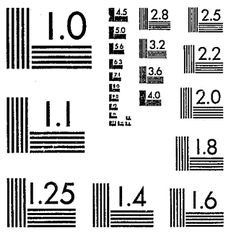

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A METHOD FOR ALLOCATING STATE POLICE OFFICERS IN ILLINOIS

ILLINOIS DEPARTMENT OF LAW ENFORCEMENT
DIVISION OF ADMINISTRATION

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ILLINOIS DEPARTMENT OF LAW ENFORCEMENT
DIVISION OF ADMINISTRATION
Springfield, Illinois

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ABSTRACT

The model designed for the allocation of state police officers or highway patrolmen to rural areas is based on assignment of manpower to three functions: administration (overhead), handling calls for service, and patrolling as a deterrent to crime and to violations of traffic law.

Administrative support represents those officers required for managing the operations including central office, line, and specialty functions. These officers normally do not patrol or perform policing actions. Their assignment to positions is a function of the executive.

Assignment of manpower to answer calls for service is dependent upon the number of calls received in two categories: accidents and generalized complaints. Sufficient personnel must be available to handle most of the requests when they are received and to respond to these requests within a reasonable time.

Finally, officers are also assigned to preventative patrol. For a state police organization; this number is dependent on the number of miles of highway that require patrol, the traffic on those highways, and the number of persons residing in rural areas.

The allocations based on these three criteria are assigned to counties. In turn, these counties are aggregated into districts which represent the primary organizational structure. The use of various parameters gives management the flexibility of selecting different policing objectives and examining the distribution of manpower that satisfies these objectives. This model works either with a predetermined allotment of police or it can be used to project the number of officers required.

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A METHOD FOR ALLOCATING STATE POLICE OFFICERS IN ILLINOIS

INTRODUCTION

A mathematical model for allocating Illinois State Police (ISP) officers to the primary unit of command, a district, has been constructed. This allocation is sensitive to the emphasis placed on two functions of the ISP: responding to calls for service and patrolling the highways as a deterrent to accidents and crime. The model allows testing of various managerial philosophies and presents a basis for planning an allocation of sworn personnel.

Such a plan must be long-range. First, there are 56,400 square miles in Illinois. Personnel can not be shifted immediately to meet the changes computed. Second, legislative mandates and the availability of local law enforcement personnel are changing. ISP priorities of police enforcement this year may be different in the next year. Finally, the present distribution of officers has been based on apparent, rather than computed, needs. In some areas, relatively large (magnitude of 10 to 15 percent) shifts may be required. This would create unwarranted problems, both with administration and with officer morale.

While a number of sources have been used, the model devised for ISP differs in construction from those already prepared. Most models of allocation are designed for urban areas and depend upon the availability of additional units to supplement response to calls. Although sheriffs' personnel may sometimes be available, in many counties such additional units of the State Police often are not

readily available. Further, the Illinois State Police are a full-service agency; the officers are expected to answer calls for service which are non-traffic related in addition to their patrolling of highways for purposes of traffic law enforcement.

BACKGROUND

Until recently, the Illinois State Police have allocated sworn personnel to the districts based on apparent need. These needs often have not been well defined nor adequately supported. Some attempts have been made to allocate manpower based on the work of Wilson.[1] This has resulted in a large percentage of police officers assigned to the populous six-county region surrounding and including Cook County (Chicago) and to a two-county region across from St. Louis, Missouri. Although serving 65 percent of the population of Illinois, such assignments have covered only ten percent of the area.

Attempts to allocate manpower to districts based on proportional needs related to crime, population, miles of highway, vehicle miles, size of district, and the number of state police actions in terms of calls for service additionally have suffered from several drawbacks:

- The variables previously used have given population a heavy weight and have been correlated. (Crimes, vehicle registrations, and vehicle miles all show strong positive correlations with population and with each other.)
- Decisions in terms of the arrival rates of calls, how promptly they would be answered, and appropriate accounting for minimum response time could not be made.
- Administrative support (overhead) has not been adequately defined, and the amount needed not adequately computed.

The literature describing allocation of police manpower in rural areas is limited. A study completed by Arizona used response to accidents as a basis for allocation.[2] Systems Science Development Corporation of St. Louis prepared methodology for assigning patrols to Interstate 80 in Illinois.[3] Even the work of Lipseff and Arnold,[4] although designed for a semi-rural police force, was more applicable to an urbanized area than to the more rural state-wide patrol.

That most of the work has been devoted to allocating manpower in urban areas is not unexpected. The areas are compact; they allow overlapping response. Traditionally, the urban police forces have been considered short of manpower. An adequate allocation of the limited resources throughout the city therefore has been important. Several theoretical approaches and models designed for specific cities are noted, including Chaiken,[5] Larson,[6] and LeGrande.[7] Even though not directly applicable to the needs for allocating state police officers in Illinois, these models have helped serve as a basis for the model presented in this paper.

