FIELD EVALUATION OF THE HYPERCUBE SYSTEM FOR THE ANALYSIS OF POLICE PATROL OPERATIONS: EXECUTIVE SUMMARY

THE INSTITUTE FOR PUBLIC PROGRAM ANALYSIS

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OF THE
HYPERCUBE SYSTEM
FOR THE ANALYSIS OF POLICE PATROL OPERATIONS:
EXECUTIVE SUMMARY

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ABSTRACT

This report is one product of the project "Field Evaluation of the NSF-MIT Hypercube Patrol Sector Design Methods," funded by the National Science Foundation, Grant Number APR75-17472. The hypercube system is a computerized planning tool used to evaluate alternative police beat structures and patrol deployment policies. The study was conducted by The Institute for Public Program Analysis in cooperation with the California Innovation Group (an NSF-funded consortium of cities active in technology transfer) and police departments in St. Louis County, Missouri, and the California cities of Burbank, Fresno, Garden Grove, Huntington Beach, Pasadena, San Diego, San Jose, Santa Ana, and Santa Clara.

The information contained in the report is based upon the latest hypercube documentation and the experiences of the 10 police departments which participated in the field evaluation project. The report highlights, in nontechnical fashion, the major findings and considerations derived from the study. Contents of the report include: what hypercube does and does not do; how hypercube is used as a beat design and patrol policy planning tool; costs involved in using the system; assessing the feasibility of using the hypercube system; and a brief case study of hypercube use.

PREFACE

This report is one product of the project "Field Evaluation of the NSF-MIT Hypercube Patrol Sector Design Methods." This project was funded by the National Science Foundation (Grant Number APR75-17472) through its program of Research Applied to National Needs (RANN), Division of Advanced Productivity Research and Technology. The study was conducted by The Institute for Public Program Analysis, a non-profit research firm located in St. Louis, Missouri, in cooperation with the California Innovation Group (an NSF-funded consortium of cities active in technology transfer) and police departments in St. Louis County, Missouri, and the California cities of Burbank, Fresno, Garden Grove, Huntington Beach, Pasadena, San Diego, San Jose, Santa Ana, and Santa Clara.

Other products of the study include the following reports:

- How to Set Up Shop for Use of the Hypercube System - a report designed to help police planners and other potential users assess the benefits, costs, and procedures involved in using the hypercube system;

- Instructional Materials for Learning to Use the Hypercube Programs for Analysis of Police Patrol Operations - a handbook describing the use of hypercube computer programs for the design and analysis of police patrol operations; and

- Field Evaluation of the Hypercube System for the Analysis of Police Patrol Operations: Final Report - a description of the objectives, methods, and findings of the field test project, including brief case studies of the experiences of participating police departments, a preliminary assessment of the accuracy of hypercube field performance estimates, costs of using the hypercube system, technical assistance required for hypercube users, and dissemination and utilization of the hypercube system.

These documents are available from The Institute for Public Program Analysis and from the National Technical Information Service (NTIS), Springfield, Virginia.

In addition to the staffs of the California Innovation Group and the participating police departments citied above, the authors gratefully acknowledge the cooperation, assistance, and support of Ms. Lynn Preston, Dr. David Seidman, and Dr. Neil Dumas, who served as NSF's program managers at various times during the project. The authors also gratefully acknowledge the assistance of the members of the project's advisory board:

- Mr. Norman Darwick, Director, Police Management

and Operations Division, International Association of Chiefs of Police;

- Mr. Del DelaBarre, Executive Director, California Innovation Group;
- Dr. George Kelling, Police Foundation;
- Col. Gilbert Kleinknecht, Superintendent, St. Louis County Police Department;
- Mr. Robert Kleismet, Vice President, International Conference of Police Associations;
- Dr. Michael Maltz, Department of Criminal Justice, University of Illinois at Chicago Circle; and
- Mr. Richard Valdez, Bureau of Planning and Research, St. Louis County Police Department.

The authors have corresponded with many other persons and organizations. They have assisted the project in a variety of ways, and their contributions are also greatly appreciated.

A special note of thanks is also extended to Mr. Grant Buby, who assisted in the preparation of this report, and to Mrs. Vicki O'Dell, who typed most of the material appearing in the project's reports and supervised the typing of the remainder.

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INTRODUCTION

Since their development at the Massachusetts Institute of Technology (M.I.T.), the hypercube programs have attracted considerable attention among law enforcement agencies. Briefly stated, the hypercube system is a computerized planning tool which can be used to evaluate alternative beat structures and patrol deployment policies. The system is based upon the hypercube queuing model developed at M.I.T. by Dr. Richard Larson and others. Prior to the hypercube field test project, the system had been utilized by police departments in New Haven, Connecticut; New York City; and Boston, Quincy, and Arlington, Massachusetts. The hypercube system also has been the subject of training workshops for police planners at M.I.T., the Northwestern University Traffic Institute, and The Institute for Public Program Analysis.

