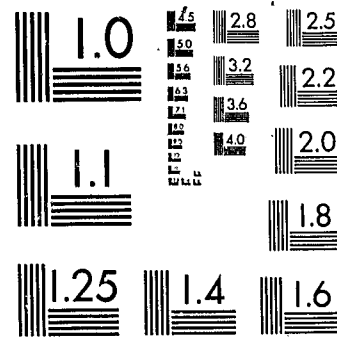


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# FBI LAW ENFORCEMENT BULLETIN

SEPTEMBER 1981

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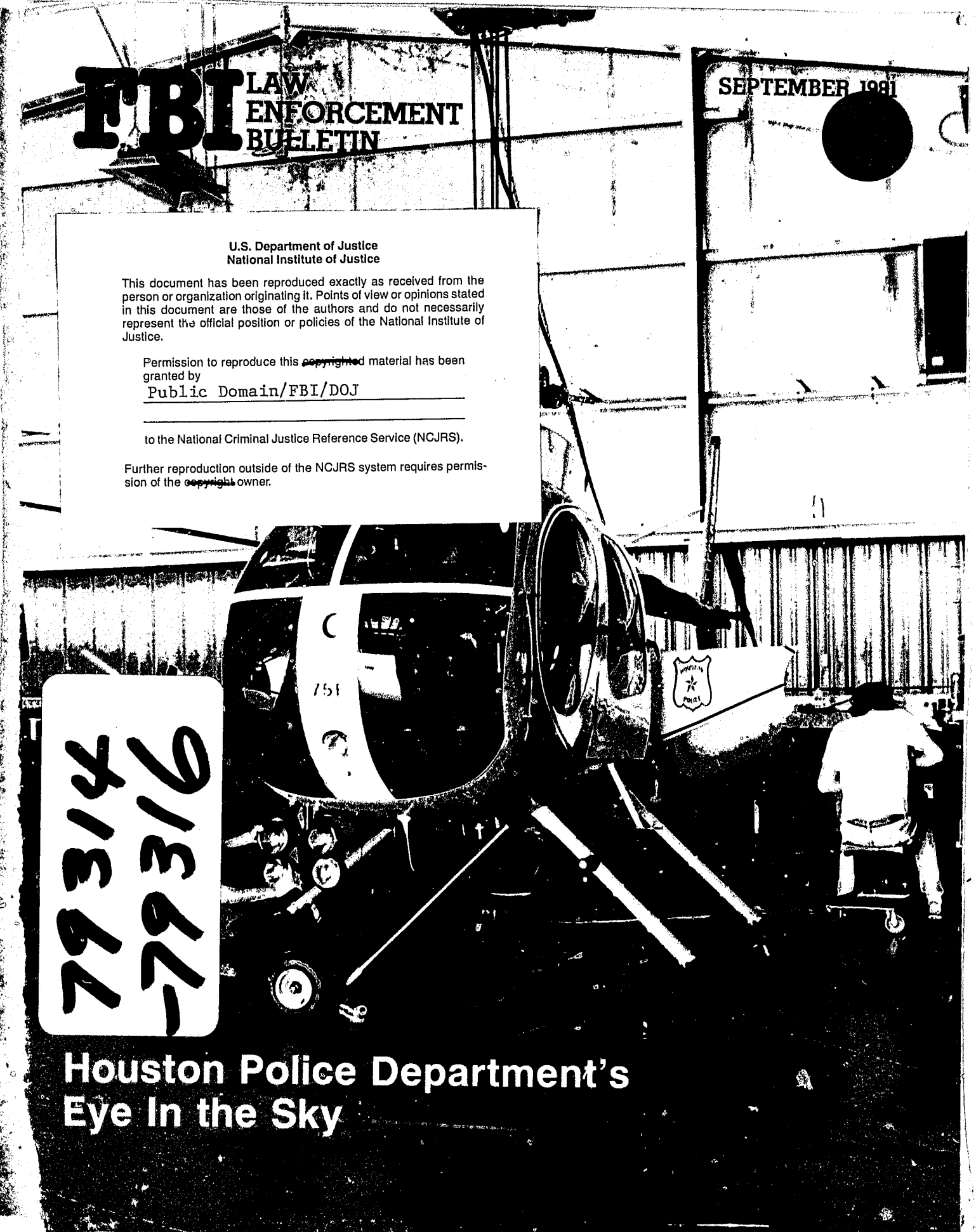
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## Houston Police Department's Eye In the Sky