NEEDS TO BE MET

The size of Illinois, its relatively sparse population and long distances between major cities, and a need for enforcement of traffic laws as well as crime prevention throughout the state must be considered. By law, the ISP currently are authorized 1,600 sworn officers.[8] An additional number of State Police Officers are working under contract with the Toll Road Authority and are not included in the authorized strength. These officers have policing powers throughout Illinois and must be reasonably available to the 11.2 million persons living in the 56,400

square miles. Although the ISP jurisdiction covers the entire state, the availability of local law enforcement personnel in most communities with a population of 2,500 or more persons allow the State Police to concentrate their activity on state and federally funded highways outside these communities. They generally work with sheriffs' departments in patrolling and policing the rural areas.

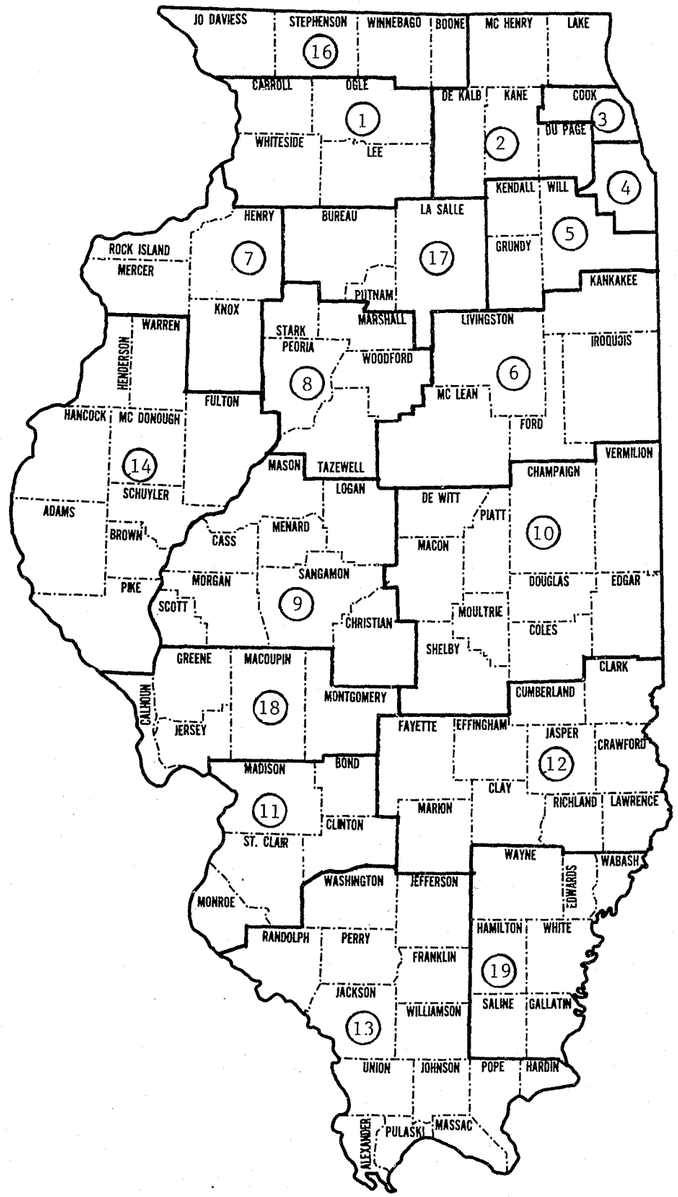
Currently, officers from the State Police are assigned to all of the 102 counties. These officers report to the basic unit of command, a district, which comprises three or more counties except in Cook County which is divided into two districts. A map showing the state, counties, and districts is given as Figure 1. Distribution of personnel to the counties and to patrols within a district is the prerogative of district management. Generally, the majority of available manpower has been assigned near the centers of population.

In addition to the personnel assigned to patrol (including their immediate supervisors), a portion of the authorized strength handles administrative matters. Some are assigned to the central office in Springfield: a number also are assigned to executive security for the governor and top elected officials. Each district, requires officers for district command, desk, and specialty functions. The latter include: public information, automotive equipment, ordnance, court, vehicle identification, Second Division (commercial vehicles), and the most recently mandated activity, enforcement of the laws governing the shipment of hazardous materials. In some of these positions, the officer is not readily available for patrol.

Those officers on patrol handle any police matter. Most of their time is spent enforcing traffic laws; however, the State Police also respond to motor

FIGURE 1

ILLINOIS STATE POLICE
DISTRICTS



vehicle accidents, criminal complaints, and assist municipal and sheriffs' police as needed. Thus, any model prepared must account for all of these functions.

Other related police services including laboratory and forensic services, crime scene technicians, criminal intelligence, criminal identification, detective services, internal investigation, and training are provided by separate divisions within the Department of Law Enforcement. The Department is examining these functions for the purpose of determining better methods for allocating personnel.

MODEL FOR ALLOCATING OFFICERS

Background and Philosophy

Several methods of allocation have served as a basis for the model described in this paper. Most of these methods have been applicable to urban areas. Size of the patrolling area and an ability to use multiple resources in responding to a call generally have been the determinates of these allocations.[9] The size of the patrol reflects on the time of response, small increments of which appear to be critical in the urban area.[10] The size of the patrols for the ISP are relatively large; many cover more than 1,000 square miles. Small differences in response time and the availability of multiple resources do not play a significant role when planning allocations for these relatively large areas.

