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DATA COLLECTION AND COMPUTER ANALYSIS FOR POLICE MANPOWER ALLOCATIONS

by

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and

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WORKING PAPER

"Innovative Resource Planning In Urban Public Safety Systems"

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Research Applied to National Needs
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Foreword

The research project, "Innovative Resource Planning in Urban Public Safety Systems," is a multidisciplinary activity, supported by the National Science Foundation, and involving faculty and students from the M.I.T. Schools of Engineering, Architecture and Urban Planning, and Management. The administrative home for the project has become the M.I.T. Laboratory of the School of Architecture and Planning. The research focuses on three areas: 1) evaluation criteria, 2) analytical tools, and 3) impacts upon traditional methods, standards, roles, and operating procedures. The work reported in this document is associated primarily with category 2, in which a set of analytical and simulation models are developed and implemented that should be useful as planning, research, and management tools for urban public safety systems in many cities.

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Richard C. Larson
Principal Investigator

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Various versions of this document were typed and reproduced, usually under great pressure, by Deborah C. Brooks whose expertise and patience continually evoke admiration.

Abstract

A computer model, based on multiserver queuing theory, is applied to the problem of police sector design in the Town of Arlington, Massachusetts. The necessary data inputs concerning spatial and temporal call for service patterns, dispatch strategies, and average service times were generated by creating a simple reporting system to monitor field activities. While collecting information required for the computer model, several beneficial insights into departmental operations were discovered in the areas of dispatch procedures and juvenile disturbances.

An example of the sector design process is presented using 1974 call-for-service data and six sector cars. This same data base was used by Arlington Police command personnel on a real time version of the computer model to design a six sector configuration for their department. This design was implemented early in 1975.

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1. Introduction

The operational and planning aspects of public systems have drawn an increasing amount of attention from operations researchers during the past few years. The MIT "Innovative Resource Planning in Urban Public Safety Systems" (IRP) project, funded by the National Science Foundation, is currently involved in research relating to police and emergency medical services. The IRP project is focusing on performance criteria, technological capacities, and planning models for these systems. This paper deals with the application of recently developed analytic models to smaller urban police forces.

One of the IRP project activities has been the regular dissemination of a newsletter detailing project activities and publications. It was through the newsletter that the authors became associated with the Arlington (Massachusetts) Police Department (APD). Our purpose was to provide aid in the operational reorganization and planning for the APD.

IRP affiliated personnel had undertaken similar activities in Boston [1], Quincy [2], and New Haven [3]. Their efforts have relied to some extent on the agencies' own data processing facilities, with the analysis emphasizing patrol allocation and sector design questions. The primary means of answering these questions was the "hypercube queuing model" developed by Larson [4], Campbell [5], and Jarvis [6]. Briefly, the model is a descriptive tool for the evaluation of alternative system designs. The model focuses on response times, preventive patrol, sector identities, and patrol car workload. Arlington posed a different situation from previous efforts in that the police force was much smaller and their data collection process was not automated.

For the above reasons, Arlington represented a potentially interesting study. The data requirements of the hypercube model involve substantial set

up costs. As one of our objectives was to assist in updating the APD data organization, this could be accomplished with the requirements of the model in mind. Also, since previous experience had been with larger departments, this was a chance to evaluate the utility of the same type of planning approach to smaller police departments.

2. Data Collection and Analysis

The town of Arlington is located in the northwest section of the Boston Metropolitan area. It has an area of 5.5 square miles (roughly 3 miles east-west by 2 miles north-south). The population is approximately 53,500. [7].

The APD had 89 sworn and 14 civilian personnel. Typically a maximum of six mobile units are fielded at one time. During the calendar year 1972, the department had a budget of $1,361,000 and responded to 12,007 calls for service. The same figures for calendar 1973 are $1,390,220 and 14,122. The budget for fiscal year 1974-75 is $1,637,639 [8]. These figures represent a 17.6% increase in demand and only a 2.1% increase in funding. Although Arlington is typical of smaller departments in that the number of patrol units is normally larger than required to handle most calls for service without excessive delay, this sort of discrepancy does reflect the increasing importance of judicious use of resources.

The data collection effort centered around a form called the "yellow complaint card," typical of that found in many police departments. When a call arrives, the card is stamped with the "Time Received" and then with "Time Dispatched" upon the assignment of a mobile patrol unit. The mobile unit notifies the dispatcher when it arrives on-scene ("Time Arrived"). When the on-scene service is completed, the dispatcher is again notified and the "Time Clear" is recorded.

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In addition to the above, the complaint card is used to record the street address of the incident, the date, the unit assigned, and the type of incident. Other forms detailing the action at the scene are also kept but were not relevant for our study.

2.1 Data Requirements

The data requirements for the hypercube model fit into three categories: calls for service by location, type, and frequency; service time information including dispatch, travel, and on-scene times; and sector configurations or dispatch rules detailing the preventive patrol patterns and the units to respond to calls for service.

The collection of data related to the service times, sector configuration, and dispatch procedure presented no immediate problems. The service times were normally recorded on the complaint card and the last two items were easily obtained from departmental operating policy. The fact that call-for-service locations were kept by street address was symptomatic of the lack of automatic data processing facilities. In many larger departments, such information is typically recorded by "reporting areas." [1]

A reporting area is the smallest geographic unit for which call-for-service information is recorded. It may be of the order of a few city blocks in urban areas or square miles in rural environments. From a practical point of view, data must be aggregated to some extent to be useful. The reporting area device is a compromise between keeping as much locational information as possible while aggregating the data in a practical manner.

