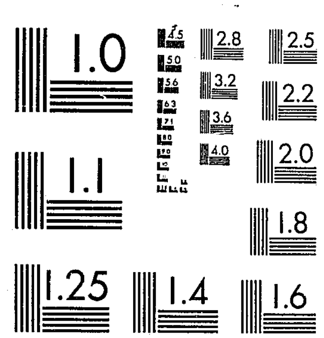

MICROCOPY RESOLUTION TEST CHART
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10/08/81

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COMPUTING AN

ALLOCATION OF MANPOWER

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June, 1980

COMPUTING AN

ALLOCATION OF MANPOWER

INTRODUCTION

An allocation of manpower is most easily performed with the assistance of a mathematical model. The purpose of such a model is to visually present a distribution of manpower resulting from decisions regarding the use of that manpower. In architecture, a model is a scale representation of the actual structure. Changes can be made to the architectural plans and the results of those changes seen before the structure is committed. When finished, the resulting structure is similar to, but not exactly the same as, the model. Models serve the same purpose in business; they give a visual representation based on operating philosophies (plans). They enable management to make informed decisions and to see the results. The actual outcome is expected to be similar to the results predicted by the model. Like architecture, the outcome also may never match the original model because of the large number of variable and unpredictable factors and because of the time required to attain the planned outcome. This is particularly true when the model is based on human and demographic factors. However, given increasing costs and decreasing resources, models become the only viable means of attempting to observe complex outcomes without having to make a commitment.

The model discussed in this paper presents assignment of manpower to districts given a set of statewide operating philosophies. These philosophies can be changed, and the model will reflect these changes. In addition to statewide assignment, the mathematics of the model allow district administrators to allocate personnel throughout their district based on more localized philosophies. Most importantly, the mathematics allow management to project the resources needed to meet longer range needs. This paper only deals with the first aspect, the distribution of a fixed set of State Police resources.

BACKGROUND

The current authorized strength of the Division of State Police is 1,600 sworn personnel. Previously, these officers have been allocated to districts using many options: "squeaky wheel", "roulette", "decree", and "friends". While these methods satisfied immediate concerns, they were not defendable.

Recognition of the need for a logical and defendable methodology appeared several years ago. At that time, an attempt was made to allocate manpower to districts based upon the relation of the district to the State as a whole, in regard to such items as registered vehicles, area, vehicle miles, criminal activity, and answering requests for service. This method was supposed to weight the needs and assign manpower accordingly. It was a good initial attempt, and the current model is a descendent of this effort.

There are a number of mathematical models available. Most have been designed for urbanized areas. Successful applications, for example, have been made in St. Louis and Chicago. Attempts at allocating rural police have met with less success. The models for urbanized areas have not been usable because they are heavily weighted toward small areas of patrol and to criminal activity. A model was produced for the Arizona Highway Patrol, but it was oriented solely toward accidents. Another model of allocating Interstate Highway patrol was prepared for the Division of State Police. It was a valid tool for its objective, patrol of Interstate Highways.

From these models, a method of allocating the State Police has evolved which takes into account the demographic and geographic factors that are important determinants of police patrol, response to calls for service, and overhead. Most importantly, the model allows for distribution of manpower as a result of many complex management philosophies. The many possible paths represented by these philosophies must be reviewed and the most desired outcome selected. The model and

computational assistance simplifies the task.

MODEL FOR ALLOCATING MANPOWER

General

What makes a model of personnel allocation difficult to understand, other than its mathematical intricacies, is that the model is dealing with factors that cannot be precisely represented mathematically. In a model of a building, all elements are known and measurable. Human behavior is not so precise. The outcomes from a model involving such behavior are therefore true only for a very specifically defined set of conditions. Because those conditions will never exist precisely, to consider any allocation projected by a model as set in concrete is an improper use of the modeling tool.

The possible geographic shifting of persons further complicates the application of any results from a model. Except in a geographically small area, persons cannot be moved like chess pieces. Therefore, even if a projected allocation is to be followed, it must be done in the long term to allow for gradual shifts in manpower as a result of attrition and transfers. During that term, changes in the factors that were used in the model, as well as the operational philosophies, will occur. The results of such changes mean that the original allocation will change. Over time, the actual allocation of manpower will move toward those decided by management based on a model. It will never match precisely. What remains critical, however, is that the managers use the model as a tool to help them make informed decisions on the effective distribution of the available manpower.