Two philosophies are employed in this model: response to calls for service and preventive patrol (both for traffic law enforcement and suppression of crime). Once the administrative support is subtracted, the remaining manpower can be

divided according to the emphasis placed on each philosophy. Greater attention given to answering calls for service will reduce the amount of manpower available for policing and patrolling, i.e., patrol remaining when the maximum number of calls have been received.

As will be discussed on the following pages, the model incorporates the following premises.

1. Wherever possible, the variables used are exogenous to the control of the agency for which manpower is allocated.
2. These variables also are weakly correlated; a change in one variable should have minimal effect on any other variable.
3. The number of officers available for allocation is less than the total available (authorized strength); the remaining officers provide administrative support and are assigned by executive decision.
4. The amount of manpower to be assigned to a specific philosophy, e.g. calls for service, is not limited except by the total number of officers available for allocation.
5. The same techniques used for allocation can also be used for projecting needs.

The remainder of this report presents the generalized equations of the model. Specific equations for each of the elements are shown in Appendix A. The model itself takes the form:

$$N_i = O_i + f(C_i) + f(D_i) \qquad (1)$$

where:

N - Number of officers allocated.

O_i - Administrative support.

$f(C_i)$ - Function of the calls for service.

$f(D_i)$ - Function of demographic and geographic variables establishing a need for patrol.

i - The smallest unit of distribution, e.g. a district.

such that:

$$N_i = T$$ (T is total manpower available for distribution.)

Administrative Support

Those officers assigned to administrative duties or to specialty functions generally are not available to answer calls for service or to engage in preventative patrol. Their allocation to central office and to districts is based upon needs perceived by the executive. (For the Illinois State Police, additional officers are assigned to Executive Security because of legislative mandate.) Therefore, increasing the number of officers required for administrative support will reduce the number to be allocated according to needs for response and patrols. This is apparent from equation (1). The danger of withholding too many officers for administrative purposes is that these assignments may bear minimal relationship to the policing needs of a district. That, in turn, will reduce the usefulness of the model.

Calls for Service

An essential service of the Illinois State Police is their response to requests for assistance. Although the ISP answer many requests, two are of special importance: handling and investigating accidents, and investigating complaints of a criminal nature. Each district should have enough officers available to answer requests adequately for each of these two services in order to minimize the number of requests placed in queue.[11] Further, these officers should be able to respond

within a maximum acceptable time. Thus, the function of response to calls for service **f (C)** minimizes both the amount of calls placed in queue and response time. Regardless of the number of officers allocated, the unexpected -- snow storms, prison riots, and the like -- cannot be predicted and cannot be considered by the model.

The minimization of the percentage of calls placed in queue can be computed from an expected rate of arrival for calls and the time taken to service each call. Arrival rates for random events fit a Poisson distribution, the relevance of which has appeared in several works.[12, 13] The need to minimize response time also is documented.[14] In the two equations below, the maximum **f (C)** is selected. The first, shown in equation (2a) provides enough personnel to answer calls for service. The second, equation (2b) satisfies a maximum response time:

$$f(C) = f(A;m) + f(B;m) \quad (2a)$$

$$f(C) = f(Q) \quad (2b)$$

where:

f (A;m) - Poisson distribution of accidents where **m** is the mean number of accidents occurring during the time taken to handle one accident.

f (B;m) - Poisson distribution of requests for assistance (criminally related) where **m** is the mean number of requests occurring during the time taken to handle one request.

f (Q) - An exponential function of the area and the maximum response time converted to distance. The conversion of maximum response time to distance is dependent upon speed of response which itself is affected by congestion.

Because each of the functions use information that applies to any one period of the day, the number of officers required can be found for any shift and the number accumulated and adjusted for 24-hour coverage. The method of computing either **f (A;m)** or **f (B;m)** is the same. The probability of any number of occurrences including zero are computed and summed. The maximum number of calls expected occurs at the point where the sum of the probabilities is equal to 1.0 minus the proportion of calls placed in queue.

The function **f (A;m)** uses the number of accidents the state police expect to handle during any one period. These can be predicted from a trend analysis which is based on the amount handled as a percent of those reported to the state (including those reported to the state police) and that number reported. Accounting for criminal complaints is more difficult. There are no data bases from which to obtain a count of the number of reported incidents and the number ultimately handled by the state police. A weakness in the model as used for Illinois is a lack of accurate information to be used with function **f (B;m)**.

The other step is computing the number of officers required to minimize response time. This is obtained by converting the maximum response time allowed to distance using the amount of congestion to reduce the distance from the maximum possible.

$$f(Q) = Q/2d^2 \quad (3)$$

where:

Q - Area in square miles

$$d = t_q / f(c) \quad (4)$$

where:

t_q - Maximum response time

f (c) - Is a percent of free moving speed dependent upon congestion as described by the American Association of State Highway and Transportation Officials.[15]
f(c) is described as $k_1 V$ where k is a constant that represents a change in patrolling speed based on the volume of traffic. It is given in the form a + bx.