Since Arlington used only street addresses, our first task was to design a set of reporting areas. The result is shown in Figure 1. For police use, the boundaries follow major streets and some geographic obstacles to travel

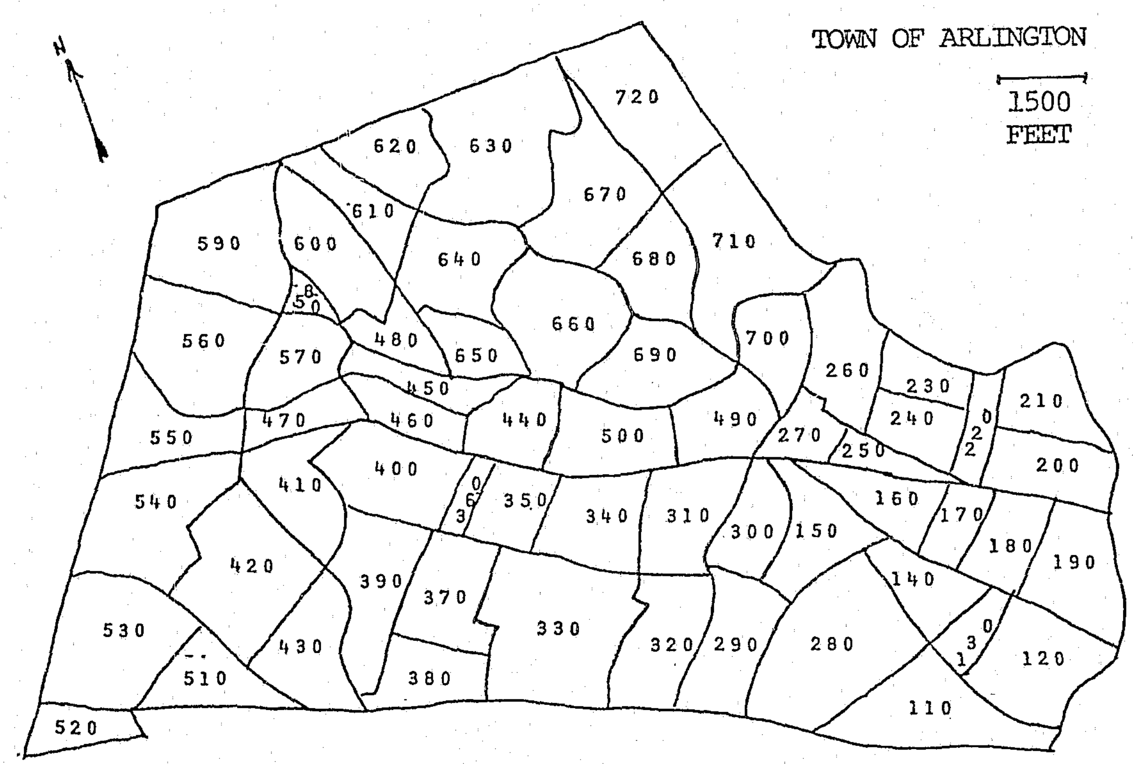

Figure 1: Arlington Reporting Area Map

such as railroad tracks, rivers, and ponds. To allow later comparison of data the reporting area boundaries include those of census tracks and voter precincts. In addition since patrol sectors (areas over which a single mobile unit patrols) are built up from reporting areas, the current (1974) sector boundaries were also included. Some effort was made to keep the reporting areas a uniform size.

Using the new reporting area design, three months call-for-service data (January, February, and August of 1973) was keypunched. For each incident, the following were coded: the location, after being converted to a reporting area; the receive, dispatch, arrive, and clear times; the type of call; and the responding unit.

2.2 Data Analysis

After the information was keypunched, several statistical runs were made to aggregate and analyze the data. Three distributions were found to be very similar to those found in previous studies of emergency services: number of calls by time of day, travel time to the scene, and service time at the scene. Two others, the number of calls each sector car handles and the average travel time to incidents in a sector, highlighted the inequities in the system as specified by the current sector design.

The calls-for-service by time of day distribution (Figure 2) very closely matches patterns found in several emergency public services. It is common that police [9], fire [10], and ambulance [11] services have lulls in the early morning hours of 4 AM to 6 AM. The number of calls for service increases until dinner time (where there is a small dip), peaks at approximately 10 PM, and then falls off to the early morning low. The difference between the highest and lowest number of calls per hour answered is typically 10 to 1.