GRB

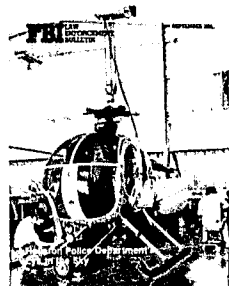
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SEPTEMBER 1981, VOLUME 50, NUMBER 9

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**Federal Bureau of Investigation  
United States Department of Justice  
Washington, D.C. 20535**

**William H. Webster, Director**

The Attorney General has determined that the publication of this periodical is necessary in the transaction of the public business required by law of the Department of Justice. Use of funds for printing this periodical has been approved by the Director of the Office of Management and Budget through December 28, 1983.

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## Patrol Resource Allocation In A Medium-Sized Police Department

By  
LT. WILLIAM J. HOOVER  
and  
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*Police Department  
Ann Arbor, Mich.*

In February 1979, the Ann Arbor, Mich., Police Department began a new system that provided more efficient use of its road patrol units.

Up to that time, assignments were usually made on the subjective basis of anticipated need. The end result was that overlap shifts and unequal distribution of patrol resources were in existence.

In turn, need usually was based on the experienced judgment of senior officers and a modest examination of historical workload. Staffing of patrol units was based on this same experience and to some degree a union contract clause which stated:

"The city agrees that, insofar as manpower allows, during the hours of darkness, all Ann Arbor Police 'marked patrol' units shall be manned by two (2) officers. In no instance shall any officer be required to ride alone during the hours of darkness for any reason other than shortage of manpower."<sup>1</sup>

The contract language regarding double units during darkness has been interpreted to apply basically from 9:00 p.m. to 7:00 a.m. The number of patrol units required on specific days at specific times was the decision of the patrol shift supervisor. Thus, it was not uncommon to have five double units at

4:00 a.m. on one Tuesday morning as compared with six single units and two double units the next Tuesday morning. The assignment of the same 10 officers on different Tuesdays was based on the supervisor's judgment, experience, and approach to the job.

In the fall of 1978, a member of the Ann Arbor Police Officer's Association filed a grievance against the department, claiming it did not strictly follow the contractual guidelines that "... during the hours of darkness, all Ann Arbor Police 'marked patrol' units shall be manned by two (2) officers. . . ." <sup>2</sup> In addition to the problems caused by some supervisors splitting up units when they were short of personnel between 9:00 p.m. and 7:00 a.m., a complaint was lodged about the period before 9:00 p.m. and after 7:00 a.m., when it was often dark. It was obvious that strict adherence to the contract language as interpreted by the association grievant would cause significant scheduling and logistics problems. Management's initial interpretation was that the contract clause had additional qualifiers that supported existing management practices, i.e., "... insofar as manpower allows . . ." and "... other than the shortage of manpower."



Lieutenant Hoover



Staff Sergeant Bodenschatz

Management understood that their chances of an arbitration victory depended on being able to justify reasonably their actions. In this case, justification boiled down to having standards against which to compare departmental actions. The perceived problem was that there were no guidelines as to when manpower allowed units to be doubled and when an actual shortage of manpower existed. It was necessary to develop guidelines.

A review of the patrol personnel assignments by time of day and day of the week during the previous year showed wide variations. These variations were caused by officers taking time off, shift assignment configurations, and individual shift supervisor preferences.

In order to retain efficient control over the allocation of patrol resources, a system which specified the minimum number of marked patrol units and officers assigned to those units by time of day and day of the week was needed. Additionally, guidelines had to be initiated regarding allowable time off and the circumstances under which over-time would be paid.

Three primary goals of the patrol resource allocation system were identified;

- 1) Consistently have on duty the number of units and officers that "fit" the workload;
- 2) Consistency in granting time off;
- 3) Use of the most efficient mix of single and double units by time of day.

