PATROL CAR ALLOCATION MODEL: EXECUTIVE SUMMARY

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AND FOR THE NATIONAL INSTITUTE OF LAW ENFORCEMENT AND CRIMINAL JUSTICE, L.E.A.A., DEPARTMENT OF JUSTICE

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R-1786/1-HUD/DOJ
SEPTEMBER 1975

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This report was prepared as an account of work sponsored by the United States government, Office of Policy Development and Research, Department of Housing and Urban Development (HUD), under Contract H-2164, and by the Department of Justice, Law Enforcement Assistance Administration, National Institute of Law Enforcement and Criminal Justice, under Grant 75-NI-99-0012. Neither the United States nor HUD, nor the Department of Justice, nor any person acting on behalf of them, makes any warranty, expressed or implied, or assumes responsibility for the accuracy or completeness of the information herein, or assumes liability with respect to the use of any information or method herein.

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Published by The Rand Corporation

PREFACE

This report describes in nontechnical terms a computer program called the Patrol Car Allocation Model. It was written to help police administrators and planning officers understand how the model can be used for policy analysis.

Preparation of this report was supported by the Office of Policy Development and Research of the United States Department of Housing and Urban Development (HUD) under contract H-2164 with The New York City-Rand Institute. Among the objectives of this HUD contract are the development, field testing, and documentation of methods to improve allocation procedures in municipal emergency service agencies in the United States.

Design of the computer program described in the report was partially funded by HUD and partially by the National Institute of Law Enforcement and Criminal Justice under grant 75NI-99-0012 to The Rand Corporation. This grant funds a study of computer programs for criminal justice agencies.

Two companion reports available from The Rand Corporation describe the Patrol Car Allocation Model in greater detail. The user's manual gives complete instructions for collecting data and operating the program, and it presents the mathematical details underlying the model's calculations:

- Jan M. Chaiken and Peter Dormont, *Patrol Car Allocation Model: User's Manual*, R-1786/2.

The program description is primarily for data-processing personnel and gives file specifications and installation instructions:

- Jan M. Chaiken and Peter Dormont, *Patrol Car Allocation Model: Program Description*, R-1786/3.

This report is part of a series that documents several different deployment models for police, fire, and ambulance agencies. Further information can be obtained by writing to the addresses in the Appendix.

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I. INTRODUCTION

The Patrol Car Allocation Model (PCAM) is a computer program designed to help police departments determine the number of patrol cars* to have on duty in each of their geographical commands. Typically, the number of patrol cars needed will vary according to the season of the year, day of the week, and hour of the day. The PCAM program tells a department how to match its actual allocations to these needs, consistent with the overall manpower resources of the department, the levels of performance it desires for patrol cars in responding to calls for service, the hours of the day at which its patrol officers start work, and its dispatching policies.

Although patrol car operations are only part of police work, in most police departments the patrol function consumes over half of the annual budget. Therefore, careful attention to the allocation of patrol resources should be the concern of all police administrators. PCAM provides a tool by which an administrator can establish objectives for the performance of the patrol force and identify those allocation policies that come closest to meeting his objectives. It is intended to substitute for the use of "hazard" or "workload" formulas, which are still widely popular although their failings have been pointed out repeatedly.[1-4]

This computer program was designed by The New York City-Rand Institute after a careful review of various patrol car allocation programs that have been previously used by police departments.[5-9] Of these, the best known ones are the Law Enforcement Manpower Resource Allocation System (LEMRAS), a product of the IBM Corporation,[5] and the Resource Allocation Program described in Richard Larson's book, *Urban Police Patrol Analysis*.[1] PCAM incorporates many of the features of both of

*By "patrol car" we mean a mobile vehicle that can respond to calls for service from the public. Typical names for a patrol car include squad car, radio car, RMP unit, black-and-white, and cruiser. Other vehicles, such as scooters, can be counted as patrol cars if they serve the same function.

these programs, together with several improvements. Among the departments that have adopted PCAM are Atlanta, Kansas City, Los Angeles, Minneapolis, Newark, N.J., New York, San Diego, Toledo, Washington, and Wilmington, Del.

