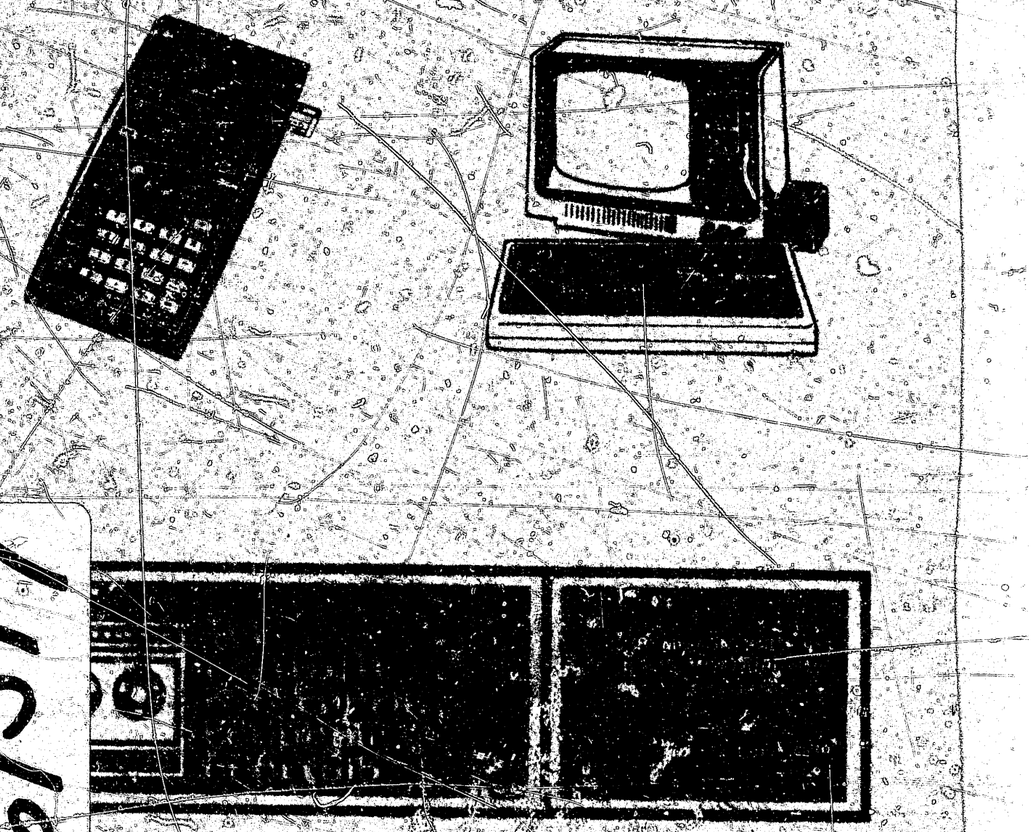
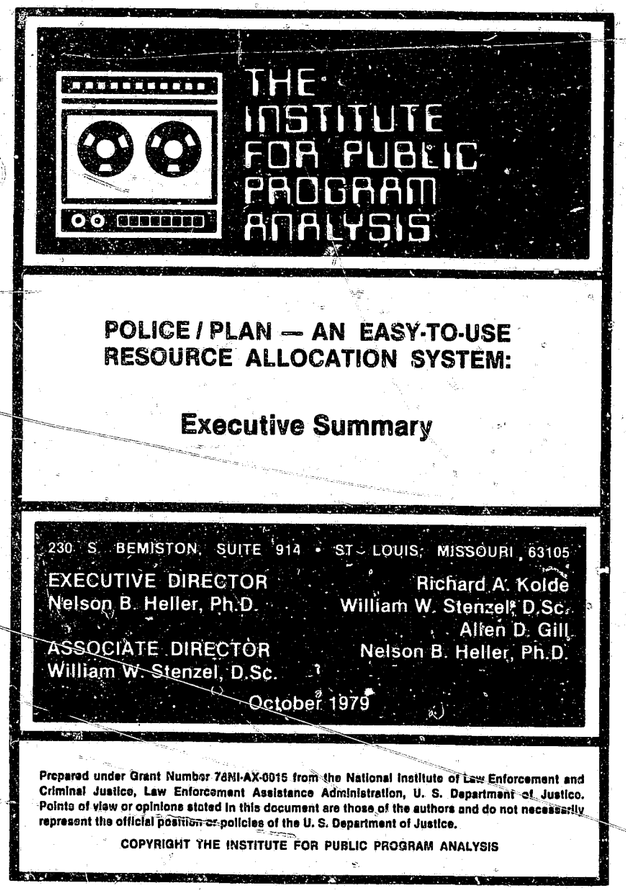
POLICE/PLAN — AN EASY-TO-USE RESOURCE ALLOCATION SYSTEM:

Executive Summary





POLICE / PLAN — AN EASY-TO-USE RESOURCE ALLOCATION SYSTEM:

Executive Summary

230 S. BEMISTON, SUITE 914 • ST. LOUIS, MISSOURI, 63105

EXECUTIVE DIRECTOR
Nelson B. Heller, Ph.D.

ASSOCIATE DIRECTOR
William W. Stenzel, D.Sc.

Richard A. Kolde
William W. Stenzel, D.Sc.
Allen D. Gill
Nelson B. Heller, Ph.D.

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ABSTRACT

This report presents a summary of the products and findings of the project "Easy-to-Use Police Resource Allocation Planning Tools--Practical Derivatives of Sophisticated Computer-Based Planning Models." The project was conducted by The Institute for Public Program Analysis, with funding from the National Institute for Law Enforcement and Criminal Justice of the Law Enforcement Assistance Administration (grant #78NI-AX-0015).

The primary product of the project is POLICE/PLAN, an easy-to-use police resource allocation planning system which runs on low cost ($300-$3800) microcomputers (sometimes called "personal computing systems"), or a programmable calculator. The system has been field tested in three police departments, and prototype versions have been obtained by 29 additional agencies, many of which have used them quite successfully. Field experience has shown that POLICE/PLAN can be used by persons with no prior data processing experience and can bring sophisticated planning capabilities within the reach of small and medium-sized police departments.

Contents of the report include: a summary of project products, activities, and findings; a description of POLICE/PLAN's capabilities, and a comparison of them with the Hypercube and Patrol Car Allocation Models; a discussion of the capabilities and limitations of micro-computer and programmable calculator equipment; an assessment of the equipment and computer programs field tested during the project; and a discussion of how law enforcement agencies can assess the feasibility of using the POLICE/PLAN system.

PREFACE

This report presents a summary of the products and findings of the project "Easy-to-Use Police Resource Allocation Planning Tools--Practical Derivatives of Sophisticated Computer-Based Planning Models." The project was conducted by The Institute for Public Program Analysis, a private non-profit research firm located in St. Louis, Missouri. The project was funded by the National Institute for Law Enforcement and Criminal Justice of the Law Enforcement Assistance Administration (grant #78NI-AX-0015).

The primary product of the project is POLICE/PLAN, an easy-to-use police resource allocation planning system which runs on low cost ($300-$3800) microcomputers (sometimes called "personal computing systems") or a programmable calculator. The findings and products of the study are presented in five reports:

- POLICE/PLAN--An Easy-to-Use Resource Allocation System: Executive Summary, Richard A. Kolde, William W. Stenzel, Allen D. Gill, and Nelson B. Heller, St. Louis: The Institute for Public Program Analysis, October 1979;

- POLICE/PLAN--An Easy-to-Use Resource Allocation System: User's Manual and Training Materials for PATROL/PLAN Software on TI Programmable 59 Calculator, Richard A. Kolde, Nelson B. Heller, William W. Stenzel, and Allen D. Gill, St. Louis: The Institute for Public Program Analysis, October 1979;

- POLICE/PLAN--An Easy-to-Use Resource Allocation System: User's Manual and Training Materials for PATROL/PLAN Software on TRS-80 Microcomputer, William W. Stenzel, Richard A. Kolde, Allen D. Gill, and Nelson B. Heller, St. Louis: The Institute for Public Program Analysis, October 1979;

- POLICE/PLAN--An Easy-to-Use Resource Allocation System: User's Manual for PATROL/PLAN, BEAT/PLAN, and DATA/PLAN Software on Apple-II Microcomputer, Richard A. Kolde, William W. Stenzel, Allen D. Gill, and Nelson B. Heller, St. Louis: The Institute for Public Program Analysis, October 1979; and

- POLICE/PLAN--An Easy-to-Use Resource Allocation System: Training Materials for PATROL/PLAN, BEAT/PLAN, and DATA/PLAN Software on Apple-II Microcomputer, William W. Stenzel, Richard A. Kolde, Allen D. Gill, and Nelson B. Heller, St. Louis: The Institute for Public Program Analysis, October 1979.

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- Chief Kenneth Matulia
  Hickory (N.C.) Police Department;
- Dr. George Kelling
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In addition, the authors acknowledge the contributions made by the following individuals, some of whom are staff members of the three police departments at which the POLICE/PLAN system was field tested:

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The authors also extend their appreciation to the many other persons with whom they corresponded during the project and to the many law enforcement training institutions which permitted project staff to lecture on and collect valuable feedback about POLICE/PLAN's sequence of prototype versions from police professionals attending regularly scheduled training programs. And finally, a special note of thanks is extended to Mrs. Vicki O'Dell, who typed most of the material contained in the project's reports and ably supervised the typing of the remainder.

Information about how to obtain the POLICE/PLAN software and documentation is available from:

- Executive Director
  The Institute for Public Program Analysis
  230 South Bemiston, Suite 914
  St. Louis, MO 63105
  (314) 862-8272

or

- Director
  Police Division
  National Institute of Law Enforcement
  and Criminal Justice
  Law Enforcement Assistance Administration
  Washington, D. C. 20531

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CHAPTER I

INTRODUCTION

This report presents a summary of the products and findings of the project "Easy-to-Use Police Resource Allocation Planning Tools--Practical Derivatives of Sophisticated Computer-Based Planning Models." The project was conducted by The Institute for Public Program Analysis, with funding from the National Institute for Law Enforcement and Criminal Justice of the Law Enforcement Assistance Administration (grant #78NI-AX-0015).

The primary product of the project is POLICE/PLAN, an easy-to-use police resource allocation planning system which runs on low cost ($300-$3800) microcomputers (sometimes called "personal computing systems") or a programmable calculator. The system has been field tested in three police departments, and prototype versions have been obtained by 29 additional agencies, many of which have used them quite successfully. Field experience has shown that POLICE/PLAN can be used by persons with no prior data processing experience and can bring sophisticated planning capabilities within the reach of small and medium-sized police departments.

POLICE/PLAN can supply estimates of field operations performance characteristics such as: average workload and travel time for each beat car, percent of dispatches that are cross-beat, minimum patrol interval, and the percent of time the entire patrol force is busy (i.e., no cars are available to accept dispatch assignments). In addition, POLICE/PLAN will calculate the minimum number of cars needed to achieve user-specified values for these variables. Thus, POLICE/PLAN can help a police department determine how many patrol cars are needed and when and where they should be deployed. With this information, departments can more easily assess or substantiate existing or proposed field operations budgets.