It appeared that accomplishment of the identified goals would improve the efficiency of the patrol force and solve four potential personnel problems.

- 1) Supervisory decisions as to how many officers could be allowed off at

any given time would be standardized, avoiding periods of "feast or famine";

- 2) Grievances of unequal treatment would be avoided. One supervisor could not allow as many officers who wanted off on a Saturday night, while another forced everyone to work;
- 3) A realistic foundation supporting management's actions regarding the number of units assigned and the number of officers in the units by time of day and day of the week would be established; and
- 4) Improved assignment of the officers by time of day and day of the week promised to improve overall and emergency response time, as well as increase officer productivity.

#### Development of the System

Data processing equipment was not available to record, tabulate, and message past workload data. Thus, the initial problem was to determine which data could be collected and analyzed manually.

Using one randomly selected test week for each month during the period July 1, 1977, to June 30, 1978, records of patrol unit-time spent were collected and tabulated by hand. The objective was to look at those tasks that required patrol unit-time usage, determine the number of minutes involved, and assign those minutes to the time zone and day of the week where they were used. The data was tabulated using unit-time. After the number of units was decided, the number of officers in each unit was determined by reviewing the requests for service requiring two officers as opposed to the requests for service requiring one officer. Figure 1 shows the source of patrol unit activity time records, as well as the time zones used to capture patrol unit data.

The data analysis phase was divided into three sections:

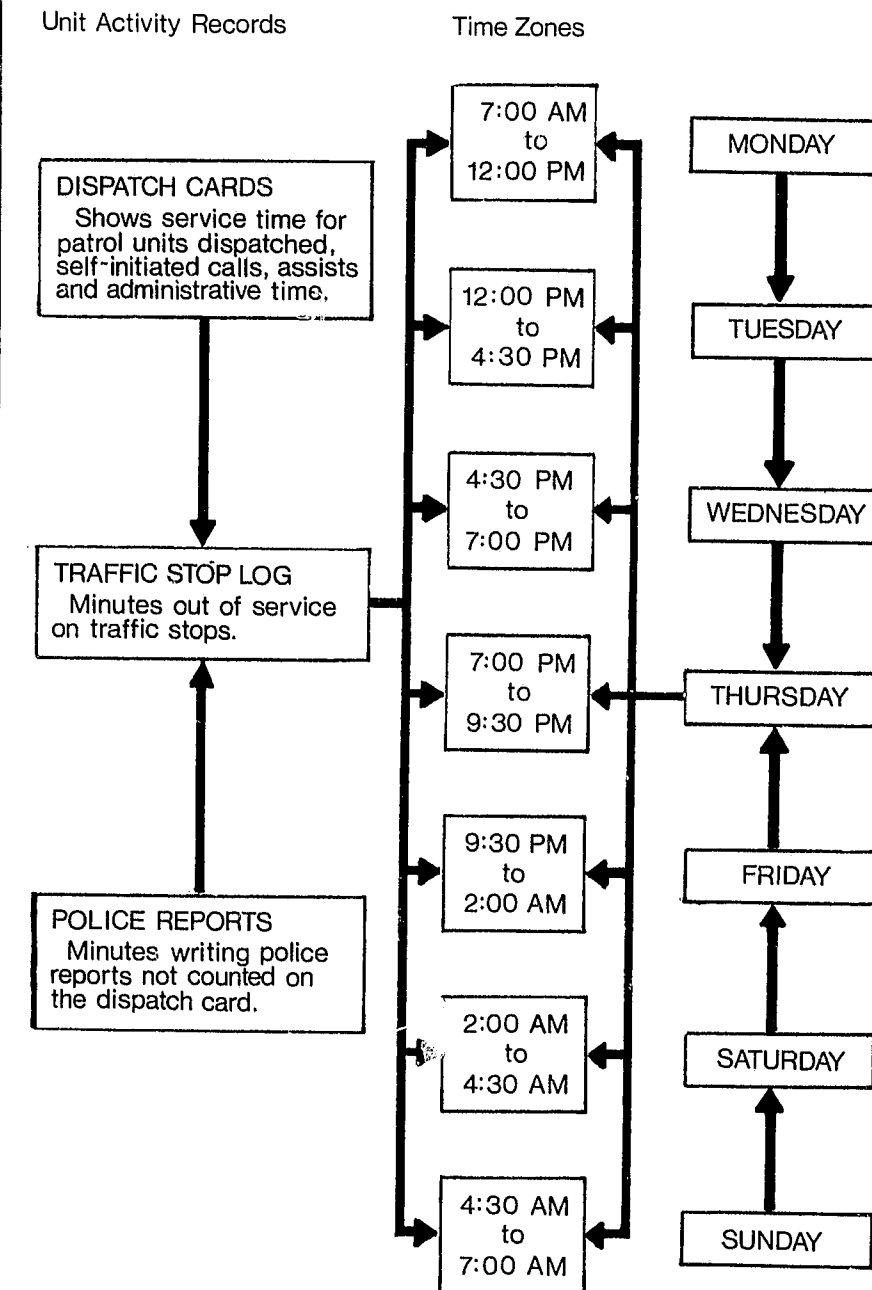
- 1) A statistical analysis of the workload using standard deviation<sup>3</sup> and Poisson distribution<sup>4</sup> techniques. These techniques were used to estimate the number of units required to handle the workload a particular percentage of the time.