The PCAM program is written in the FORTRAN language and is designed to run in either batch mode (where user input is on cards or a suitable substitute) or in interactive mode (where the user types commands on a teletype or similar terminal and receives output at the same terminal). Any police department can obtain a copy of the program for installation on its own computer system, or it can access the program by subscribing to a commercial time-sharing service.* As the program is distributed, it requires 160K bytes of core storage, but many users, including all departments having eight or fewer geographical commands, will be able to reduce the core requirements if desired.

The program is provided on cards at a cost of $35, or on tape at a cost of $25, plus $15 if we supply the tape.** There is an added charge of $50 for all copies mailed outside the United States. In order to install and operate the program on a department's computer system, it is necessary to obtain copies of the PCAM user's manual[10] and the PCAM program description.[11] The user's manual describes typical applications, provides complete instructions for collecting data and operating the program, and gives the mathematical equations underlying PCAM's calculations. The program description is primarily for data processing personnel and gives detailed file specifications and installation instructions. It also documents the program in sufficient detail for data processing personnel to modify the program, if desired.

This executive summary is a companion to the user's manual and the program description. It tells when PCAM should be used, how it works, and the amount of effort and expertise required to use it.

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*To obtain a copy of the program or information about time-sharing services, write to the address given on page 15.

**A postage charge is added on all orders.

II. WHEN TO USE PCAM

The Patrol Car Allocation Model can be used to analyze any policy question related to the *number* of patrol cars or patrol officers a department should have on duty, or the *times of day* at which patrol cars should begin work. Examples of typical applications are as follows:

1. *Determining the total number of patrol officers a department should have.* This question arises in budget preparation or in considering whether to reallocate officers among functions (e.g., from patrol to investigation or vice versa). By establishing desired performance levels for patrol car operations, a department can use PCAM to determine the smallest number of patrol officers needed to meet its objectives. This information can be particularly useful when demands from the public for responses by patrol cars have increased, and the department wants to maintain previously acceptable performance levels. The output from PCAM specifies exactly how many additional officers are needed for this purpose.
2. *Allocating a fixed total number of patrol officers among geographical commands.** In departments that have more than one geographical command, the number of officers assigned to each of them is changed from time to time. In some departments this occurs at infrequent intervals, such as when the total number of officers changes. Other departments experience seasonal variations in demands for patrol cars (for example, one command may contain a summer resort area). These departments may reassign officers among commands every month or every three months.

   Whether the geographical allocations are made infrequently or regularly, PCAM can be used to determine how many of the patrol officers should be assigned to each geographical command.

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*A *geographical command* is an administrative unit commonly called a precinct, district, division, or area. (Sometimes, but rarely, it is called a sector or beat.)

3. *Assigning patrol cars to geographical commands at the start of each tour.*[*] Some departments have a group of patrol officers (possibly all of them) who report to central headquarters at the start of each tour. These officers do not have permanent geographical assignments but are moved from one command to another in accordance with current requirements. PCAM can be used to determine how many of them should be assigned to each command at the start of each tour of duty.
4. *Allocating patrol cars by time of day.* In many departments the number of patrol officers on duty can be varied from tour to tour and can be different on one day of the week as opposed to another. Such departments require guidance concerning the number of patrol cars to have on duty during each tour of the week. PCAM will specify these allocations in such a way that the number of man-hours allocated to the various tours adds up to the total man-hours available in each command.

   Departments that have fixed manning around the clock may also want to use PCAM to see the extent to which performance measures could be improved by establishing variable manning by tour.
5. *Allocating patrol cars to an overlay tour.* Typical manning patterns involve three 8-hour tours, for example beginning at midnight, 0800, and 1600 hours. However, it is also possible to have an additional fourth tour that begins work during one of the regular tours (for example at 1900 hours) and ends during the next one (for example at 0300 hours). Such a tour is called an *overlay* tour.

   A unique feature of PCAM is its capability to recommend allocations of patrol cars to tours when one tour of each day is an overlay.[**] Departments that already have an overlay tour

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[*] A *tour* is a period of time (commonly eight hours) during which a patrol car is on duty. Other names for a tour are watch, shift, and platoon.