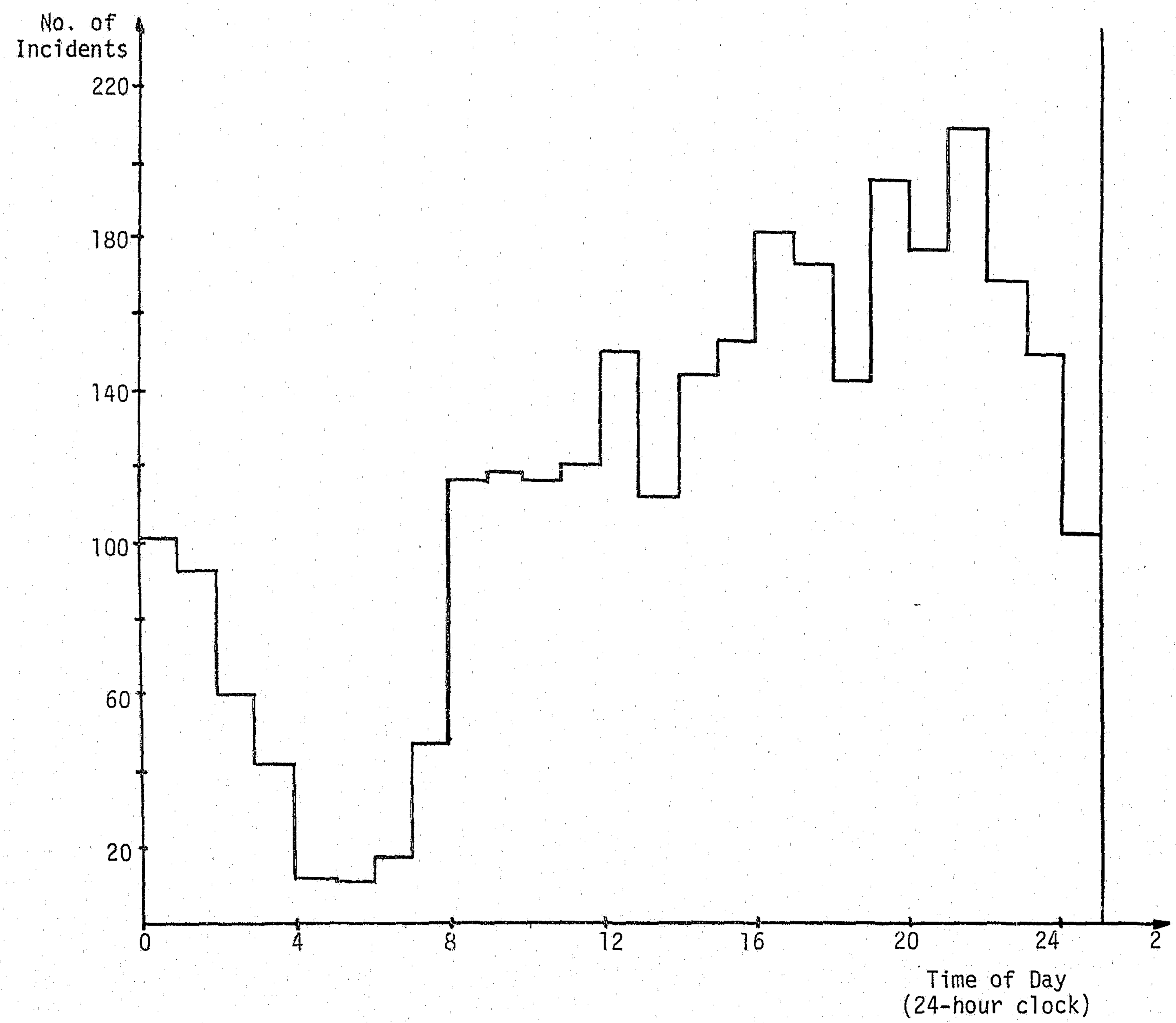

Figure 2: Histogram of Number of Incidents Against Time of Day; Three Month's Data. Mean 1.3 Call/Hr.

In the case of Arlington, the highest number of calls for service was 208, recorded between the hours of 9 and 10 PM and the smallest number, 21, arrived between 4 and 5 AM (three months data).

The travel data time was also analyzed. As is expected with police services, the travel times are typically quite short. The travel time to all incidents averages slightly more than 4 minutes and 10 seconds (median, 3 minutes 14 seconds). Over 90% of all calls (emergency and non-emergency) are answered in less than 8 minutes, and there is an officer on the scene in less than 3 minutes on over 55% of the calls. This is very good considering that less than 20% of the calls would be considered "high priority." Overall, the city-wide travel times are excellent. However, it is also important to examine each sector individually for the equality of service.

Sector travel times are a function of both the area of the sector, its location in the town, and the number of calls generated within the sector. If the sector car is often busy handling a call within its area when another request for service arrives, the car from a neighboring sector must be sent in with a consequential increase in travel time. In the case of Arlington, the workloads of each patrol unit were small enough that the effect of intersector dispatches on sector travel times was dominated by the sector area. As shown in Table 1, the absolute difference in sector travel times was small. As a result this study focuses on balancing the workloads of the units. Historically, the maximum imbalance in workload was roughly two to one (Units 1 and 3).

The on-scene times are distributed similarly to travel times but are much more spread out. This component of the service time averages slightly over 10 minutes 20 seconds with a quarter of the incident needing less than two minutes (median, 6 minutes 7 seconds). This reflects the great number of gone-on-arrival and unable-to-locate calls received by the Arlington department. Twenty percent of the calls required 15 minutes or longer to service.

Table 1: Historical Data. Fraction of calls generated by sector (Sector Workload); Fraction of calls answered by each unit (Unit Fraction); Average travel time to answer a call by sector (Sector Travel Distance, Minutes). Maximum unit fraction difference is 0.242 - 0.127 = 0.115 (69% of average workload).

Sector/ Unit	Sector Workload	Unit Fraction	Sector Travel Time (minutes)
1	0.239	0.242	3.75
2	0.160	0.169	4.30
3	0.142	0.127	4.16
4	0.139	0.149	4.17
5	0.155	0.157	4.55
6	0.165	0.156	5.36

2.3 Some Applications

Although the data preparation was intended to provide input for the hypercube model, it proved quite useful on its own right. It provided the APD with definitive data on the spatial and temporal distribution of calls for service and service time.