A. Project Summary

Objectives

The primary objective of the "Easy-to-Use Police Resource Allocation Planning Tools" project was to develop and field test a police planning system that would include the most useful capabilities of the more sophisticated computerized planning models and make use of new low-cost microcomputers and programmable calculators. A secondary objective was to assess the potential for broader use of such equipment in law enforcement agencies.

The "easy-to-use" planning system developed by the project has been made possible by the development in recent years of inexpensive microprocessors, often referred to as "computers on a chip." A direct result of the new microprocessor technology has been the development of relatively inexpensive hand-held programmable calculators such as the Texas Instruments Programmable 59 and similarly inexpensive microcomputers, such as the Radio

Shack TRS-80 and the Apple-II. More information on the types of microcomputer equipment is contained in Chapter III.

Activities

The activities which comprised the project included the following:

- review of the capabilities of various microcomputer systems;
- development of microcomputer and calculator software utilizing and extending previously-developed police resource allocation models;
- field testing of prototype systems and subsequent revision of programs in response to user feedback; and
- technology transfer activities, including publicizing project findings through law enforcement publications and demonstrating prototype systems at law enforcement training programs and at national meetings.

More information on project activities and findings is contained in later sections of this report.

Project Products

The primary products of this project include software for use on the TI Programmable 59 calculator, the Radio Shack TRS-80 microcomputer, and the Apple-II microcomputer, and accompanying documentation. The programs are described in more detail in Chapter II of this report. A total of five reports were produced by the project:

- POLICE/PLAN--An Easy-to-Use Resource Allocation System: Executive Summary, Richard A. Kolde, William W. Stenzel, Allen D. Gill, and Nelson B. Heller, St. Louis: The Institute for Public Program Analysis, October 1979;
- POLICE/PLAN--An Easy-to-Use Resource Allocation System: User's Manual and Training Materials for PATROL/PLAN Software on TI Programmable 59 Calculator, Richard A. Kolde, Nelson B. Heller, William W. Stenzel, and Allen D. Gill, St. Louis: The Institute for Public Program Analysis, October 1979;
- POLICE/PLAN--An Easy-to-Use Resource Allocation System: User's Manual and Training Materials for PATROL/PLAN Software on TRS-80 Microcomputer, William W. Stenzel, Richard A. Kolde, Allen D. Gill, and Nelson B. Heller, St. Louis: The Institute for Public Program Analysis, October 1979;
- POLICE/PLAN--An Easy-to-Use Resource Allocation System: User's Manual for PATROL/PLAN, BEAT/PLAN, and DATA/PLAN Software on Apple-II Microcomputer, Richard A. Kolde

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B. History of Computerized Police Planning Models

Manual Allocation Planning

Patrol allocation plans have normally been designed using intuitive methods, with the planner sometimes relying only upon subjective knowledge of the jurisdiction and the workload distribution. The most casual of these methods was once referred to facetiously as the "Bud Shell System," since the planner's tools consisted of a six-pack of Budweiser beer and a Shell Oil Company street map. When time, personnel resources, and data availability have permitted, more objective methods based on historical workload patterns and specific workload objectives for patrol units have been used. When these types of planning methods are employed almost anyone with patrol experience can participate in the planning effort. This makes it easy to include commanders and staff members in deployment decisions, which in turn smooths the way for later implementation. The fundamental problem with these intuitive and workload-based allocation methods, however, is that they offer no way of estimating many important field operations performance characteristics before implementation. As a result, plans may be accepted which produce little beneficial change in actual performance, or which fall far short of practically attainable improvements.

Development of Computerized Models

Within the last two decades, there has been considerable interest in the development of computer-based models of police patrol operations. A computer model uses mathematical logic to define relationships between resource levels and performance; such models can now be used to provide insights into the consequences of alternative patrol operations decisions.

Reasons for using computers. Recently developed police field operations planning systems have tended to rely on computers because:

- computers are able to solve complex mathematical problems with great speed, allowing fairly detailed models of patrol operations to be developed;
- computers can analyze many more deployment alternatives and design criteria than are possible when working by hand;

- computerized planning tools, once validated, do not necessarily require the user to have a thorough understanding of how all of the calculations are performed;
- many police departments now have routine access to data processing services.

Disadvantages of using computers. The disadvantages of using computer-based models result mainly from their complexity and cost:

- computer hardware and commercial data processing services are often expensive;
- many computer models require large amounts of input data which are not routinely collected in many police departments;
- computer calculations are often difficult for patrol personnel to understand and therefore may not be accepted or trusted; and
- sophisticated analytical skills may be required.

Currently available field operations models. References listed at the end of the report present a review of the computer-based police field operations models which had been developed prior to the initiation of this project. Those most relevant for potential users of the POLICE/PLAN programs are described in the following paragraphs.

Patrol car allocation models are used to evaluate or specify the number of patrol cars to be fielded in each patrol region at various times of the day and for each day of the week. They can be used to analyze policy issues of the following types: (1) determining the total number of patrol officers needed to meet specified patrol performance objectives, (2) allocating a fixed number of officers among distinct geographical regions, (3) determining how many officers in a region should work each tour or shift, and (4) determining the hours at which shifts should begin. The most widely used model of this type has been the Rand Corporation's Patrol Car Allocation Model (PCAM), which is discussed in Chapter IV of this report. PCAM requires a full sized computer, such as the IBM 370, for operation.

Patrol beat design models are used for evaluating alternative beat boundaries, car assignments to beats, and dispatching policies. They are most readily used when the number of patrol units to be fielded for each day of the week, region, and shift have already been determined by some other method, but it is also possible to use them as patrol car allocation models. The Hypercube model developed at the Massachusetts Institute of Technology is the most well known model of this type, and is also discussed in Chapter IV. It too requires a full sized computer for operation.

Manpower scheduling models are used to assign each officer's

work shifts and days off, and, for schedules utilizing rotating shifts, when he should rotate from one shift to another. These models are especially useful in planning work schedules when the number of on-duty officers varies by day of the week and shift, but they can also yield improved schedules when manning levels are uniform. The most widely used set of scheduling models is the SCHEDULE/PLAN system developed by The Institute for Public Program Analysis. Unlike PCAM and Hypercube, versions of SCHEDULE/PLAN are available for operation on some low cost microcomputers and a programmable calculator.

Disappointing Results of Previous Models

Despite their many advantages, none of the aforementioned large computer-based planning tools has yet received widespread application by police departments. In addition to the disadvantages cited above, these disappointing results can be attributed to conditions such as the following:

- Use of these systems sometimes amounts to "piling high technology on relatively primitive management systems." The majority of the nation's police agencies do not have the capability to operate sophisticated computer models.
- Outside researchers and technical consultants have often played significant roles in system development and implementation. When their participation terminates, use of the systems has often proven too complex for local agency personnel.
- Continued use of a planning model can be easily interrupted by the transfer or departure of the in-house persons familiar with its operation.
- Proper computer support may be lacking even in agencies having access to suitable software and equipment. In-house staff are unfamiliar with complex models and often hesitate to try them. Also, routine processing usually has first priority, so new implementation (especially complex ones) may be relegated to low level status.

C. Project Findings and Recommendations

Findings of Interest to Prospective Users

Project findings of particular interest to prospective POLICE/PLAN users include the following:

- The POLICE/PLAN system was used successfully as a decision-making tool in three field test police departments, and, of 29 additional agencies which obtained copies of prototype software during the project, a considerable number achieved impressive results with little or no assistance from the project team.

- Persons with little or no previous data processing experience easily learned to set up and operate the microcomputer and calculator equipment used during the project. In contrast, users of PCAM and Hypercube normally require assistance from data processing personnel to set up and run the software.

- The system proved to be useful in departments fielding as few as 3-4 patrol units per watch.

- POLICE/PLAN is the first software package which provides data tabulation, patrol car allocation, and beat design as part of an integrated and cohesive planning system (e.g., Hypercube and PCAM are written in different languages, require different amounts of core storage, and utilize different command codes for problem definition).

- The cost of the equipment needed to operate POLICE/PLAN, which ranges from about $300 for the calculator-based system to about $3800 for the most powerful microcomputer-based system (including the cost of a good printer), is so low that many police agencies which had previously thought computers and computer-based planning to be far out of their reach now are reacting favorably to purchase of this type of system.

- The system was demonstrated to be a valuable field operations management training aid, regardless of whether the trainees' departments later implemented it.

- Formal training in the use of POLICE/PLAN is not essential, although some form of training or technical assistance may be necessary for users to completely utilize all its capabilities.

- There seem to be many other law enforcement applications for the type of microcomputer systems used by this project, and police users of such systems, many stimulated in part by this project, are already writing their own programs in areas such as crime analysis and traffic accident analysis. It should be noted, however, that software developed for one brand of microcomputer may not be easily transferrable to another brand of microcomputer, and that the equipment used during this project is not appropriate for use as a management information system (i.e., large data base management).

Policy Findings and Recommendations

In addition to the findings listed above, the project's outcomes suggest several policy-related findings and recommendations:

- Sophisticated large-computer-based models can be adapted for use on low-cost microcomputer equipment while preserving the essential capabilities of the original models.

- There appear to be additional resource allocation and decision-making models which could also be successfully adapted for use on microcomputer equipment.

- The adaptation of sophisticated models for use on microcomputers requires substantial effort, sophisticated programming skills, and a thorough knowledge of microcomputer capabilities; thus, microcomputer adaptation of a model will often require skill levels similar to those needed for development of the original model.

- Persons with no prior data processing experience, who thought themselves incapable of using computer models, have successfully applied POLICE/PLAN programs to actual patrol deployment decision-making processes.

- To achieve maximum benefits to the law enforcement community, dissemination of POLICE/PLAN programs needs to be coordinated with a program of education related to the potential benefits of using computer-based models for police planning.

CHAPTER II

INTRODUCTION TO POLICE/PLAN

The POLICE/PLAN system was designed to allow potential users a range of choices regarding equipment costs, equipment manufacturer, and system capabilities. For this reason the user has three versions of the system from which to choose:

- a programmable calculator-based version having patrol car allocation capabilties, which requires equipment costing $300-500 depending on whether an optional printer is obtained;
- a microcomputer-based version having more powerful patrol car allocation capabilities, which requires equipment costing $988-2240 depending on whether an optional printer is obtained; and
- an extended microcomputer-based version having the more powerful patrol car allocation capabilities and also capabilities for data tabulation and beat design, which requires equipment costing $2180-3725 depending on whether an optional printer is obtained.

The component of POLICE/PLAN used for patrol car allocation is called PATROL/PLAN; the one for beat planning, BEAT/PLAN; and the one for data tabulation, DATA/PLAN. Each "component" is a software package. The capabilities of these packages (which are sometimes simply called "programs") are summarized in the following discussion; they are described in detail in the related user's manuals referenced in Chapter I. For convenience, a summary of POLICE/PLAN's hardware and software alternatives is presented in Table 2-1.