[**] The program can also be operated without any overlay tours.

will find PCAM specially suited to their requirements. Other departments can use PCAM to determine the extent to which performance levels would be improved if an overlay tour were established, and the number of officers that would have to be reassigned from each regular tour to the new overlay tour.

6. *Changing tour starting times.* Some tour starting times may be far superior to others in terms of the match between manpower requirements and manpower on duty. For example, if the largest numbers of calls for service occur during the hours from 1800 to 0200, followed by a period with few calls for service, a tour that begins at midnight will either have too few units on duty for the first two hours or too many for the last six. Beginning the tour at 0200 will permit a better match. PCAM allows the department to study possible changes in tour starting times.
7. *Analyzing priority structure.* PCAM permits calls for service to be classified into three priority levels: priority 1 calls require the immediate dispatch of a patrol car, priority 2 calls are important enough that a rapid response is preferred over a slow response, and priority 3 calls can wait for a response without deleterious effect. This capability allows the department to consider how performance levels would change if new policies were adopted for classifying calls by priority.

The PCAM program cannot be used to analyze possible changes in the locations of patrol cars or the practices of dispatchers. In particular, PCAM is not suitable for designing patrol beats. For this purpose we recommend use of the Hypercube Queuing Model.[12,13] Ordinarily, however, a department would want to use PCAM to determine the number of patrol cars to have on duty before designing patrol beats with the Hypercube Queuing Model.

Examples of dispatching practices that *cannot* be studied using PCAM are the following:

- Dispatching patrol cars across command boundaries for high-priority calls

- Placing low-priority calls in queue to await the availability of the local beat car, even when other patrol cars in the command are available to be dispatched
- Holding some cars in reserve for high-priority calls
- Preempting service on low-priority calls in order to dispatch the busy car to a high-priority call.

The only types of models that can take all such complexities into account are simulation models.[1,14] While simulation models are more accurate than PCAM and can also be used for allocating patrol cars, they are substantially more expensive to operate on a computer than PCAM is, they require much more detailed input data than PCAM, and most police departments would require outside assistance to use a simulation model. For a complete discussion of how to choose an appropriate computer model for a particular patrol allocation question, see Ref. 4.

III. HOW PCAM WORKS

The Patrol Car Allocation Model has both *descriptive* and *prescriptive* capabilities. The *descriptive* capabilities permit displaying quantitative information about any allocation of patrol cars by time of day and geographical command. This information may refer to the current allocation, any proposed allocation created by the user, or the particular allocations that are suggested by PCAM when operated in prescriptive mode. This information permits the user to compare allocations and determine which one he thinks is best. The *prescriptive* capabilities of PCAM specify particular allocations that best meet the standards of performance established by the user.

The information provided to the user when PCAM is operated in descriptive mode include the following:

- The number of patrol cars assigned to each geographical command at each time of day
- Information about the workload of the patrol cars
- Information about the amount of preventive patrol engaged in by the patrol cars
- Average length of time from the dispatch of a patrol car until its arrival at the scene of an incident (*travel time*)
- The percentage of calls that will have to wait in queue until a patrol car is available to dispatch to the incident
- The average length of time (minutes) that calls of various levels of importance (or *priority*) will have to wait in queue
- The average *total response time* (time in queue plus travel time).

In prescriptive mode, PCAM has several capabilities. One of them will tell the user the *minimum number* of patrol cars that must be on duty in each geographical command at all hours of the day to meet *standards of performance* related to the information listed above. Examples: What is the smallest number of patrol cars needed to assure that no more

than 20 percent of calls must be placed in queue? What is the smallest number of patrol cars needed to assure that the average total response time is less than 10 minutes? What is the smallest number needed so that both of these conditions are met?

The second prescriptive capability will tell the user the "best" allocation of his existing resources among geographical commands and/or among different times of the day or week. PCAM permits the department to choose among several definitions of "best":

- The average percentage of calls that must be placed in queue is as small as possible, given existing resources,
- The average length of time calls of a given priority must wait in queue is as small as possible, or
- The average total response time is as small as possible.

The third prescriptive capability is a combination of the two already described. It finds an allocation of specified total resources that (a) meets the department's performance standards and (b) is the "best" allocation that can be achieved while meeting those standards.