The duties of a police agency generally fall into two categories: administrative and patrol (reaction and prevention). The model for allocating Division of State Police sworn personnel handles these duties with three elements: overhead (administrative), calls for service (reaction), and discretionary (preventive patrol). In this paper and in the construction of the model, rank is unimportant: rather the duties performed by an officer are the important elements. The designation of a rank to fill a specific position is the task of local management. The model simply indicates the number of persons required to adequately fulfill a managerial philosophy.

Overhead

A portion of the sworn officers regularly perform administrative duties or are assigned to specialty functions. Although these positions are part of the authorized strength, they are not part of the manpower generally available to answer calls for service or for preventive patrol. The portion of the model termed overhead accounts for these positions. Their allocation to individual districts will be left to management. In the initial computations performed for the model, the overhead has included:

- Administration and Executive Security (Districts 50 and 52)
- District administrative personnel (Captain, two Lieutenants, and six Sergeants)
- Specialty Officers (automobile equipment, public information, vehicle identification, 2nd division, and hazardous materials)
- (This list could also include field supervisors, court officers, scale supervisors, etc.; however, the net effect of increasing overhead is to reduce the manpower available for patrol and may or may not be made to affect all districts equally.)

After the manpower representing overhead has been removed and the remaining available manpower has been allocated, the overhead is added to each district. The allocation of this overhead is a managerial decision.

Calls for Service

An essential part of police service is response to requests for assistance from the public. These requests take many forms: weather related damage, accidents, crimes, etc. Based on the average number of complaints received and time

taken to answer the complaints, an estimate of the manpower required can be made. When not answering calls for service, the officers are still on patrol and thus, are helping prevent accidents and crime. Because the State Police generally patrol rural areas, a smaller percentage of the officers on duty will be answering calls for service than counterparts in a larger urban area. A large portion of the available manpower will be patrolling. Only in unusual circumstances will all officers be needed.

A call for service is a random event. The time at which a call will be received cannot be predicted. What is known is the average time between calls as well as the time taken to handle the call. For example, if there were two calls for service in a day, the average time between calls would be 12 hours. On any given day, both calls could come at the same minute.

The receipt of calls can be compared to the tossing of coins. A coin, on the average, comes up heads once in every two tosses. If ten coins are tossed, five heads should appear every toss, but anywhere between zero and ten heads can appear. If one bets that exactly five heads will occur (five calls), he would win approximately once in every four tosses (more precise odds are 246 times in 1,000 tosses). This can be found by tossing the coins enough times or turning to a statistical table which gives the odds (probabilities). Likewise, one can bet that at least five heads will appear (five through ten). The odds are better than three out of five times (624 in 1,000). The same principle applies to estimating how many persons are needed to answer calls for service. For example, the manager bets that 99 times in 100 there will be enough persons to immediately answer all calls. The information needed is the time taken to handle a call (number of coins tossed) and the average number of calls during that period (change of getting ahead).

Figure 1 shows three simulations of the occurrence of accidents during an 80-hour period. Line A shows 40 accidents occurring, one every two hours (the average). Lines B and C show accidents happening randomly (40 and 80 accidents). The random occurrences were taken from a Table of Random Numbers (Neter, Wasserman, and Whitmore, Applied Statistics, 1978).

In a predictable world, the 40 accidents would occur as shown in Line A. Every two hours one accident must be handled. If an officer took two hours to handle the accident, only one officer would be required per shift. Doubling the number of accidents would double the number of officers required.

Accidents are not predictable; they occur randomly. There will be periods when more than one accident occurs and there will be periods when no accidents occur. This is depicted on Line B in Figure 1. According to this distribution, three accidents occur at hour 67 and again at hour 78. On the other hand, there is a period from hour 35 to hour 42 when no accidents occur. If a span of two hours (time taken to investigate one accident) is placed at different locations on the chart, this block will cover any where from no accidents (hours 7 and 9) to four accidents (hours 78 and 79). There are 80 possible two-hour blocks. The number of accidents occurring in each of these blocks (Lines A through C) is summarized on Table 1. Of the 80 block for Line B, no accidents will occur in 29 of them, 36.2 percent of the time. Zero or one accident will occur in 77.4 percent of the blocks (36.2 plus 41.2). Four accidents will occur only once, or 1.3 percent of the time.