A. PATROL/PLAN

PATROL/PLAN is an easy-to-use patrol car allocation model used chiefly for evaluating and improving the deployment of police field operations units by time and geographic area. The program, versions of which can be run on either the TRS-80* or Apple II** microcomputers or the Texas Instruments Programmable 59 calculator,*** uses basic operations data supplied by the user to produce estimates of numerous field operations performance characteristics including:

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*Requires a minimum of 16K RAM and Level II BASIC.

**Requires a minimum of 32K RAM, one disk drive, and APPLESOFT BASIC.

***The calculator version lacks a number of the features of the microcomputer version. See the calculator software user's manual for details.

Table 2-1

POLICE/PLAN's HARDWARE AND SOFTWARE ALTERNATIVES AND EQUIPMENT CONFIGURATIONS

Software	TI-59[a]	TRS-80[b]	Apple II[c]
PATROL/PLAN (calculator)	X		
PATROL/PLAN (microcomputer)		X	X
BEAT/PLAN (microcomputer)			X
DATA/PLAN (microcomputer)			X
Equipment Cost Range	$300-500	$988-2240	$2180-3725

[a]The Texas Instruments Programmable 59 Calculator, list price $300, is used for the "Display" version of the software. For the "Print" version, the Texas Instruments PC/100B Print/Security Cradle, list price $200, is also required.

[b]The minimum equipment configuration is the Radio Shack TRS-80 Model I microcomputer with 16K RAM, Level II Basic, and tape cassette unit. This configuration lists for $988. To utilize the software's printing capabilities, a printer and possibly some interfacing hardware (depending on the type of printer) are required, adding $500-$1252 to the system's cost.

[c]The minimum equipment configuration is the Apple II microcomputer with 32K RAM, Extended BASIC, one Disk II Floppy Disk and Controller, and a black and white video monitor. This configuration lists for $2180. To utilize the software's printing capabilities, a printer must be added, adding $695-$1545 to the system's cost.

- average number of patrol units dispatched to each call-for-service (CFS),
- average service time spent by each unit on a CFS,
- total service time spent by all units dispatched to each CFS,
- total service time per hour spent by the entire patrol force on CFS work, by call priority level,
- average amount of time spent by each patrol unit on CFS work, non-CFS work, and uncommitted activities per hour,
- average number of free units available to respond to incoming calls,
- minimum patrol interval,
- percent of incoming CFS that must be "stacked" (i.e., calls delayed by the dispatcher) because all units are busy,
- average number of CFS stacked by dispatchers,
- average queue delay (time spent in the stack) by call priority level,
- average travel time by call priority level, and
- average response time by call priority level.

These performance estimates can be used for many planning functions: to assess the effectiveness of an existing deployment plan, to compare plans for different time blocks or geographic regions, or to investigate the effects of changes in workload (e.g., the number of calls-for-service received per hour), operations (e.g., the number of units fielded), or geographic configuration (e.g., the area serviced).

The PATROL/PLAN program is designed to be used by persons who are not familiar with data processing or computer programming. Field operations data are entered interactively into the microcomputer or calculator. The program requests each input data item in a tutorial manner using easy-to-understand English language commands.* As each data item is entered, it is examined by the program and obvious errors are immediately identified. Field data needed to run the PATROL/PLAN program include:**

- number of patrol units fielded,
- average number of CFS per hour,

*One version of the calculator software uses numerically coded commands.

**This list assumes that POLICE/PLAN's most detailed level of analysis is required--if less detail is needed some of these data items are optional. See the POLICE/PLAN user's manual for details.

- percent of CFS in each call priority level (1, 2, or 3 levels),
- percent of calls that require exactly 1,2,..., units (six units maximum),
- average number of minutes spent on non-CFS activities per hour by each unit,
- dispatching policy used when a CFS is received and all units are busy,
- area of the region,
- average response speeds by call priority,
- street miles patrolled, and
- patrol speed.

PATROL/PLAN can accommodate input data for up to seven time periods or geographic areas at the same time.*

Use of the PATROL/PLAN program has been simplified by structuring each program activity (e.g., data input) as a program "page." The seven pages in PATROL/PLAN are

1. Table of contents
2. Enter number of blocks
3. Enter/modify block data
4. Display input data for each block
5. Display performance measures for each block
6. Satisfy multiple constraints for one block
7. Allocate units among several blocks.

At the completion of each activity, the user can "turn" to any page in the program. If the user is unsure about which page to turn to, he/she can turn to the table of contents on page 1.

In addition to assessing or comparing existing deployment plans, PATROL/PLAN can be used to

- determine the minimum number of units needed to simultaneously satisfy several user-specified performance standards, or
- allocate a given number of units over several blocks based on a user-specified performance measure.

The first capability allows the user to set standards for up to six of the following 17 performance measures:

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*The generic term "block" is used to refer to each input data set (e.g., PATROL/PLAN can be used to analyze up to seven shifts for a single geographic area, or seven different geographic areas for a single shift, etc.)

- actual CFS work/unit (min/hr),
- uncommitted time/unit (min/hr),
- average number of free units,
- minimum patrol interval (hrs),
- percent of calls received when all patrol units are busy,
- average queue (stacking) delay (min),
- queue (stacking) delay - priority 1 calls (min),
- queue (stacking) delay - priority 2 calls (min),
- queue (stacking) delay - priority 3 calls (min),
- average travel time (min),
- travel time - priority 1 calls (min),
- travel time - priority 2 calls (min),
- travel time - priority 3 calls (min),
- average response time (min),
- response time - priority 1 calls (min),
- response time - priority 2 calls (min), or
- response time - priority 3 calls (min).

The second capability allows the user to allocate a specified number of units over any combination of blocks for which input data has been provided. The user can use any one of the 17 performance measures indicated above for the allocation, and can select either of two allocation procedures: (1) minimize/maximize the average performance measure over all blocks, or (2) minimize/maximize the greatest/least value for the performance measure for any block. The user can also specify limits on the minimum and maximum number of units that can be allocated to each block.

B. BEAT/PLAN

BEAT/PLAN* is the component of the POLICE/PLAN system which deals with the assignment of response units to patrol areas, termed beats. This assignment, termed a beat plan, designates the area in which each unit has patrol and called-for-service response responsibility. BEAT/PLAN may be used to evaluate a current beat plan

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*BEAT/PLAN is currently available only for the Apple II microcomputer. The program requires a minimum of 32K RAM, a disk, and APPLESOFT BASIC (see Chapter III).

or to design new plans using methods based on balancing (1) additive* beat level characteristics such as population, area, or numbers of calls for service, (2) beat workloads or index values computed using hazard or weighted workload formulas, or (3) non-additive unit and beat performance characteristics computed using sophisticated mathematical models such as the Hypercube queuing model.

With any of these methods, the region** in which the beat plan is to be used must have previously been divided into small non-overlapping reporting areas, for which certain required input data must be available. In addition, the designer identifies a beat for each unit allocated to the region for the time block being studied, by designating which reporting areas are included in each car's beat. BEAT/PLAN then uses these inputs to compute estimates of various field operations planning indexes and performance characteristics. The input data required and the outputs produced--which depend on the design method used--are described below in Chapter IV.

After analyzing BEAT/PLAN's outputs, the beat designer has three options: (1) accept the beat plan as satisfying department beat design objectives (e.g., workload balancing, preservation of neighborhood integrity, or the minimization of response time or cross-beat dispatches), (2) propose an alternative beat plan and obtain new estimates of the outputs which can be compared to those for the previous plan, or (3) utilize BEAT/PLAN's prescriptive capabilities to suggest modifications to the proposed beat plan to balance one of the beat level measures among the beats. In the latter case, the beat designer may accept or reject each modification proposed by the BEAT/PLAN program.

The various beat design methods available in BEAT/PLAN are described in the following sections.

Balancing Additive Beat Level Characteristics

In order to design beats by balancing additive beat level characteristics, the user enters values for the characteristics of interest for each reporting area in the region. There are no specific input data requirements when this method is used. In fact, any characteristic can be used provided that (1) the value of the characteristic is known for each reporting area, and (2) a beat total for the characteristic can be obtained by summing the values of the characteristic for the reporting areas in the beat. Examples of characteristics that may be used are the average number of calls for service per hour, the area (in square miles), the

*An additive characteristic for a beat is one which can be computed by summing the value of the characteristic for each of the beat's reporting areas; a non-additive characteristic is one which cannot be computed in this way.

**A region may consist of the department's entire jurisdiction, or a single field operations territory such as a precinct, across whose boundaries units are rarely dispatched.

number of businesses, or the number of burglaries reported in the previous year. If a reporting area is covered by more than one beat, the user can instruct the BEAT/PLAN program to add the full value for a characteristic to the total for each beat within which the reporting area is located, or to divide the value of the reporting area characteristic among these beats. For example, the former procedure might be used for a characteristic such as the area, while the latter procedure might be used for characteristics such as the number of calls for service or crime totals.

When this method is used, BEAT/PLAN computes, for each characteristic for which data is supplied by the beat designer, the total over all reporting areas in the region, the total over all reporting areas in each beat, and the percentage of the region total in each beat. Using these outputs, the beat designer can identify those beats to which reporting areas must be added or from which reporting areas must be deleted in order to balance a beat level measure, or determine the effects on these measures of moving reporting areas from one beat to another.

Balancing Beat Workloads or Index Values

In departments which design beat plans using methods based on weighted workloads or hazard formulas, BEAT/PLAN can be used to calculate beat index values which are a weighted sum of the percent of the region wide total for any user-supplied characteristic falling in each beat. The input data that must be supplied to utilize this feature of BEAT/PLAN are similar to those described for the previous method. In addition, the user must specify relative weights for each characteristic to be used in calculating the index values.

Balancing Non-Additive Unit and Beat Performance Characteristics

To assess the effect of alternative beat plans on non-additive operations performance characteristics such as average response time or the percent of calls for service requiring a cross-beat dispatch, BEAT/PLAN uses a modification of the Hypercube queuing model. These performance characteristics are computed for the entire region, for each beat, and for each unit. In addition, the minimum patrol interval can be computed for the region and for each beat.

To obtain these performance characteristics, the user must supply the following geographic data for each reporting area: the location of the reporting area's center, it's size in square miles, and the number of miles of patrolled streets in the area. (Patrolled streets are required only if the minimum patrol interval is to be calculated.) In addition, the following data related to workload and patrol operations are required: average call rate, average service time, average number of non-CFS minutes per hour per unit, workload distribution by reporting area, average response and patrol speeds, whether calls for service arriving when all primary units are busy are queued (stacked), and whether the beat unit is preferred if available (i.e., even if it is not the closest free unit).

Prescriptive Beat Design

To utilize BEAT/PLAN's prescriptive features, which are applicable only to the additive performance characteristics, the user must supply (1) the value of the characteristic of interest for each reporting area, (2) a preliminary beat plan, and (3) for each reporting area, a list of the reporting areas adjacent to it. The user may also specify groups of reporting areas that must always be assigned to the same beat.