The user can consider a single tour and specify the total number of patrol cars on duty in the entire city. PCAM will then prescribe how many of them should be assigned to each geographical command. Or, the user can consider a single geographical command and specify the total number of car-hours that can be fielded on one day, say Monday. PCAM will then prescribe how many cars should be on duty during each tour on Monday in such a way that the allocated car-hours add up to the specified total. The user can also consider a single command for an entire week or the entire city for a day or a week.

PCAM calculates performance measures such as queuing delays, travel times, and preventive patrol frequencies, using approximate mathematical equations that have been found to give reasonably accurate estimates. While the numbers shown in output from PCAM will not exactly match the performance levels of patrol cars in the field, what is important for allocation is how the performance measures *change* when the numbers of patrol cars change. PCAM estimates these changes with a degree of

accuracy that is sufficient for the intended applications of this model. Using a much more accurate and expensive model would often lead to the same conclusions as PCAM gives regarding the number of patrol cars to have on duty, and, even if the allocations are not the same, the differences would ordinarily be only one or two patrol cars in certain tours.

When operating the program in *interactive mode*, the user sits at a terminal and types a series of commands to the program. Some of the commands request PCAM to display certain information at the terminal, for example the performance measures for the current allocation. Others ask PCAM to prescribe allocations that meet objectives specified by the user when he types his command. He can then ask PCAM to display what the performance measures would be with the recommended allocation, and these will be printed out immediately at the terminal. The user compares the performance measures and decides whether he is satisfied with the recommended allocation or he wants to try something else. This process continues until a satisfactory allocation is achieved.

The user's judgment plays an important role in using the model, since it is impossible for one allocation to be better in all parts of the city at all times of day than another allocation that has the same total number of car-hours. Therefore, the user will have to inspect the performance measures carefully for each alternative and decide which one he prefers.

When operating the program in *batch mode*, the user enters commands just as if he were sitting at a terminal, but he has to prepare his entire sequence of commands before running the program. Batch operation is particularly convenient after the department has determined the objectives it wants its allocations to meet, and then the same sequence of commands is to be entered periodically (for example, every month) as the data are updated.

IV. WHAT DATA ARE NEEDED

GEOGRAPHICAL INFORMATION

PCAM imagines the city to be divided into geographical commands. However, a city with only one geographical command is permitted. The department chooses a word to be used in referring to these commands, e.g., precinct, district, division, or area. The chosen word is used when typing commands into the program, and it appears as a heading in tables of printout.

Each geographical command is also given a name, such as Midtown, North, or Fifth. The only geographical data needed to describe a command are its area (square miles) and number of street-miles to be patrolled. If the department is not interested in performance measures related to the amount of preventive patrol, it is not necessary to determine the number of street-miles to be patrolled.

TIME OF DAY INFORMATION

For purposes of collecting data for PCAM, time is divided into 24-hour days, and each day is divided into tours. As in the case of geographical commands, the department may choose a word to substitute for the word *tour*, e.g., shift, watch, or platoon. Tours may be any number of hours in length, and, as mentioned earlier, one tour in each day can be an overlay tour, if desired. The starting and ending hours of tours must be specified in the data base for PCAM, and they must be the same on every day in every geographical command.*

For each hour of each day in each geographical command, PCAM requires data telling the expected number of calls for service and the average length of time a patrol car will be unavailable once it has been dispatched to a call for service. PCAM does not assist the user in calculating these statistics from raw data such as dispatchers' cards, so they must be estimated by averaging past data or by writing a special

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*If tours start at different times in different commands, a separate data base can be prepared for each command, but then it is not possible to allocate patrol cars among commands in different data bases.

computer program for this purpose.* If desired, data relating to calls for service can be averaged by tour rather than by hour. However, PCAM's calculations will be more accurate if hourly data are provided. If calls are to be distinguished according to their priority, data must be provided for each tour in each day in each command specifying the fraction of calls expected to be in each priority level.