The Hypercube Field Test Project

This report summarizes the findings of an extensive field test of the hypercube system. The project, entitled "Field Evaluation of the NSF-MIT Hypercube Patrol Sector Design Methods" was funded by the National Science Foundation through Grant Number APR75-17472 and was conducted by The Institute for Public Program Analysis (TIPPA) of St. Louis, Missouri, in cooperation with the California Innovation Group (a consortium of cities active in technology transfer), and 10 police departments.

The prime objective of the project was to assess the usability of the hypercube system. Specifically, the project sought answers to basic questions often raised by potential users of the hypercube system:

- What benefits can my police department derive from using hypercube?
- What computer hardware is needed, and what software (computer program) options are available?
- What costs are involved in using hypercube?
- What kinds of data will be needed?
- What are the sources for additional hypercube materials, training, and technical assistance?

Answers to each of these questions are presented in this summary.

Table S-1 lists the 10 police departments which participated in the field test project. Police planners in these departments were trained in the use of the hypercube system and were given technical assistance in collecting the necessary input data and operating the system. The planners used portable data terminals provided at project expense to access the hypercube programs

Table S-1

BASIC INFORMATION ON FIELD TEST POLICE AGENCIES

Police Department	Population of Jurisdiction[a]	Size of Jurisdiction (Square Miles)[a]	Number of Beats[b]	Number of Statistical Reporting Areas[b,c]
Burbank	85,000	17.1	14	-
Fresno	175,900	51.0	16	367
Garden Grove	119,600	17.5	6-8	110
Huntington Beach	146,400	25.8	12	127
Pasadena	112,000	22.7	7	150
St. Louis County (Mo.)	350,000	360.0	41-73	476
San Diego	766,100	310.1	96	200
San Jose	547,500	147.4	40	-
Santa Ana	174,800	27.6	8	127
Santa Clara	90,200	18.5	7	50

[a]Based on 1975 estimates supplied by the California Innovation Group and the St. Louis County Police Department.

[b]As of 1975, prior to commencement of field test program.

[c]The cities of Burbank and San Jose did not use statistical reporting areas prior to the field test program. San Jose, however, did devise a system of 280 "Beat Building Blocks" (BBBs) specifically for use during the last beat redesign in 1973.

implemented on the National CSS (NCSS)* time-sharing system.

Three departments completed patrol deployment analyses and implemented new beat plans designed with hypercube assistance. The remaining departments experienced varying degrees of progress in their hypercube analyses. Summaries of the experiences of all 10 participating departments are contained in the report, Field Evaluation of the Hypercube System for the Analysis of Police Patrol Operations: Final Report. An excerpt of one summary is included at the end of this report.

In another phase of the project, the hypercube software was evaluated in terms of both its usability by police department personnel without prior experience in using computers, and the accuracy of the hypercube performance estimates. Based on suggestions by department representatives, a number of changes were incorporated into the system to improve its usability.

Project Findings

In general terms, the results of the field test project verified that under proper conditions the hypercube system is an excellent planning tool for assessing the relative merits of alternative beat configurations. No other computerized planning tool available today permits police planners to systematically examine the complex interactions between workload, interbeat dispatching, and travel times. The interactive version of the system is an excellent aid for introducing planners and other police personnel to the intricacies and trade-offs of the beat design process.

The field test project revealed, however, that the accuracy of hypercube results is often limited by the basic assumptions of the hypercube model itself, and the reliability of input data collected from police records. In addition, the project also demonstrated that a beat design exercise based on the hypercube system may require considerable cost and effort for staff training, data collection, and data processing. In view of these costs, use of the hypercube system may be difficult to justify in many departments.

Project Publications

As an Executive Summary of the field test project, this report highlights, in nontechnical fashion, the major findings and considerations derived from the study. Specific contents of the summary include:

- what hypercube does and does not do - the kind of field performance characteristics that can be estimated for user-specified beat plans and patrol policies;

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*"CSS," always abbreviated in the corporate title, stands for "Conversational Software System."

- how hypercube is used - as a planning tool in assessing and reviewing alternative patrol policies or beat configurations, differences between available versions of hypercube software, and implementation alternatives;

- costs involved in using hypercube - personnel, data processing, and technical assistance costs in terms of their ranges among participating cities;

- assessing the feasibility of using hypercube - the circumstances which indicate when use of the hypercube system may be beneficial;

- assessing the availability and feasibility of competing models; and

- a brief case study of hypercube use.

Additional information on the methods and findings of the field test project can be found in the other products of this study. These products include:

- Field Evaluation of the Hypercube System for the Analysis of Police Patrol Operations: Final Report - a description of the objectives, methods, and findings of the field test project; included are brief case studies of the experiences of participating police departments, a preliminary assessment of the accuracy of hypercube field performance estimates, costs of using the hypercube system, technical assistance required for hypercube users, and dissemination and utilization of the hypercube system.

- Instructional Materials for Learning to Use the Hypercube System for Analysis of Police Patrol Operations - a handbook describing the use of the hypercube computer programs for the design and analysis of police patrol operations.

- How to Set Up Shop for Use of the Hypercube System - a report designed to help police planners and other potential users assess the benefits, costs, and procedures involved in using the hypercube system.

