-1 TELEPHONE CALL HANDLING CAPABILITY OF GROUPED LINES

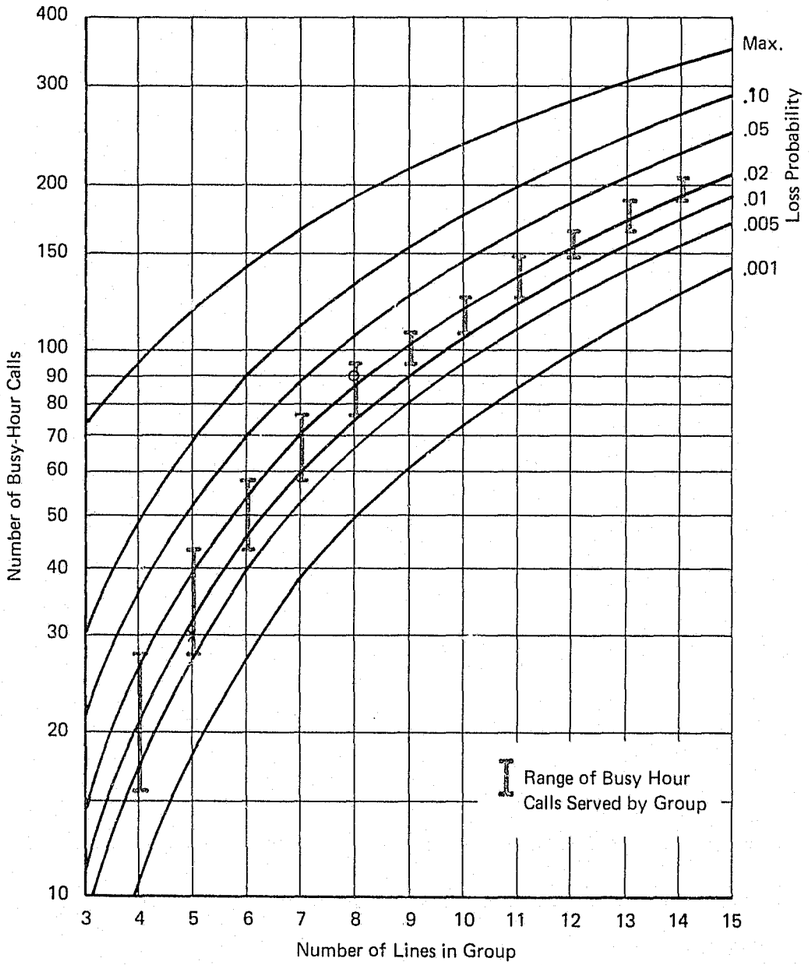
FUTURE SERVICE EXPANSION

In Figure A-1 it is shown that a fixed number of lines in a group can handle a variable number of busy-hour calls, to a full occupancy limit, but with the probability of a call encountering a busy signal increasing as the load increases. The practical limit to the average number of busy-hour calls served by a fixed number of lines is the loss (busy encounter) probability which produces reasonable service. The loss probability for the present BPD busy-hour service was calculated above at .023. This appears to be a reasonable figure inasmuch as it permits a peak hour equal to 150% of the average busy-hour with a loss probability of .10.

Figure A-2 shows the range of busy-hour calls which should be handled by the various line group sizes, using the .023 loss probability figure as a cutoff for the load for each group size. This demonstrates that the 5-line group should be increased to a 6-line group when the average busy-hour load exceeds 42 calls.

In Figure A-3 are plotted growth curves of 10 and 14 percent per year for the number of busy-hour calls. These growth estimates were provided by Captain Ahearn as recent experience factors. For the next 10-year period, 14 percent may represent a higher growth rate than one could expect from normal population and telephone habit growth experience. However, this figure could be achieved if crime, civil disorders and other police-oriented activities grow at faster-than-normal rates. Probably the 10 percent growth curve represents a more realistic long-term growth and, based on this growth, a 10-line group serving each of three zones would be adequate until 1984.

Of most importance to the telephone requirements planning for the BPD is that moving averages of the evening shift emergency calls can be compared against Figure A-2 to estimate fairly accurately the line group expansion requirements on a per zone basis. The methodology involved here is simply to take a daily moving average each month for the previous six to twelve months for the busy shift calls, divide



Note: Holding Time 2.5 Minutes

FIGURE A-2 SIZING OF LINE GROUP FOR .023 LOSS PROBABILITY

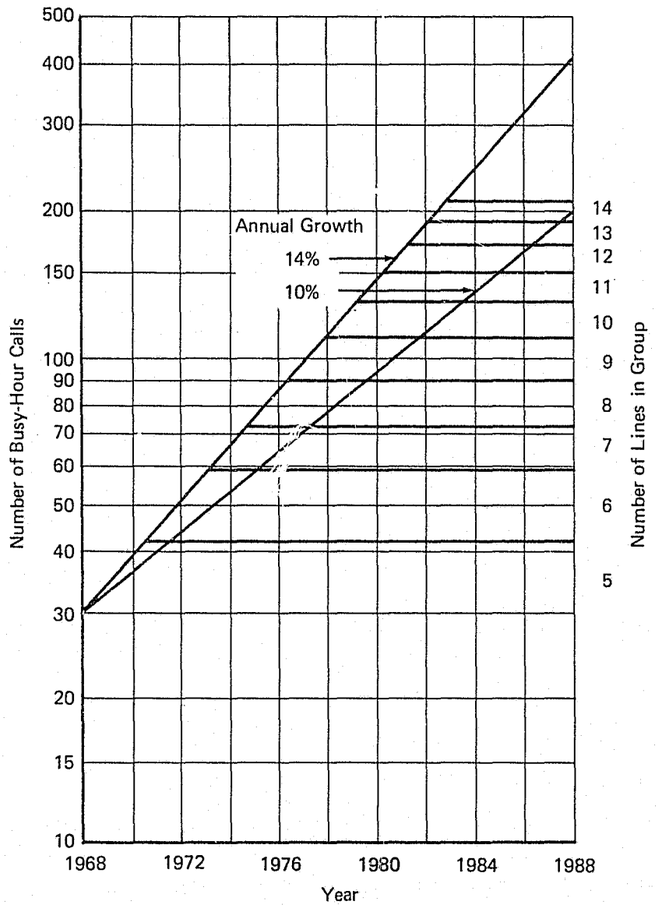


FIGURE A-3 GROUP EXPANSION PROJECTION

by eight for the average hourly calls and multiply by 1.37 (or other empirically-derived factor, as in the Detroit example above) for the average busy-hour call density. A monthly plot of these figures can be used to establish a trend towards the load limits established in Figure A-2 and an additional line can be ordered months in advance of actual requirements. Also, each zone can be expanded independent of other zone requirements, giving considerable flexibility to the actual line arrangements.