Using these inputs, BEAT/PLAN suggests a modification to the current beat plan which reduces the imbalance among the beats in the characteristic of interest, while ensuring that the reporting areas in each of the modified beats remain contiguous. The modification suggested consists of the transfer of a single reporting area, or group of areas, from one beat to another. The beat designer can accept or reject each suggested modification. In either case, BEAT/PLAN continues to suggest modifications until the imbalance in the characteristic cannot be reduced by moving a single reporting area, or group of reporting areas, or until the user terminates the process.

C. DATA/PLAN

DATA/PLAN* is the component of the POLICE/PLAN system designed for use in tabulating the field operations data needed as input to PATROL/PLAN and BEAT/PLAN. It can also be used for tabulating any other kind of numerical data. For police departments which do not routinely code their dispatch tickets or incident reports for machine processing, DATA/PLAN will greatly simplify the job of preparing the input data required by the other components of POLICE/PLAN. The use of DATA/PLAN consists of two steps. First, the user enters the values of selected data items from the set of dispatch tickets or incident reports selected for the analysis. This data can then be displayed in several different formats, errors can be corrected, and the data can be stored in a disk file for later use. Second, the various data items can be tabulated in a variety of ways (e.g., to yield the inputs needed by PATROL/PLAN and BEAT/PLAN). In tabulating these data items, all of the previously input data can be used, or the tabulation can be limited to a specified subset of the data (e.g., calls for service on the afternoon shift, priority 1 calls, or calls in a single beat). DATA/PLAN inputs and outputs are discussed below.

Input Data

There are no specific input data items required to use DATA/PLAN, although each data record must be assigned a unique identification number (an existing numbering system used in manual record-keeping systems, such as a complaint number, will usually suffice). The only restriction on the data items used is that all data must

*DATA/PLAN is currently available only for the Apple II microcomputer. The program requires a minimum of 32K RAM, a disk, and Applesoft BASIC (see Chapter III).

be numeric (e.g., if one of the data items to be entered is a shift indicator and shifts are normally designated as "A," "B," and "C," this item must be recorded as "1," "2," and "3," for example, before inputting it to DATA/PLAN). Unlike BEAT/PLAN, a value need not be specified for each data item in every record.

The tabulations desired will determine which input data items must be specified. For example, to determine the percent of calls for service which are priority 1, 2, or 3, priority level must be one of the data items. Similarly, to determine call rates and non-CFS workload, an indicator for type of incident is required (e.g., 1 for CFS incidents and 0 for a non-CFS activity). To compute average service times, the input data items must include either the actual service times for individual calls, or both the time the unit was dispatched and the time service was completed, and so on. Additional data items may also be required if separate tabulations are to be performed on subsets of the data. For example, if several time blocks are to be analyzed, some indicator of time of day and/or day of week may be required. Other data items that might be needed in compiling input data for PATROL/PLAN and BEAT/PLAN include the number of units dispatched, service times for the second and subsequent units dispatched, the reporting area in which the call occurred, and either the travel time or the times of dispatch and arrival at the call location.

Output Statistics

Using DATA/PLAN, three types of data tabulations can be performed:

- Statistics such as the total, average, median, minimum, and maximum values of individual data items can be computed. For example, this type of tabulation could be used to determine average service times, the maximum response time to priority 1 calls, or total time spent on non-CFS activities.
- The frequencies with which individual data item values occur in data records meeting user-specified criteria can be counted. This type of tabulation could be used to determine the number of calls for service, number of non-CFS incidents, or the number of priority 1 calls.
- Pairs of data items can be cross-tabulated. For example, average service time can be computed by time block, or the distribution of calls for service by priority level or reporting area can be determined.

For any of these tabulations, DATA/PLAN also provides a count of the number of data records processed, the number which met user-specified selection criteria, and the number for which the data item being tabulated was missing.

CHAPTER III

MICROCOMPUTER AND CALCULATOR EQUIPMENT

This chapter briefly summarizes the characteristics of microcomputer and programmable calculator equipment, and describes the specific systems used during the field test project. In addition, the procedure used by the project team in assessing alternative equipment configurations is discussed.

A. Characteristics of Microcomputer and Programmable Calculator Equipment

In the last several years, the data processing industry has been revolutionized by the development of microprocessors or so-called "computers on a chip" which have enabled the production of microcomputers and programmable calculators whose capabilities rival those of large computer systems of a few years ago, and which are available for a fraction of the cost. Characteristics of the resulting microprocessor-based systems compared to mini-computers and larger systems include the following:

- Storage capacity--The program and data storage capacity (termed random access memory) of microcomputers usually ranges from 4 to 64 K-bytes (characters) where one K-byte equals 1024 characters. Larger computer systems can have memory capacities of one million characters or more.

- Auxilliary storage--Microcomputers typically use audio or digital cassette tape recorders or one to four floppy disk storage devices for offline storage of programs and data, whereas larger computers use much larger magnetic tape or disk units. The capacities of auxilliary storage devices used with the low cost microcomputers on which the project focussed ranged up to several hundred K-bytes of information (this is likely to increase considerably in the near future).

- Processing times--Microprocessor-based systems require more time to perform calculations and other operations than do larger computer systems. Similarly, peripheral equipment such as printers, tape units, and disk storage devices used in microcomputer systems are much slower than those used with larger computers. However, for the types of calculations and input-output activities utilized in an interactive planning system like POLICE/PLAN, the speed of the microcomputer is more than adequate (e.g., 500 additions per second).

- Reliability--Many electronic components of new micro-computer systems are more reliable than those of older large computer systems. Mechanical components tend to break down more frequently. Maintenance is less readily

available for microcomputers than for large computers. When repairs are needed, microcomputers must usually be returned to the manufacturer or distributor for service. Manufacturers of large computer systems usually provide on-site maintenance service.

- Installation--Installation of microcomputers seldom involves more than connecting cables between system components such as the keyboard, cassette recorder, and video display units. By following the instructions provided by the manufacturer, this installation can easily be accomplished by persons with no special electronic or computer-related skills.

- Higher-level languages--Unlike large computer systems which may support several higher-level languages, microcomputer systems in their minimum configurations usually support only a version of one higher-level language called BASIC. With the addition of several disk units and extra random access memory, some microcomputers can support other languages such as COBOL or FORTRAN.

- Size--Most microcomputers are small in size (most weigh less than 50 pounds and can be set up on a desktop) and can easily be transported from one location to another.

- Cost--Basic microcomputer systems can be purchased for as little as $500 and complete systems with several disk units, printers, and large amounts of random access memory seldom cost more than $10,000.

B. Microcomputer Equipment Used During the Field Test Project

In order to assess the adequacy of low-cost microcomputer equipment for use by police departments in resource allocation planning, and to determine the minimum system features required for such an application, the field test project used a variety of equipment with a wide range of capabilities. The equipment tested, which has been mentioned briefly earlier, included the following systems:

- Apple II microcomputer with 32K bytes of random access memory, a single floppy disk storage unit, a video monitor, and floating point (Applesoft) BASIC in read-only memory;

- TRS-80 microcomputer with 4K and 16K bytes of random access memory, cassette tape storage unit, video display, and level II BASIC in read-only memory;

- Commodore PET microcomputer with 8K bytes of random access memory, cassette tape storage unit, built-in video monitor, and extended BASIC in read-only memory; and

- Texas Instruments TI programmable 59 calculator with a capacity of up to 960 program steps, up to 100 storage registers, and magnetic card storage system.

In addition, each of these systems was used with and without printed output.

The Apple II, TRS-80, and PET were selected for use in the field test project because, at the project's outset in December 1977, they were (1) the most readily available (demand for microcomputer systems at that time produced delivery delays of up to six months for some types of microcomputers), and (2) among the lowest cost systems on the market, ranging from $500 for the 4K TRS-80 system to approximately $2200 for the Apple II system. The TI programmable 59 calculator was selected because of its low cost ($500 with and $300 without an optional printer), and unique features such as a relatively large storage capacity for programs and data, and, if the printer was used, alphanumeric print capabilities.

Equipment assessment was accomplished by developing versions of the POLICE/PLAN software which provided the maximum resource allocation planning capabilities in an easy-to-use form for each of the alternative equipment configurations. The equipment and software was then used by police personnel in training programs, at the project's test sites, and elsewhere. This procedure and the equipment configurations tested enabled the field test project to address the following questions:

- Can microcomputer and calculator equipment be set up and used by persons with no prior computer-related experience?

- What are the minimum system capabilties and capacities required in using microcomputer and calculator equipment for police resource allocation planning?

- How reliable are microcomputer and calculator equipment for these uses?

- Are maintenance services available when needed for these types of equipment?

- How much training and technical assistance is required to use the equipment?

The results of this assessment are summarized in Chapter IV.

CHAPTER IV

PROJECT ASSESSMENT

This chapter provides an assessment of microcomputer and calculator equipment and its uses in police resource allocation planning, based on the experience of project staff in developing the POLICE/PLAN software, and of users of the software and equipment at the project's test sites and elsewhere. The POLICE/PLAN software is also evaluated and compared to large-computer-based resource allocation models such as the patrol car allocation model (PCAM) and the Hypercube queuing model. The final section of this chapter discusses implementation experiences of the field test agencies and other POLICE/PLAN users.

A. Microcomputer Equipment

The experience of project staff and most users of the equipment during the field test project support the following conclusions regarding the use of microcomputer equipment for police resource allocation planning:

- Due to the low cost of the equipment, police departments appear to be willing to purchase microcomputers or programmable calculators if relevant software is available. For example, at least 13 police departments purchased microcomputers during the project as a result of the availability of prototype versions of POLICE/PLAN and other software. At least 12 other departments purchased programmable calculator equipment for the same reason. These departments ranged in size from very small, such as Glen Ellyn and Carol Stream, Illinois, to very large departments with existing data processing facilities, such as San Diego, California, and St. Louis County, Missouri.

- Microcomputer and calculator equipment is sufficiently reliable to be used for planning activities where occasional interruptions in equipment availability are tolerable. Equipment breakdowns do occur periodically, however, and repairs generally require several days to complete. Service is usually provided through equipment distributors.

- Microcomputer and calculator equipment can be set up and used by persons who have no prior data processing experience.

- The efficient use of microcomputer equipment for data management activities requires a disk storage capability. The storage of data files on cassette tape is unreliable and inconvenient. Tape storage of programs is usually acceptable, although problems in loading programs into the microcomputer from tape are not uncommon.

- Printed output is desirable, but not essential to the effective use of POLICE/PLAN. Departments considering the purchase of a printer will need to assess the additional equipment costs (approximately $1000) versus the cost of staff time required to copy information from the video display, plus the potential for error in transcribing this information.

- Software developed for one microcomputer (e.g., the TRS-80) may not be easily transferrable to another microcomputer (e.g., the Apple II), even though both systems support versions of the same language (BASIC). As a result, departments considering the purchase of a microcomputer should identify software developed specifically for that system.