Assignment to Policing and Patrolling

The number of officers required for administrative support and the number needed to answer calls for service are subtracted from the authorized strength. If a negative number results, either the number assigned to administrative support is too many or the parameters used for allocating officers to calls for service too liberal. Remaining are the number of officers available to meet a minimal standard for the patrol of highways as well as preventative patrol in rural areas. This preventative patrol supplements that of the sheriff and other smaller municipal forces. Allocation to specific patrols within the district remains the commander's prerogative.

The model uses three types of patrol for allocating the remaining manpower: Interstate highways, other two-lane roads, and rural areas. The latter is assumed to be shared with county and small municipal departments. In this case, to the extent possible, the State Police provide additional patrolling where local enforcement does not meet expected requirements for manpower.

$$f(D) = f(M_1, V_1) + f(M_2, V_2) + f(R,L) \qquad (5)$$

where:

$f(M_1, V_1)$ - Miles of Interstate highway and the volume of traffic on those highways.

$f(M_2, V_2)$ - Miles of other highways and the volume of traffic on those highways.

$f(R, L)$ - Rural population and number of sheriffs' patrols and municipal police.

Available from the Illinois Department of Transportation are current highway mileages and traffic volumes expressed in vehicle-miles. The equations for determining the number of officers required for Interstate highway patrol and patrol of two-lane roads are similar. Two separate equations have been written because Interstate highways, while representing only 2.5 percent of the mileage, carry 48 percent of the volume of traffic. Use of a separate equation for Interstate highways allows for more realistic assignment of patrol to this type. On any highway, the miles driven on patrol are a function of the average patrolling speed, which in turn is a function of volume and the number of traffic stops made.

Because traffic stops are correlated to volume, the number of officers required for a specific length of patrol on either Interstate or other highways **f (M, V)** can be written:

$$f(M, V) = M\ (55 - f(c))\ /\ 55\ G \qquad (6)$$

where:

55 - National maximum speed limit.

M - Miles of road.

G - Miles of patrol.

f (c) - Factor based on volume which accounts for both reduced driving speed and increased number of vehicle stops resulting from increasing volume.

and:

$$f(c) = V\ (k_1 + k_2) \qquad (7)$$

(Given as the form $a + bx$)

where:

k_1 - Constant representing a change in patrolling speed.

k_2 - Constant representing a change in the number in traffic stops.

V - Volume of traffic.

Because the amount of manpower required for policing and patrolling depends upon the length of patrol **G**, either it must be given or found by solution. When a fixed number of officers are assigned to this portion, **G** is found so that the sum of the officers assigned to the patrol of the specific type of highway will equal the proportion of officers available for patrolling that type of highway:

$$f(M, V) = p\ f(D) \qquad (8)$$

note: The proportions **p** of manpower assigned to each of the three categories of patrol, when summed, equal 1.0. The portion assigned to any one category is a managerial prerogative.

The equation for two-lane roads follows the form of equations (6) through (8) except that they comprise two components, state two-lane highways and other local roads.

Finally, a portion of this remaining manpower is assigned to patrolling rural areas. Because the state police assist local law enforcement personnel in the prevention of crime, the primary factor is the number of local law enforcement personnel. Limits should also be placed on the number of state police required for this function. A computation of less than zero officers means that the number of officers assigned to a specific county will be reduced. This would occur because there are more than sufficient local police to patrol the rural area. In applying the model to the Illinois State Police, a lower limit of zero was set for equation (9) below. The number allocated by the remainder of the computations, therefore, will not decrease. On the other hand, some jurisdictions fail to provide a sufficient number of law enforcement personnel to adequately patrol. Where this occurs

one state police officer could be assigned. To ensure adequate coverage for 102 counties in Illinois, a limit of one state police officer per shift was set as a maximum. Such a limit is not as severe as it seems initially. Other parts of the model have allotted police to handle accidents, answer calls for service, and patrol the highways. Thus, officers have been assigned to the county in addition to the number assigned by equation (9) solely for rural patrol:

$$f(R, L) = R/r - L \qquad (9)$$

such that $0.0 \quad f(R, L) \quad$ max. officers per shift

where:

R - Rural population (assumed to be unincorporated areas and municipalities of less than 1,500 persons).

r - Number of persons per shift per law enforcement officer.

L - Number of sheriffs' patrols and local law enforcement personnel (in municipalities of less than 1,500 persons).

note: When there is a fixed number of officers to be assigned, **r** is found such that the sum of the officers assigned in equation (9) satisfies the number of officers, totally, to be assigned to rural patrol. This is similar to that shown in equation (8).

SUMMARY

What has been shown are equations of a model designed to allocate a fixed number of Illinois State Police officers to districts throughout the state. This is

done by computing the needs for each county and combining these counties into districts. With the use of computing equipment, the managerial options such as percentage of calls placed in queue, the percentage of officers assigned to four-lane, two-lane, and rural patrol, response time, etc., can be varied and different allocations produced. This gives the manager an opportunity to examine the results of choices of action without first taking any action. A sample of the output from the version programmed for the computers at the Department of Law Enforcement is shown in Appendix B. This version works with an authorized strength of 1600 officers.