CONCLUSION

This paper presents the methods by which telephone line requirements for multi-line groups can be accurately estimated and projected. The degree of accuracy depends on the accuracy of the statistical information used and it is suggested that the following statistics be developed from records or from current observations in order that these methods can be used to give defensible results for further planning and design efforts:

- Average busy-shift/busy-hour relationship and changes for the past 3-5 years;
- Holding time distributions for time on line plus ringing times;
- Monthly moving average of busy-hour call density for the past 3-5 years.

This paper has briefly alluded to the number of answering positions required. In design of the new command facility it will be most important to know the busy-hour duties, other than telephone answering, which will be required of the answering positions. It has been estimated that records now involve almost as much time as telephone calls. This condition is not likely to continue with the new command and control system being designed. Final decisions on the number of lines required in the future will have to be made on the basis of data obtained by operation of the planned system. Meanwhile, since it has not been

possible to conduct an analysis of the value of a three-zone telephone capability the command and control system is being designed to work with either a split or a single area capability.

APPENDIX B

PATROL VEHICLE ACTIVITY

INTRODUCTION

There are times when large areas of the city do not have an adequate number of cars on patrol to respond to service needs. A suggested remedy is to provide more vehicles and men to operate them. This solution will certainly be costly and may not be efficient. An alternative is to look for ways to change how the present patrol vehicles are used. This requires determination of what patrol cars do on a typical day. The results of the study provide information needed for the design of the proposed command and control system. They also suggest a better method for allocating the patrol resources of the department. In contrast to the simple solution, a quantitative increase of cars, these results tell at what times and in what areas cars should be allocated and how their time may be spent more efficiently.

The paragraphs to follow mention "white card" and "pink card" incidents using local jargon for convenience. A "white card" incident is one for which a permanent record is made, including an identification number, on a white Complaint Message Card. Patrol vehicle activities which do not need a permanent record are reported on "pink cards". These are used as a temporary status-record for vehicles on such activities as lunch, vehicle repair, etc. Until this year the "pink cards" were destroyed after a few weeks. Only once have the "pink cards" been examined systematically, and then under somewhat artificial conditions.

OBJECTIVES

The analysis has attempted to determine the following facts:

- The in-progress work load of "white card" and "pink card" incidents, both separately and together, as a function of time of day, and district. Earlier analysis had considered

only incident starts, not incidents in progress at any time.

- The number of cars available for patrol and/or response as a function of time.
- The probability that a patrol vehicle is actually operating in the area to which assigned.
- The distribution of incident duration, and average durations for various types of white and pink card activity.
- The nature and distribution of "pink card" events, and the feasibility of fulfilling the functions by some other means than the patrol cars.

APPROACH

The data base consists of a complete listing of pink and white card incidents covering the twenty-four hour period of December 3, 1968. The data available on each incident includes the Central Complaint (identification) number, the time the call was received, the time broadcast, the time the patrol car cleared the incident, the car-sector, the car number, the origin, and the appropriate crime code number. The total number of incidents is 1080. The basic data have been punched up on IBM cards and sorted in several different ways. They were sorted first by car, then by car and incident code, and finally by time.

The data have been analyzed first by individual patrol car activities. Secular charts as a function of time of day have been made to show both pink and white card activities of each vehicle over the 24 hour period. From these time charts for each vehicle similar charts have been made for districts and the city as a whole. For simplicity of presentation, the activity analysis at the individual car level will not be presented: there is simply too much of it either to prepare as figures and charts or to comprehend readily.

RESULTS

Workload

Figure B-1 shows the "white card" incident-starts per half-hour for the whole city over the 24 hours examined. It is this distribution which is used to allocate vehicles by time of day.

From Figure B-1 it appears that the work load of calls for service rises from a low at 6:00 in the morning to a high at 7:00 in the evening. From 7:00 p.m. until midnight there is a decreasing demand for service, with a low centered on midnight, an increase around 1:00 or 2:00 p.m., and then a decline to the low at 6:00 a.m.

On the day that these data were taken there were 65 vehicles in operation during the day shift and 71 in the evening. A comparison of these numbers with the Figure would lead one to believe that there should be thirty or more vehicles available for assignment at any time. The Figure is misleading, however, for two reasons. First, it is based upon the number of incidents which start in any time interval rather than the number which are in progress. Second, it completely neglects police activities other than those which result from calls for service: the "pink card" activities.

Figure B-2 is a plot of the incidents in progress in each half hour period for both "white card" and "pink card" incidents. The lower curve in this figure is directly related to Figure B-1. If all "white card" incidents were of the same duration, the two curves would differ only in verticle scale. Actually the duration of "white card" incidents varies throughout the day, in part because the nature of these incidents changes. The number of "white card" incidents in progress has three low points in the day: at midnight, at 6:00 a.m. and at 2:00 p.m. After 6:00 a.m., the number of incidents in progress rises steadily until noontime and then drops very noticeably around 2:00 p.m. It then rises erratically to 7:00 in the evening and decreases after that until midnight. The low at 2:00 in the afternoon indicates that the average time spent per incident in this period is less than at other times in the day. This probably results from a desire to go to lunch:

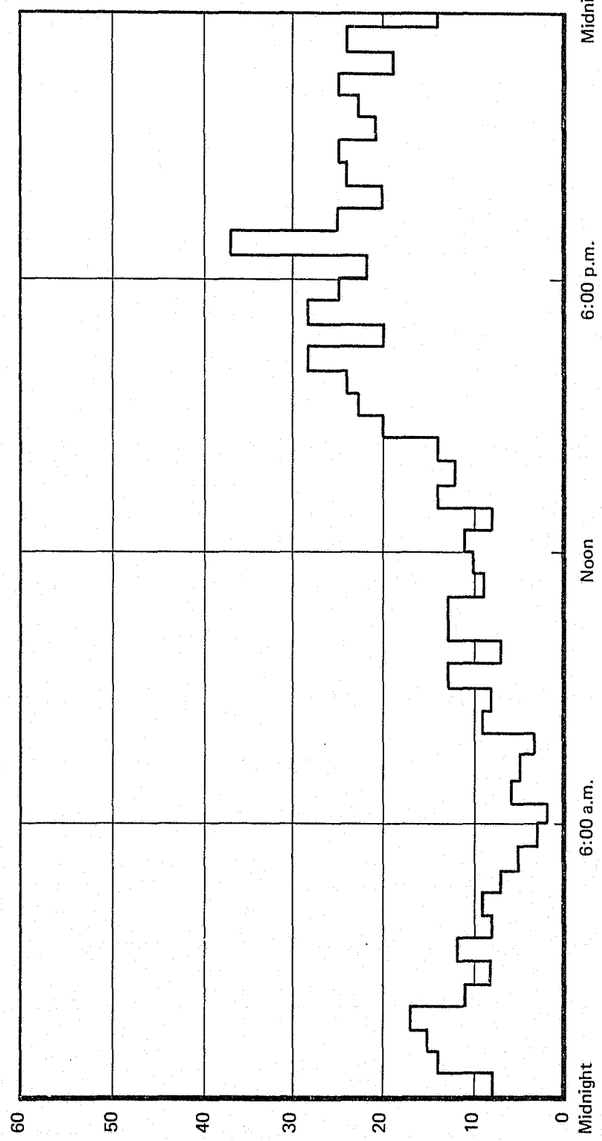


FIGURE B-1 "WHITE CARD" INCIDENT STARTS PER HALF HOUR

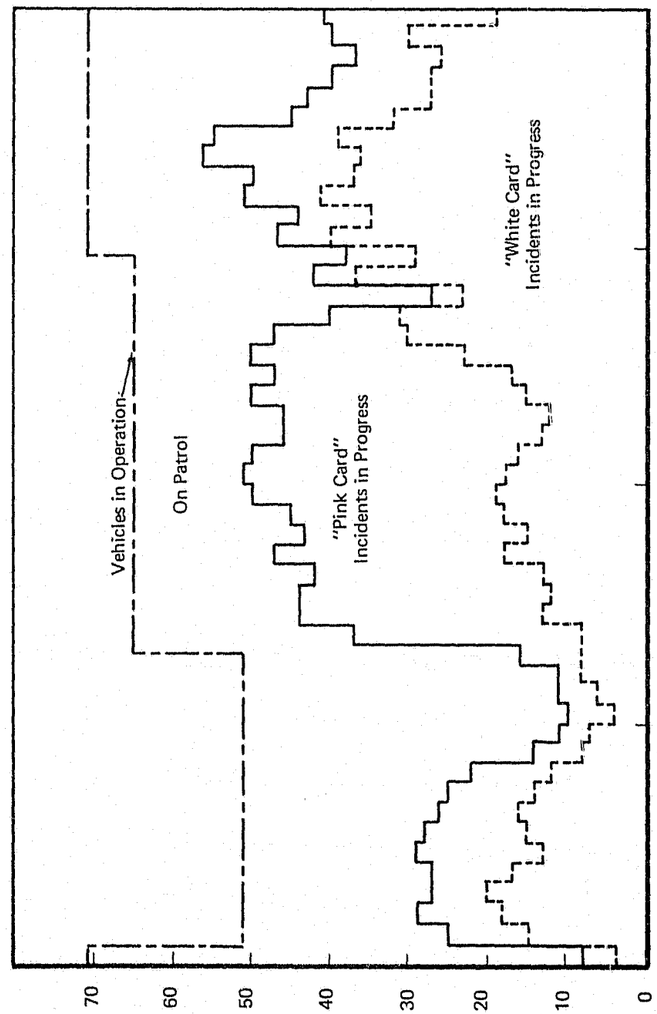


FIGURE B-2 INCIDENTS IN PROGRESS IN EACH HALF-HOUR PERIOD

TABLE B-I

CONGRUENCE OF CAR SECTOR AND CAR ASSIGNED

District	"White Card" Incidents to which a Sector Car was Assigned	Number of Incidents with Car in Own Sector	% of Incidents with Car in Own Sector
1	60	19	32%
3	50	25	50%
4	82	11	13%
5	26	9	35%
6	42	11	26%
7	19	13	68%
9	71	13	18%
10	48	19	40%
11	61	20	33%
13	25	14	56%
14	40	10	25%
15	13	6	46%
	542*	170	31%

*does not include 17 cases in which a car was dispatched across a District boundary.

TABLE B-II

INCIDENT LOCATION VS CAR SECTOR
OF RESPONDING VEHICLE

SECTOR OF INCIDENT	ASSIGNED SECTOR OF RESPONDING VEHICLE									ROVING VEHICLES	
	1-1	1-2	1-3	1-4	1-5	1-6	1-7	1-8	1-9	1-100	1-101
1-1	5	1	1		2		1			2	
1-2	4	2	1		3						
1-3	2	1	5		1		1			1	4
1-4				1		1	1			1	
1-5			2		1	1	3	2	1		
1-6	1					1	1				1
1-7			1			1	1		2	2	
1-8				1			1	1			
1-9			2			1	1		2		

Car Sector = Sector of Occurrence 19

Vehicle Responds Outside of Sector 41

Congruence = $\frac{19}{60}$ = 32%

there is apparently a strong preference on the part of patrolmen to take lunch between 1:00 and 2:00 p.m.

The number of "pink card" incidents in progress has been added to the "white card" incidents to produce the second curve in Figure B-2. The difference in the two curves is very low at the change of shift at midnight and also at 6:00 in the morning. The number of "pink card" incidents in progress is very high from 8:00 in the morning until 4:00 in the afternoon. During this daytime period, the number of vehicles occupied on these incidents exceeds the number occupied on calls for service by about 50%. In the evening hours, from 7:00 until midnight, there are always ten to fifteen vehicles tied up on "pink card" incidents. This is only about 50% of the number engaged on calls for service during the evening.

Car Availability

Figure B-2 also shows the number of vehicles in operation in each shift. It is clear that the midnight to morning shift has twenty to thirty vehicles available for assignment to incidents at any time, even though the number of incidents starts per half-hour averages ten or fewer for the period. During the day shift there are fifteen to twenty vehicles available for assignment and in the evening shift from fifteen to twenty-five depending upon the precise time.

