Patrol Car Allocation Model

Executive Summary

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Rand

The research described in this report was supported by the National Institute of Justice, U.S. Department of Justice under Grant No. 81-IJ-CX-0088.

Library of Congress Cataloging in Publication Data

Chaiken, Jan M.
Patrol car allocation model.

Vol. 3 written by Jan M. Chaiken, Warren E. Walker, and Peter Dormont.
"Prepared for the National Institute of Justice, U.S. Department of Justice."
"July 1985."
Includes bibliographies.
"R-3087/1-NIJ - R-3087/3-NIJ."
Contents: v. 1. Executive summary — v. 2. A user's manual — v. 3. Program description.
1. Patrol Car Allocation Model (Computer program) 2. Police patrol—Computer programs. I. Walker, Warren E. II. Dormont, Peter, 1946- . III. Rand Corporation. IV. National Institute of Justice (U.S.) V. Title.
HV8080.P2C45 1985 363.2'32'0724 85-16779
ISBN 0-8330-0664-9 (v. 1)
ISBN 0-8330-0665-7 (v. 2)
ISBN 0-8330-0666-5 (v. 3)

Published by The Rand Corporation

R-3087/1-NIJ

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PREFACE

This report describes in nontechnical terms a computer program called the Patrol Car Allocation Model (PCAM85). It was written to help police administrators and planning officers understand how the model can be used for policy analysis. The program is a modernized version of one written in 1975.

The development of the original version of PCAM was supported by the Office of Policy Development and Research of the United States Department of Housing and Urban Development (HUD) and by the National Institute of Law Enforcement and Criminal Justice. The modernization was funded under Grant 81-IJ-CX-0088 from the National Institute of Justice.

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 its appendixes present details of the model's calculations:

- Jan M. Chaiken, Peter Dormont, and Warren E. Walker, *Patrol Car Allocation Model: User's Manual*, R-3087/2, July 1985.

The Program Description is primarily for data-processing personnel and provides file specifications, installation instructions, and a listing of the program:

- Jan M. Chaiken, Peter Dormont, and Warren E. Walker, *Patrol Car Allocation Model: Program Description*, R-3087/3, July 1985.

This report and its two companions update reports of identical titles numbered R-1786/1-HUD/DOJ, R-1786/2-HUD/DOJ, and R-1786/3-HUD/DOJ, September 1975.

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I. INTRODUCTION

The Patrol Car Allocation Model (PCAM85) is a computer program designed to help police departments determine the number of patrol cars[1] to have on duty in each of their geographical commands. Typically, the number 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 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. PCAM85 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 the 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. [1,4,10,11,16]

The original version of PCAM was developed at The New York City-Rand Institute in 1975 after a careful review of various previously used patrol car allocation programs. [1,10,15,21,22] Between 1975 and 1984, PCAM was used by over 40 police departments [7,23] and was incorporated in The National Institute of Justice program called Managing Patrol Operations. [2] The latest version, PCAM85, incorporates many improvements recommended by users or developed in recent research. [12,13,14] The three major types of changes are (1) explicit modeling of multiple-car dispatches, (2) smoother performance measures over time, and (3) improved output reports.

The PCAM85 program is written in the FORTRAN language and is designed to run in either batch mode (where user input is on cards or a file prepared in advance) or in interactive mode (where the user types commands on a 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.[2] As the program is distributed, it requires 240K bytes of storage when compiled on an IBM 3032. Users in departments having more than eight geographical commands will want to modify the program and increase the memory requirements slightly. The program will operate on mainframe or desktop computers having adequate memory, a compiler compatible with the FORTRAN 77 standard, and a library of commonly used FORTRAN functions (such as square root).

The program is provided on punched cards at a cost of $35, on magnetic tape at a cost of $25 (plus $15 if we supply the tape), or on diskettes formatted for DOS 2.0 at a cost of $40.[3] There is an added charge of $50 for all copies mailed outside the United States. To install and operate the program on a department's computer system, it is necessary to obtain copies of the PCAM85 User's Manual [8] and the PCAM85 Program Description. [9] The User's Manual describes typical applications, provides complete instructions for collecting data and operating

[1]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.

[2]To obtain a copy of the program, write to the address given in the appendix.

[3]A postage charge is added on all orders.

the program, and explains the mathematical equations in the program. 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.

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 the decision whether to reallocate officers among functions (e.g., from patrol to investigation or vice versa). By establishing the lowest acceptable performance levels for patrol car operations, a department can use PCAM to determine the smallest number of patrol officers needed to meet these standards. For example, the department could specify a performance level such as keeping response time under four minutes in every precinct. This information can be particularly useful when public demands for responses by patrol cars have increased, and the department wants to maintain previously acceptable performance levels. The output from PCAM specifies how many additional officers are needed for this purpose.
2. *Allocating a fixed total number of patrol officers among geographical commands.*[1] 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.
3. *Assigning patrol cars to geographical commands at the start of each tour.*[2] 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 from day to day. 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 officer-hours allocated to the various tours adds up to the total officer-hours available in each command.