The model is not limited to an allocation of a fixed strength. Manpower can be projected. When the model is used for projection, the miles of patrol on each type of highway and the number of persons in rural areas per police officer, instead of being solved mathematically as shown in equations (8) and (9), are set by the user. Thus, the number of officers needed to handle calls for service, the number required for policing and patrolling, and the total allocated vary according to the parameters used. A total of those computed for each of the three categories (including administrative support) then becomes the projected number of officers required to satisfy a managerial philosophy. Many philosophies can be proposed. Their effects on future strength, as well as its allocation, can be projected. Once a path is selected, the requisite justification for changes has already been set forth.

While the number of equations and variables used preclude accurate and rapid computations with a desk-top calculator, the model is readily adaptable to small computers. The amount of storage needed to operate the model is relatively small; programming is relatively simple. Further, because of the number of parameters

used to control the computations, the model is extremely flexible. This would make it readily adaptable to other states that have a full-service police agency, traffic enforcement responsibility, and concurrent local law enforcement bodies, and who were seeking a method to help allocate their officers.

NOTES

(1) O. W. Wilson and R. C. McLaren, Police Administration, 2nd ed., Charles C. Thomas, Springfield, Il., 1972.

(2) J. Stoneberger and L. Deitch, Manpower Requirement and Allocation Study, Arizona Department of Public Safety, Phoenix, Az. (undated).

(3) A Compendium of Illinois I-80 Project, Systems Science Development Corporation, St. Louis, Mo., June 1970.

(4) F. R. Lipseff and J. G. Arnold, "Computer Simulation of Patrol Operations of a Semi-Rural Police Force," Journal of Police Science and Administration, 2:2, June 1974.

(5) J. M. Chaiken, Patrol Allocation Methodology for Police Departments, Report R-1852-HUD, Corporation, Santa Monica, Ca., September 1975.

(6) R. C. Larson, A Hypercube Queuing Model for Facility Location and Redistricting Emergency Services, Report R-1238-HUD, RAND Corporation, Santa Monica, Ca., March 1973.

(7) J. L. LeGrande, "Distribution of Municipal Police Patrol Manpower," Planning and Research Bulletin, No. VI, School of Police Administration and Public Safety, Michigan State University, Lansing, July 1968.

(8) Illinois Revised Statutes, 121-307.1, Amended by PA 76-270, July 1, 1969.

(9) P. S. Mitchell, "Optimal Selection of Police Patrol Beats," Journal of Criminal Law and Police Science, 63:4, December 1972, pp. 577-584.

(10) C. Clawson and S. K. Chang, "The Relationship of Response Delays and Arrest Rates," Journal of Police Science and Administration, 5:1, March 1977, pp. 53-68.

(11) In this paper, the term "queue" is used in a broad sense to represent those activities that the state police do not handle the moment the call is received, including delaying response, requesting assistance from another agency, dispatching a state police unit from some distance, or dispatching a state police unit currently on a call of lower priority.

(12) Larson, supra.

(13) W. Bennett and J. R. DuBois, The Use of Probability Theory in the Assignment of Police Patrol, Edina Police Department, Edina, Mn., July 1970.

(14) For example: S. A. Smith, "Estimating Territory Size," Management Science, 25:4, April 1979, pp. 301-311, and P. Kolesar and E. M. Blum, "Square Root Laws for Fire Engine Response Distances," Management Science, 19:12, August 1973, pp. 1368-1378.

(15) American Association of State Highway and Transportation Officials, A Policy on Geometric Design of Rural Highways, 1965, Washington, D.C., 1977, p. 96.

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APPENDIX A

MATHEMATICAL FORMULAE FOR ALLOCATING STATE POLICE OFFICERS

1. MODEL

$$N_i = O_i + C_i + D_i$$

such that: $T = \sum N_i$

variables:

N_i - Number of officers allocated
O_i - Officers performing administrative support
C_i - Officers answering calls for service
D_i - Officers patrolling
T_i - Total number of persons available for allocation

subscript

i - any county

note: If the model is used for projection, this portion of the formula is not used.

2. CALLS FOR SERVICE
(note: each of the steps below is performed for each county, as the smallest unit of area, and for each of three shifts within that county.)

$C = 1.66\ C_1$ or $1.66\ C_2$ (whichever is greater)

note: 1.66 represents the number of persons required to staff a 24-hour shift (4.98 for this model) divided by three shifts.

Calls

$C_1 = A + B$

$A = \sum f(A\ ;\ m)_s$ (Accidents)

where for each shift:

$m = A' p_{as} t_a / 2920$

$P(x) = e^{-m} m^x / x!$

such that: $\sum P(x) \geq (1.0 - q_{as})$

$B = \sum f (B ; m)_s$ (Criminal Investigation)

where for each shift:

$m = B' p_{bs} t_b / 2920$

$P(x) = e^{-m} m^x / x!$

such that: $\sum P(x) \geq (1.0 - q_{bs})$

Minimum Response Time

$C_2 = Q / 2 d_s^2$

where:

$d_s = d' [(60 - g_{ts}) M_t + (60 - g_{os}) M_o] / 60 (M_t + M_o)$

$g_{ts} = V_t p_{ws} / 2000$

for $V_t p_{ws}$ 3400

$g_{ts} = 5.15 + (V_t p_{ws} - 3400) / 70$

for all other $V_t p_{ws}$

note: g_{os} is found in the same manner as g_{ts} by substituting V_{os} for V_{ts}.