The minimum number of vehicles on patrol or otherwise available for assignment on this same day is fourteen. This means that at minimum there is on the average slightly more than one vehicle per district ready for assignment. These available vehicles, however, are not distributed evenly over districts but tend to be less available in the districts where the demand is higher. The detailed figures indicate that between the hours of 10:00 a.m. and 4:00 p.m. the availability of cars in the busy central districts is 19% and in the outlying and less busy districts it is 26%.

CAR SECTOR VERSUS SECTOR OF OCCURRENCE

For administrative purposes the city is divided into twelve districts. The area of each district is sub-divided into car sectors. The official description of patrol activities indicates that at times of peak activity there is at least one patrol car assigned to each car sector. For a particularly busy sector there may be two cars assigned. At times of lower activity a patrol car may be assigned to two or more sectors of responsibility. In theory, a sector car will be assigned to a call for service in its sector. What actually happens, however, is that all of the cars in a particular district are used to respond to any call for service within the district.

Table B-1 shows for the sample day the congruence of car sector and car assigned to a call for service. The fraction of incidents for which a car was assigned to an incident in its own sector varied from 13 percent to 68 percent. Overall, only 31 percent of the incidents involved a car responding within its own sector. The probability of congruence was lowest for the busiest districts.

The fact that each patrol vehicle operates with the entire district as its beat suggests that unnecessary amounts of time are spent in transit to the location of a call for service. A major revision in the operating methods of patrol is probably in order.

Table B-II shows for a single district the geographic distribution of responses for each patrol vehicle during the 24 hour sample day. The vehicle assigned to sector 1-7, for example, responded to only one call in that car sector but did respond to calls in 8 of the 9 sectors in the district. Further, of the 7 incidents in car sector 1-7 the assigned vehicle responded to only one.

NATURE AND DURATION OF INCIDENTS

The total amount of patrol vehicle time available in the 24 hour period was used as shown in Table B-III.

TABLE B-III

USE OF PATROL VEHICLE TIME

Function	Time
"White Card" Incidents	20.5%
"Pink Card" Incidents	24.7%
Patrol and/or available	54.8%

Table B-III indicates that approximately 1/5 of the available patrol vehicle hours was spent responding to calls for service. Approximately 1/4 of the available time was spent on other police business and more than half of the available time was spent either on patrol or ready for assignment. As is apparent from Figure B-II, a large faction of available time occurs in the midnight to morning shift.

Table B-IV gives the statistics on "white card" events for the 24 hour period. The events are categorized with the total number and the average duration for each category. The average duration per "white card" event was 40.6 minutes. This is an increase of roughly 5 minutes over the average duration measured roughly a year earlier.

Table B-V gives the statistics for "pink card" events during the 24 hour period. The table shows the total number of minutes spent on each category of event, the total number of such events, and the average length of time for each category. The average duration for "pink card" event is 51.4 minutes, more than 10 minutes longer than the duration of the average call for service.

It is clear that "pink card" events absorb more of the available patrol time than do calls for service. It is useful to ask whether some other method might be available for carrying out some of the activities and duties which use up this time. It would seem, for example, that vehicle maintenance, radio maintenance and car wash might be done while a vehicle is in the garage, having been exchanged for a pool vehicle. Other categories such as court, school crossing, warrant

TABLE B-IV

"White Card" Statistics

Incident Type Code Name	Total Minutes/ 24 Hours	Total Events/ 24 Hours	Average Time
01 Homicide	0	0	0
02 Rape	0	0	0
03 Robbery	358	8	44.8
04 Aggravated Assault	71	2	35.5
05 Burglary	1891	39	48.5
06 Larceny	1527	33	46.3
07 Auto Theft	1894	42	45.1
08 Simple Assault	232	9	25.8
09 Arson	64	1	64
10 Forgery & Counter.	0	0	0
11 Fraud	49	2	24.5
12 Embezzlement	0	0	0
13 Stolen Property	212	3	70.7
14 Vandalism	1202	27	44.5
15 Weapons	0	0	0
16 Vice/Prostitution	73	2	36.5
17 Sex	0	0	0
18 Narcotics	0	0	0
19 Gambling	0	0	0
20 Family	66	2	33
21 Drunk Driving	0	0	0
22 Liquor Laws	0	0	0
23 Drunkenness	37	1	37
24 Disorderly Conduct	0	0	0
25 Vagrancy	217	8	27.1
26 All Other Offenses	589	17	34.6
27 Suspicion	101	5	20.2
28 Parking	0	0	0
29 Traffic	33	1	33
30 Medical	2815	57	49.4
31 Investigations	2383	81	29.4
32 Lost & Found	244	6	40.7
33 Minor Disturbances	2268	72	31.5
34 Miscellaneous	150	4	37.5
35 Missing Persons	539	10	53.9
36 City Affairs	69	2	34.5
37 Vehicular Accidents	1288	19	67.8
38 MDC	61	1	61

Total Time in Hours: 307.2

Total Hours on Patrol: 1,496

Percent "White Card" Activity: 20.5%

Average Time/"White Card" Incident: 40.6 minutes

TABLE B-V

"Pink Card" Statistics

Incident Type Code Name	Total Minutes/ 24 Hours	Total Events/ 24 Hours	Average Time
01 Vehicle Maint.	1276	23	55.48
02 Radio Maint.	228	2	114
03 Drunks	341	14	24.36
04 Headquarters	326	4	81.5
06 Court	986	10	98.60
07 Escort	74	2	37
08 School Crossing	2614	49	53.35
09 Assist Other Vehicles	1131	23	49.17
10 Lunch	4215	55	76.64
11 Warrant Service	544	12	45.33
12 Prior Incident	1539	48	32.06
14 Towing	24	1	24
15 Traffic Incident	1944	46	42.26
16 OPER 16	181	3	60.33
17 Car Wash	338	9	37.56
18 Station Assign	1868	53	35.24
19 Contact Someone	267	9	29.67
20 Trip to Prison	66	2	33
21 Trip to Hospital	515	8	64.38
22 Specified Location	2244	50	44.88
00 Unspecified	1461	35	41.74

Total "Pink Card" Event in Hours: 369.7

Total Hours on Patrol: 1,496

Percent "Pink Card" Activity: 24.7%

(Car-Hours of all Types) = 62 equiv. full-time cars

1 day = 1440 mins. x = equiv. full time cars

service, trips to prison or hospital may not really require the service of a marked patrol vehicle. A police vehicle pool or the use of public transportation might in many cases save the time of the marked patrol vehicle.