- Microcomputer equipment is easier to use, more powerful, and performs calculations more rapidly than the programmable calculator equipment. On the other hand, the calculator equipment is more portable and marginally less expensive than the microcomputer equipment.

- Training in the use of these types of equipment is helpful, but not essential.

B. POLICE/PLAN Software

Throughout the field test project, the POLICE/PLAN software was continually modified and improved as a result of the experiences and suggestions of POLICE/PLAN users at training seminars, the project's test sites, and elsewhere. These experiences also provided the basis for the following observations about the software:

- POLICE/PLAN can be used successfully by persons who have no prior data processing experience.

- Formal training in the use of the POLICE/PLAN is not essential (e.g., nine of 19 users of prototype microcomputer versions of POLICE/PLAN and 13 of 16 users of prototype calculator versions of POLICE/PLAN had not received extensive training). Training or some form of technical assistance, however, may be necessary for most users to completely utilize all the capabilities of POLICE/PLAN.

- POLICE/PLAN is the first software package which provides data tabulation, patrol car allocation, and beat design as part of an integrated and cohesive planning system (e.g., Hypercube and PCAM are written in different languages, require different amounts of core storage, and use different command codes for problem definition).

- Most users find that POLICE/PLAN outputs agree very well with previous subjective or empirical estimates

of field operations performance characteristics, and believe that estimates obtained from the software are sufficiently accurate to be used for planning purposes.

- Of users who experienced problems in using the POLICE/PLAN software, the most commonly reported difficulty concerned data collection--input data items such as response speed, patrol speed, and non-CFS workload are sometimes not available from any routinely maintained records.

- The microcomputer versions of POLICE/PLAN are more powerful and easier to use than the programmable calculator versions.

The following sections compare PATROL/PLAN and BEAT/PLAN with the two most widely used resource allocation software packages currently available for large computers.

Comparison of PATROL/PLAN and PCAM

As mentioned earlier, the police resource allocation planning model whose function is most similar to that of PATROL/PLAN is the Patrol Car Allocation Model* (PCAM). Written in FORTRAN for computers such as the IBM 360/370, PCAM was developed by Dr. Jan Chaiken and others at the Rand Corporation. PCAM addresses the problem of allocating available patrol cars among time blocks and/or geographical regions (e.g., precincts). PATROL/PLAN emulates PCAM in that it has both descriptive and prescriptive capabilities. In the descriptive mode, PCAM computes numerous performance estimates, such as average response time and unit workload, for a user-specified allocation of patrol cars (e.g., six cars assigned to time block 1, eight cars assigned to time block 2, and so on). In the prescriptive mode, PCAM determines (1) the minimum number of cars needed to meet user-specified constraints on performance estimates, (2) the allocation of a user-specified number of cars which optimizes the resulting value of one of the performance estimates (e.g., minimizes response time), or (3) the best allocation of units which also meets user-specified constraints on the performance estimates.

Principle differences between PCAM and PATROL/PLAN include the following:

- Differences in the performance characteristics computed by PCAM and PATROL/PLAN, which are summarized in Table 4-1.**

- PCAM utilizes some input data that is not required to use PATROL/PLAN. In addition, some common input data items are specified in slightly different form in the

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*Many of PCAM's formulas for computing performance estimates have been used in PATROL/PLAN.

**See PATROL/PLAN and PCAM user's manuals for a detailed discussion of program inputs and outputs.

Table 4-1

PERFORMANCE CHARACTERISTICS COMPUTED BY PATROL/PLAN AND PCAM

Performance Characteristic	PATROL/PLAN	PCAM
A. Descriptive Statistics		
1. Workload		
• Incoming work per unit	Yes	Yes
• Actual CFS work per unit	Yes	Yes
• Non-CFS work per unit	Yes	No
• Work per effective unit	No	Yes
• Workload distribution by priority level	Yes	No
• Workload distribution between primary and backup units	Yes	No
2. Average travel/response time		
• Average travel time	Yes	Yes
• Average response time	Yes	No
• Average travel and response times by priority level	Yes	No
3. Queue delay		
• Average queue delay	Yes	Yes
• Average queue delay by priority level	Yes	Yes
• Fraction of calls delayed	Yes	Yes
• Average number of calls in queue	Yes	No
4. Patrol interval/frequency		
• Average number of free units	Yes	Yes
• Uncommitted time per unit	Yes	Yes
• Minimum patrol interval	Yes	No
• Average patrol frequency	No	Yes
• Patrol hours per suppressible crime	No	Yes
• Patrol frequency times suppressible crimes per hour	No	Yes
Descriptive Statistics (continued)		
5. Dispatch		
• Average number of units dispatched per call for service	Yes	No
• Average service time per dispatched unit	Yes	No
• Average service time per call for service	Yes	Yes
B. Prescriptive Statistics--Allocation of Units to a Time Block to Meet Constraints		
1. Minimum number of units required to meet all specified constraints	Yes	Yes
2. Minimum number of units required to meet each specified constraint	Yes	No
C. Prescriptive Statistics--Allocation of Units Among Time Blocks		
1. Minimum number of units required per time block	Yes	Yes
2. Optimal allocation of specified number of units among time blocks based on selected performance characteristic	Yes	Yes
3. Change in selected performance characteristic when one unit is added to each time block	Yes	No
D. Summary of Input Data Used for Each Time Block	Yes	Yes

two programs. Input data needed to use PCAM and PATROL/PLAN are summarized in Table 4-2. Note that some of the input data items are optional. If these items are omitted, some of the program outputs discussed below and in Chapter II may not be available.

- To use PCAM, a database containing the required input data must be created. This database is usually stored on magnetic tape or disk, and can be accessed repeatedly for PCAM analyses performed at different times. This database must be created using a rigid format requiring data items to be entered in a specified order, and in specific "columns" of the data records. PATROL/PLAN users, on the other hand, enter input data interactively in response to prompts from the program. The data cannot, however, be saved on tape or disk for use in subsequent analyses at a later date.

- Once the input data has been entered, PATROL/PLAN prompts users in their analyses by explaining the options available at each point. Users indicate the option they have selected, usually by entering a one or two digit code number. PCAM users, however, must learn a specific, although simple, command language (e.g., MEET C(2) = 4, which specifies that travel time must be four minutes or less).

- PATROL/PLAN performs extensive error-checking of user inputs to ensure that all input data values are valid and consistent with previously entered items. When an error is detected, the user can correct the error before proceeding. While PCAM checks the syntax of the user's commands, input data in the database is not checked and errors usually result in the termination of an analysis or incorrect results. In either case, the database must be corrected before the analysis can be repeated.

- PATROL/PLAN can be loaded into a microcomputer and run by persons having no previous data processing experience. PCAM, on the other hand, must be installed on a computer system by data processing personnel. Once installed, PCAM can also be used by persons who are untrained in the use of computers.

- The use of PCAM is normally limited to larger police departments having their own computer, or having access to a commercial system. In contrast, with a relatively small investment for the purchase of a microcomputer (see Chapter III), PATROL/PLAN can be used by very small departments.

- When implemented on a department's own computer, PCAM competes with other departmental data processing functions for computer resources. As a result, it

Table 4-2

INPUT DATA ITEMS USED BY PATROL/PLAN AND PCAM*

Data Item	PATROL/PLAN	PCAM	Data Item	PATROL/PLAN	PCAM
Block names	Yes	Yes	Area of region	Yes	Yes
Number of units	Yes	Yes	Number of miles of patrolled streets	Yes	Yes
Average call rate by time block	Yes	Yes	Average response speed	No	Yes
Average call rate by hour	No	Yes	Average response speed by priority level	Yes	No
Fraction of calls requiring one, two, ... units to be dispatched	Yes	No	Average patrol speed	Yes	Yes
Average service time by time block	No	Yes	Procedure for handling calls when all units are busy	Yes	No
Average service time by hour	No	Yes	Average number of suppressible crimes by time block	No	Yes
Average service time for first, second, ... unit dispatched	Yes	No	Terminology used to refer to divisions, precincts, and tours	No	Yes
Average non-CFS work per unit	Yes	No	Maximum/minimum acceptable values for user-selected constraint variables	B	B
Unavailability parameters used to compute non-CFS work from CFS work	No	Yes	Minimum and maximum number of units that can be allocated to a time block	C	No
Fraction of calls which are priority 1, 2, and 3	Yes	Yes	Number of units to be allocated among time blocks	C	C

*The notation "yes" indicates that the data item must be specified in order to use the program. "No" indicates that the data item is not used by the program. Other notations, such as "B" and "C," identify performance characteristics (see Table 4-1) for which the data item is required. If these performance characteristics are not of interest, then the data item can be omitted. For required items, fairly rough estimates will suffice in some instances (see the user's manuals for details).

may not be available to department planners when needed. Since PATROL/PLAN is used on a separate computer, it is always available to the planner, except when equipment breakdowns cause a temporary interruption in service (see Section A of this chapter).

Features of PATROL/PLAN which are not available in PCAM include the following:

- PATROL/PLAN provides three options for handling calls for service which arrive when all units are busy: (1) all calls, regardless of priority, are queued (stacked), and serviced on a first-come, first-served basis by priority level, (2) all calls, regardless of priority, are immediately dispatched to backup units, or (3) priority 1 calls are immediately dispatched to backup units, while priority 2 and 3 calls are queued (stacked). PCAM assumes that all calls arriving when all units are busy are queued (stacked) and serviced by priority level.

- PATROL/PLAN can allocate units among time blocks on the basis of average unit workload, uncommitted time per unit, travel time to priority 1, 2, or 3 calls, response time to priority 1, 2, or 3 calls, and patrol interval, in addition to the performance characteristics usable for allocation in PCAM (i.e., fraction of calls queued, average queue delay, queue delay for priority 1, 2, and 3 calls, and average response time).

- PATROL/PLAN provides two options for allocating units among time blocks: (1) units can be allocated in a way which minimizes (or maximizes) the average value of a performance characteristic over all time blocks, or (2) units can be allocated in a way which minimizes the maximum value (or maximizes the minimum value) of a performance characteristic over all time blocks.

Features of PCAM which are not supported by PATROL/PLAN include the following:

- PCAM utilizes hourly call rate and service time data in computing its estimates of performance statistics. The resulting estimates are more accurate than those computed by PATROL/PLAN, which uses an average call rate and service time for the entire time block.

- PCAM allows the amount of time spent on non-CFS activities to vary with the amount of time units spend on calls for service. PATROL/PLAN assumes that non-CFS workload is constant by hour and unit for a time block.

- PCAM allows one overlay shift to be used. PATROL/PLAN does not allow time blocks to overlap.

- PCAM's database can include any number of time blocks and geographical regions. A PCAM analysis can cover all time blocks and regions, or be limited to selected regions, days of the week, or time blocks. PATROL/PLAN allows a maximum of seven time blocks, and separate analyses of selected time blocks may not be possible without reentering some of the input data.