FIGURE 1
DISTRIBUTION OF ACCIDENTS

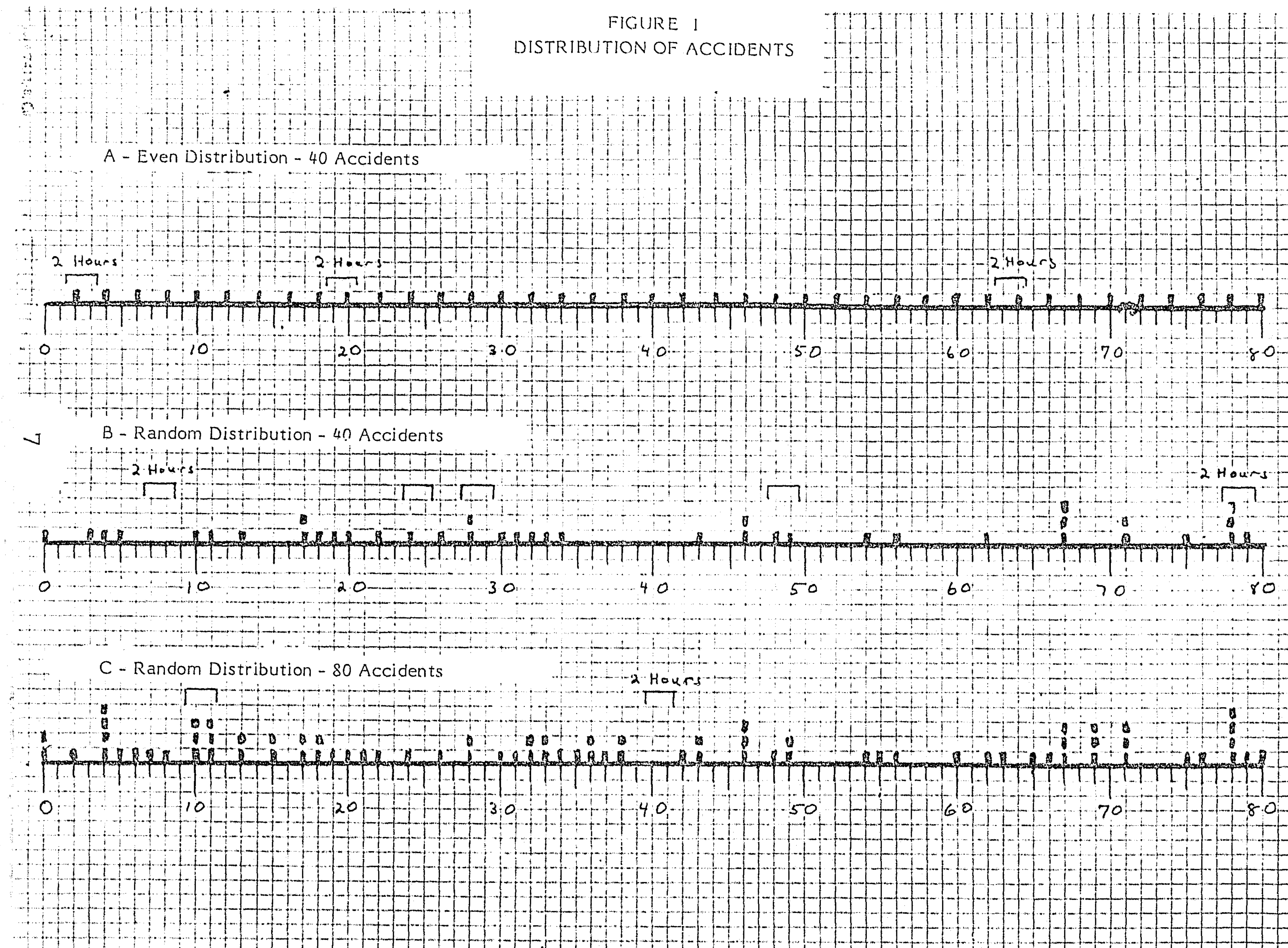

TABLE 1

NUMBER OF ACCIDENTS

IN TWO-HOUR PERIODS

(80 Hours - Figure 1)