APPENDIX C

THE "MISCEL" CODE

For those incidents listed in Table C-I which involve routine investigations it is now normal practice to report to the secondary dispatcher using the number/letter code shown. After such an incident is investigated a car returns to service by giving its car designation, stating "miscel" and the appropriate incident number and police action letter. It is occasionally necessary to give two or more action letters.

Examples are:

To report a False Fire Alarm - state "Miscel-Five Ocean."
To report Illegal Parking - Issued Parking Citation - state "Miscel-Fourteen-Lincoln."
To report Family Trouble - Peace Restored and Advised Warrant - state "Miscel-Six-Frank George."

TABLE C-I

ROUTINE MISCELLANEOUS INCIDENT REPORTING TABLE

No.	Incident	Phonetic	Police Action
1.	ADT and/or Burglar Alarm	A-Adam	Not Bona Fide Incident
2.	Citizen Alarm	B-Boy	No Person can be Found
3.	Citizen Calling for Help	C-Charles	No Such Address
4.	Escort Duty	D-David	No Police Service Necessary
5.	Fire Alarm	E-Edward	Perpetrator Gone on Police Arrival
6.	Family Trouble	F-Frank	Peace Restored
7.	Gathering Causing Annoyance-Outside	G-George	Advised Warrant
8.	Investigation Persons, Routine	H-Henry	Advised to Recontact Police if Repeated or Returned
9.	Investigation Premises,-"	I-Ida	Taken to District Station
10.	Landlord-tenant Disturbance	J-John	Field Interr. Report Prepared
11.	Lock-out	K-King	Issued Traffic Citation
12.	Noisy Party, Radio, TV, etc.	L-Lincoln	Issued Parking Citation
13.	Prowler (No Description)	M-Mary	Advised Legal Help
14.	Police Services, Traffic, etc.	N-Nora	Accidental or Defective Alarm
15.	Disturbance, Drunk	O-Ocean	False - No Prosecution
16.	Disturbance, Inside	P-Paul	Service Rendered

APPENDIX D

A PATROL EXPERIMENT

SUMMARY

An experiment was conducted within the Boston Police Department to determine the effect of increasing the actual time spent on patrol, as distinct from time spent on other duties, within a given district. Three additional patrol cars were assigned to District 13 during the "first half" (5:45 p.m. to 12:30 a.m.) tour of duty for a period of one week in November, 1968. This district normally has four cars on patrol during this watch, so three additional cars was a significant increase.

District 3, a similar area, was chosen as a control. Additional data covering a similar week in 1967 were gathered to compare Districts 3 and 13 when patrol activity was "normal" in both.

It was impossible to draw any conclusions from the results of this experiment which relate directly to its purpose. The several reasons for this difficulty include the nebulous character of the data; changes which took place between 1967 and 1968, particularly the introduction of the "Miscel" system of reporting; and activity level differences between District 3 and District 13.

Although it was not possible to make inferences about effects stemming from the increased patrol time, analysis of the data from this experiment did yield other useful results. Since the data included a record of all assigned activities of all cars in two districts for the "first half" watch during two weeks, one in 1967 and one in 1968, it was possible to assemble a substantial body of information regarding the typical breakdown of activities of the patrolmen in those districts. Also, data collection, reduction and analysis methods were developed which will have value in further resource allocation studies. One note-

worthy finding was that the time spent on all incidents decreased significantly between 1967 and 1968, and that the reduction in time spent was particularly marked for investigations of maintenance-of-order complaints and of false-alarms. This result appears to be attributable to the introduction of the "Miscel" system of reporting routine investigations.

INTRODUCTION

Planning the allocation of a police department's resources is complicated by the inherent difficulty in determining the ultimate effect of a given deployment upon such goals as preventing crime, preserving order, enforcing laws, and rendering service to citizens. The imprecision of police goals and the relative emphasis given to each result in varying degrees of discretionary behavior on the part of patrolmen in different departments.* The patrol experiment was not an attempt to redefine any goals of the Department or to measure the effectiveness of the patrol force. It was instead a recognition of the fact that the activities which a patrolman is called upon to perform may limit his availability for effective patrol.

Presumably, some of the benefits provided by constantly available, visible, patrolling police include increased speed of response to calls, a deterrent effect on crime and disturbances, and an increased probability of being at the scene of an incident as it occurs. Although it was believed that increasing the effective patrol time within a district might have a detectable and salutary effect upon these factors, it was impossible to determine a direct cause and effect relationship between increased patrol time and a measurable result.

The experiment did provide a detailed set of data describing the activities of the patrol cars in two districts for the "first half" tour of duty for one week in 1967 and 1968. Because of our analysis of these data:

*This point is explained at great length in: James Q. Wilson, Varieties of Police Behavior, Harvard University Press, 1968.

- The ADL effort profited by a detailed breakdown of police activities, limited though the scope was in both time and area.
- A clearer conception was gained of the problems, and their possible solutions, concerning the collection and analysis of data on police activities.
- More precise knowledge was obtained concerning the distribution of types of activities and will aid further efforts in police resource allocation, even though that knowledge is based on a fairly small and unrepresentative data sample.
- Methods were developed by which police activity information could be efficiently tabulated and analyzed in the future.

DESCRIPTION OF EXPERIMENT

The experimental plan was to saturate District 13 with cars from the Tactical Patrol Force so as to double the number of cars working there, which would more than double the available patrol time. Data were collected regarding the activities of the patrol cars during the period of interest. Data were also gathered for the corresponding week in the previous year (1967), so that a comparison would be made to determine the effect of doubling the patrol force. Additional control data were collected for District 3, an area with similar characteristics, for the same time periods.

The experiment was originally planned for the week of November 17, 1968, in the new District 1 (encompassing all of former Districts 1 and 2, as well as certain areas of District 4). That week was the last full week in November; it was selected because it did not contain a holiday and was believed to be the last week in the year prior to the Christmas shopping season.

It was necessary, however, to change the location of the experiment. A week before the experiment was to have taken place, it was

learned that the stores in the downtown shopping area intended to open the Christmas shopping season one week earlier than usual. This would have interfered with the experimental plan because more police were assigned to District 1 during the Christmas shopping season to cope with the crowds. Any data collected during that period would not be representative of the rest of the year.

The location of the experiment was therefore changed from District 1 to District 13, and the dates were changed to November 20-26 due to the resultant delays. District 13 includes Jamaica Plain, a predominantly residential area. Of a population of about 45,000, about 55 percent earn more than $6000 and 35 percent own their own homes.