WHAT DOES HYPERCUBE DO?

The hypercube system is a computerized planning tool which can be used to evaluate alternative beat structures and patrol deployment policies. The hypercube computer programs employ information about both the geographic distribution of police called-for-service incidents and field operations policies to evaluate patrol beat plans by estimating performance characteristics such as car and beat workloads, the amount of interbeat dispatching, and travel time by car and beat.

Information Provided by the Hypercube Model

Based on a user-specified beat configuration or patrol policy, the hypercube model estimates the following field performance statistics:

- average workload throughout the region being analyzed, as well as the workloads associated with each unit, beat, and reporting area in the region;*
- average travel times to calls for service throughout the region, in each beat and reporting area, and to calls handled by each unit;
- average fraction of dispatches that are interbeat (i.e., dispatches that require the assigned unit to travel to an incident not located within that unit's beat) for each unit and beat, and for the entire region;
- fraction of calls throughout the region and in each reporting area to which a unit other than the closest available unit is dispatched; and
- fraction of calls for service that occur when no unit is available.

Value of Hypercube Performance Estimates

Performance estimates from the hypercube model can be used to obtain tentative answers to many questions of interest to department planners and field commanders. For example:

- Is one set of beat boundaries "better" than another in terms of established department objectives?
- How will field performance be affected by anticipated increases in the numbers of calls for service, or by a decreased call-for-service rate resulting from the screening of low-priority calls?
- Will significant improvements in field performance result if automatic vehicle location equipment is installed?
- What effect will a change in the distribution of

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*Associated with each patrol unit is an area usually termed a beat or district in which that unit has preventive patrol responsibility. A reporting area is a sub-area within a beat and is used as the smallest geographical unit for aggregating statistics on calls for service and preventive patrol coverage. A region is a group of beats administered as an autonomous field operations territory.

preventive patrol coverage have on the various field performance measures?

- How will field performance be affected by alternative dispatching policies, such as dispatching the "closest" available unit rather than an available beat unit, or by the use of special units to handle calls arriving when no beat units are available, rather than holding the calls until a beat unit becomes available?

The findings of the field test project suggest that performance estimates obtained from the hypercube model are most useful when used to compare two or more alternative patrol policies or beat configurations to determine which alternative best satisfies department objectives. Absolute agreement between hypercube performance estimates and observed field performance, however, should not be expected for two reasons. First, the model uses a number of simplifying assumptions about the nature of patrol operations and demands for service, and in most departments, some of these assumptions may not be completely valid.* Second, the model requires considerable input data, some of which may be unavailable in some departments and will need to be estimated.

What the Hypercube Programs Do Not Do

Police planners should bear in mind that the hypercube programs are not:

- a prescriptive system that will design a "best" beat plan for the user;
- a management information system;
- a "real time" (immediate) inquiry system, such as that of the National Crime Information Center operated by the FBI;
- a computer-assisted dispatch system, operating out of a sophisticated "command post;"
- an automatic vehicle location system, which shows the approximate location of on-street police units; or
- a day-to-day planning or evaluation tool.

HOW IS HYPERCUBE USED?

Hypercube as a Planning Tool

The results of the field test project suggest that the hypercube system is best used as an iterative planning tool to aid

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*For a list of assumptions made by the model, see How to Set Up Shop for Use of the Hypercube System, p. 14.

police department planners in assessing beat design and patrol policy changes. This iterative process is schematically depicted in Figure S-1. The figure illustrates how the hypercube system can be used to analyze alternative beat designs or policy changes proposed by the user. The iterative process consists of three general operations:

- analysis of the existing beat plan;
- redesign of patrol beats; and
- analysis of changes in patrol operations policies.

Each operation is described below.

Analysis of existing beat plan. In this step the need for beat redesign is determined and problem areas within the present plan are identified from statistics generated by the hypercube model. Typical problem areas may include the following:

- Workload imbalances among response units - Units significantly over- or under-utilized can be identified by examining unit workloads.
- Lengthy response to calls for service - Neighborhoods not receiving rapid response to calls for service can be identified by examining average travel times.
- Lack of beat identity - Desirable officer familiarity with an area, its people, and special conditions, can be achieved only when a patrol unit spends adequate time in its own area; the amount of time each unit spends outside its assigned beat can be identified by examining its interbeat dispatching fraction.

Redesign of beats. With problem areas in the present beat plan identified, the hypercube programs can be used to evaluate and compare proposed alternative configurations in terms of workloads, travel times, and interbeat dispatches for units and beats. By running the hypercube programs several times to compute performance statistics while changing only the beat configuration or dispatching preferences (the iterative process noted above), a plan most nearly satisfying department objectives can be identified.

An attractive feature of this design process is that alternative configurations can be identified by field commanders who are most familiar with patrol problems. By using the program once for each alternative, the results can be used to select the most acceptable plan.