For example, it was found that in the first-half shift (4PM to midnight) that 31.4 percent of the calls were "disturbing the peace"; primarily youth disturbances. Overall, 26.2 percent of the calls were of this nature. On the basis of this large percentage, the APD felt justified in assigning a special three man team primary responsibility for such disturbances over the entire town. In addition, it was noted that 37.8 percent of these disturbances came from just five reporting areas; thus giving the special squad more information as to likely trouble spots. By providing some continuity in the personnel dealing with these disturbances, tensions were lessened to the extent that the frequency of dispatch of a second car to such disturbances was decreased significantly.

Along these same lines, a special squad was formed to concentrate on breaking and entering offenses. Using the data analysis to determine the spatial frequency of these crimes, the squad concentrated their patrol efforts on certain areas. On their first night of operation, three plain clothesmen intercepted such an incident in progress and apprehended three suspects. While this one example may not be statistically significant and the project is still under evaluation, the outlook is promising.

3. The Hypercube Model

Without going into great detail, a few words about the hypercube model are necessary. Traditionally, police departments have used such methods as hazard formulas for allocating personnel [12]. This sort of approach tends to oversimplify the actual behavior and requirements of a police force. For example, it is often assumed that a sector car handles all of the calls from its home area. An examination of the Arlington data demonstrates the weakness of this assumption.

3.1 Intersector Dispatches

As part of our data analysis, a cross tabulation of responding unit against call origin by sector was made (see Table 2). Although the sector unit handles most of the calls from its geographical sector, there is a significant number of "inter-sector dispatches." (The sector configuration is given in Figure 3).

Generally speaking, if a unit is busy (unavailable to respond to calls for service) 20 percent of the time, then one would expect approximately 20 percent of the calls from the unit's sector to arrive when the unit is busy and thus be serviced by another unit [12]. For the time period convered by Table 2, the average unit was busy roughly 10 percent of the time. Of the 2,352 calls noted, 830, or 35.3 percent were handled by other than the sector unit. This discrepancy will be treated in more detail later.

The hypercube model deals explicitly with unit availability and the probabilistic nature of the arrival of calls for service and travel time by mobile units to the scene. As input to the model, historical data is used to predict the location and time between successive calls and the time necessary to service the incident. Also, a description of where units are to perform preventive patrol and rules for which units are to be dispatched must be specified. (See the appendix.)

Table 2: Crosstabulation of Calls for Service by Sector of Origin Versus Responding Unit. Three months of historical data indicate degree of cross sector dispatching.

Sector \ Unit	1	2	3	4	5	6	Sector Total
1	347	58	28	2	2	1	438
2	68	213	4	5	3	3	297
Overlap*	65	93	1	2	1	0	162
3	46	8	214	27	48	5	348
4	14	28	24	263	1	27	357
5	3	7	155	31	158	20	374
6	5	3	27	153	18	169	376
Unit Total	549	410	453	484	231	225	2352

*Overlap of sector 1 and sector 2.

3.2 Sector Patrol and Dispatch Rules

The concepts of sector configuration and dispatch rules are best illustrated by example. Figure 3 gives the sector configuration for the period from which data was collected. A unit is assumed to perform preventive patrol in its own sector and to provide backup for other units as necessary. Sectors are formed by aggregating sets of reporting areas.

The time that a unit spends on preventive patrol in a particular reporting area is assumed to be proportional to the fraction of calls from that reporting area. For example, of 374 calls from sector 5, 27 were from reporting area 600; hence, car 5 is assumed to spend rough $100 \times 27/374 = 7.2$ percent of its preventive patrol effort for reporting area 600. In other words, preventive patrol is concentrated in those areas which generate the most calls.

In deciding which unit to send to an incident, the sector car would normally be the first choice; hence sector design will have a great influence on each unit's workload. A dispatcher must be able to dispatch other than the sector car if it is unavailable, a not infrequent occurence as noted above. Although the model includes several options in this area, a reasonable procedure is to dispatch the closest unit on the basis of the origin of the call by reporting area and the expected position of a unit within its sector. "Closeness" can be measured in terms of time or distance.

The use of the model is hardly more technical than the description above. A current version is designed to be used in a conversational mode that handles the details of the computer implementation. A sample session with the model is contained in the appendix.