variables:

A' - Number of accidents handled
B' - Number of criminal investigations handled
M - Highway mileage
Q - Area
V - Volume expressed as average daily traffic (ADT)

variables (cont'd):

d' - Maximum response time
e - Natural log, 2.7183...
g - Reduction in speed resulting from congestion
p - Proportion assigned
t - Time taken to handle in hours

subscripts

a - accidents
b - incidents
o - other highways
s - any shift
t - two-lane road
w - volume

notes:

g_{ts} - Reduction in speed on two-lane roads resulting from congestion.

g_{os} - Reduction in speed on county and local roads resulting from congestion.

p_{as} - Proportion of accidents occurring in any shift.

p_{bs} - Proportion of criminal incidents reported during any one shift.

p_{ws} - Proportion of volume during any one shift.

3. POLICING AND PATROLLING
(note: This portion is solved for each county and, within each county, for each shift.)

$D = T - \sum O_i - \sum C_i$

$D_i = 1.66 D_{fi} + 1.66 D_{hi} + 1.66 D_{ri}$

note: Allocation for any county is the sum of the allocation of manpower to four-lane (Interstate) patrol, other highway (two-lane and local) patrol, and patrol for the rural population. If the model is used for projecting manpower, then D and D_i in each of the sections below are not solved.

Four-lane Patrol

$$\sum D_{fi} = p_f D$$

where:

$$D_{fi} = 55 M_f / \left[H_f (55 - g_{fs}) \right] + 13.75 Y_{fs} / (55 - g_{fs})$$

$$H_f = 55 \sum \left[M_f \sum 1 / (55 - g_{fs}) \right]_i / \left\{ p_f D / 1.66 - 13.75 \sum \left[\left[\sum Y_{fs} / (55 - g_{fs}) \right]_i \right\} \right.$$

note: Unless projections are being computed, H_f must be solved first.

$$g_{fs} = V_f P_{ws} / 8000$$

for $V_f P_{ws} \leq 10300$

$$g_{fs} = 3.88 + (V_f P_{ws} - 10300) / 1300$$

for all other $V_f P_{ws}$

$$Y_{fs} = 6.0 W_f P_{ws} / 2920$$

variables:

H - Miles of patrol
Y - Reduction in patrolling speed resulting from traffic stops
W - Volume expressed in vehicle miles or V * M

subscript

f - four-lane highway

notes:

Y_{fs} - Reduction in speed on four-lane roads resulting from stops of vehicles for the purpose of enforcing traffic regulations.

g_{fs} - Reduction in speed on four-lane roads resulting from congestion.

Other Highway Patrol

$$D_{hi} = p_h D$$

where:

$$D_{hi} = 55 M_t / H_t (55 - g_{ts}) + 13.78 Y_{ts} / (55 - g_{ts}) + 55 M_o / H_o (55 - g_{os}) + 13.75 Y_{os} / (55 - g_{os})$$

g_{ts} and g_{os} are given above

$$H_h = 55 \sum \left[M_t \sum 1 / (55 - g_{ts}) \right]_i / \left\{ p_h D / 1.66 - 13.75 \left(\sum \left[\sum Y_{ts} / (55 - g_{ts}) \right]_i + \sum \left[\left[Y_{os} / (55 - g_{os}) \right]_i \right) - 55 \sum \left[M_o \sum 1 / (55 - g_{os}) \right]_i / H_o \right\}$$

note: H_o is given because this is a single equation with the unknown as H_h. H_o represents the miles of patrol along local and county roads by one officer. Because such roads generally serve few residences or businesses and are patrolled by the sheriff, a length of patrol of 4000 or more miles is not unrealistic. This represents one pass per month per shift.

$$Y_{ts} = 8.75 W_t P_{ws} / 2920$$

$$Y_{os} = 1.83 W_o P_{ws} / 2920$$

subscript:

h - patrol of two-lane and local roads

notes:

Y_{ts} - Reduction of patrolling speed resulting from traffic stops on two-lane roads.

Y_{os} - Reduction of patrolling speed resulting from traffic stops on other (local) roads.

Patrol for Rural Population

$$\Sigma D_{ri} = p_r D$$

where:

$$p_r = 1.0 - p_f - p_h$$

$$D_{ri} = R / H_r / 1.66 - L / 4.98$$

variables:

R - Rural population
L - Local police including deputies and those police officers in municipalities of less than 1500 persons

subscript

r - rural patrol

notes:

D_{ri} cannot fall below a specific minimum nor rise above a specific maximum number of officers per shift.

Available local police are divided by 4.98 to represent the number of such police available for one shift.

When used for allocation, H_r must be solved iteratively until the solution $\Sigma D_{ri} = p_r D$. In practice, $D_{ri} = p_r D \pm 0.01 p_r D$.