Analysis of policy changes. Patrol policy changes can be analyzed by modifying input data to the hypercube programs. These changes may include:

- alternative preventive patrol strategies,

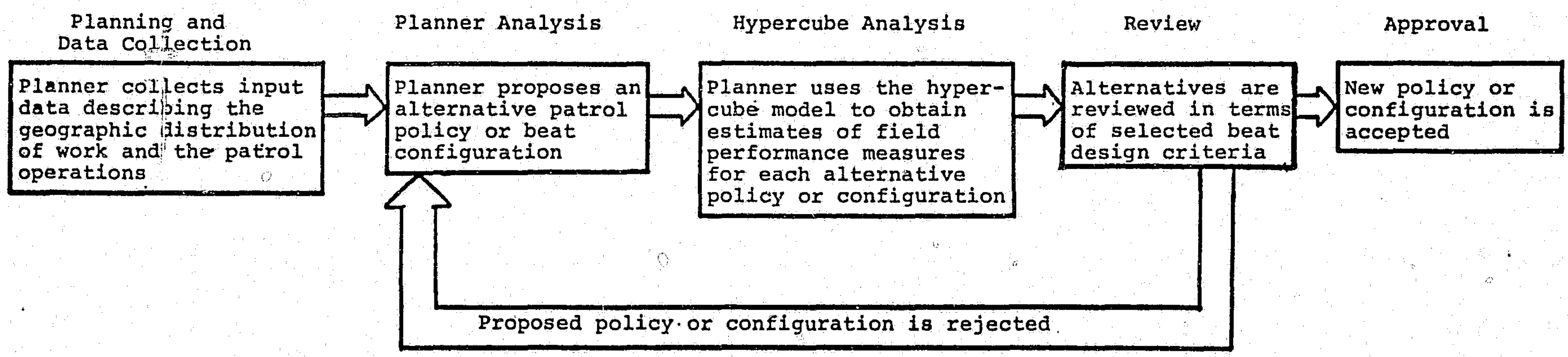

Figure S-1

ITERATIVE DESIGN PROCESS USING THE HYPERCUBE SYSTEM

- team policing,
- vehicle location systems,
- one-man versus two-man patrol cars, and
- alternative dispatching policies.

Input Data Required

The hypercube computer programs require information about the geography and workload distribution of a region, deployment practices for the patrol force, rules used by dispatchers in assigning patrol units to calls for service, and the average service time and travel speed of patrol units. Each type of input data is discussed briefly in the following paragraphs.

Geographic data. For each reporting area in the region being examined, the hypercube programs require a unique numeric label, the x,y coordinates of the geographic center, and the area in square miles.

Workload data. Two workload data items are needed: the relative workload for each reporting area, usually based on the number of called-for-service incidents for a specific period of time; and the total number of calls the patrol force must handle each hour in the entire region.

Deployment data. Data items needed include the number of patrol units, the reporting areas included in the beat patrolled by each unit, and the relative amount of time each patrol unit spends in each reporting area of its beat while on preventive patrol.

Dispatch policy data. The dispatching policy assumed by the hypercube model is determined by user-supplied answers to the following questions:

- Do dispatchers assign the closest available unit to calls for service or make assignments based upon fixed preference lists?
- If available, is the beat unit always dispatched to calls in its assigned beat?
- How accurately do dispatchers know the location of each call and each available unit?
- If all beat units are unavailable, are calls "stacked" or are they assigned to other backup units?

Operations data. The hypercube model requires data on the average amount of time required to complete calls for service and the average travel speed when responding to calls for service.

Versions of Software Available

Currently four versions of the hypercube software (programs) are available:

- M.I.T./Rand hypercube system - This is the original hypercube system developed through grants from the National Science Foundation and the U.S. Department of Housing and Urban Development; to date it is the most widely-distributed version.

- M.I.T. advanced hypercube system - This is an advanced version of the original M.I.T./Rand system which incorporates automatic vehicle location and expanded user control of the types of output produced.

- TIPPA advanced hypercube system - This is an adaptation of M.I.T.'s advanced system which evolved during TIPPA's field testing of the hypercube model. It contains several features lacking in the M.I.T. system, such as utilization of user-supplied terminology, and incorporates many improvements suggested by police planners during the field tests.

- Texas A&M police officer deployment system (PODS) - This system was developed through a grant from the Criminal Justice Division, Office of the Governor of Texas. A version of the hypercube model is included as one component of this system.

The major differences between these versions are summarized in Table S-2. Figure S-2 may be used as an aid in selecting the version that is most appropriate for a particular operational environment.

Data Processing Alternatives

In implementing the hypercube system, three major alternatives are available for obtaining data processing services:*

- In-house - Use of an in-house computer offers potentially low-cost data processing services and readily-available technical assistance in software (program) implementation. Major drawbacks include: department data processing equipment probably will not support the interactive version, and the computer's data storage capacity may limit the scope of the analysis.

- Commercial - Several commercial time-share systems are suitable for implementing both the interactive and non-interactive versions of the hypercube software written in

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*For details on how to obtain data processing services, refer to How to Set Up Shop for Use of the Hypercube System, pp. 47-51.