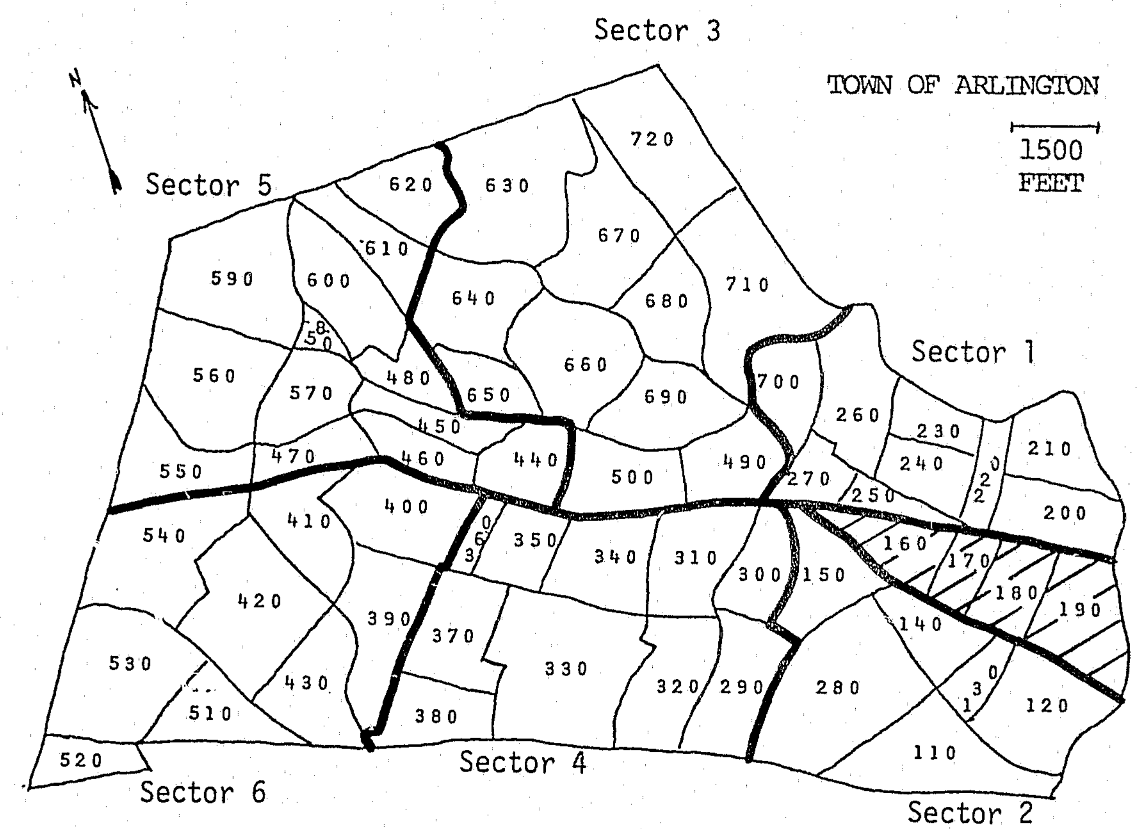

Figure 3: Original Sector Configuration: (Cross-Hatched Area is Overlap of Sectors 1 and 2).

4. Application to Sector Redesign in Arlington

The first step in a sector redesign is the evaluation of the current sector design (Figure 3). When this was done for the first-half shift, large discrepancies were observed between the fraction of calls answered by each unit as given by the model versus historical data (see Table 3). Attempts to adjust the model to fit the historical data indicated that the dispatch procedure was causing the difficulty. As noted in Section 3, the fraction of intersector calls was much larger than expected. A closer examination of the operation of the APD revealed the problem.

4.1 Dispatch Data

A tabulation of number of calls handled by each sector car in each reporting area was made. This technique yielded some interesting insights into the dispatching process. Data for eleven of the reporting areas show that the sector car was used less often than expected in handling calls from its own sector. In a few cases, the adjoining sector car handled such a large proportion of the calls that the sector boundaries were effectively redefined by the dispatchers.

This last finding prompted a series of interviews with some of the dispatchers operating in Arlington. During the interview each dispatcher was given a reporting area map with sector boundaries drawn on it and a piece of paper listing each reporting area. The officer was asked to list the sector cars in order of preference for each reporting area. Also, the officers were given 15 addresses of locations withing the town and asked to list the three most preferred units.

An evaluation of the responses by two of the officers that do night-time dispatching showed fairly significant inconsistencies in dispatching cars. For the 62 reporting areas, the officers disagreed as to the first preferred

Table 3: Comparison of Historical and Modelled Data for Fraction of Calls Answered by Each Unit for Three Reporting Areas.

Reporting Area (Sector)	Percent of Calls Answered by Unit					
	1	2	3	4	5	6
400 (6)						
Historical	1.5	0.0	7.6	48.5	7.6	34.8
Model	0.0	0.0	0.1	1.2	7.9	90.7
440 (5)						
Historical	1.4	1.4	51.4	15.3	26.4	4.2
Model	0.2	0.1	12.2	2.3	84.8	0.5
630 (3)						
Historical	12.5	0.0	43.8	0.0	43.8	0.0
Model	0.0	0.0	90.4	0.1	8.4	0.1

Table 4: Historical Data Detailing Fraction of Calls Responded to by Sector Unit and Next Most Frequently Used Unit. Indication of cross sector dispatches.

		Percentage of calls answered	
Reporting area	Sector	By sector unit	By next most Frequent Unit (unit number)
150	2	54	30 (1)
300	4	63	27 (2)
370	4	65	24 (6)
390	6	35	48 (4)
400	6	35	48 (4)
410	6	42	42 (4)
440	5	26	51 (3)
460	5	44	41 (3)
630	3	44	44 (5)
650	3	57	29 (5)
660	3	67	26 (5)

unit five times. They further disagreed on the second preferred unit in twenty of the remaining 57 reporting areas. In only 32 of the 62 reporting areas did they agree on the order of the first three preferred units. Table 5 gives sample data for the three reporting areas of Table 3. This represents a dispatch policy that is difficult to model.

A look at the answers given for the fifteen addresses further points to the "fuzzy" sector dispatching that was taking place. Each officer made four mistakes in assigning an address to its proper sector. They also displayed internal inconsistencies in ranking the first three preferred units. In over 50% of the responses, the unit preference differed for a reporting area and for an address in that reporting area. Once again, this type of behavior is very difficult to model in the hypercube framework. Recognizing the inconsistencies in the present dispatching system, the authors found it desirable to use a uniformly reasonable and consistent dispatch policy for the model and then attempt to orient the dispatchers to this preference scheme when the new sector design is implemented.