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[1] 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.)

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

Departments that have fixed staffing around the clock may also want to use PCAM to see the extent to which performance measures could be improved by establishing variable staffing 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.[3]

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. *Managing demand.* 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.

   By omitting certain types of calls for service from the PCAM database, the department can analyze the effects on patrol performance of screening out (not responding to) those types of calls. The screened out calls can be handled by various other means, such as taking reports over the telephone, asking the caller to file a report at the police station, or dispatching civilian service aides.

8. *Analyzing the number of cars dispatched to each call.* Some types of calls may receive two or three patrol cars. This practice is particularly common in departments that have one-officer patrol units. PCAM will determine how performance measures change when changes are made in the number of cars dispatched to calls. This capability helps evaluate the possibility of introducing one-officer patrol cars or changing the mix of one-officer and two-officer patrol cars.

The PCAM program cannot be used to analyze possible changes in dispatching practices or the locations of patrol cars within commands. In particular, PCAM is not suitable for designing patrol beats. For this purpose we recommend use of the Hypercube Queuing Model. [15,19,20] 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.

[3]Although many departments have more complicated arrangements of overlapping tours, they cannot be included exactly in a model with the simplicity of the PCAM program. The User's Manual explains how to handle complicated overlap arrangements approximately with PCAM.

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. [1,17] Although such models are more accurate than PCAM and can be used for allocating patrol cars, they are substantially more expensive to operate on a computer, they require much more detailed input data, and most police departments would require outside assistance to use a simulation model. For discussions of how to choose an appropriate computer model for a particular patrol allocation question, see Refs. 10 and 20.

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 allocations that are suggested by PCAM when operated in prescriptive mode. This information permits users to compare allocations and determine which ones they believe are best. The *prescriptive* capabilities of PCAM specify 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 includes the following:

- The number of patrol cars assigned to each geographical command at each time of day
- The workloads of the patrol cars
- The amount of uncommitted time available to the patrol cars (which can be used for directed patrol or preventive patrol)
- 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 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 meets the department's performance standards and is the "best" allocation that can be achieved while doing so.

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 intervals using approximate mathematical equations that have been found to give reasonably accurate estimates. Although 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. Users can then ask PCAM to display what the performance measures would be with the recommended allocation, and these will be displayed or printed out immediately at the terminal. The users compare the performance measures and decide whether they are satisfied with the recommended allocation or want 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, because it is impossible for one allocation to be better in all parts of the city at all times of day than another allocation having 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.

While operating the program in *batch mode*, users enter commands just as if they were sitting at a terminal, but they have to prepare the 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 the tables of printout.

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 one tour in each day may be an overlay tour. 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.[1]

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 records from a computer-aided dispatch (CAD) system, so they must be estimated by averaging past data or by writing a special 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.

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 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 anti-crime 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

[1]If tours start at different times in different commands, a separate database may be prepared for each command, but then it is not possible to allocate patrol cars among commands in different databases.

cars are typically busy on such activities somewhere between 35 and 60 percent of their 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 [8] gives detailed advice, and the Program Description [9] lists a separate computer program (not part of PCAM) that may assist some departments in calculating the input data required by PCAM.

In addition, if different numbers of patrol cars are to be dispatched to different types of calls for service, this information must be provided in the database.

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 240K 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 database, or to increase the core requirements, 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. [9]

The cost of running the program on a mainframe computer will vary from installation to installation, but a rough idea of the range of costs can be given based on our experience. On the Rand Computation Center IBM 3032, compiling the program costs about $14, 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 on Rand's computer have typically cost under $12 for computer time, and even fairly complex calculations cost less than $20. In general, PCAM is an inexpensive program to operate and compares favorably with any other program that could answer similar policy questions.[1]

The amount of effort required to prepare a database 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 summarized data are to be converted manually into a form suitable for input into PCAM, about one man-day's effort will be required per geographical command. A computer program to perform the conversion will require about three man-week's work initially, but then subsequent updating of the database 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 database for PCAM.

Persons with the skills to set up and run PCAM and analyze its output are likely to be found in most municipal, county, or state governments. The 1975 version of the program was operated by over 40 law enforcement agencies with little or no outside assistance. For agencies that have already used PCAM75, the new version is upward-compatible: Their existing PCAM database can be read into the new program without change, and they will receive output in the new formats. However, to take advantage of additional features in PCAM85, they will want to modify the database. These features include the capability to model dispatch of more than one car to incidents and the ability to request calculation of output statistics under conditions of high workload.