District 3, which includes Dorchester and Mattapan, was chosen as a control district. It adjoins District 13 and is similarly residential in nature. Its population is about 66,000, of which 48 percent earn an income greater than $6000 and 34 percent are homeowners. Both districts have very small non-white populations.

There are four patrol car sectors in District 13; during the week of November 20-26, 1968, three patrol cars from the Tactical Patrol Force (TPF) were assigned to that district. These cars patrolled from 5:45 p.m. to 12:30 a.m. to coincide with the normal tour of duty for District 13 patrol cars.

DATA COLLECTION AND REDUCTION

One of the difficulties in analyzing the experiment's results arose from the task of reconstructing the activities of the patrol cars from the complaint message cards, the journals and the district control logs for the weeks and shifts of interest. To aid in the reconstruction of activity, charts were drawn up which showed the nature and duration of the duty activities of each car during the shift of interest for one day. These helped resolve the many inconsistencies in the data and provided a visual representation of patrol vehicle activity.

For the period covered by the experiment, data were available only for the "white card" or assigned-duty activities of the patrol cars. There are other activities which consume much of a patrolman's time that are unassigned or peripheral, and which are not permanently recorded. This group includes activities that are unrelated to police duties such vehicle maintenance, lunch, and car wash, and also such duty-related activities as school-crossing control, appearance in court, and warrant service. These other activities are recorded by the dispatcher on "pink cards" for the purpose of controlling patrol vehicles. Until quite recently, the pink cards were held for a short period of time and then discarded.*

Because of the importance of "pink-card activity," it was necessary to obtain an estimate of the amount of time devoted to it relative to that spent on "white-card activity." The pink cards for the period covered by the experiment had already been discarded, but both white and pink cards were available for one day in December, 1968. From this meager sample, "pink-card activity" was estimated to comprise about 20 percent of the total (non-patrolling) activity during the 5:45 p.m. to 12:30 a.m. shift. (During the day, the corresponding percentage is a good deal higher.)

In order to present graphically the activity of patrol cars distributed, over both time and type of activity, daily charts of the activity of individual cars were grouped and added by separating all activities into four types: (1) law enforcement (e.g., robbery, assault and battery, auto theft); (2) maintenance of order (e.g., family trouble, disturbances, prowler); (3) medical assists; and (4) false incidents (e.g., false fire alarms, false citizen alarms). For each one-minute period, the total patrol car time (shift hours multiplied by number of patrol cars) minus the "busy" time gives available patrol time. This quantity must, however, be reduced by the assumed pink-card time,

*Since the beginning of 1969, the pink cards are being retained.

as discussed above. Repetition of this basic computation made it possible to construct a visual display of available patrol time as it varied with time, day and district, as well as a visual display of the type of activity which made up the "busy" time.

A computer program was also developed to analyze the activity data. A principal function of this program is to assign each incident to one of the four major categories used in the graphical analysis (law enforcement, preservation of order, medical assists, false alarms) by examining the crime code. Table I lists the crime codes according to the category to which they have been assigned.

ANALYSIS OF DATA

One of the most interesting findings is the significant reduction from 1967 to 1968 in the average time spent on incidents, particularly those in the preservation-of-order and false-alarms categories. Since the "Miscel" system of reporting such types of incidents was introduced during 1968, it appears that the new reporting system is directly responsible for this reduction in time spent. Figure D-1 shows this phenomenon graphically.

One of the implications of this reduction can be stated in a slightly different form. Approximately 200 hours of incident-occupied time from each year were studied (209 hours in 1967, 203 hours in 1968, combining both districts). For the hours studied, 50 percent more incidents were investigated or serviced in 1968 than in 1967 (197 in 1967, 295 in 1968). The reduction in time spent per incident is not a result of having "filled up the available time". The patrol time (with the correction for "pink-card" time) was very nearly equal to the incident-occupied time and also remained nearly the same from 1967 to 1968 (233 hours in 1967, 240 hours in 1968, combining both districts but excluding the TPF in 1968).

Figure D-2 shows the percentage distribution of types of incidents by categories and the distribution of time spent investigating or servicing complaints also by incident categories. As expected, the

TABLE I

LAW ENFORCEMENT

1 Homicide
2 Rape
3 Robbery
4 Assault
5 Burglary
6 Larceny
7 Auto theft
8 Assault & battery
9 Arson
10 Forgery & counterfeit
11 Fraud
12 Embezzlement
13 Stolen property
18 Narcotics
19 Gambling
2603 Bribery
04 Extortion
05 Contrib. to delinq.
06 Rescue prisoner
09 Glue sniffing
11 Abduction
14 Hypodermic possession
16 Possession of burg. tools
17 Conspiracy
18 Explosives
19 Arrest fug. from justice
22 Kidnapping
24 Op. w/o authority
26 Perjury
36 Escaped prisoner
27 Suspicion of 1-19

PRESERVATION OF ORDER

14 Vandalism
15 Weapons violations
16 Prostitution & vice
17 Sex offense
20 Desertion, non-support
21 Driving under influence
22 Liquor laws
23 Drunkenness
24 Disorderly
25 Vagrance
2601 Abortion
08 Stubborn child
10 Trespassing
12 Ice box
13 Cruelty to animals
15 Bigomy
20 Stoning trains
21 Illegitimacy
23 Obscene lit.
25 Park rules
27 Barking
28 Obscene phone call
31 Concealing leased prop.
32 Evading fare
33 Runaway
35 Unlicensed dog
37 Fish & game
38 Labor laws
39 Lord's day
40 Non-payment of wages
41 Peddler
42 Truancy
43 Small loan act
44 Abroad in night time
45 Railroad offense

PRESERVATION OF ORDER CON'T

2646 Drinking in street
47 Threats of bodily harm
48 Bomb hoax
49 Election laws
50 Auto rental
51 Harbormaster regs.
52 Harbor rules
53 Littering
54 Loitering
55 Snow
56 Abandoned auto
57 City ord.
58 Hackney
59 Minor w/liq. in car
60 Other
61 Obstruc. fire apparatus
28 Parking
29 Traffic, motor vehicle
31 Investigations
32 Lost & found
33 Minor disturbance
34 Misc. service
35 Missing person
36 Reports = other city depts.
37 Vehicular accidents
38 MDC