4.2 Sector Design Objectives and Procedure

Since the travel times in Arlington were satisfactory and previous studies have shown that travel times are not radically affected by other than major changed in sector design [13], the sector design effort focused on individual unit workloads. The objective was the equalization of unit workloads without introducing inequities in the response time to any sector. The following example illustrates the sort of procedure used to balance workloads.
Table 6 shows the fraction of calls answered by each unit, the internal workload generated by each sector, and the average travel distance to each sector for the original sector configuration as predicted by the model. It should be noted

Table 5: Preferred Order in Which Units are Dispatched for Three Reporting Areas: For Two Dispatchers and Order From Historical Data. Indicates inconsistencies in dispatching.

Reporting Area	Sector	First Three Preferred Units		
		Dispatcher 1	Dispatcher 2	Historical Data
400	6	6 4 5	6 4 3	6 3 5
440	5	3 4 5	5 3 4	3 5 4
630	3	3 5 4	3 5 4	3 5 1

Table 6: Model Predictions. Fraction of calls generated by sector (Sector Workload); Fraction of calls answered by each unit (Unit Fraction); Average travel distance to answer a call by sector (Sector Travel Distance, Miles) for original sector design (Figure 3). Maximum unit fraction difference is 0.219 - 0.136 = 0.083; 49.8% of the average (.167).

Sector/ Unit	Sector Workload	Unit Fraction	Sector Travel Distance (Miles)
1	0.231	0.219	0.601
2	0.168	0.172	0.612
3	0.156	0.159	0.702
4	0.133	0.136	0.641
5	0.156	0.158	0.741
6	0.156	0.155	0.704

that the fraction of calls handled by a particular unit is not equal to the fraction of calls generated by its sector. The difference between the busiest unit (car 1) and the least busy (car 4) is .219 - .136 = .083; 49.8% of the average fraction of calls handled by each unit.

To improve this imbalance, the number of calls handled by unit 1 must be decreased. Since the sector car has primary responsibility for its sector, such a change is strongly related to decreasing the size of sector 1. With these ideas in mind, reporting areas 270 and 700 are moved from sector 1 to sector 4. The latter change is made to increase the workload of unit 4. The results of this configuration change are shown in Table 7.

The next iteration was to decrease the workload of unit 3 which had been raised too high by the first change. This was done by moving reporting areas 640 and 650 to sector 5. The results are summarized in Table 8. As noted previously, changing the sector configuration had little change upon the sector travel distances.

The changes made above are a compromise between workload balance and sector integrity. From the data of Table 8, to balance workloads alone would entail increasing the size sector 6 at the expense of sector 5. Unfortunately, the boundary between these sectors is a major street which, for reasons of accessibility, should remain a sector boundary. Similarly, the double coverage on reporting areas 160, 170, 180 and 190 prevents further workload balancing between sectors one and two. The use of the hypercube model in sector design has been illustrated by the previous example.

Using this methodology, several alternative sector designs were developed. The final design (see Figure 4) was a compromise between the workload and travel distance considerations presented by the authors and certain issues of geographical accessibility known to APD personnel more familiar with local

Table 7: First Iteration in Sample Sector Design. Data from design of Figure 7; Move RA's 270 and 700 to Sector 3, RA 150 to Sector 4. Maximum unit fraction difference is 0.180 - 0.155 = 0.025; 18.6% of average.

Sector/ Unit	Sector Workload	Unit Fraction	Sector Travel Distance (Miles)
1	0.173	0.180	0.563
2	0.152	0.158	0.602
3	0.178	0.186	0.804
4	0.155	0.162	0.722
5	0.153	0.159	0.775
6	0.149	0.155	0.741

Table 8: Second Iteration in Sample Sector Design. Move RA's 640 and 650 to Sector 5. Maximum unit fraction difference is 0.179 - 0.156 = 0.023; 14.4% of average.

Sector/ Unit	Sector Workload	Unit Fraction	Sector Travel Distance (Miles)
1	0.172	0.179	0.560
2	0.151	0.157	0.601
3	0.168	0.175	0.769
4	0.154	0.160	0.720
5	0.165	0.172	0.782
6	0.150	0.156	0.748