Chief William J. Corbett

Figure 1

#### Patrol Unit Time Spent: Record Sources and Time Zones



2) Workload data was massaged by a programable pocket calculator to estimate the mathematical probability that all patrol units on duty during a shift would be busy simultaneously. For example, given past workload in the 2:00 a.m. to 4:30 a.m. time zone on Tuesdays, if five patrol units are on duty, what is the expected percentage of time all will be busy at once?

3) Finally, a subjective evaluation was made of other general factors to assist in making the proper judgment as to the number of units to be assigned.

In the statistical analysis stage, the mean of the minutes of unit service time required for a specific day of the week and time zone was obtained, as well as the standard deviation. The standard deviation was multiplied by two and added to the mean to give an expectation of the number of patrol unit minutes necessary to handle workload expectations 95% of the time.<sup>5</sup> Figure 2 shows the patrol unit minutes used during the 2:00 a.m. to 4:30 a.m. time zone on Tuesdays during the July 1, 1979, to June 30, 1980, period, as well as the calculations completed to obtain the number of patrol units needed. Calculations to obtain the standard deviation are not shown.

In figure 2, analysis of the standard deviation suggests that 6.2 patrol units assigned between 2:00 a.m. and 4:30 a.m. on Tuesdays will supply enough patrol response units to handle adequately workload expectations in 95 out of 100 occurrences.

The Poisson distribution was also used in the statistical analysis stage. Based on the historical mean of workload minutes by time zone, a relative frequency of required workload minutes at the 80%, 85%, 90%, and 95% levels was calculated. In other words, workload minutes to handle 80 out of 100, 85 out of 100, 90 out of 100, and 95 out of 100 occurrences were calculated using the Poisson techniques. Each of these workload estimate levels was then divided by the number of service minutes available to one patrol unit in that time zone, thus estimating

**“ . . . workload is up and response time is down, even though there are now fewer officers and units in the field.”**

Figure 2

**Unit Determination With Standard Deviation**

Patrol Minutes Used on Tuesdays Between 2:00 a.m. and 4:30 a.m.

July	561	January	261
August	660	February	513
September	969	March	383
October	283	April	425
November	422	May	320
December	759	June	606

Total 6,162 Min.

Mean 513.5 Min.

Standard Deviation 210.5 Min.

Mean Plus Two Standard Deviations 934.5 Min.

Minutes Available to One Patrol Unit in the 2:00 A.M. to 4:30 A.M. Time Zone 150

Number of Units Needed to Handle Expected Workload 934.5/150  
95% of the Time =6.2 Units

the necessary number of patrol units. Figure 3 shows an example of this method for the Tuesday 2:00 a.m. to 4:30 a.m. time zone.