Comparison of BEAT/PLAN and Hypercube

BEAT/PLAN emulates the Hypercube queuing model in that it is a computer-based resource allocation planning tool which addresses the problem of assigning patrol units to geographic areas (beats) for a specified time block and region. Developed by Dr. Richard Larson and others at M.I.T., Hypercube was originally written in PL/I for large computers. Since its inception, several versions have evolved,* including one version written in COBOL. The most powerful version of Hypercube currently available is an interactive, user-oriented version intended for use on a time-sharing-type computer system accessed with a teletypewriter-type data terminal. Principle differences between BEAT/PLAN and this latter version of Hypercube include the following (the other versions of Hypercube lack many of the features identified below):

- Hypercube provides more detailed performance characteristics by computing many performance estimates at a reporting area level. Performance estimates at the region, beat, and unit levels--which are the estimates most frequently used in designing beat plans--are provided by both Hypercube and BEAT/PLAN. Hypercube and BEAT/PLAN outputs are summarized in Table 4-3.**

- Many input data items required to use BEAT/PLAN and Hypercube are quite similar, although the format of the inputs differ slightly in some cases. In addition, each program can utilize optional input data items to produce additional outputs or more accurate estimates of performance characteristics. Table 4-4 summarizes the input data used by BEAT/PLAN and Hypercube.

- To use Hypercube, beat designers must familiarize themselves with a number of commands used to initiate various features of the system (e.g., the command WORKLOAD is used to specify or modify the average

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*See How to Set Up Shop for Use of the Hypercube System for a discussion of the characteristics and features of the various versions of the program.

**See the BEAT/PLAN and Hypercube user's manuals for a detailed discussion of program inputs and outputs.

Table 4-3

PERFORMANCE CHARACTERISTICS COMPUTED BY BEAT/PLAN AND HYPERCUBE

Performance Characteristic	BEAT/PLAN	HYPERCUBE
A. Region, Unit, Beat, and Reporting Area Performance Characteristics		
1. Average workload per unit		
• Region-wide	Yes	Yes
• Unit	Yes	Yes
• Beat	Yes	Yes
• Reporting area	No	Yes
2. Response/travel time		
• Region-wide	Yes	Yes
• Unit	Yes	Yes
• Beat	Yes	Yes
• Reporting area	No	Yes
3. Cross-beat dispatches		
• Region-wide	Yes	Yes
• Unit	Yes	Yes
• Beat	Yes	Yes
• Reporting area	No	Yes
4. Patrol interval/frequency		
• Region-wide	Yes	Yes
• Beat	Yes	No
• Reporting area	No	Yes
5. Dispatch error probabilities		
• Region-wide	No	Yes
• Reporting area	No	Yes
Region, Unit, Beat, and Reporting Area Performance Characteristics (cont'd.)		
6. Miscellaneous statistics		
• Inter-reporting area travel times	No	Yes
• Average unit-to-reporting area travel times	No	Yes
• Unit-to-reporting area travel times perceived by dispatcher	No	Yes
• Fraction of each unit's free time spent in each reporting area	No	Yes
• Percent of time all units are busy	No	Yes
• Average travel time for queued calls	No	Yes
B. Reporting Area Data Aggregated by Beat		
1. Region-wide totals, beat totals, and percent of region total in each beat	Yes	No
2. Beat index values	Yes	No
C. Prescriptive Beat Plan Modification		
1. Suggested transfer of reporting areas from one beat to another	Yes	No

Table 4-4

INPUT DATA ITEMS USED BY BEAT/PLAN AND HYPERCUBE*

DATA ITEM	BEAT/PLAN	HYPERCUBE
Reporting area identifiers	Required	Required
X, Y-coordinates of reporting area centers	A	Required
Size of reporting areas	A	Required
Relative reporting area workloads	A	Required
Number of miles of patrolled streets per reporting area	A.4	A.4
Average response speed	A	Required
Average response speeds in X and Y directions	Not Used	Optional
Average patrol speed	A.4	A.4
Average service time	A	Required
Average service time by unit	Not Used	Optional
Average call rate	A	Required
Non-CFS workload	A	Required
Preventive patrol factors	Fixed	Optional
Inter-reporting area travel times	Fixed	Optional
Average unit-to-reporting area travel times perceived by dispatcher	Fixed	Optional
Dispatcher knowledge of call and unit locations	Fixed	Required
Dispatch procedure when a unit other than beat unit appears to be closest to call	A	Required
Procedure for handling calls when all units are busy	A	Required
Proportionality constant used to compute intra-reporting area travel times	Fixed	Required
Terminology used to refer to beats, units, etc.	Fixed	Optional
Beat identifiers	Required	Required
Beat names	Required	Not Used
Reporting areas assigned to each beat	Required	Required
Values, for each reporting area, of other data items to be aggregated by beat	B,C	Not Used
Data item weighting factors used to compute beat index values	B.2	Not Used
Procedure for handling reporting areas assigned to more than one beat when aggregating data	B,C	Not Used
Reporting area adjacencies	C	Not Used

*The notation "required" indicates that the data item must be specified in order to use the program. "Fixed" indicates that the program assumes a value for the data item which cannot be modified by the user. "Optional" indicates that the data item can be specified and will be used by the program if available. If omitted, the program will assign a value to an optional data item or compute its value from other user inputs. "Not used" indicates that there is no provision in the program to use a data item, even if it is available. Other notations, such as "A" or "A.4," identify performance characteristics (see Table 4-3) for which the data item is required. If these performance characteristics are not of interest, then the data item can be omitted.

call rate and service time). Once one of these commands has been entered, the user is prompted for any additional input data items that are needed. BEAT/PLAN, on the other hand, does not require the use of a command language. Instead, BEAT/PLAN identifies the options available to the beat designer at each point of an analysis, and prompts the user for the option selected, plus any input data required. Both BEAT/PLAN and Hypercube perform extensive error-checking of user inputs.

- Like PATROL/PLAN, BEAT/PLAN can be loaded into a microcomputer and run by persons with no prior computer-related experience, whereas Hypercube must first be installed on a larger computer system by data processing personnel.

- Like PCAM, Hypercube usage is limited to police departments with access to large computer systems. Even departments with in-house computers will probably be able to use the most powerful version of Hypercube only through commercial or university-based time-share networks because (1) the language in which the programs are written is not supported by most police department computers, (2) interactive program operation is rarely supported, and (3) the large amount of core storage that may be required to use Hypercube is seldom available (see How to Set Up Shop for Use of the Hypercube System for a discussion of system requirements).

- When large amounts of core storage are available, hypercube can be used to analyze larger regions (i.e., having more reporting areas) and larger beat plans (i.e., having more beats) than can be analyzed with BEAT/PLAN. For example, Hypercube has been used to analyze regions with as many as 249 reporting areas and 29 beats. With BEAT/PLAN, comparable analyses are limited to approximately 100 reporting areas and 10 beats. (If fewer beats are required, more reporting areas can be used and vice versa.)

Features of BEAT/PLAN which are not provided by Hypercube include the following:

- BEAT/PLAN has prescriptive, as well as descriptive, capabilities. That is, given a proposed beat plan and an additive performance characteristic to be balanced among the beats, BEAT/PLAN can suggest modifications in the form of reporting areas to be moved from one beat to another which will reduce the imbalance among beats in that performance characteristic. Hypercube has no prescriptive capabilities.

- BEAT/PLAN can be used to automate manual beat design methods, including those based on workload or hazard formulas. Factors such as beat size, population, or the number of businesses in a beat are not easily included in Hypercube analyses.

Features of Hypercube which are not provided by BEAT/PLAN include the following:

- Hypercube provides two options for computing performance characteristics: (1) statistics can be computed "exactly"* or (2) they can be computed using certain mathematical approximations which simplify the calculations (thereby reducing computing time and cost) and produce results which are usually within two percent of the "exact" estimates. BEAT/PLAN produces only the approximate performance characteristics.

- Hypercube provides greater flexibility in modelling dispatch operations. For example, the user can specify how precisely the dispatcher knows the location of a call (i.e., whether the reporting area in which the call occurs is known), and how precisely the dispatcher knows the locations of available units (i.e., whether the exact location, the reporting area, or the beat in which the unit is located is known). BEAT/PLAN assumes that the dispatcher knows the reporting area in which a call is located and beat in which each available unit is located.

- Hypercube provides greater flexibility in specifying the preventive patrol policy used. For example, the user can indicate the relative amount of free time units spend in each reporting area in their beat. BEAT/PLAN assumes that preventive patrol is proportional to the relative call-for-service workload in each reporting area.

- Hypercube allows an average service time to be specified for each unit. BEAT/PLAN assumes that the average service time is the same for all units.

- Hypercube allows the user to specify the terminology used in program outputs to refer to beats, units, reporting areas, etc. The terminology used in BEAT/PLAN cannot be modified.

C. Field Implementation of POLICE/PLAN

This section discusses the POLICE/PLAN system field test. Test activities included a detailed assessment of the implementation and use of the system in three police departments, and a telephone survey of 29 other agencies which used prototype versions of the system without direct project support. The final subsection illustrates a successful implementation by presenting a brief summary of POLICE/PLAN use at the Norfolk, Virginia, Police Department during the field test.

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*A more complex and more accurate mathematical model is used--the results, however, are not literally "exact."

Selection of the Three Field Test Departments

The three police departments selected as sites for the field test of prototype versions of POLICE/PLAN were participants in the LEAA Integrated Criminal Apprehension Program (ICAP). Because this program required participating departments to conduct a comprehensive review of their patrol functions, these departments were deemed prime candidates for use of POLICE/PLAN.

In July 1978 an information package about POLICE/PLAN was distributed to the approximately 30 police departments then involved in the ICAP program. The enclosures detailed the potential benefits of using POLICE/PLAN and the projected obligations of the test sites. Interested agencies were invited to attend a demonstration of POLICE/PLAN in Arlington, Texas, on August 29th, in connection with a national meeting of ICAP project participants.

Following the meeting, fourteen ICAP agencies expressed interest in participating as test sites. These departments were asked to submit application forms which detailed their staff capabilities and their reasons for wanting to use POLICE/PLAN. Nine agencies submitted completed applications by the September 15th deadline: East Providence (RI), Lawrence (KS), New Orleans (LA), Norfolk (VA), Pontiac (MI), Portsmouth (VA), Racine (WI), Springfield (MO), and Stockton, (CA).

Review of these applications was accomplished by having them evaluated by seven members of the Project Advisory Board, two members of LEAA's ICAP management team, the NILECJ project monitor, and three members of TIPPA's research team. Applications were rated on five issues: (1) the department's need for an improved field operations deployment planning system, (2) capabilities of the department staff expected to be assigned to the project, (3) adequacy of the department's data base, (4) probability of implementation of field operations plans based on POLICE/PLAN, and (5) an overall assessment of the department as a test site. Reviewers' ratings were subsequently tabulated and, after some final information verification by phone, the three agencies having the highest total scores were selected as the test sites: Stockton, CA, Springfield, MO, and Norfolk, VA. ICAP departments not selected as test sites were invited to obtain and use project software on their own, without technical assistance from TIPPA. Their experience is summarized in a later section of this chapter.