Table S-2

CHARACTERISTICS OF CURRENTLY AVAILABLE VERSIONS OF THE HYPERCUBE SOFTWARE

	Software Version			
	M.I.T./Rand	M.I.T.	TIPPA	Texas A&M
Interactive or Non-Interactive	Non-Interactive	Non-Interactive	Interactive	Non-Interactive
Programming Language	PL/I	PL/I	PL/I	COBOL
Approximate or Exact Model[a]	Both	Both	Both	Approximate Only
Limitations on Problem Size[b]	200 reporting areas and 15 beats	200 reporting areas and 15 beats	Unlimited number of reporting areas and 34 beats	125 reporting areas and 25 beats

[a]Certain calculations performed by the hypercube programs can be made "exactly" or they can be made using mathematical approximations which reduce data processing costs and produce results which are almost always within five percent of those produced by the exact model. However, some advanced features of the hypercube programs cannot be used with the approximate model.

[b]Size limitations apply only to the approximate hypercube model. All versions of the exact hypercube model limit the number of beats to 15. In most cases, the limits specified can be relaxed through internal programming changes.

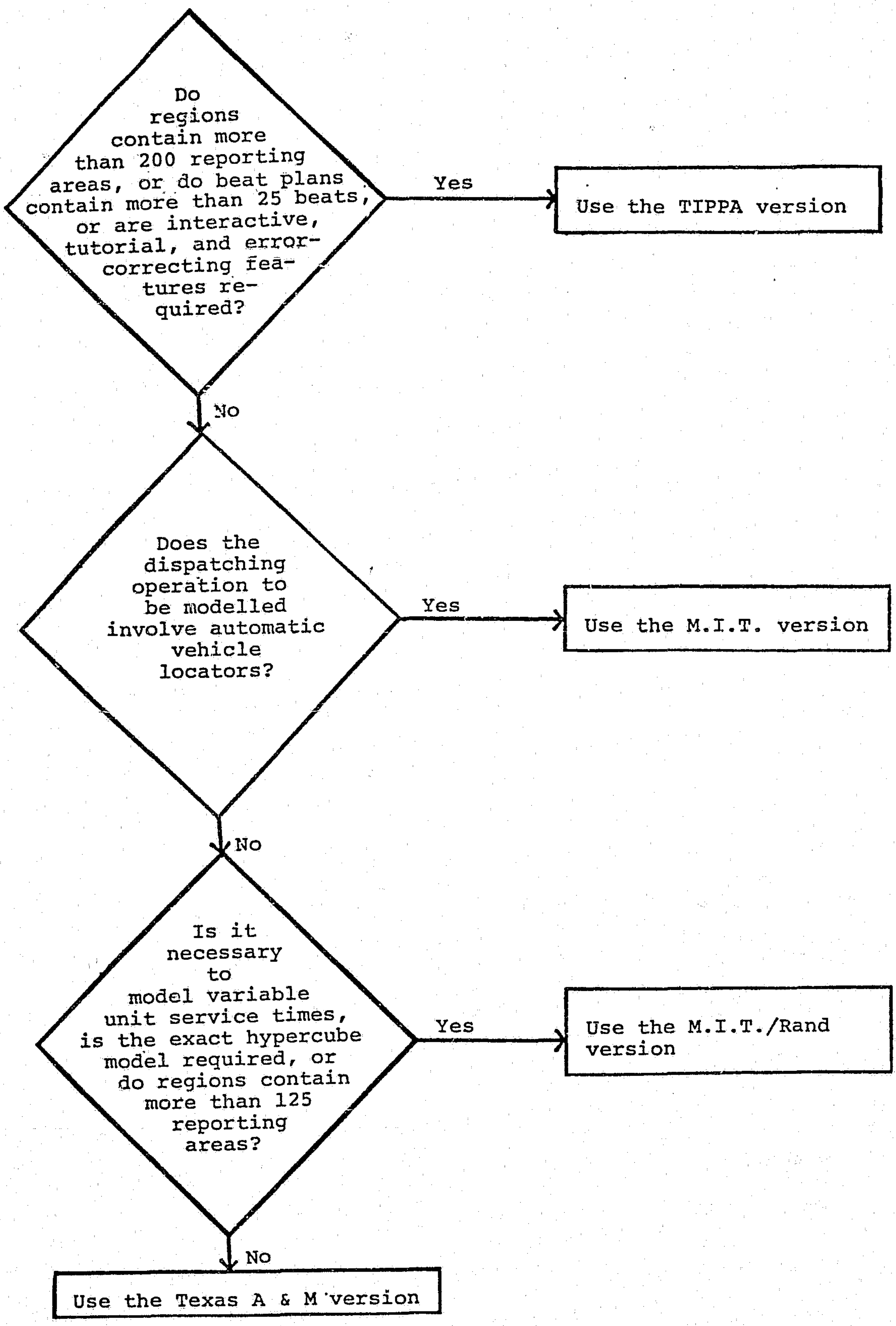

Figure S-2

SELECTING AMONG AVAILABLE VERSIONS OF THE HYPERCUBE SOFTWARE

PL/I; most can support the non-interactive COBOL version. These time-share systems give convenient access to data processing services via data terminals and standard telephone networks. However, this alternative is relatively expensive because of the high cost of the services, on-line storage (instant retrievability) of programs and data, and possibly substantial communications costs.