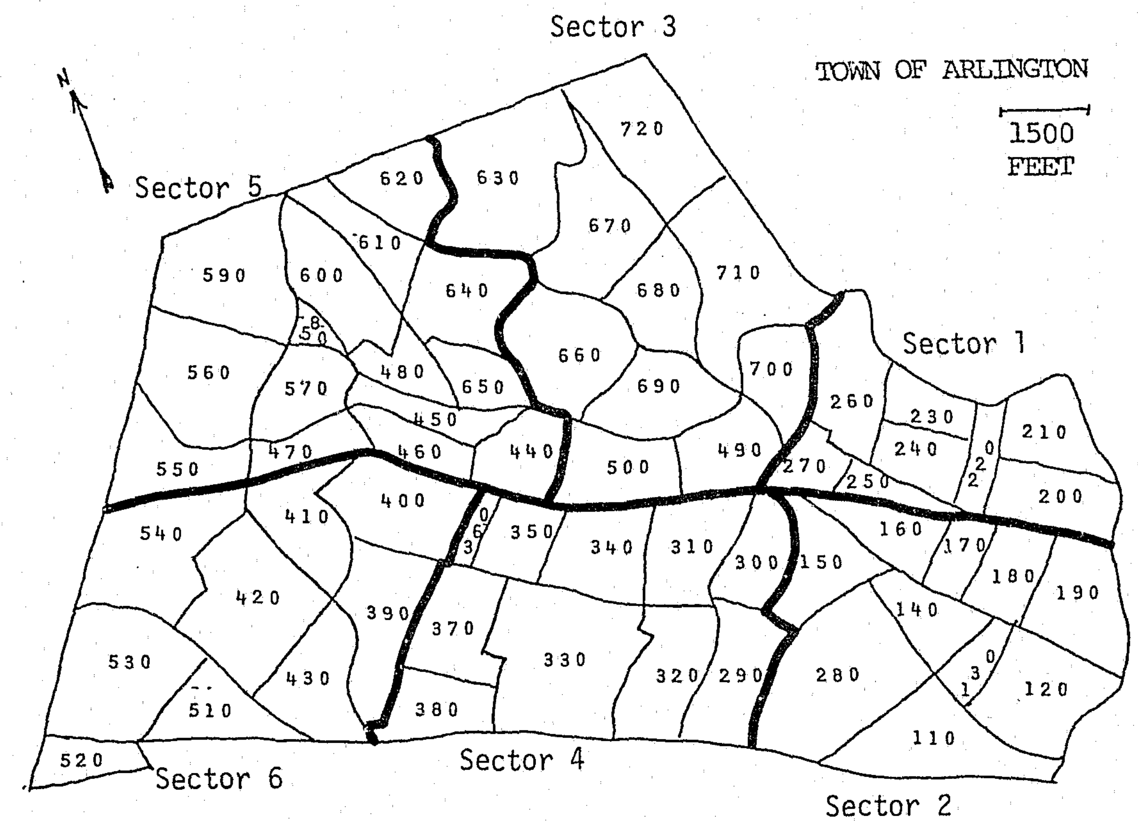

Figure 4: Final Sector Configuration

travel considerations. The final configuration was obtained in approximately two hours of a combination computer session (utilizing a remote terminal at the APD) and discussion involving the authors and APD personnel. The model predictions for the design are summarized in Table 9.

5. Conclusions and Summary

Although the IRP personnel working with the APD are primarily concerned with the development of the models, it is only fair to say that the data analysis phase of this study was at least as important as the application of the models. Even the simple data collection outlined above provided a set of statistics which had not been previously available. This is not to say that a police force of this size operates in the dark, but that it is virtually impossible for accurate processing of such a volume of data without some systematic procedure.

Since the IRP project cannot engage in routine data collections, one of the objectives of this study was to leave the APD sufficient information to continue the analysis. The use of the reporting area scheme makes this possible. With little extra clerical effort, call for service data can be keypunched and then sorted by mechanical means to reproduce the statistics mentioned above. Hence, many of the benefits of the data analysis can be continued without the relatively expensive setup costs for in-house computer analysis.

The authors do not intend to imply that the hypercube model is the answer to manpower allocation problems. However, with a simple data collection which is useful in its own right, the hypercube model does allow a relatively inexpensive and efficient means for evaluating sector and manpower changes as they affect the response function.

Table 9: Summary Statistics for Sector Design of Figure 3. Maximum unit fraction difference is .057 which represents 34% of the average workload.

Sector/ Unit	Sector Workload	Unit Fraction	Sector Travel Distance (Miles)
1	0.188	0.191	5.4
2	0.204	0.195	6.3
3	0.146	0.151	7.0
4	0.130	0.138	6.4
5	0.176	0.171	7.5
6	0.156	0.156	7.1

The sector design given in Figure 3 was implemented by the APD in June 1975. At the time of this writing, it was too early to determine how the new design would operate.