Major Field Test Activities

Activities of the field test component of the project were clustered into three time segments: orientation, Phase I, and Phase II.

Orientation. Following selection of the field test agencies, personnel from each department attended a 5-day training workshop at TIPPA. Each agency then received a PET microcomputer for on-site use and a copy of the latest version of the PATROL/PLAN program (DATA/PLAN and BEAT/PLAN had not yet been written). The objectives of the orientation period were (1) familiarization of test agency

personnel with microcomputer equipment and its use, and (2) initial investigation of the availability at these sites of the data needed as input to PATROL/PLAN.

"Phase I. During Phase I, each field test department was required to complete a hypothetical field operations planning exercise using project equipment and software and to develop a preliminary plan for study of their department's own field operations during Phase II.

To initiate Phase I, a meeting of test site representatives was held in St. Louis on February 9, 1979. The agenda included: review of recent project activities involving design of additional software and expansion of the capabilities of the existing software; discussion of the upcoming field test activities and timetable; feedback from the test site personnel regarding the December training program and use of PATROL/PLAN on the PET microcomputers; overview of the Phase I field test exercise; and instruction in the use of the latest versions of the POLICE/PLAN package's components (BEAT/PLAN, DATA/PLAN, and PATROL/PLAN) on the TRS-80 microcomputer.

Test site personnel were also asked to complete a questionnaire after they returned home regarding the project software and their experience with the PET microcomputers loaned to them by the project.

The Phase I Field Test Exercise (FTE) was designed to be a realistic simulation of a police department resource allocation problem which required the use of all of the project's microcomputer software packages. One aspect of the problem also tested the calculator version of PATROL/PLAN. The FTE included a sample set of dispatch cards which formed the basic source of operational input data. Also provided were draft user's manuals for the different software packages.

Upon completion of the FTE, each test site was visited by two TIPPA staff members. A questionnaire had been devised by TIPPA to cover the following areas: time and cost of completing the FTE, ability of users to operate each of the programs and types of equipment, quality of the user's manuals, accuracy of POLICE/PLAN's performance estimates, and local plans for Phase II of the field test.

Test site responses to this questionnaire were then used by the project team to structure the next round of revisions to the microcomputer programs and user's manuals.

Phase II. During Phase II of the field test, each test department used TRS-80 microcomputer equipment and the newest prototype programs to analyze a local resource allocation problem based on their own department's data. The results of these efforts were summarized at a June 28, 1979, field test wrap-up meeting at TIPPA and were detailed in written reports prepared by each department. At the meeting, planners from the three departments reported successful application of the software. The Norfolk Police Department had already implemented new field operations deployment plans covering one half of their city, designed with POLICE/PLAN (see

below for a more detailed review of Norfolk's analysis). Stockton had studied the patrol performance implications involved in several proposed alternatives for deploying seven newly-hired officers and redeploying a specially-trained group of "strike force" officers. Springfield reported using POLICE/PLAN for an extensive analysis of their call-for-service workload and for reallignment of the city's patrol beats.

Telephone Survey of Other User Agencies

By April 1979, 29 other police agencies which had learned of POLICE/PLAN through the project's information dissemination activities, had obtained copies of prototype versions of project software. During April and May 1979, all of these agencies were contacted by telephone and asked to comment on the ways in which the system had been used, any problems encountered, and possible improvements to the programs and documentation. The following paragraphs summarize the results of this survey.

Of the 29 agencies, 15 were using calculator PATROL/PLAN systems, 8 were using the microcomputer version of PATROL/PLAN-I (5 on TRS-80s, 2 on PETs, and one on a Honeywell minicomputer), and 6 were using PATROL/PLAN-II (5 on TRS-80s and one on a Burroughs computer).* The smallest user department was located in Carol Stream, Illinois, and had 24 sworn personnel and 3-5 units fielded per watch. The largest was the Jacksonville, Florida, Sheriff's Department, which had about 966 sworn personnel and 66-112 units fielded per watch. None of the 29 agencies was using DATA/PLAN or BEAT/PLAN. Further information regarding the 29 agencies and their use of PATROL/PLAN is summarized in tables 4-5 and 4-6. Several departments reported completing successful patrol allocation studies using PATROL/PLAN, including some which had already been implemented in the field and documented in in-house reports. In addition, several had used PATROL/PLAN's field operations performance statistics to help justify existing or proposed department staffing levels and budgets. This had most frequently been accomplished by estimating the service levels (e.g., average response times, percent of calls stacked, minimum patrol intervals) that could be expected with different numbers of patrol officers. One police respondent called the system "an excellent tool for educating the City Council."

The primary difficulty encountered by these PATROL/PLAN users related to collecting the necessary input data, especially in departments not having automated management information systems. However, several departments lacking such systems used PATROL/PLAN successfully, and the desire to use PATROL/PLAN had motivated some of them to institute systematic manual procedures for collecting the needed call-for-service and other data.

The PATROL/PLAN output variable which was generally seen as most valuable was the "percent of time no units are free." Some

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*The agencies which had implemented project software on the Honeywell and Burroughs computers had translated it to the appropriate dialect of BASIC themselves, starting with microcomputer code listings supplied by TIPPA. "I" and "II" refer to intermediate prototype versions of the software (the final versions were identified by the index "III," but this has since been dropped from the program names).

Table 4-5

POLICE/PLAN TELEPHONE SURVEY:
MICROCOMPUTER IMPLEMENTATIONS

Agency	City Size: Pop. (Thous.)	City Size: Area (Sq. Mi.)	Department Size: No. of Officers	Department Size: Units Fielded Per Match (Min. - Max.)	Systems Used: PATROL/PLAN-I: Calc.	PATROL/PLAN-I: PET	PATROL/PLAN-I: TRS-80	PATROL/PLAN-I: Other	PATROL/PLAN-II: TRS-80	PATROL/PLAN-II: Other	BEAT/PLAN, DATA/PLAN: TRS-80	BEAT/PLAN, DATA/PLAN: Other	Comments
Albuquerque, NM, Police	320	85	286	50(av)			x		x		x		MPO Test Site; have run demonstrations and test problems only; used system to facilitate training of staff to use PCAM and hypercube;
Alexandria, VA, Police	117	15.7	233	12-19		x							System used in Manpower Needs Study to determine required number of officers and beats;
Carol Stream, IL, Police	12	7	24	3-5			x						System used for budget justification-charted levels of service attainable with present manpower;
Charlotte, NC, Police	330	124	582	45-100			x		x		x		MPO Test Site; used to explain patrol modeling to field personnel to prepare for use of PCAM and hypercube; used BEAT/PLAN to design new command areas;
Glen Ellyn, IL, Police	25	8	33	4-6			x						Examined impact of annexation - found patrol performance to be only slightly affected;
Jacksonville, FL, Sheriff	600	840	966	66-112	x				x	x	x		ICAP department which implemented system on Burroughs 7700 computer; used for patrol allocation and budget review; examined effect of reduction in size of the force;
Lawrence, KS, Police	68	19.2	78	6(av)					x		x		ICAP department; plans to use system in upcoming redeployment study;
Lawrence Livermore Labs	-	-	-	-		x							System used for demonstrating the value of microcomputer-based planning systems for local governments;
Long Beach, CA, DP Dept.	-	-	-	-			x						System used for demonstration purposes only;
Multnomah Co., OR, Dept. of Public Safety	150	300	225	10-15			x	x					Program converted for use on Wang computer; analyses used to justify request for more officers;
Oklahoma City Police	400	650	712	38(av)				x					Program converted for use on Honeywell computer; used for budget and Patrol allocation; estimated impact of 10% increase in call rate;
Portsmouth, VA, Police	108	29.9	208	(varies by sector)					x		x		ICAP department; system used for patrol allocation by sector and shift;
Sacramento, CA, Police	260	97.4	500	16-31			x		x		x		MPO test site; used to facilitate implementation and use of Hypercube and PCAM;
Southwest Innovation Group	-	-	-	-			x						System used to demonstrate benefits of resource allocation planning to police departments in member cities;
Field Test Cities													
Norfolk, VA, Police	281	63.1	597	19-29	x	x			x		x		
Springfield, MO, Police	155	63	190	12-24	x	x			x		x		ICAP Department
Stockton, CA, Police	130	42	231	7-15	x	x			x		x		ICAP Department
													ICAP Department
Post-Survey Users													
Cambridge, MA, Police									x		x		ICAP Department; planning redeployment of patrol resources
University City, MO, Police									x		x		ICAP Department; planning redeployment of patrol resources

NOTE: Telephone interviews with software users conducted during April and May 1979.

Table 4-6

POLICE/PLAN TELEPHONE SURVEY:
CALCULATOR IMPLEMENTATIONS

Agency	City Size: Pop. (Thous.)	City Size: Area (Sq. Mi.)	Department Size: No. of Officers (Approx.)	Department Size: Units Fielded Per Watch (Min. - Max.)	Systems Used: PATROL/PLAN-I: Calc.	PET	TRS-80	Other	PATROL/PLAN-II: TRS-80	Other	BEAT/PLAN, DATA/PLAN: TRS-80	Other	Comments
Ann Arbor, MI, Police	106	24	102	4-15	x								Used for occasional patrol analysis to control fraction of time when no units are available to respond to incoming calls;
Boca Raton, FL, Police	57	16	94	5-20	x								System used for patrol analysis; also uses calculator software for budgeting, crime analysis, and scheduling;
Bristol Twp., PA, Police					x								System not yet used for patrol allocation; obtained PATROL/PLAN to supplement calculator software for shift scheduling;
Connecticut Justice Comm.	-	-	-	-	x								System used by regional planners assisting muni. police departments throughout State; cities vary from 20,000 to 120,000 population;
Corvallis, OR, Police	74		71	6(av)	x								System not being used since original user left department and City and County departments merged;
Jacksonville, FL, Sheriff	600	840	966	66-112	x				x	x	x		ICAP Department; calculator used extensively prior to implementation of PATROL/PLAN-II on Burroughs computer;
Kent State Univ., Dept. of Criminal Justice	-	-	-	-	x								System used as classroom training aid for student analyses of resource allocation at local police agencies;
Madera, CA, Police	20	10	37	3-7	x								System used for patrol allocation and budgeting; studied patrol needs through 1981; primary staff user has written several other calculator programs for police planning;
Maricopa Co., AZ, Sheriff	175	9,280	358	30-40	x								System used for patrol allocation and budget justification; estimated the benefits of hiring additional officers;
Pima Co., AZ, Sheriff	600	9,240	157	30(av)	x								System not being used, due to lack of interest by field personnel; still hopes to use system to improve manual allocation methods;
St. Louis Co., MO, Police	425	350	550	37-61	x								System used along with Hypercube and PCAM for patrol allocation planning by shift and precinct;
San Diego, CA, Police	805	620	800	64-85	x								System not being used due to lack of data and reluctance to change existing deployment plans; system showed need for more sophisticated data collection;
San Diego Co., CA, Sheriff					x								System not used since expiration of planning grant for which it was purchased; was used under grant for patrol allocation studies;
Vincennes Trail Law Enf. Comm. (Salem, IL)	-	-	-	-	x								Original user left agency, and no one else has been trained to use it; would like to have PATROL/PLAN implemented on agency computer;
Washington State Patrol					x								System not being used due to lack of training; Chief still wants system implemented;
Westchester Co., NY, Ofc. of Criminal Justice Planning	-	-	-	-	x								System not being used for patrol allocation; hoped to demonstrate application of system to 1 or 2 depts. in County, but none have volunteered; shift scheduling software is being used

NOTE: Telephone interviews with software users conducted during April and May, 1979.

users found the minimum patrol interval estimate quite useful, especially for budget justification purposes in departments in which preventive patrol was being emphasized. Likewise, some users felt the average travel time estimate to be most useful even though the emphasis on travel time has been somewhat lessened due to recent research findings on the subject.