For purposes of relating the amount of preventive patrol to crime rates, PCAM permits the user to enter as data the number of "suppressible" crimes in each tour in each command. This category of crimes can be defined in whatever way the department wishes, and the data can be omitted entirely if the department is not interested in performance measures related to preventive patrol.

DATA CONCERNING THE OPERATIONS OF PATROL CARS

The user must determine the response speed and the patrol speed of patrol cars, which may vary among commands or by time of day. The response speed is used by PCAM to estimate average travel times. It may be determined by collecting data showing actual travel times in the field and then adjusting the response speed until PCAM's estimates conform to reality. The patrol speed is used to estimate how often a patrol car will pass by a randomly located point. A reasonable guess at the patrol speed (usually in the range from 7 to 15 mph) will ordinarily be satisfactory for most applications.

The user must also provide data to enable the program to estimate how often patrol cars will be busy for reasons other than a prior dispatch to a call for service. (Typical activities that make cars unavailable for dispatch are meals, self-initiated anticrime activities, maintenance or repair for the vehicle, special assignments by a superior officer, and authorized or unauthorized personal activities.) This information is particularly important because patrol cars are typically busy on such activities somewhere between 35 and 60 percent of their

*Several police departments have written such programs. Information regarding their availability can be obtained by request to the address listed in the Appendix.

working hours. However, obtaining accurate data concerning non-call-for-service unavailabilities may be the most difficult task for the PCAM user. The companion user's manual[10] gives detailed advice, and the program description[11] lists a separate computer program (not part of PCAM) that may assist some departments in calculating the input data required by PCAM.

V. WHAT RESOURCES ARE NEEDED

The PCAM program can be installed for batch operation on any computer system having a FORTRAN compiler and at least 160K bytes of core storage available to run the program. For such installations, it is not necessary for any of the agency's staff to understand the FORTRAN language. To reduce the core requirements, which may be possible depending on the number of geographical commands and days in the user's data base, it is necessary to modify the program.

To install the program for interactive operation, the user must have access to a computer system that supports interactive programs and must make four minor modifications that are clearly indicated in the program description.[11]

To access the program via the commercial time-sharing service, the user needs only a computer terminal that can be coupled to a telephone line.

The cost of running the program will vary from installation to installation, but a rough idea of the range of costs can be given based on our experience with two computer systems. Compiling the program costs about $10, and this is more expensive than most runs of the program after compilation. It is therefore desirable to save the object code from the compiled program.

Realistic sample sessions with the program have typically cost under $2 for computer time, and even fairly complex calculations cost less than $10. In general, PCAM is an inexpensive program to operate and compares favorably with any other program that could answer similar policy questions.

The amount of effort required to prepare a data base for PCAM depends primarily on the amount of information currently available to the department concerning calls for service and other unavailabilities of patrol cars. If available data are to be converted manually into a form suitable for input into PCAM, about one man-day's effort per command will be required. If a computer program is to be written to perform the conversion, this will require about three man-weeks' work initially, but then subsequent updating of the data base will be easy.

If the department has not previously collected information from dispatchers concerning the unavailabilities of patrol cars, several man-months should be allowed for preparing a data base for PCAM.

Persons with the skills to set up and run PCAM and analyze its output are likely to be found in most municipal governments. Little or no outside assistance should be required.

Police departments wishing to use PCAM can obtain all necessary materials as indicated in the Introduction. Questions should be directed to the address or telephone number listed in the Appendix, but neither The New York City-Rand Institute nor The Rand Corporation provides full consultation or user services in connection with the products of its research.

APPENDIX

Addresses for Further Information

1. For documentation of the Patrol Car Allocation Model, copies of the program on cards or tape, information about the time-sharing computer service, or answers to questions about the program:

   Jan Chaiken
   The Rand Corporation
   1700 Main Street
   Santa Monica, California 90406

   (213) 393-0411

2. For copies of the reports listed in the references:

   Publications Department
   The Rand Corporation
   1700 Main Street
   Santa Monica, California 90406

   (213) 393-0411

3. Research Sponsor:

   U.S. Department of Housing and Urban Development

   Alan Siegel, Director
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   Office of Policy Development and Research
   Community Development and Management
   Research Division
   451 Seventh Street, S.W.
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   (202) 755-6970

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