Number of Accidents	Line A Number of 2-Hour Periods	Percent	Line B Number of 2-Hour Periods	Percent	Line C Number of 2-Hour Periods	Percent
0	--	--	29	36.2%	10	12.5%
1	80	100.0	33	41.2	27	33.7
2	--	--	14	17.5	22	27.5
3	--	--	3	3.8	13	16.3
4	--	--	1	1.3	5	6.2
5	--	--	--	--	2	2.5
6	--	--	--	--	1	1.3
	80	100.0%	80	100.0%	80	100.0%

If all accidents occurring as shown on line B must be handled immediately, then four officers must be on duty for 80 hours. (Those four accidents at hours 78 and 79 could have been as likely to have occurred at hours 10 and 11, or hours 34 and 35.) The fourth officer is needed for only two of the 80 hours to handle one accident. The remaining 78 hours will be free. An examination of Table 1 gives another option. If the manager decides to handle 90 percent of the accidents immediately, he adds percentages starting at zero occurrences until 90 percent is reached. In Table 1 this falls at 2 occurrences. In other words, two persons will be able to immediately handle at least 90 percent (actually 94.9 percent) of all accidents when they occur. An interesting point is that even with only two officers, one will be free 77.4 percent of the time (fewer than two accidents). The other will be free 36.2 percent of the time.

With random events, a doubling of the frequency does not double the needs to handle those events. Line C shows what would happen if 80 accidents occurred instead of 40. There still are periods where no accidents occur, e.g., hours 40 and 41, but there are now fewer such periods. The maximum number of accidents has now risen but only from four to six. These six occur during the two hours from 10 to 11. The frequencies and percentages of occurrences from Line C are also shown in Table 1. The maximum number of officers has risen by 2, from four to six. However, the number of officers needed to handle 90 percent has risen by only 1, from two to three.

A 19th Century mathematician named Poisson showed that the information depicted on Lines B and C (a random occurrence of events) could be reproduced mathematically. Thus Table 1 could be produced without plotting Figure 1. The information required is the same as used to complete Figure 1, the number of accidents, e.g. 40, the period, e.g. 80 hours, and the block to time, e.g. 2 hours. For example, if 2,920 accidents occur in a year (there are 8,760 hours in a year), the rate of occurrence is 0.3 per hour. If two hours are required to handle an accident, on the average 0.6 accidents will occur during this period. Table 2 summarizes the percentage of time zero through four accidents are expected to occur. From the Table, a decision onthe number of officers needed can be made. If 99 percent of the accidents must be handled immediately, three are needed. On the other hand, two officers are needed if 95 percent must be handled. The term probability can be substituted for percent.

TABLE 2

DISTRIBUTION OF ACCIDENTS

IN TWO-HOUR BLOCKS

(0.3 Accidents Per Hour)

Number Of Accidents	Percent of 2-Hour Blocks	Cummulative Percent
0	54.9%	54.9%
1	32.9%	87.8%
2	9.9%	97.7%
3	2.0%	99.7%
4	0.3%	100.0%

In the model, two surrogates for calls for service were selected: accidents handled by the Illinois State Police and Field Reports. All accidents occurring could have been used, but this would not have adequately reflected the variations in the percentage handled by local police. The use of Field Reports for a variable is more difficult to justify. There is a wide variation in the number filed on a "per officer" basis. More importantly, the numbers themselves can be changed to affect the manpower required. (This was one step that was avoided where possible in the construction of the model.) There are, however, no state-wide statistics that can be substituted. Several districts have been collecting data which reflect the activity at the desk. Whether such data will be collected statewide or whether there is a correlation between these data and field reports is not known. Once these answers are known, there may be a more accurate and representative number for activity requiring police response.

The average number of accidents handled per hour, as well as the average number of Field Reports per hour, is known. The average length of time to handle an accident and a Field Report has been estimated. From this information, the number of officers required to handle 90, 95, 99, etc. percent of each can then be computed.