Next, using a programable pocket calculator, data on calls for service per hour, service minutes per call, percentage of calls that require assists, assist minutes per assist call, and administrative minutes per unit per hour for a set number of units was processed, developing a mathematical expectation of the percentage of time when no patrol units would be available. The calculator program assumes calls are dispatched as soon as received and thus uses a “no stacking” concept. This procedure comes from the “patrol plan” program developed by the Institute for Public Program Analysis in St. Louis, Mo.

The results of the standard deviation, Poisson distribution, and expectation of having no units available procedures were then simultaneously and subjectively examined along with seven other relevant factors:

- 1) Past number of units fielded by time zone and day of the week;
- 2) Past number of unit assists by time zone and day of the week;
- 3) A manual past estimation of the number of minutes no units were available by time zone and day. These figures were collected by communications dispatchers during the randomly selected weeks each month;
- 4) History of when and how often workload requests were delayed from one time zone to another;
- 5) Police response time by time zone and day of the week;
- 6) Uncontrollable time of trends—when sick and personal leave days are most likely to be taken; and
- 7) The ratio of requests for service by time of day and day of the week that require a single or double unit at the time of dispatch.

Figure 3

**Unit Determination With Poisson Distribution**

Level	Minutes	Minutes Available To A Patrol Unit In Time Zone	Patrol Units Required
95%	733.3	150	4.89
90%	669.5	150	4.46
85%	633.0	150	4.22
80%	580.9	150	3.87

From this subjective analysis, a chart was produced listing the minimum number of patrol units and road personnel required by time zone and by day of the week. (This contained a built-in ratio of single to double units developed from the historical workload.) Figure 4 shows an example of the results obtained.

The minimum number of units and personnel listed in figure 4 is not the *desired* level of units and personnel. Instead, it is the *minimum* level at which supervisors are allowed to operate even to the extent of calling back off-duty officers and paying overtime to maintain specified levels.

Using the described method for each day and time period of the week, the minimum level of units and personnel was developed and the total available patrol force was assigned by time of day and day of the week. Fixed positions, such as vacation and desk officers, were deleted from the total number of officers available and considered as part of the minimum number of personnel to be assigned to each time zone. To create a consistent “cushion” of officers over the minimum and fixed positions, personnel over the minimum were allocated as dictated by the workload analysis. This insured that routine sick calls did not cause overtime, and a reasonable amount of compensatory time could be allowed.

By contract, the Ann Arbor Police Department compensates officers at either time and a half or double time for overtime hours. Compensation may be taken in pay or compensatory time. Personnel are limited to 120 compensatory hours and only may use 80 hours of compensatory time in a fiscal year.

**Results of the System**

The system was developed in the fall of 1978, and implemented in February 1979. By November 1980, it had been updated twice, each time using the most recent fiscal year's workload data, as well as looking at the overall 2- and 3-year workload trends. Not surprisingly, as sophistication in dealing with the system developed, there were minor changes in the number of units specified as minimum for a specific time and day. For example, one

time period was originally scheduled to have 10 units on duty as a minimum. In the first revision, it was cut to nine because of better than satisfactory results, and in the most recent update, it was further reduced to eight units. There are many such examples of both increases and decreases in the number of units specified by time zone as a result of continuous updating of the system.

Retraining sessions for patrol supervisors have recently been conducted to familiarize them with system changes. During the retraining session, an evaluation was made of the measurable results achieved under the manpower allocation system. Figure 5 shows some of those results.

As can be seen, workload is up and response time is down, even though there are now fewer officers and units in the field. On the negative side, sick time is up and the percentage of time all units are busy is up slightly. It was expected that since time off controls were tightened, use of sick time would increase. The increased percentage was believed to be acceptable in light of the positive benefits received.

Overtime to operate the system is estimated at approximately 600-700 hours per year at a cost of \$11,000 to \$12,000. Overtime costs appear small when compared with the cost of the 4.5% fewer police officers used during the July 1, 1979, to June 30, 1980, period. The cost of using those officers is estimated at \$135,000. The department is satisfied that:

Figure 4

**7:00 a.m. to 12:00 p.m. Manpower Allocation Chart**

	Sun	Mon	Tues	Wed	Thurs	Fri	Sat
Minimum Units	4	6	5	5	5	5	4
Double	1	2	1	1	1	1	1
Single	3	4	4	4	4	4	3
Minimum Personnel	5	8	6	6	6	6	5



- 1) Assignment and time off decisions are made in the best interests of the organization, with the same guidelines applicable to all subordinate and supervisory personnel;
- 2) Management's guidelines with regard to the number of units and their level of staffing is based on a solid and defensible position; and
- 3) Efficiency has increased.