- University-based - Many university computer centers can support non-interactive versions of the hypercube system, and some can support interactive versions in a time-sharing environment; however, data storage capacity may be less than available on commercial systems. The amount of data processing services and technical assistance available to non-university-affiliated organizations may also be limited. Even though universities do not provide toll-free access to their services, their data-processing charges are usually much less than those of commercial vendors.

COSTS INVOLVED IN USING HYPERCUBE

The costs of using the hypercube system fall into three major categories: personnel, data processing, and technical assistance. Personnel costs include manpower costs associated with planning, training, data collection, data analysis, and beat plan implementation. Data processing costs include setting up, maintaining, accessing and using a data processing facility for training and data collection; and setting up, maintaining, and using the hypercube system for beat analyses. Technical assistance costs include the cost of training materials and the cost of consulting services for project planning, training, data collection, use of the hypercube programs, and interpretation of hypercube results.

Personnel Costs

Most departments will require up to six months to design and implement a beat plan using the hypercube system. During this period, one or more persons will be needed to plan project activities, learn how to use the hypercube system, monitor data collection efforts, perform hypercube analyses, coordinate in-house review and approval of new plans, and initiate appropriate implementation procedures.

The actual time required to design and implement a new beat plan depends on department personnel's familiarity and experience with computerized design models, the accessibility of data processing services, and the amount of cooperation among personnel responsible for design, approval, and implementation of the new beat plans.

Based upon the results of the field test project, it is estimated that from 8 to 28 weeks are required to complete the major tasks involved in a beat design project (see Table S-3). The lower estimate assumes that at least one person works full-time on the project, and that the department has trained personnel, data suitable for use as hypercube input, and readily-accessible data processing services.

The higher time estimate assumes that a department is using hypercube for the first time and that the project coordinator devotes only part time to the project, both of which contribute to delays in completing major project tasks.

Data Collection Costs

In most departments planning to use the hypercube system, some special data collection activities will be required to obtain input data not available in existing department records. These data collection efforts should be carefully planned and supervised. Data planning activities should include the following:*

- Review of hypercube input data items by key project personnel - Personnel responsible for data collection activities should have a thorough understanding of each data item used in the hypercube programs, the units in which it is measured, and the required accuracy of each.

- Determination of the number of beat plans to be designed - Input data collected for each beat plan should be based only on the region and time periods for which each plan will be used.

- Survey of department records - An accurate appraisal of specific input data items not readily available in department records, and realistic estimates of the collection effort required to obtain them, may influence a department's decision as to whether it can profitably use the hypercube system.

- Planning data collection activities - Careful design and coordination are important to the collection of accurate input data with minimum effort and the least disruption of other department activities.

The ability to obtain accurate estimates of the time required for data collection depends largely on the quality of the assessment made during the data planning task. This assessment should determine which source documents contain the data items, their accessibility, and the procedures that will be needed to obtain

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*For a more detailed discussion of planning and implementing data collection activities, see How to Set Up Shop for Use of the Hypercube System, pp. 51-60.

Table S-3

ESTIMATED NUMBER OF WEEKS
REQUIRED TO COMPLETE THE MAJOR TASKS
OF A HYPERCUBE BEAT DESIGN PROJECT[a]

Task	Activities	Number of Weeks[b]
1. Training	Study hypercube documentation; learn the assumptions of the model, the data required, and how to use the computer programs.	2 - 4
2. Planning	Assess department operations, data sources, and data processing capabilities; organize project task force.	2 - 4
3. Data Collection	Plan and coordinate the collection of data required by the hypercube programs.	1 - 8
4. Data Analysis	Prepare the input data, run the hypercube programs, and analyze the output.	1 - 8
5. Beat Plan Implementation	Coordinate in-house review of proposed plans, and all documentation, operations, and policy changes required to accommodate the approved plan.	2 - 4
Total Beat Design Effort		8 - 28

[a]The elapsed time estimates are based on the experience of eight police departments which participated in the field test project.

[b]The lower estimate for each task assumes that at least one person works full-time on the project. The higher estimate for each task assumes that the project coordinator devotes only one-third or one-half time to the project.

and translate each data item into hypercube-usable form.

Data Processing Costs

Costs associated with data collection. The hypercube field test project provided limited information about data processing costs associated with data collection efforts, since TIPPA staff provided considerable data processing support to several participating departments. The field test results clearly indicate, however, that to minimize data processing costs, careful attention should be given to reviewing all data needs, and data processing options, including the possibility of not using data processing at all.

Costs association with data analysis. The costs of data processing required for data analysis depend on the version of the hypercube programs used (interactive or non-interactive) and whether an in-house, commercial, or university-based computer facility is used. Data processing costs may include the cost of equipment and supplies, set-up charges, communications costs (such as long-distance telephone charges associated with using some remote data processing services), on-line storage charges, and computer usage costs based upon the time the user is connected to the computer, the amount of computer resources used in processing, and the amount of input and output operations.*

Table S-4 summarizes information on data processing costs derived from the experience of the police departments participating in the field test project.