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APPENDIX

Use of computer program to evaluate sector design of Figure 3. (Computer types in capitals, user in lower case; a question mark, ?, supplies additional information.) Evaluate for 6 cars, average 15 minute service time, 2.4 calls per hour. A more detailed description is given by Weissberg [4].


```
monit output(example) city(arling)

MONITOR HERE.
WHENEVER YOU HAVE DOUBTS ABOUT WHAT YOU CAN OR SHOULD TYPE,
JUST TYPE '?'.

ENTER COMMAND:?

YOU ARE NOW AT COMMAND LEVEL.  THE COMMAND 'LISTCMDS'
LISTS ALL AVAILABLE COMMANDS.  THE MOST FREQUENTLY USED
COMMANDS ARE THE FOLLOWING:

CREATE -- LEADS THE USER THROUGH CREATION OF A NEW RUN FILE.
MODIFY -- LEADS THE USER THROUGH MODIFICATION OF AN ALREADY
     EXISTING RUN FILE.
CONFIG -- LEADS USER THROUGH MODIFICATION OF SECTOR
     CONFIGURATION
SUMMARY -- TYPES OUT SUMMARY OF CURRENT RUN INCLUDING ANY
     MODIFICATIONS MADE.
QUIT -- SAVES THE NEW RUN FILE AND RETURNS THE TERMINAL
     TO TSO.
EXIT -- RETURNS THE TERMINAL TO TSO WITHOUT SAVING THE NEW
    RUN FILE.

ENTER COMMAND:create

ENTER TITLE OF RUN:Evaluation of Arlington sector design.
RUN TITLE ENTERED:
'Evaluation of Arlington sector design.

ENTER NUMBER OF REPORTING AREAS:62

ENTER PATROL UNIT SPEED:10
PATROL UNIT SPEED ENTERED:  10.00

ENTER DISPATCH POLICY:mcm
DISPATCH POLICY ENTERED:  MCM

NO SPECIAL PREFERENCE FOR SECTOR CAR.
CHANGE?:yes
FIRST PREFERENCE FOR SECTOR CAR.

ZERO CAPACITY QUEUE.
CHANGE?:yes
INFINITE CAPACITY QUEUE .

DO YOU WANT TO CHOOSE YOUR OWN SET OF PREVENTIVE PATROL
   FACTORS?:no
```

```
TO DEFINE THE SECTOR CONFIGURATION, ENTER THE NAMES OF THE
   SECTORS AND THEIR ASSOCIATED REPORTING AREAS.

ENTER SECTOR NAME:sec1
TYPE LIST OF REPORTING AREAS
   IN SECTOR SEC1:200 210 220 230 240 250 260 270

MORE SECTORS?:yes

ENTER SECTOR NAME:sec2
TYPE LIST OF REPORTING AREAS
   IN SECTOR SEC2:110 120 130 140 150 160 170 180 190 280

MORE SECTORS?:yes

ENTER SECTOR NAME:sec3
TYPE LIST OF REPORTING AREAS
   IN SECTOR SEC3:490 500 630 660 670 680 690 700 710 720

MORE SECTORS?:yes

ENTER SECTOR NAME:sec4
TYPE LIST OF REPORTING AREAS
   IN SECTOR SEC4:290 300 310 320 330 340 350 360 370 380

MORE SECTORS?:yes

ENTER SECTOR NAME:sec5
TYPE LIST OF REPORTING AREAS
   IN SECTOR SEC5:440 450 460 470 480 550 560 570 580 -
+:590 600 610 620 640 650

MORE SECTORS?:yes

ENTER SECTOR NAME:sec6
TYPE LIST OF REPORTING AREAS
   IN SECTOR SEC6:390 400 410 420 430 510 520 530 540

MORE SECTORS?:no

ENTER PATROL UNIT SERVICE TIME (IN MINUTES):15
SERVICE TIME ENTERED:  15.0

ENTER NUMBER OF WORKLOAD LEVELS:1
NUMBER OF WORKLOAD LEVELS ENTERED: 1

ENTER ARRIVAL RATE OF CALLS FOR SERVICE (NUMBER OF CALLS
   PER HOUR):2.4
```



```
ARRIVAL RATE ENTERED:  2.4

      SUMMARY OF RUN

NUMBER OF SECTORS:          6
NUMBER OF REPORTING AREAS:        62
TITLE OF RUN: Evaluation of Arlington sector design.
PATROL UNIT SPEED:  10.00
NUMBER OF RUNS:            1
PATROL UNIT SERVICE TIME:   15.0
NUMBER OF CALLS FOR SERVICE PER HOUR:     2.4
DISPATCH POLICY:  MCM
SECTOR CAR FIRST.
INFINITE CAPACITY QUEUE.

ALL REPORTING AREAS APPEAR IN AT LEAST ONE SECTOR.

NO REPORTING AREAS APPEAR IN MORE THAN ONE SECTOR.


ENTER COMMAND:quit


OUTPUT COMPLETED.

READY



runhyp run(example) city(arling)

INDICATE OUTPUT LEVEL:?

THE POSSIBLE OUTPUT IS DIVIDED INTO THREE CATEGORIES:
     1) GLOBAL STATISTICS
     2) UNIT STATISTICS
     3) SECTOR STATISTICS.
THE OUTPUT LEVEL SPECIFIES THOSE CATEGORIES TO BE PRINTED AS FOLLOWS:
     OUTPUT LEVEL           CATEGORIES PRINTED
          0                        1
          1                        1,2
          2                        1,3
          3                        1,2,3.
INDICATE OUTPUT LEVEL:3
```

```
OUTLIST.DATA
Evaluation of Arlington sector design.
HYPERCUBE RUN 09 JUL 1975, 1611 HRS.  OUTPUT COMPUTED 09 JUL 1975, 1614 HRS
 6 UNITS        62 ATOMS
INFINITE LINE CAPACITY
MCM, SECTOR CAR FIRST
TOTAL OF 1 RUNS

UTILIZATION                  0.1000
AVERAGE TRAVEL TIME          0.0655
AVERAGE WORKLOAD             0.1000
MAXIMUM WORKLOAD IMBALANCE   0.0341
INTERSECTOR DISPATCHES       0.1018
SATURATION PROBABILITY       0.0000

 UNIT           SCALED   FRACTION   TRAVEL   FRACTION
INDEX WORKLOAD WORKLOAD  OF CALLS    TIME    INTERSECTOR
   1   0.1143   1.1433   0.1905     0.054     0.1263
   2   0.1167   1.1668   0.1945     0.060     0.0756
   3   0.0907   0.9072   0.1512     0.072     0.1202
   4   0.0825   0.8254   0.1376     0.068     0.1327
   5   0.1023   1.0233   0.1705     0.074     0.0737
   6   0.0934   0.9341   0.1557     0.069     0.0903

 SECTOR          WORKLOAD    INTERSECTOR    TRAVEL TIME
SEC1              0.1880       0.1143         0.054
SEC2              0.2035       0.1167         0.063
SEC3              0.1463       0.0907         0.070
SEC4              0.1300       0.0825         0.064
SEC5              0.1760       0.1023         0.075
SEC6              0.1562       0.0934         0.071

READY
```

END