APPENDIX B

DATE: SEPTEMBER 03, 1981

ILLINOIS DEPARTMENT OF LAW ENFORCEMENT

ALLOCATION OF PERSONNEL

CALLS FOR SERVICE

REPORT NO: SPJ0030A
PAGE NO: 1
SEQUENCE NO: 1

AVAILABLE MANPOWER: 1,124.00

DISTRICT	CASE DATA REPORTS NUMBER HANDLED	OFFICERS/SHIFT 1ST	2ND	3RD	ACCIDENTS NUMBER HANDLED	OFFICERS/SHIFT 1ST	2ND	3RD	MINIMIZED DRIVING	TOTAL PERSONS ALLOCATED
01	382.00	1.00	2.00	.00	926.00	3.00	3.00	.00	8.10	19.32
02	944.00	3.00	4.00	.00	2,515.00	4.00	4.00	3.00	7.94	33.68
03	1,247.00	3.00	3.00	2.00	4,941.00	4.00	4.00	2.00	1.50	29.88
04	2,172.00	5.00	4.00	2.00	2,737.00	3.00	3.00	2.00	1.59	31.54
05	1,752.00	4.00	4.00	2.00	1,784.00	2.00	3.00	1.00	4.90	28.82
06	1,230.00	4.00	4.00	1.00	1,804.00	4.00	4.00	.00	13.79	33.37
07	356.00	1.00	1.00	.00	817.00	2.00	3.00	.00	7.74	17.89
08	1,085.00	4.00	4.00	.00	1,827.00	4.00	4.00	1.00	7.66	31.90
09	748.00	3.00	2.00	1.00	1,411.00	3.00	2.00	1.00	13.02	31.32
10	1,320.00	3.00	4.00	.00	1,714.00	2.00	2.00	1.00	18.32	39.45
11	432.00	1.00	1.00	.00	2,644.00	5.00	6.00	1.00	8.10	25.81
12	872.00	2.00	2.00	.00	1,675.00	3.00	3.00	1.00	14.60	34.65
13	943.00	4.00	4.00	.00	2,591.00	7.00	9.00	1.00	17.20	54.05
14	621.00	2.00	3.00	.00	2,220.00	7.00	7.00	.00	17.17	40.11
16	1,000.00	2.00	2.00	1.00	935.00	2.00	2.00	1.00	6.08	21.49
17	534.00	2.00	2.00	1.00	771.00	2.00	2.00	1.00	6.70	18.53
18	100.00	.00	.00	.00	787.00	2.00	3.00	.00	8.43	15.26
19	197.00	.00	.00	.00	751.00	3.00	3.00	.00	8.61	17.58
TOTALS	19,124.00	45.00	46.00	10.00	32,867.00	82.00	87.00	16.00	171.65	524.71

DATE: SEPTEMBER 03, 1981

ILLINOIS DEPARTMENT OF LAW ENFORCEMENT
ALLOCATION OF PERSONNEL
CALLS FOR SERVICE

REPORT NO: SPJ0030A
PAGE NO: 2
SEQUENCE NO: 2

PERCENT REQUIRED FOR CALLS:

NUMBER OF PERSONS FOR 24-HOUR COVERAGE	4.98	PERSONS
CASE DATA REPORTS		
TIME TO HANDLE	2.00	HOURS
MULTIPLIER	400.00	PERCENT
PERCENT HANDLED		
0700-1459	90.00	%
1500-2259	90.00	%
2300-0659	75.00	%
ACCIDENTS		
TIME TO HANDLE	2.00	HOURS
MULTIPLIER	100.00	PERCENT
PERCENT HANDLED		
0700-1459	95.00	%
1500-2259	95.00	%
2300-0659	90.00	%

DATE: SEPTEMBER 03, 1981

ILLINOIS DEPARTMENT OF LAW ENFORCEMENT
ALLOCATION OF PERSONNEL
POLICING AND PATROLLING

REPORT NO: SPJ00308
PAGE NO: 1
SEQUENCE NO: 3

AVAILABLE MANPOWER: 604.23

DISTRICT	FOUR-LANE OFFICERS REQUIRED	FOUR-LANE	TWO-LANE AND OTHER	TWO-LANE AND OTHER OFFICERS REQUIRED	RURAL PATROL RURAL POLICE	LOCAL POLICE	TOTAL OFFICERS REQUIRED	TOTAL PERSONS ALLOCATED
01	[illegible]	14.37	3.46	17.83	38.71	35.00	5.11	25.19
02	13.69	29.07	9.41	38.50	107.41	103.00	5.88	45.08
03	13.46	2.95	.56	3.52	33.44	50.00	.00	16.88
04	19.33	3.13	.59	3.83	37.24	55.00	.00	19.21
05	11.68	9.14	2.63	11.77	65.05	70.00	2.02	25.42
06	15.99	29.19	6.70	41.89	68.06	183.00	4.82	52.70
07	9.32	13.37	3.27	16.64	40.98	42.00	3.99	29.95
08	6.69	15.20	3.41	19.68	60.07	56.00	9.40	32.78
09	10.78	19.72	5.79	24.52	65.26	79.00	5.09	40.40
10	16.41	34.06	8.84	42.93	90.48	124.00	1.35	60.90
11	15.14	10.17	3.56	19.73	96.84	92.00	6.44	41.32
12	12.26	18.49	7.60	26.03	51.37	72.00	2.72	41.61
13	19.53	26.88	7.04	33.93	79.96	113.00	2.19	55.66
14	.48	25.50	7.40	32.90	54.64	88.00	5.30	39.08
16	4.77	7.14	3.03	10.18	60.25	80.00	3.07	16.03
17	5.83	12.04	3.05	15.09	38.58	38.00	.00	20.93
18	4.12	11.36	3.52	14.89	34.22	35.00	1.27	20.30
19	2.46	10.31	4.27	14.59	27.63	41.00	1.27	18.33
TOTALS	161.29	282.25	80.31	362.57	1,097.14	1,419.00	59.99	603.84