To assign officers to calls for service and ignore driving as part of that response would have been unrealistic. The model accounts for driving under the following premise: the distance driven in all districts should be equal. The method used for equalizing these distances was the ratio of the average mileage in a given district to the average mileage in the smallest district. If that ratio were three to one, then three officers would be required in the larger district to ensure that the driving distance was equal to the smaller district. The number of officers needed to minimize driving distance is then compared to the number of officers needed to handle calls for service. The larger of the two numbers is used.

The required factors for computing the number of officers needed to handle calls for service are:

1. Number of accidents handled by the State Police;
2. Number of other calls (currently measured by Field Reports);
3. Average time required to handle an accident and to handle other calls;
4. Percent of accidents and other calls to be handled immediately;
5. Average driving distance (a function of area); and
6. Minimum driving distance.

Of the factors shown, numbers 1, 2, and 5 are based on available data. The remainder can either come from available data or can be estimated. The decisions made in terms of these remaining variables, e.g., percent of accidents to be handled immediately, (could be 50 percent or 99 percent) will affect the allocation of manpower among districts dependent upon the size of the district, number of accidents handled, and number of other requests for assistance. More manpower will be assigned to handle calls for service when the average time to handle calls (either accidents or other services) or the percent of calls handled immediately is increased. It will also increase if the minimum driving distance is reduced.

The number of officers required for overhead and the number required to answer calls for service are subtracted from the fixed amount of manpower. The remaining available manpower can then be allocated to preventive patrol of highways and rural areas. These remaining officers represent the minimum coverage of patrol that will be available if the maximum expected number of calls is received. However, as was shown in Figure 1, and Tables 1 and 2, the maximum number of calls occurs infrequently. Thus, there will normally be far more than the minimum number of officers on patrol.

Discretionary (Preventive Patrol)

The allocation of discretionary manpower is based on two elements: patrol of the highways for traffic law enforcement and patrol of rural areas to assist in crime prevention. This allocation represents the minimum patrol that will be maintained when the maximum expected number of calls for service are received. Most of the time when calls for service are not received, the number of officers available for preventive patrol will be greater than that labelled as such in the model. For example, if one result of the allocation indicates a 50-mile patrol of Interstate Highways, and this is the maximum. If there is another officer available for calls for service but is patrolling the Interstate Highways, there are two officers for 50 miles or 25 miles per officer.

Patrol for traffic law enforcement is further defined in the model as patrol of four-lane highways (generally Interstate Highways) and patrol of other roads. Because of the volume of traffic, a substantial amount of patrol will be devoted to four-lane highways. To include these highways with all others would minimize the importance of patrol along four-lane roads. (While four-lane highways represent less than three percent of all rural highway miles, they carry 46 percent of the traffic.)

The mechanics of allocating patrol on the four-lane highways is the same as that for allocating patrol to the other highways. The first decision made is the

percentage of discretionary manpower to be assigned to four-lane patrol, other highway patrol, and to general patrol of the rural population. A greater percentage given to four-lane patrol will allocate more officers to districts with long segments (or heavily traveled segments) for four-lane highways. On the other hand, assigning a large percentage of the allocation to rural patrol will be to the detriment of the more populous areas.

The following factors are used in computing the allocation of manpower to highways:

1. Percent of discretionary manpower to be assigned;
2. Miles of highway;
3. Traffic volume; and
4. Density factor.

Factors 2 and 3 are historic data. The weight given to factors 1 and 4 must be determined. In its computation, the model solves for the miles of patrol required in order to meet the percentage of discretionary manpower established. A key element in these computations is congestion because it reflects on the actual amount of patrol that can be performed. Congestion increases with increases in traffic volume. On four-lane roads, traffic engineers have found that a volume of 10,000 vehicles per day (this will be referred to as a "density factor") is generally sufficient to generate periods when traffic is moving at less than the speed limit. Simplistically, the greater the volume, the lower the average speed. Traffic volume on four-lane roads is divided by the density factor and the result multiplied by the highway miles. If the average daily traffic (volume) is 20,000 and the density factor 10,000, the result would be 2.0. Multiplying the actual miles of highway by 2.0 would be the same as cutting in half the average speed on the highway. Because patrol speed should never exceed 55 m.p.h. where volumes are less than the density factor, the minimum multiplier must be 1.0. At the same time there must be an upper limit. This upper limit is adjustable (a decision that has to be made) but should not exceed