MEDICAL ASSIST

30 Medical

FALSE ALARM

2607 False fire alarm
2629 False citizen alram

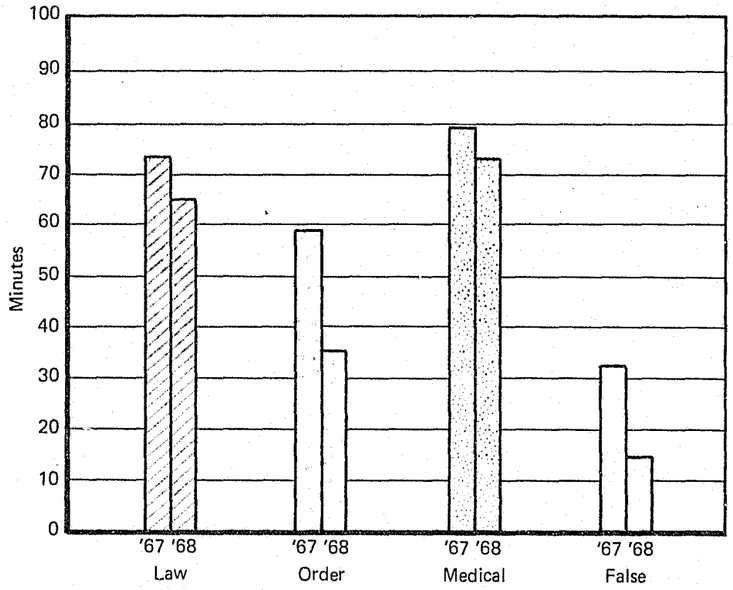
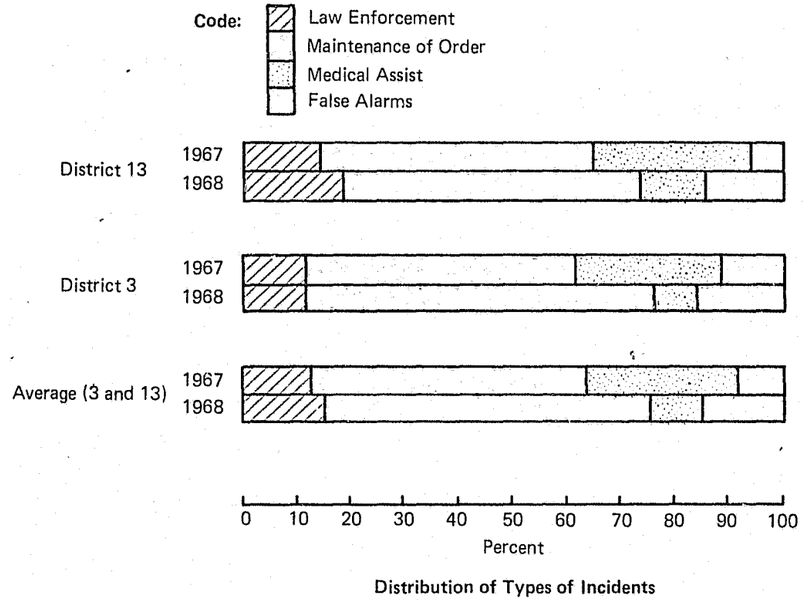


FIGURE D-1 AVERAGE TIME SPENT ON FOUR TYPES OF INCIDENTS (Combining District 3 and District 13)



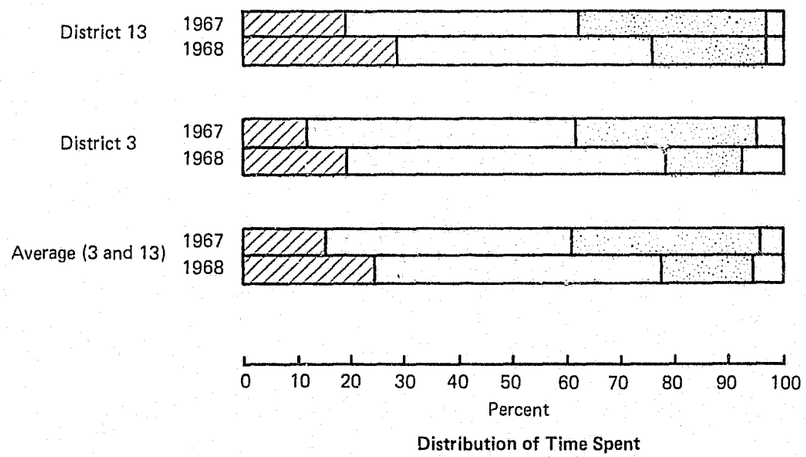


FIGURE D-2

apparent efficacy of the "Miscel" system shows up on these charts also. For example, in District 13, the percentage of incidents which were false alarms more than doubled between 1967 and 1968, but the time spent investigating them remained the same percentage of the total.

An attempt was made to correlate the number of on-site discoveries of incidents with some quantity such as available patrol time. In District 13 during the week in 1968 when the patrol experiment was conducted, police action was initiated 18 times by patrolmen who came on the scene while patrolling. In 9 of these cases, the encounters were made by TPF patrol cars (three of which were assigned to District 13 at that time). This compares with 13 on-site occurrences in the same district in the same week in 1967 (when there were no TPF cars on patrol) and 7 and 4 in the control district in 1968 and 1967, respectively. Most of these incidents involved the recovery of stolen cars and/or the arrest of persons for unauthorized use of a motor vehicle. It is difficult to draw any conclusions from the above data aside from the fact that most of the stolen cars recovered and auto thieves apprehended were done so by patrolmen who happened on the scene while patrolling.

CONCLUSIONS

The major drawback of the above analysis is that the data sample was limited in scope, both in time and area. It was taken from a fairly homogeneous low-crime-rate area of the city and does not include "pink-card" activity. It is not by any means, therefore, representative of the City of Boston as a whole. The patrol experiment does, however, serve as a guideline for future analytic work of this nature. Methods have been developed for reducing and analyzing police activity data. Furthermore, this experience has revealed the difficulties which attend the apparently simple task of collecting data from which the activities of a patrol force can be reconstructed.

The knowledge gained from this experiment will be helpful in designing more meaningful experiments in the future. Since the Boston Police Department is now retaining the "pink cards," it will be possible to

assemble a complete set of data for the whole city. The experience of trying to collect information from the cumbersome records now maintained by the BPD will enable us to recommend improvements in record-keeping procedures. More controlled experiments and easier access to police activity information will both be valuable to future resource allocation studies.