Technical Assistance Costs

Technical assistance costs include the costs of documentation and training materials, training seminars or workshops, and consulting services required by department personnel during a beat design project. Documentation which describes the basic assumptions and theoretical foundations of the hypercube model, use of its programs, data collection procedures for the system, and analysis and interpretation of its results can be purchased for less than $100.

Police personnel who participated in the field test project generally agreed that some formal training in the use of the hypercube system is a prerequisite to its efficient use. Technical assistance and formalized training in a classroom setting are available from several agencies.**

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*Some of these charges are not applicable if an in-house computer facility is used.

**For an annotated list of such documents and sources of training refer to How to Set Up Shop for Use of the Hypercube System, pp. 41-47.

Table S-4

DATA PROCESSING COSTS ASSOCIATED WITH THE HYPERCUBE SYSTEM

Type of Cost	Estimated Cost
1. Computer costs, including charges for connect time, computer usage, and input/output operations	\$450 - \$3500[a]
2. Rental of teletypewriter data terminal	\$75 - \$150 per month[b]
3. Other equipment-related costs, including terminal supplies and service, and shipping charges	\$125 - \$250[b]
4. Set-up costs, including the cost of obtaining a copy of the hypercube programs, compiling and testing the programs, and developing additional software	\$200 - \$750[c]
5. Communications costs	\$0 - \$600[b]
6. Storage charges, including the cost of storing the hypercube programs, input data, and program output	\$125 - \$200 per month[a]

[a]Estimated cost ranges are based on the experiences of eight police departments participating in the field test project. The departments used the interactive version of the hypercube programs, implemented on the National CSS time-sharing system during 1976. Costs for other police departments, versions of the programs, data processing systems, or rate schedules may fall outside of these ranges.

[b]Costs apply only when the hypercube programs are implemented on a remote data processing system and accessed via telephone.

[c]Costs apply only when the hypercube programs must be implemented on a data processing system where the programs are not currently available.

ASSESSING THE FEASIBILITY OF USING HYPERCUBE

The hypercube system is an excellent planning tool for assessing alternative beat plans and patrol policies. However, use of the system may require substantial cost and effort. Therefore, use of the system may not be feasible or practical in every police department. A department considering the use of hypercube should carefully assess the need for hypercube analysis, the advantages and disadvantages of the system, departmental circumstances which affect the success of hypercube analyses, and the availability of alternative resource allocation models.

Need for Hypercube Analysis

Sometimes, even a cursory review of field operations within a police department may provide clear evidence that the department needs to revise its patrol beat plan and perhaps its operational policies as well. For departments with five or more patrol units in operation which experience any of the situations listed below, the hypercube system may be useful:

- substantial workload imbalance among patrol units;
- excessive amounts of interbeat dispatching -- that is, patrol units are often dispatched to calls outside their assigned beats;
- excessive time required by some patrol units to travel to calls for service;
- frequent delays in servicing calls for service -- that is, there are considerably more calls for service than can be handled by patrol units without undue delay;
- inappropriate distribution of preventive patrol among beats; or
- regions with high concentration of calls for service in some areas and low concentration in other areas, as in a police command that covers both urbanized and rural areas.

Advantages and Disadvantages of the Hypercube System

During the field test project, many advantages and disadvantages of both the hypercube system and computerized planning tools in general were identified.

Advantages of the system. The results of the field test project indicate that the hypercube programs provide the following advantages:

- The programs allow changes in field performance to be estimated without actually changing patrol operations, thus avoiding costly and disruptive field experimentation.

- The hypercube iterative design process allows police planners to involve field commanders in all phases of the design process; based on their knowledge of patrol operations in their regions, field commanders can propose alternative beat plans and patrol policies, verify input data, and review hypercube performance estimates.

- The programs constitute a powerful training tool for learning how to plan field operations.

- Efficient use of the hypercube programs may reduce police planning costs.

- The programs aid in creating a continuing data base for field operations planning and evaluation.

- All calculations used in "by-hand" beat design methods are automated.

- The interactive version makes it unnecessary to own either a computer or the programs.

- The programs are easy to use. The interactive version -- in which the user communicates directly with the computer via a remote teletypewriter terminal -- provides "tutorial" assistance for the novice user. Data processing experience is not a prerequisite for using the interactive version of the programs.

- The interactive version contains built-in error-checking features; data and instruction errors are revealed as soon as they are entered into the computer.

Disadvantages of the system. Offsetting the foregoing advantages are the following disadvantages:

- The use of the system often requires a special data collection effort, which can be costly and time-consuming.

- Unless the system is carefully used, high data processing costs may result.

- The interactive version may necessitate use of a costly commercial data processing service.

- If technical assistance is needed in using the programs effectively, there may be a charge for such services.

- If a non-interactive version of the hypercube system is used, the tutorial and error-correcting features of the interactive version are lacking.

- The system will be used infrequently by most police departments, usually only once or twice a year.

- The system requires training for the user of the hypercube programs, an investment which may be lost with his transfer or resignation.