4.0. In fact, 2.5 is recommended which translates to an average speed of patrol of approximately 20 m.p.h.

Although the model computes an allocation for two-lane state highways, and county and local roads based on a separate percentage of available manpower, the methodology is the same. Highway miles and traffic density are used. Because two-lane roads are more susceptible to less than 55 m.p.h. speeds as a result of volume, the density factors are much lower. In addition, because two unknowns (patol mileage for both two-lane and other rural roads) are being solved, one must be fixed. Currently, the patrol mileage of other local roads is fixed - a one patrol (minimum) per month or approximately 10,000 miles of road adjusted for density on those roads. This could be changed dependent upon the weight to be given to patrol county and township roads.

The final portion of allocating discretionary manpower is the assignment to rural patrol. The factors are:

1. Percent of discretionary manpower assigned;
2. Rural population; and
3. Rural law enforcement personnel.

As with assignment based on highway mileage, the percent of discretionary manpower to be assigned to rural patrol must be decided prior to computation. If the percent of manpower assigned to highway patrol has been fixed, the remainder (from 100 percent) is assigned to this portion. Rural population is defined as total population less the number of persons living in cities (the minimum size of a city is the same as the maximum size used to compute the number of rural law enforcement officers, e.g. 1,500). The duties of rural law enforcement personnel (other than state police) in this portion of the model are considered the same as State Police. There is overhead; therefore, in the larger sheriff's departments, not all officers are available for patrol. The number of vehicles on patrol available the Uniform Crime Report is

used. To this is added the number of police officers in rural towns (the size of the town determined, e.g. 1,500 persons).

The computations combine State Police and other law enforcement personnel into a category called "rural police". At the conclusion of the computations, the number of State Police allocated is derived from the number of "rural police" in each district less the number of other rural law enforcement officers. The minimum is zero State Police. To prevent undue weight given to persons in those areas who are unwilling to support rural law enforcement, a maximum of one State Police officer per shift per county is the upper limit. What is being solved mathematically is the "number of persons per rural police officer" such that the total State Police officers in this category are equal to the percent of discretionary manpower assigned.

SUMMARY

When used in allocating manpower, the model works with three elements: overhead, reaction to incidents, and preventive patrol. Overhead represents those positions not generally available for patrol or answering calls for service. The allocation of overhead to districts is the prerogative of management. The remaining available sworn personnel are allocated dependent upon certain state-wide decisions as shown below:

1. Percent of requests for service to be answered;
2. Relative weight given to the time spent to handle various calls;
3. Percentage split of discretionary manpower to minimum patrol of four-lane and two-lane highways and to the rural population;
4. Importance of traffic density; and
5. Limits to rural population and number of other rural law enforcement officers available.

Based on these decisions, the model will present an allocation of manpower district by district which will satisfy the constraints. Because the model uses a computer, two benefits are available. First, the allocation of manpower can be performed at the level of the county and the counties subsequently accumulated into districts. This will improve the results. Second, a wide range of decisions can be made and the results viewed more rapidly than if the same calculations were made by hand. In the end, management can select a series of constraints which more closely match their philosophy and prepare an allocation plan, based on the model, that will help attain that philosophy.

The plan must be long-term, at least for a ten-year period. Its accomplishment should be brought about by a combination of attrition, promotions, transfers, and assignment of new personnel. There could be some immediate shifts in personnel, but such forced changes, particularly considering the economic conditions in the housing market, should be minimized. Once the plan is prepared, it remains flexible. At least once each year the model must again be presented. The computations will use updated information as well as changes in philosophy that may have occurred. Such changes will modify the allocation plan.

What has not been discussed is the contribution of the model toward supporting needs for additional manpower. The model can operate without setting a maximum on available manpower. Each of the three elements - overhead, reaction, and the preventive patrol can be computed using more desirable and practical factors and the results made part of the manpower requests. The benefits of such operation of the model is that requests for increases can rationally be supported. However, until the planned distribution of manpower can be considered optimal, requests for more manpower may be difficult to justify.

The utility of planning, of which this model is a part, rests with the users. When the users examine their individual needs in relationship to the whole, then the planning (along with the model) is a valuable tool. It assists in intelligent decision making.

END