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[1]The 1975 version of PCAM, which is still available from Rand, is even less expensive to run. If the following two situations, which are modeled by PCAM85, are not relevant to your department, you should consider using the 1975 version:

- more than one patrol car dispatched to a large proportion of calls for service
- periods of some days when all the cars in one geographical command are busy.

Police agencies 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 The Rand Corporation does not provide 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, or answers to questions about the program:

   Warren Walker
   The Rand Corporation
   1700 Main Street
   Santa Monica, California 90406
   (213) 393–0411

   Jan Chaiken
   55 Wheeler Street
   Cambridge, Massachusetts 02138
   (617) 492–7100

2. For copies of the Rand Reports listed in the references:

   Publications Department
   The Rand Corporation
   1700 Main Street
   Santa Monica, California 90406
   (213) 393–0411

REFERENCES

1. *An Analysis of the Patrol Car Deployment Methods of the Los Angeles Police Department*, Engineering School report by Public Systems Analysis class, University of California at Los Angeles, 1975.
2. Donald F. Cawley, and H. Jerome Miron, *Managing Patrol Operations*, National Institute of Justice, Washington, D.C., 1977.
3. J. Chaiken, T. Crabill, L. Holliday, D. Jaquette, M. Lawless, and E. Quade, *Criminal Justice Models: An Overview*, 1976.
4. Jan M. Chaiken, *Patrol Allocation Methodology for Police Departments*, The Rand Corporation, R-1852-HUD, 1975.
5. Jan M. Chaiken, *Hypercube Queuing Model: Executive Summary*, The Rand Corporation, R-1688/1-HUD, 1975.
6. Jan M. Chaiken, "Transfer of Emergency Service Deployment Models to Operating Agencies," *Management Science*, Vol. 24, 1978, pp. 719–731.
7. Jan M. Chaiken, *Two Patrol Car Deployment Models: History of Use, 1975-1979*, The Rand Corporation, P-6458, March 1980.
8. Jan M. Chaiken, and Warren E. Walker, *Patrol Car Allocation Model: User's Manual*, The Rand Corporation, R-3087/2-NIJ, 1985.
9. Jan M. Chaiken, Peter Dormont, and Warren E. Walker, *Patrol Car Allocation Model: Program Description*, The Rand Corporation, R-3087/3-NIJ, 1985.
10. Jan M. Chaiken, and Richard Larson, "Methods for Allocating Urban Emergency Units: A Survey," *Management Science*, Vol. 19, 1972, pp. P110–P130.
11. Joseph Ferreira Jr., "Comparing Patrol Unit Allocation Methods," Chapter 10 in Richard C. Larson (ed.), *Police Deployment: New Tools for Planners*, Lexington Books, Lexington, Mass., 1978.
12. Linda Green, "A Queueing Model of Police Patrol Operations," *Management Science*, Vol. 30, 1984, pp. 653–664.
13. Linda Green, and Peter Kolesar, "Testing the Validity of a Queueing Model of Police Patrol," Research Working Paper No. 521A, Graduate School of Business, Columbia University, New York, June 1983.
14. Linda Green, and Peter Kolesar, "A Comparison of Multiple Dispatch and M/M/c Models of Police Patrol," *Management Science*, Vol. 30, 1984, pp. 665–670.
15. IBM Corporation, "LEMRAS Applications Description Manual," Document H20-0629; "Law Enforcement Manpower Resource Allocation System (LEMRAS) Program Description Manual," Program 5736-G21, Document SH20-0695-0.
16. James S. Kakalik, and Sorrel Wildhorn, *Aids to Decisionmaking in Police Patrol*, The Rand Corporation, R-593-HUD/RC, 1971.
17. Peter Kolesar, and Warren E. Walker, *A Simulation Model of Police Patrol Operations*, The Rand Corporation, R-1625/1-HUD *(Executive Summary)*, R-1625/2-HUD/NYC *(Program Description)*, 1975.
18. Richard C. Larson, *Urban Police Patrol Analysis*, MIT Press, Cambridge, Mass., 1972.
19. Richard C. Larson, *Hypercube Queuing Model: User's Manual*, The Rand Corporation, R-1688/2-HUD, 1975.

20. Richard C. Larson (ed.), *Police Deployment: New Tools For Planners*, Lexington Books, Lexington, Mass., 1978.
21. J. Thomas McEwen, Project Director, *Allocation of Patrol Manpower Resources in the Saint Louis Police Department*, Vols. I and II, report of the St. Louis Police Department, 1968.
22. J. Thomas McEwen, and R. C. Larson, "Patrol Planning in the Rotterdam Police Department," *Journal of Criminal Justice*, Vol. 2, 1974, pp. 235–238.
23. Richard Mudge, and Peter Dormont, *A Description of the New York Police Department RMP Allocation Model*, The New York City-Rand Institute, unpublished, December 1974.

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