APPENDIX E

IMPLEMENTATION PHASES

The command-and-control/information-management system is described in the body of the report and in various supporting detailed specifications. The "final" system is complex and requires interaction among men and hardware that are resident in the Boston Police Department's Headquarters, Districts, and patrol cars, and also in surrounding communities and perhaps state agencies as well. A system of this scope and complexity is best developed and implemented in stages both to assure that each of the component parts is suited appropriately to the needs of its users and to give the users an opportunity to learn how to interact with the system and make recommendations for its improvement. This Appendix describes briefly the implementation phases or stages that are currently planned for the computer based activities of the Boston Police Department.

Phase Zero	-	A Pre-Prototype Test Environment to Familiarize Potential Users with Display Format Types
Phase I	-	A Prototype Command and Control System Involving only the Turret
Phase II	-	An Operational Prototype Command and Control System Involving only the Turret with Limited Reporting Capability and Restricted Search and Retrieval Ability.
Phase III	-	An Operational Command and Control System Involving only the Turret with Full Reporting Capability and Unrestricted Search and Retrieval Ability.
Phase IV	-	An Operational Command and Control System Involving the Turret and All Districts with Full Reporting Capability and Unrestricted Search and Retrieval Ability.
Phase V	-	A Comprehensive Information Management System Embodying Phase IV Activities.
Phase VI	-	A Comprehensive Information Management System Capable of Supporting Remote Inquiry and Retrieval by Communities Outside the City of Boston.

Discussion

Phase Zero

During this phase potential users of the Command and Control System will be able to retrieve and display various format types. To the extent that actual Turret operations can be simulated, these display types can be used to enter information, and ease of terminal usage can be evaluated. Information entered by an operator will be buffered in the terminal and will not be transmitted to the computer. Although Phase Zero provides only a simple inquiry and retrieval capability, the feedback obtained will make possible a preliminary evaluation of the basic display formats, the command language, and file record content file and organizaiton.

Phase I

The prototype system defined by the functional specifications will be implemented by utilizing an IBM software package called FASTER. Incorporating the knowledge gained from Phase Zero, the design will be modified as required based on the actual "hands-on" experience of dispatchers and complaint clerks. Because of FASTER's ability to simulate a communications environment, each of the transactions will be tested "off-line" without disturbing existing data processing operations. Thus all internal message processing will be checked prior to actual system operation. In testing system operation, careful consideration will be given to utilizing real-time data input and realistic but simulated operator response. Furthermore, additional flexibility in testing will be gained by proper utilization of FASTER's maintenance macro to execute several scenarios that re-enact a realistic sequence of dispatching events.

Phase II

Dispatching activities in the Turret will be centered around an operational Prototype Command and Control System. Complaint clerks will minimize the use of paper to record data and will enter information about incidents directly to the system.

Dispatchers will rely upon system supplied vehicle availability status to assign vehicles to incidents. Non-incident vehicle activity will

be reported to the system and this information will be saved and can be used for subsequent summary reports and analyses. The system will capture the progression of events that relate to each incident, will extract and condense significatn data and display this information to Turret personnel on request for subsequent analysis and decision-making. Each day, the system will generate, for each district, the District Control Log thereby relieving district personnel of the need to prepare such a log manually. The system will support current search and retrieval activities centered around the Stolen Auto and Warrant file, but will not be able to support unlimited search and retrieval of large files. This will require more complex software which will enable messages of higher priority to be processed first and also the simultaneous processing of several messages residing within the system.

Phase III

Situated in the proposed, new operations center, this system will provide Turret personnel with the ability to search several files without degrading response time. To provide this capability will require new software which may be available from the vendor or may have to be completely developed and written anew. Regardless of which option is selected, a completely new set of message processing routines will have to be written to interface with the selected message control program. Additional non-real-time routines will have to be written to process the information developed as a by-product of dispatching operations. These batch processing routines will either run in a background partition or completely off-line and will produce a variety of reports relating to incident and vehicle activity. If the batch programming routines cannot be written in parallel with the development of real-time software then this phase will be divided into two sub-phases. In either case, the Phase II system will be retained until an orderly cut-over to Phase III operation can be guaranteed. Furthermore, since it may become desirable to expend dispatching operations to encompass the districts as soon as it is feasible. The second sub-phase (i.e. the development of a batch-processing capability) can be merged with Phase IV. Also, during this

phase, or perhaps earlier, consideration will be given to the level of reliability required by the nature of the dispatching function. Each alternative, ranging from fall-back to manual operation to a completely duplexed system with redundant data paths and duplicate files, will be evaluated in the light of various trade-offs. It is now felt that it will not be cost/effective for the Boston Police Department itself to maintain a duplexed system. In the event of a catastrophic failure the ability to pre-emp another City Department's system would be desirable, but this capability is not being considered at this time.

Phase IV

Since most of the district-oriented transactions will have already been specified and implemented, the emphasis will shift from software to hardware considerations. That is, during this phase, display terminals with hard-copy feature will be installed at the district stations and will be connected to the system. The precise manner in which they will be connected has yet to be determined and is dependent upon several factors relating to economics, security, and system design. Hopefully, this evaluation will overlap with a previous phase of implementation and be completed early. Thus, by the time the district stations are ready to be connected to the system, the desired communication network will have been installed and tested. Careful planning of district station tie-in will minimize system disturbance and will make it possible for those features incorporated through Phase III to remain operational.

Phase V

During this phase, emphasis will be placed on automating those activities whose scope may include those relating to command and control but are not restricted to it. An example would be automatic notification, message switching, and administrative message handling. Another example would be the development of abstracted information that points to the location of similar information in greater detail. A natural concomitant of such a program would be the investigation of the feasibility of developing a micro-film retrieval system that would contain many of the

bulk documents now stored in the Records Section and permit easy and quick retrieval of them.

Since the scope of Phase V will be all encompassing and its successful completion will appear asymptotic, there is no reason why this phase cannot and should not overlap with Phase VI.

Phase VI

During this final phase of implementation local police departments in surrounding communities would be able to interrogate certain files and retrieve a variety of information about criminal activities. To the extent that the active interchange of data would be mutually desired, the ability to update certain files would also be implemented. In all probability, a remote terminal would be connected to the system on a dial-up basis over ordinary telephone lines. However, if the element of security were to become significant, more complex methods of connecting to the system would have to be investigated. Furthermore, some form of payment-for-service-rendered scheme could be devised (such as a charge per message basis) which would provide additional revenue to offset some of the costs of maintaining the system.

END