Figure 5

**Premanpower Allocation vs. Postmanpower Allocation Results**

	Total Number of Patrol Responses During Test Weeks		Percentage of Time Patrol Units Were Available		Response Time	
	Pre	Post	Pre	Post	Pre	Post
7:00 a.m. to 12:00 p.m.	1,342	1,359	97.5%	96.9%	15.2	12.9
12:00 p.m. to 4:30 p.m.	1,628	1,728	97.9%	97.4%	17.1	16.1
4:30 p.m. to 7:00 p.m.	1,214	1,174	97.8%	97.7%	20.8	16.2
7:00 p.m. to 9:30 p.m.	1,141	1,142	99.8%	98.7%	17.7	16.5
9:30 p.m. to 2:00 a.m.	1,913	2,286	99.9%	99.2%	13.8	13.2
2:00 a.m. to 4:30 a.m.	551	736	96.8%	94.6%	11.4	14.7
4:30 a.m. to 7:00 a.m.	208	310	97.2%	95.6%	16.8	11.3
Total	7,997	8,735	98.2%	97.4%	16.3	14.6
Percentage Change	+9.2%		-0.8%		-10.4%	

	Mean Number of Units on Patrol		Mean Number of Patrol Officers Available	Average Sick Hours Used per Officer
	Pre	Post		
7:00 a.m. to 12:00 p.m.	6.7	6.2		
12:00 p.m. to 4:30 p.m.	8.2	8.0	Pre—79.3	Pre—72.9
4:30 p.m. to 7:00 p.m.	8.4	8.3	Post—74.8	Post—78.9
7:00 p.m. to 9:30 p.m.	10.4	8.0		
9:30 p.m. to 2:00 a.m.	11.3	10.1		
2:00 a.m. to 4:30 a.m.	6.1	5.6		
4:30 a.m. to 7:00 a.m.	4.4	3.9		
Percentage Change	-7.4%		-5.7%	
			+8.2%	

**Postsystem Adjustments**

A patrol audit system was developed to inspect 1.2% of unit assignments. One of the primary objectives is to insure that the amount of time used is in line with how much time is actually taken. Each audit is conducted by a supervisor.

**Future Expectations of the System**

In November 1980, the Ann Arbor Police Department went on-line on a minicomputer. The department's goal within the next 12-18 months is to computerize the manpower allocation, data gathering, and massaging procedures to allow more frequent overall system updates. The system, however, was developed, implemented, operated, and updated by hand. It has been successful and may well be successful in other law enforcement agencies, particularly those without electronic data processing. **FBI**

*The Ann Arbor Police Department will be pleased to supply any interested agency with further details of the system, such as forms used, data collection methods, etc. Inquiries should be directed to the authors at the Ann Arbor Police Department, 100 N. 4th Avenue, Ann Arbor, Mich., 48107.*

**Footnotes**

- <sup>1</sup> Collective Bargaining Agreement, City of Ann Arbor and Ann Arbor Police Officer's Association, p. 36.
- <sup>2</sup> Ibid.
- <sup>3</sup> "If a distribution can be approximated closely with a normal curve, about 95% of the cases fall within two standard deviations of the mean..." John E. Freund and Frank J. Williams, *Modern Business Statistics*, p. 153. For example, in a normal distribution of Tuesdays between 2:00 a.m. and 4:30 a.m., the number of required patrol unit minutes to handle workload should be less than some number 95% of the time.
- <sup>4</sup> Find the mean number of calls for a particular time of day, locate the mean number on the "Poisson probability distribution" chart, and pinpoint the desirable expectation (80, 85, 90, or 95%); take the expectation number times the average number of minutes a call during that time period requires. John R. Stockton and Charles T. Clark, *Business And Economics Statistics*, p. 571.
- <sup>5</sup> Freund and Williams, p. 153.

**END**