PARAMETERS:		
FOUR-LANE		
PERCENT ASSIGNED	30.00	PERCENT
MILES OF PATROL	37.39	MILES
TWO-LANE		
PERCENT ASSIGNED	50.00	PERCENT
MILES OF PATROL		
TWO-LANE	219.84	MILES
OTHER	6,000.00	MILES
RURAL PATROL		
PERCENT ASSIGNED	10.00	PERCENT
PERSONS PER RURAL POLICE OFFICER	3.147	PERSONS

DATE: SEPTEMBER 05, 1981

ILLINOIS DEPARTMENT OF LAW ENFORCEMENT

ALLOCATION OF PERSONNEL

SUMMARY

REPORT NO: SPJ0030C
PAGE NO: 1
SEQUENCE NO: 5

DISTRICT	ADMINISTRATIVE SUPPORT	CALLS FOR SERVICE	POLICING AND PATROLLING	TOTAL ALLOCATION	CURENT DSP DEPLOYMENT TOTAL	PATROL	COMMAND
01	15.00	19.32	25.19	57.51	51.00	43.00	8.00
02	22.00	33.63	45.05	100.78	87.00	77.00	10.00
03	17.00	29.82	16.58	63.40	86.00	76.00	10.00
04	22.00	31.54	19.21	72.75	81.00	71.00	10.00
05	18.00	28.82	25.42	72.24	73.00	63.00	10.00
06	21.00	33.37	52.70	106.08	84.00	77.00	7.00
07	15.00	17.89	24.96	60.85	61.00	52.00	9.00
08	16.00	31.00	32.78	80.08	69.00	60.00	9.00
09	17.00	31.32	40.40	90.73	94.00	84.00	10.00
10	16.00	29.45	50.90	116.35	95.00	86.00	9.00
11	14.00	25.81	41.32	81.14	81.00	72.00	9.00
12	12.00	34.65	41.91	88.26	73.00	65.00	8.00
13	17.00	54.05	55.66	126.71	109.00	98.00	11.00
14	14.00	40.11	39.08	93.20	77.00	67.00	10.00
16	15.00	21.49	18.03	52.52	55.00	46.00	9.00
17	4.00	18.53	20.73	48.46	40.00	36.00	4.00
18	8.00	16.22	20.30	44.85	35.00	32.00	3.00
19	13.00	17.58	13.35	45.92	55.00	51.00	4.00
50--52	52.00	.00	.00	52.00	.00	.00	.00
TOTAL ALLOCATED	327.00	524.71	603.84	1,454.55	1,236.00	1,136.00	150.00

PARAMETERS:

ADMINISTRATIVE SUPPORT 325 PERSONS
PERSONS TO BE ALLOCATED 1,455 PERSONS

PARAMETERS UTILIZED

ADMINISTRATIVE SUPPORT	326.00
PERSONS TO BE ALLOCATED	1,495.00
AMOUNT OF OVERHEAD ASSIGNED	14.00
MANPOWER FOR 24-HOUR COVERAGE	4.98
MINIMUM STATE POLICE PER COUNTY	.00
MAXIMUM STATE POLICE PER COUNTY	1.00
PROPORTIONAL FACTOR-CASE DATA	4.00
PROPORTION TO BE QUEUED-1 CASE DATA	.10
PROPORTION TO BE QUEUED-2 CASE DATA	.10
PROPORTION TO BE QUEUED-3 CASE DATA	.25
PROPORTIONAL FACTOR-ACCIDENTS	1.00
PROPORTION TO BE QUEUED-1 ACCIDENTS	.05
PROPORTION TO BE QUEUED-2 ACCIDENTS	.05
PROPORTION TO BE QUEUED-3 ACCIDENTS	.10
PROPORTION OF ADT-1 OTHER	.45
PROPORTION OF ADT-2 OTHER	.40
PROPORTION OF ADT-3 OTHER	.15
PROPORTION OF MANPOWER-INTERSTATE	.30
PROPORTION OF MANPOWER-OTHER	.60
PROPORTION OF MANPOWER-RURAL	.10
AVERAGE TIME TO HANDLE-CASE DATA	2.00
AVERAGE TIME TO HANDLE-ACCIDENTS	2.60
MAXIMUM RESPONSE TIME-1	20.00
MAXIMUM RESPONSE TIME-2	30.00
MAXIMUM RESPONSE TIME-3	30.00
MILES OF PATROL-2 LANE	219.84
MILES OF PATROL-4 LANE	37.3
MILES OF PATROL-LOCAL ROAD	6,000.00

END