- The system's output may be rejected by field operations personnel because it is the product of a computer or because the model ignores important subjective considerations.

- The hypercube system requires commitment of the chief administrator and other command and staff personnel to support the planning effort through field implementation.

Circumstances Affecting the Success of Hypercube Analyses

It is desirable to know in advance the circumstances under which a police department is most likely to benefit from use of the hypercube system. Some of these circumstances are listed below. While not all these circumstances have to be present for successful policy analysis and beat design, some combination of them usually has been lacking in those departments which have failed to benefit from using the system.

- Recognized need to analyze the patrol plan. This need is most apparent in departments with heavy workloads, frequent queuing delays, and other field operations problems.

- Cooperation between field, support, and planning personnel. Without this, design efforts are usually not successful.

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

- Design objectives other than balanced beat workloads. Beat workloads can be balanced using simpler and less costly manual design techniques.

- Adequate time for analysis. Allowing insufficient time for the project leads to inefficient use of the hypercube system, increased costs, and less meaningful results.

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

- Access to in-house data processing, or a sufficient budget for purchasing commercial services.

- Available data and commitment of department resources to collecting it.

- Patrol operations which satisfy the assumptions of the hypercube model. Hypercube assumptions should apply reasonably well to a department's patrol operations for reliable and valid results.

Alternative Planning Models

Readers interested in comparing the hypercube model with other planning models should refer to Criminal Justice Models: An Overview* or The Deployment of Emergency Services: A Guide to Selected Methods and Models.** Such comparisons can be useful in identifying the planning model that is most appropriate in terms of the current needs and capabilities of a department. At the present time, however, no other model is available which does as much as hypercube with respect to analyzing alternative beat configurations. The Patrol Car Allocation Model (PCAM), developed by the Rand Corporation, may be of interest to some department administrators and planners.*** The PCAM model can be used in several ways: to determine the number of patrol cars that should be on duty in each patrol region at various times of the day and each day of the week; to determine the total number of patrol officers a department should have; to allocate a fixed number of officers among distinct geographic regions; and to determine how many officers in a region should work each shift and when the shifts should begin.

A CASE STUDY IN HYPERCUBE USE

The experience of the Fresno, California, Police Department in using the hypercube system to deploy its field operations resources illustrates how hypercube operates and its potential benefits. Fresno is about 54 square miles in area and has a population of about 175,000. Prior to the hypercube project, begun in 1976, the Fresno Police Department had used the same beat configuration on all shifts for over 10 years. Sixteen patrol cars were used on each of three shifts every day of the week. Five more cars were assigned to an overlay shift for back-up assistance between 8:00 p.m. and 4:00 a.m. This manpower allocation produced workload imbalances and frequent queuing of incoming calls, among other problems, but no adequate alternative plan had been found.

When the department learned about hypercube, it saw the programs as an excellent tool for studying alternative plans because of the programs' ability to show the relationships between, and compute estimates of, workloads, response times, preventive patrol levels, and inter beat dispatching. Consequently, two department members were assigned full-time to an interbeat project from July through October, 1976.

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*Chaiken, Jan M., T. Crabill, L. Holliday, D. Jaquette, M. Lawless, and E. Quade, Criminal Justice Models: An Overview, R-1859-DOJ, Santa Monica: The Rand Corporation, October 1975. (Also available from the U.S. Government Printing Office, Washington, D. C.)

**Walker, Warren E., The Deployment of Emergency Services: A Guide to Selected Methods and Models, R-1867-HUD, Santa Monica: The Rand Corporation, September 1975.

***Chaiken, Jan M. and Peter Dormont, Patrol Car Allocation Model: Executive Summary, R-1786/1-HUD, Santa Monica: The Rand Corporation, September 1975.

Most of the required input data were available through the city's data processing center although geographic data had to be estimated from a map of the city.

Beginning July 1, 1976, department personnel, with limited technical assistance from TIPPA, analyzed numerous alternative beat configurations, examining each of five different time periods into which a day was divided. Thirty-six hypercube runs were made in the process of identifying final beat plans calling for 13 to 29 beats. Total data processing costs were nearly $5,000. (Other field test cities experienced considerably lower costs.) About 35 man-weeks were expended for planning, training, data collection, data analyses, and beat plan implementation.

Prior to implementation, the plans were carefully reviewed and slightly modified by a departmental task force. Despite a major reallocation of manpower among shifts and significant changes in beat boundaries, the new plan was implemented with few problems.

Preliminary data indicate that positive results have been achieved:

- The percent of calls for service held by dispatchers for more than three minutes decreased from 62 percent to 45 percent during the first month's operation under the new plan.
- The number of calls for service being held by dispatchers at the end of the busiest shift decreased markedly -- from as many as 45 under the old plan to about 5 under the new.
- Average travel time to calls for service decreased significantly.
- Manpower reallocation resulting from the hypercube study eliminated the previously-assumed need to hire additional personnel.

Department administrators and line personnel are please with the results achieved from hypercube, and the department plans to use the model periodically to assess and revise, as needed, field deployment policies.

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