Use of POLICE/PLAN by the Norfolk Police Department

As mentioned earlier, the Norfolk Police Department, which served as one of the project's three test sites, used POLICE/PLAN in conjunction with its LEAA-funded Integrated Criminal Apprehension Program (ICAP). At the time of the field test, Norfolk's field operations commanders were confronted with two major resource allocation problems--correcting an apparent imbalance in the distribution of patrol resources between the department's two patrol divisions, and planning a change from one-man to two-man patrol units. A decision was made to use POLICE/PLAN to study both problems. The following paragraphs, adapted from the planner's subsequent report, provide an excellent example of police use of POLICE/PLAN.*

> The Norfolk Police Department employs 795 personnel (597 sworn, 198 civilian) of which 321 are assigned to the two patrol divisions under the Bureau of Operations. The municipality contains a population of 281,000 persons, much of which is transient due to the large number of military installations in the area. This military-oriented characteristic also results in a high influx of people commuting to Norfolk from surrounding areas for reasons of employment. The other factor affecting the population is Norfolk's role as the center of economic activity for the Tidewater area.
>
> Several major changes to previous deployment strategies have been made during the last few years to make patrol operations more effective. In January 1973, the patrol districts (beats) were redesigned. This was again accomplished in March 1975. Other operational changes made during this time frame included the implementation of one-man patrol units and the establishment of a sector command operational hierarchy. The city was divided into two command divisions, North and South, with three patrol sectors in each division. Each sector consisted of 6-8 districts (beats).
>
> Although the sectors designed under the sector command concept had fairly equal workloads, the patrol districts continued to display an unacceptable variance of activity levels. It was not uncommon to have certain districts unpatrolled while units assigned to them were working other districts. Along with this characteristic went a high level of back-up responses, and numerous

*Banwell, Albert, "Phase II Report: Field Test/Evaluation of Easy-to-Use Police Resource Allocation Planning Tools," June 1979.

> units often responded as back-up assistance to single calls for service.
>
> Specifically, the goal of the POLICE/PLAN analysis was to determine the minimum number of two-man patrol units required to provide, on an average: a) 30 minutes of uncommitted time per hour, b) 30 minutes per hour answering calls for service and administrative details, and c) a saturation probability (i.e., percent of time no units are free) of less than 15 percent. Also desired was the maintenance of the sector command concept with cross-sector dispatching being held to a minimum. Contingent on this determination was the redrawing of patrol districts by sector to equalize patrol force workload.
>
> A major problem arose concerning the accuracy of department data on calls for service. First, no definition of the term "call for service" had been made. Officer-initiated work was not always coded as a call for service. Second, dispatches were coded to coincide with the responding unit designation, not geographically to coincide with the actual location of the call. Thus, a major data collection effort was undertaken by ICAP staff.
>
> Calls for service were coded geographically by location of origin (city planning district). Non-call-for-service assignments were coded by the unit assigned since these in actuality did not have a geographic origin, or were not initiated due to any specific locality. The data base used for the POLICE/PLAN analysis consisted of all incidents during the months of December 1978 and January 1979.
>
> Estimates on the probable reduction in multiple unit dispatches resulting from the shift to two-man units were determined by examining the unit message sheets for notations on assist calls (10-2 code) indicating no assistance required, a minimal length of time spent on an assistance dispatch, or the requirement of an additional officer and not a vehicle. These findings were reduced to percentages and applied to the one-man unit data to derive corresponding input under two-man unit operations.
>
> The actual POLICE/PLAN runs were made by the staff analyst assigned to the ICAP program, but the decision-making process involved several additional persons, including Planning and Research analysts, commanding officers of both patrol divisions and the Special Operations Division, and the Deputy Chief of the Operations Bureau. Alternative district plans were reviewed in terms of the objectives listed above.
>
> During the course of analysis, it was determined that a total of 25 two-man units could provide services

to the community on a city-wide basis within the constraints imposed if the sector command concept were not considered. This was deemed to be a zero base level of service to meet citizen demand. However, to maintain the integrity of the sector command concept and to minimize cross-sector dispatching, each sector had to be treated individually. Under this condition, it was determined that 29 two-man units would be required. Table 4-7 indicates the unit allocations under this constraint by sector.

The final proposal was accepted and implemented in the Second Patrol Division (the northern section of the city). Implementation of this plan in the First Patrol Division (the southern sector of the city) was delayed, due to other patrol programs being implemented.

Table 4-7

NORFOLK POLICE DEPARTMENT
PROPOSED SECTOR ALLOCATIONS

Sector	Number of Old Districts	Number of New Districts	Change
First Patrol Division			
Red	7	6	-1
Blue	8	4	-4
Green	7	5	-2
Second Patrol Division			
Red	7	5	-2
Blue	6	5	-1
Green	6	4	-2
Total	41	29	-12

CHAPTER V

ASSESSING THE FEASIBILITY OF USING POLICE/PLAN

This chapter provides guidelines for police agencies assessing the feasibility of using the POLICE/PLAN system. It is suggested that such a feasibility study include assessment of the expected benefits of using PO CE/PLAN, estimation of the costs of implementing and using the system, assessment of department conditions which are necessary for successful use of the system, and a thorough review of system documentation. These topics are briefly discussed in the sections that follow.

A. Expected Benefits

The advantages of using POLICE/PLAN have been described in previous chapters of this report. In summary, they are as follows:

- The use of microcomputer and programmable calculator equipment can make sophisticated planning capabilities available at greatly reduced cost.
- The system can be used successfully by persons with no prior data processing experience.
- POLICE/PLAN provides estimates of field performance characteristics of current or proposed patrol policies and beat configurations not otherwise available to police planners. Other types of estimates, presently available from large-computer planning systems like Hypercube and PCAM, are made available for the first time in an integrated and cohesive system.
- Use of POLICE/PLAN enables the planner to estimate the effects of policy and deployment changes on field performance before such changes are actually implemented. This can avoid costly and disruptive field experimentation.
- POLICE/PLAN automates most calculations normally required to design beats manually; as a result, the system can significantly reduce the effort needed to produce a new beat plan, even for departments otherwise uninterested in sophisticated patrol analyses.
- POLICE/PLAN is a useful tool for teaching patrol managers and planners the fundamental concepts of patrol allocation planning.

B. Costs Involved in Using POLICE/PLAN

The costs of implementing and using POLICE/PLAN fall into three categories:

- Equipment and programs--The cost of obtaining microcomputer or calculator equipment and programs ranges from about $300 to about $3800, depending on the configuration selected; departments intending to use POLICE/PLAN on equipment other than the Apple II or TRS-80 will need to prepare a careful estimate of the cost of reprogramming POLICE/PLAN, since software of this nature is not easily transferrable to other systems.

- Training and technical assistance--While formal training is not essential for POLICE/PLAN users, it is quite helpful for understanding the capabilities and limitations of the system and for speeding up the learning process; likewise, some users will find on-site technical assistance to be helpful and may want to retain the services of a consultant (e.g., to assist with data collection or interpretation of POLICE/PLAN output).

- Personnel--Hardest to estimate is the cost of the staff time which will be required for planning, training, data collection, data analysis, preparation of reports, and implementation of any new patrol deployment plans.

Full use of POLICE/PLAN will require considerable information about the geography and workload distribution of the jurisdiction, the patrol deployment practices in use including the procedures used by dispatchers to select patrol units for assignments, and the service times and travel speeds of patrol units. Since very few police departments routinely collect all of the input data required by the POLICE/PLAN programs, most departments planning to use the system will find it necessary to initiate some new data collection activities. Depending on the available data resources, these data collection activities may be quite simple or take considerable effort. Interested departments can probably get some help in estimating the data collection costs of using POLICE/PLAN by contacting previous users. Any such estimate should specifically account for the personnel time and other costs associated with the following activities:*

- review of POLICE/PLAN input data items;

- determination of the number of distinct field operations plans to be examined (as the number of plans increases, the amount of data to be collected usually increases);

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*POLICE/PLAN's user's manuals discuss data collection activities in more detail.

- surveying existing department records to identify new data collection activities required; and

- preparation and coordination of data collection activities.

C. Conditions Under Which Use of POLICE/PLAN is Most Likely to be Successful

Circumstances in which a police department is most likely to benefit from using POLICE/PLAN are summarized below. While these circumstances are not necessarily prerequisites, some of them have almost always been missing in departments which have failed in their efforts to use computerized field operations planning systems:

- Recognized need to improve patrol operations--A need to improve patrol operations will be most apparent in departments experiencing heavy workloads, frequent queuing delays, and other field operations problems. Departments which are generally satisfied with their patrol policies and deployments are less likely to benefit from use of POLICE/PLAN or to maintain the motivation required to complete the analysis and then implement new field operations plans.

- Cooperation and communication between field, support, and planning personnel--Field operations plans almost never succeed without cooperation between planning, field, and, where applicable, data processing personnel.

- Agreement among administrative, field, and planning personnel on a set of objectives for patrol operations.

- Adequate time for analysis--Allowing insufficient time for planning, data collection, or analysis of POLICE/PLAN output will lead at best to inefficient use of the system and, at worst, to erroneous results.

- Acceptance of computers and mathematical modelling as reliable planning tools.

- Availability of data and/or the willingness to commit department resources to data collection efforts.

- Patrol operations satisfying the assumptions of the POLICE/PLAN model--The assumptions upon which POLICE/PLAN is based must apply reasonably well to the department's patrol operations in order to insure reliable and valid results.*

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*These assumptions are discussed in the POLICE/PLAN user's manuals.

D. Obtaining POLICE/PLAN Programs and Documentation

Persons considering implementing POLICE/PLAN should obtain and review the POLICE/PLAN user's manual appropriate for the data processing equipment to be used. Additional information on patrol allocation and computerized planning models can be found in the documents listed at the end of this report. Information about the POLICE/PLAN programs and user's manuals is available from:

- Executive Director
  The Institute for Public Program Analysis
  230 South Bemiston, Suite 914
  St. Louis, MO 63105
  (314) 862-8272

or

- Director
  Police Division
  National Institute of Law Enforcement
  and Criminal Justice
  Law Enforcement Assistance Administration
  Washington, D. C. 20531

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